



Quasar Management Services Pty Limited
ABN 21 003 954 210
Not-for-profit consulting structural and civil engineer
Subsidiary of Partner Housing Australasia (Building) Incorporated
69 Renwick Street, Redfern NSW 2016, Australia
Phone: +61 432 611 550
Email: RodJohnstonAUS@gmail.com

DANCER Building System

**Direct Anchorage Noncyclonic Cyclonic Earthquake Resistant
Building System for Wind, Earthquake and Tsunami Resistance**



Five Police Houses constructed using the Partner Housing Australasia **DANCER** building system at Baiyer River for the Government of Papua New Guinea.

Contents

Partner Housing Australasia (Building) Incorporated.....	7
Disclaimer	7
Copyright	7
Acknowledgements	7
Dedication.....	7
Scope of Manual	7
Part 1 – DANCER Manual	1
Introduction.....	2
Background.....	2
DANCER Elevated Timber Buildings.....	3
DANCER Timber Superstructure on Concrete Slab-on-Ground.....	4
DANCER Reinforced Concrete Masonry on Concrete Slab-on-Ground.....	5
DANCER Rafter System	6
Purpose and Structure of This Manual	7
Part 2 – DANCER Design	1
DANCER Design Workbook.....	2
Design Actions	4
Wind Action Applicable to DANCER Standard Buildings	4
Other Actions Applicable to DANCER Standard Buildings	4
Timber Applicable to DANCER Standard Buildings.....	4
Roof Anchorage of DANCER Standard Buildings	5
Typical Arrangements for Non-cyclonic and Cyclonic Applications	6
DANCER Truss System	7
Part 3 – DANCER Details	8
Purpose of Standardization	8
Standard DANCER 8.4 Buildings	8
Prefabrication	10
Variations of DANCER Truss Arrangements.....	11
Typical Arrangements for Non-cyclonic and Cyclonic Applications	12
Typical DANCER Details	13
Frequently Asked Questions regarding DANCER Timber Superstructures.....	14
Example 1 - DANCER 5.7 x 8.4 Elevated Timber House.....	18
Example 2 - DANCER 5.7 x 8.4 House with Timber Superstructure and Concrete Slab-on-Ground	33

Example 3 - DANCER 5.7 x 8.4 House with Reinforced Concrete Masonry Superstructure and Concrete Slab-on-Ground	37
Elevations	38
Example 4 - DANCER 8.4 x 5.7 Elevated Timber House with Porch.....	43
Example 5 - DANCER 8.4 x 5.7 Timber House with Concrete Slab-on-Ground	44
Example 6 - DANCER 5.7 x 5.7 Elevated Timber House with Veranda	45
Example 7 - DANCER 5.7 x 5.7 Reinforced Concrete Masonry House with Concrete Slab-on-Ground.....	47
Example 8 - DANCER 8.4 x 6.6 Elevated Timber House, 1.8 Veranda	48
Example 9 - DANCER 8.4 x 6.6 Reinforced Concrete Masonry House with Concrete Slab-on-Ground and 1.8 Veranda	49
Example 10 - DANCER 11.1 x 8.4 Aid Post Including 1.8 Veranda	50
Example 11 - DANCER 6.0 x 3.6 Transition House	52
Concrete Slab-on-Ground Details.....	53
Frequently Asked Questions regarding DANCER Concrete Slab-on-Ground.....	53
Concrete Slab-on-Ground, DANCER Walls, DANCER Roof.....	55
Concrete Slab-on-Ground, Reinforced Concrete Masonry Walls, DANCER Roof.....	56
Concrete Slab-on- Ground, Reinforced Concrete Masonry Walls, DANCER Roof.....	57
Concrete Slab-on- Ground, Reinforced Concrete Masonry Walls, DANCER Roof.....	58
Concrete Slab-on- Ground, Reinforced Concrete Masonry Walls, DANCER Roof.....	59
Timber Stairs.....	60
Timber Veranda Balustrades	61
Timber Veranda Balustrades with Seat	61
Porch Awning for Timber Superstructure	62
Porch Awning for Masonry Superstructure.....	63
Window Shades for Timber Superstructure	64
Window Shades for Masonry Superstructure	65
Ramp with Maximum Slope of 1 in 14	66
Ridge Ventilator	67
Gable Ventilator	68
Part 4 – DANCER Specifications	69
Timber.....	70
Scope	70
Relevant Standards.....	70
Levels, Dimensions, Square and Setting Out.....	70
Bracing	70

Tie Down.....	70
Timber Shrinkage.....	70
Preservatives	70
Design and Construction	71
Minimum Strength Grade.....	71
Timber Type, Properties, Preservation and Application	72
Timber and Timber Products for Use Below Found Level	72
Timber and Timber Products for Above-ground External Exposed Framing	72
Timber and Timber Products for Above-ground Internal Protected Framing.....	73
Concrete	74
Scope	74
Building Regulations and Standards	74
Relevant Standards.....	74
Definitions	74
Sand Bedding.....	75
Vapour Barrier	75
Reinforcement.....	75
Placing Concrete	75
Finishing Concrete	75
Curing Concrete.....	76
Stripping Formwork.....	76
Maintenance.....	76
Bedding Sand Bedding.....	76
Vapour Barrier	76
Bar Chairs.....	76
Reinforcement.....	77
Concrete	77
Formwork	77
Curing Compounds	77
Joint Material.....	77
Concrete Jointing Accessories	77
Masonry.....	79
Scope	79
Relevant Standards.....	79
Mortar.....	79

Damp-Proof Course	80
Flashings	80
Termite Protection	80
Mortar Joints	80
Provision for Timber Shrinkage	80
Reinforced Masonry Construction (Excluding Retaining Walls)	81
Hollow Concrete Masonry Units.....	81
Cement	82
Water Thickener	82
Sand	82
Concrete Grout	82
Flashings	82
Damp Proof Course	83
Termite Barriers Consisting of Woven Stainless Steel Mesh.....	83
Termite Barrier Parging Material for Woven Stainless Steel Mesh.....	84
Termite Barriers Consisting of Composite Fibre Blanket and Plastic Membrane with Termiticide Impregnation	84
Part 5 – DANCER Cost Comparisons and Bills of Quantities.....	1
DANCER Cost Comparisons.....	2
Cost Comparison 5.7 x 5.7 Building, Cyclonic Wind C2, Timber MGP 10	3
Example 1 – BOQ for DANCER 5.7 x 8.4 Elevated Timber House	4
Part 6 – DANCER Fabrication and Construction Guide	1
DANCER Prefabrication Procedure	2
DANCER Trusses – Setting Out Assumptions.....	3
DANCER – Jig for Prefabrication of Standard Trusses	4
DANCER – Manufacture of Production Trusses.....	11
Part 7 – DANCER Development and Testing Program.....	1
Background.....	2
Purpose.....	4
Summary of Principal Conclusions	4
Exclusions	4
Basis of Testing and Analysis	5
Product Development Process	5
Description of Test Program.....	5
Materials use for Test Specimens.....	6

Nailed Joint Connection Tests8

Full-scale Purlin/Truss/Stud/Bearer Assembly Tests.....9

Apex Connection Tests 13

Summary of Apex Connection Tests..... 21

Interpretation of Tests..... 23

Revisions

Q21110101-1a	1 November 2021	First published in the current format
Q21110101-1b	7 September 2022	Minor corrections and formatting
Q21110101-1c	2 February 2026	QMS document, minor corrections

Partner Housing Australasia (Building) Incorporated

Partner Housing Australasia is an entirely voluntary organisation, which aims to transform the lives of people living in Asia-Pacific villages by improving the cyclone, earthquake and tsunami resistance of their houses, clinics, schools and community buildings; and by providing clean water supplies and hygienic sanitation.

Disclaimer

This manual has been prepared by Quasar Management Services Pty Limited for use by Partner Housing Australasia and its partner organisations. It is intended for use by qualified and experienced structural design engineers, who must assume responsibility for the exercise of their professional judgement in selecting appropriate probabilities of exceedance, design actions and combinations for the particular applications.

Copyright

© Quasar Management Services Pty Limited

All rights are reserved. Permission is given for not-for-profit NGOs (non-governmental organizations) and agencies of the governments of South Pacific countries to use this material in the preparation of building skills training programs and for the design, specification and construction of village buildings and infrastructure in the South Pacific region. Use of this material for any other commercial purposes is prohibited without the written permission of the copyright owner.

Acknowledgements

The following personnel were engaged on this system development program. Given that their involvement was on a pro-bono basis, Partner Housing Australasia extends the deepest appreciation for their assistance, expertise, workshop space and equipment. Rod Johnston, Grant Wood, Ron Albert, Ian Volke, Daniel Harvey, Chris Broadbridge, Graham Vant, David Wilmshurst, Bruce Hutchison, Bill Ryan, David Kaunitz, Peter Cheers, Mohamud Ibrahim and Kelly Kombra Peng.

Partner Housing Australasia also acknowledges the generosity of David Mahaffey of Mahaffey Associates for providing laboratory space, equipment and staff during the second phase of the testing.

Partner Housing Australasia also recognises the dedication of the Board of Vision for Homes (PNG) and their commitment to this project.

Dedication

The members of Partner Housing Australasia remember with fondness our friend and colleague, Ron Albert, who passed away during the development of the **DANCER** Building System. Ron Albert volunteered his considerable CAD skills and building experience for the preparation of the **DANCER** 3D drawings and details. Ron's quiet commitment to "getting the job done" is an inspiration to all of us.

Scope of Manual

The **DANCER** Building System Design Manual continues to be updated on an on-going basis. This Manual is not intended for routine construction, but serves as the source document from which working drawings, cutting lists, bills of quantities and specifications can be derived for specific projects.

Part 1 – DANCER Manual

Part 1 provides the background and brief description of the **DANCER** Building System, together with guidance on the use of this Manual.

Introduction

Partner Housing Australasia and its consultants have long considered the practical problems associated ensuring the cyclone, earthquake and tsunami resistance of village houses, schools and clinics in locations where supervision is lacking, the builders are relatively unskilled and steel fittings are either unavailable or very expensive. This situation has led us to the development of the **DANCER** Building System.¹

Background

The South Pacific region is home to a diverse range of people, many of whom live in small villages with housing, clinics, schools and community buildings that must withstand the ravages of cyclonic wind, earthquake and (in some cases) tsunamis. Previously these buildings were often destroyed by natural disasters, but today there is an expectation that, no matter how humble, these buildings should remain intact when subjected to cyclone, earthquake or tsunami.

Unlike the cyclone resistant housing and small building systems developed for Australia, the **DANCER** Building System does not require screwed steel anchor rods, steel brackets, steel nailing plates, extensive steel strapping or large quantities of concrete.

The **DANCER** Building System is a simple timber framed house building system incorporating sawn timber framing fixed by a handful of bolts and nuts, steel posts, a small quantity of concrete for piers, steel roof cladding, sawn timber flooring and local or imported wall cladding.

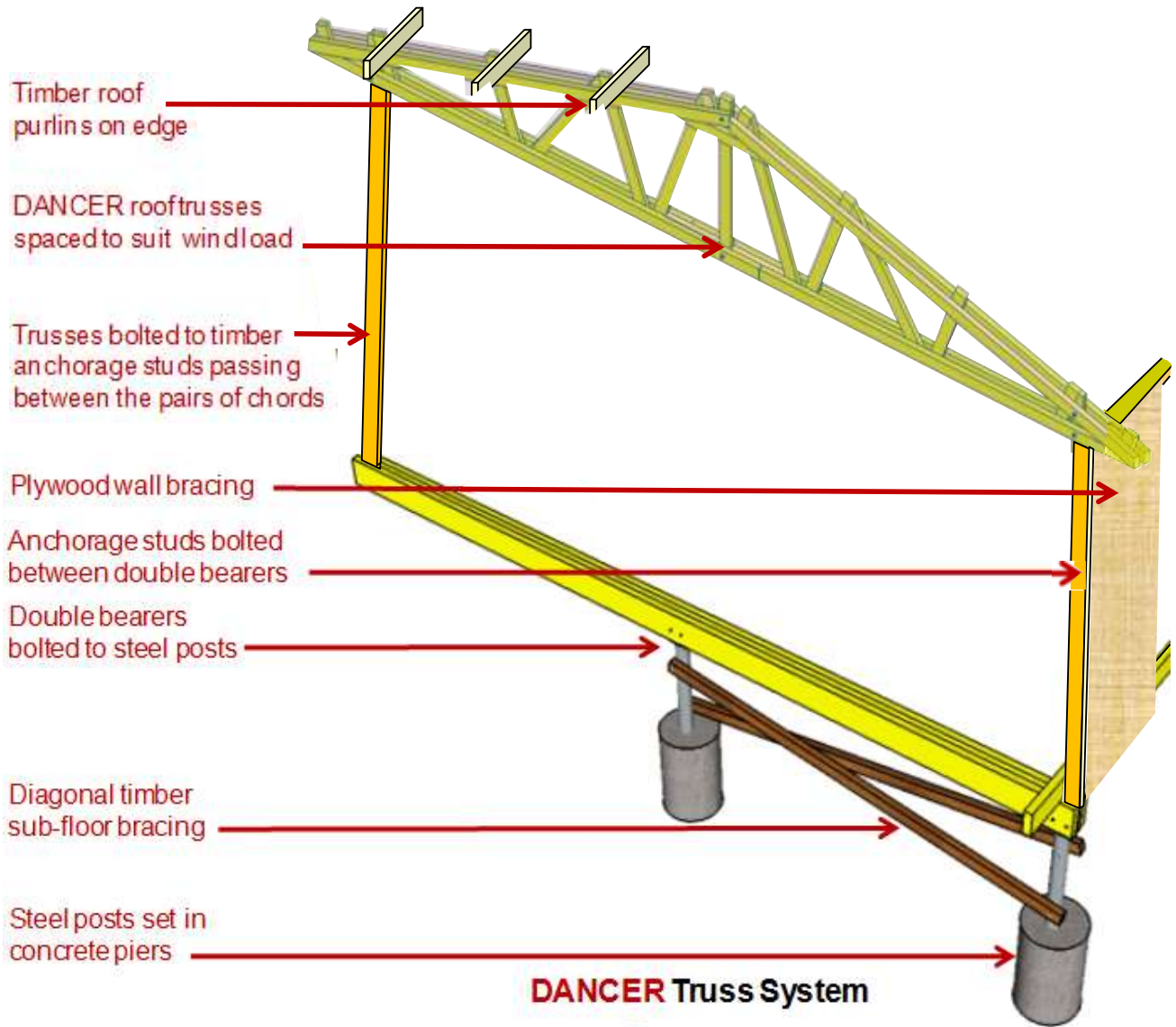
The cyclone/earthquake/tsunami resistance is economically achieved by orienting the timber purlins such as to maximize the truss or rafter spacing and ensure that the uplift loads are transmitted to the ground via bolted connections directly between rafter/truss, anchorage studs, double bearers and posts. The key is in the name:

The **DANCER** building system consists of the following:

- Timber roof purlins, on edge (to maximize the span) are nailed horizontally to timber lacing members that are fixed between the double truss chords (or double rafters, as appropriate). They are fixed at 900 mm maximum centres to support corrugated steel roof sheeting.
- **DANCER** Trusses (or **DANCER** Rafters) consisting of double top chords and double bottom chords (enabling the lacing/purlin cleats to be nailed between from both sides and the anchorage studs bolted in double shear between).
- The **DANCER** Trusses (or **DANCER** Rafters) are bolted to timber Anchorage Studs between both pairs of chords.
- The timber Anchorage Studs are bolted in double shear between the Double Bearers, providing a direct load path from the roof system to the floor and subfloor
- Double Bearers are bolted to steel (or timber) posts, which are set in concrete piers.
- Diagonal timber and/or plywood wall bracing, together with diagonal timber sub-floor bracing provide racking resistance.
- Variations of the **DANCER** building system include:
 - timber superstructures (roof and walls) anchored to concrete slab-on-ground; and
 - timber roofs anchored to reinforced concrete masonry walls and concrete slab-on-ground.

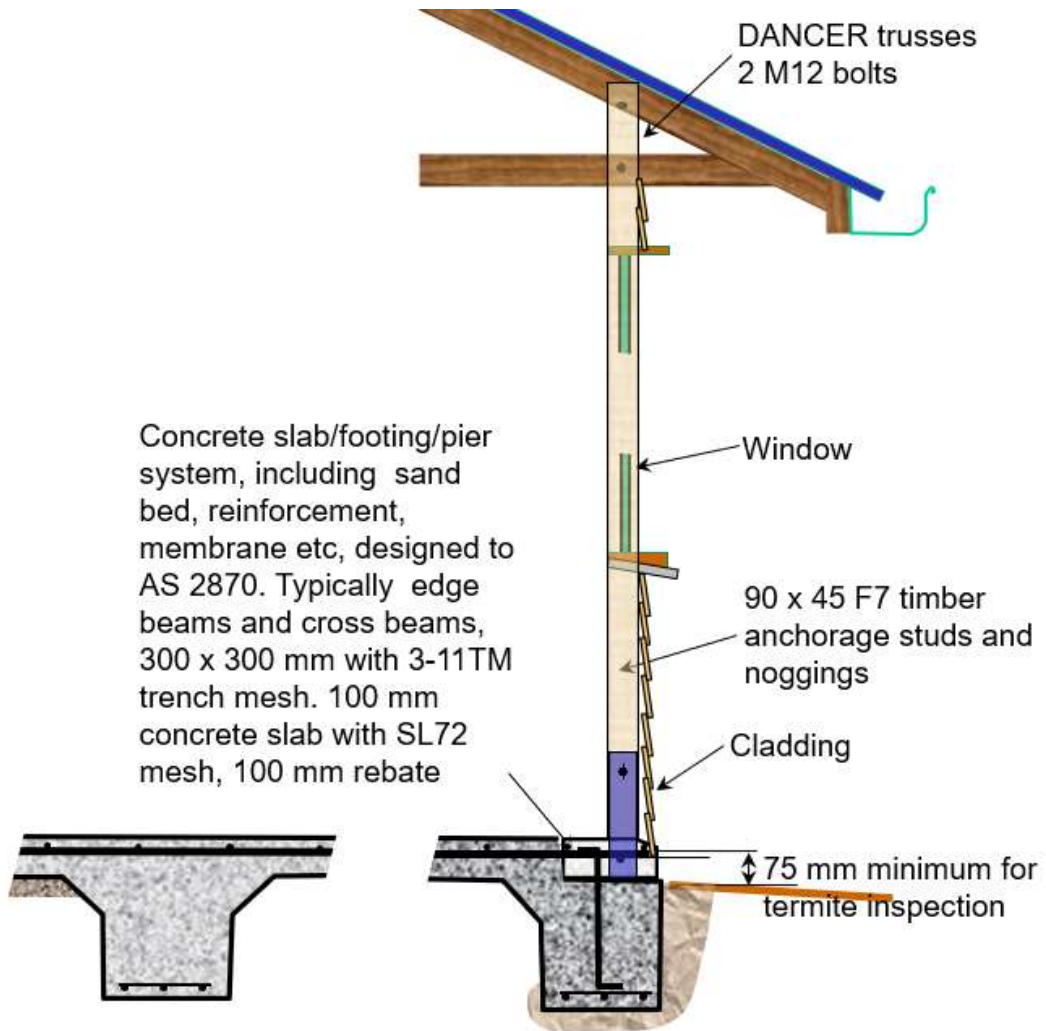
¹ **DANCER - Direct Anchorage Noncyclonic / Cyclonic Earthquake Resistant**

DANCER Elevated Timber Buildings



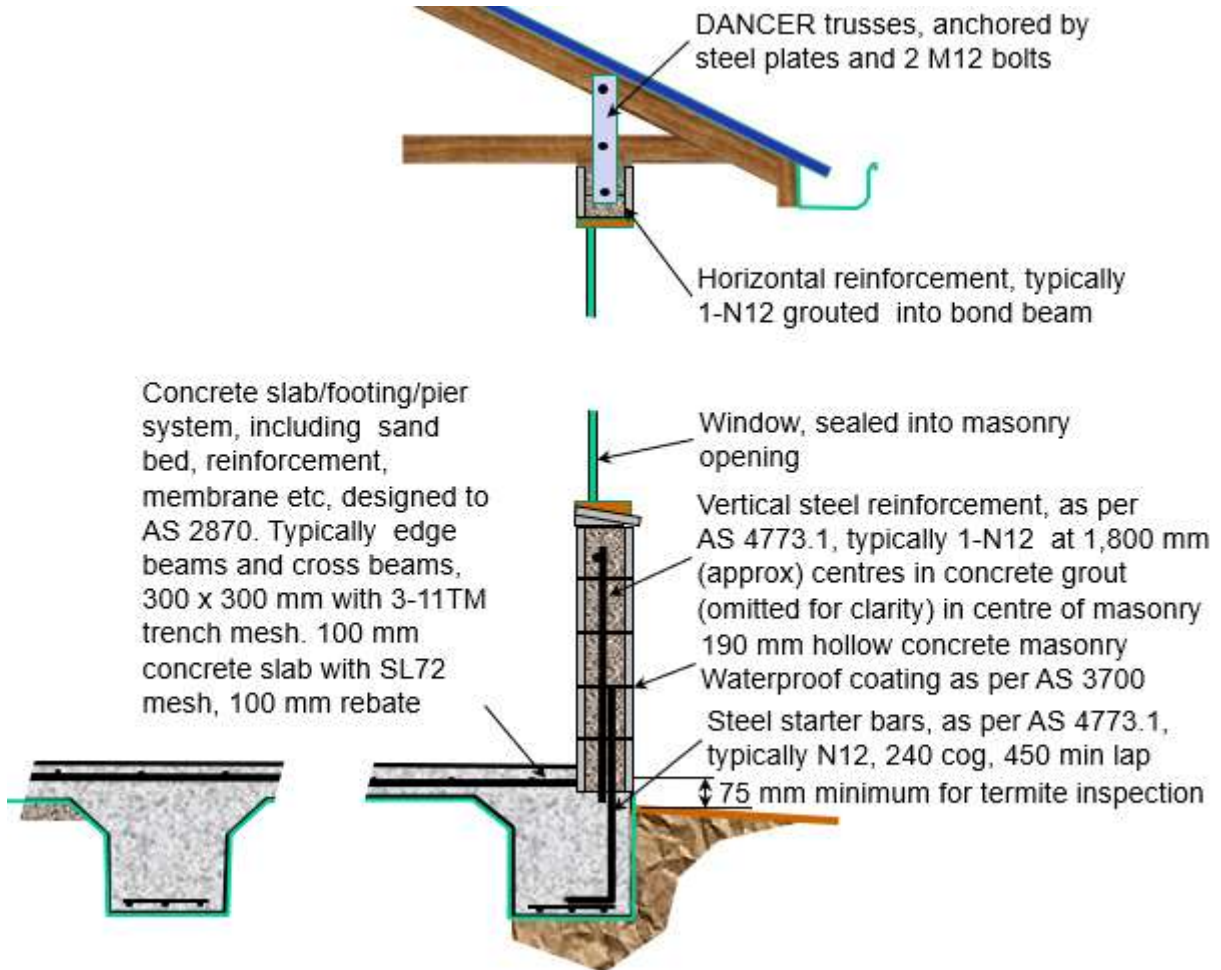
DANCER Timber Superstructure on Concrete Slab-on-Ground

DANCER timber roof and wall systems may also be used on concrete slab-on-ground construction.

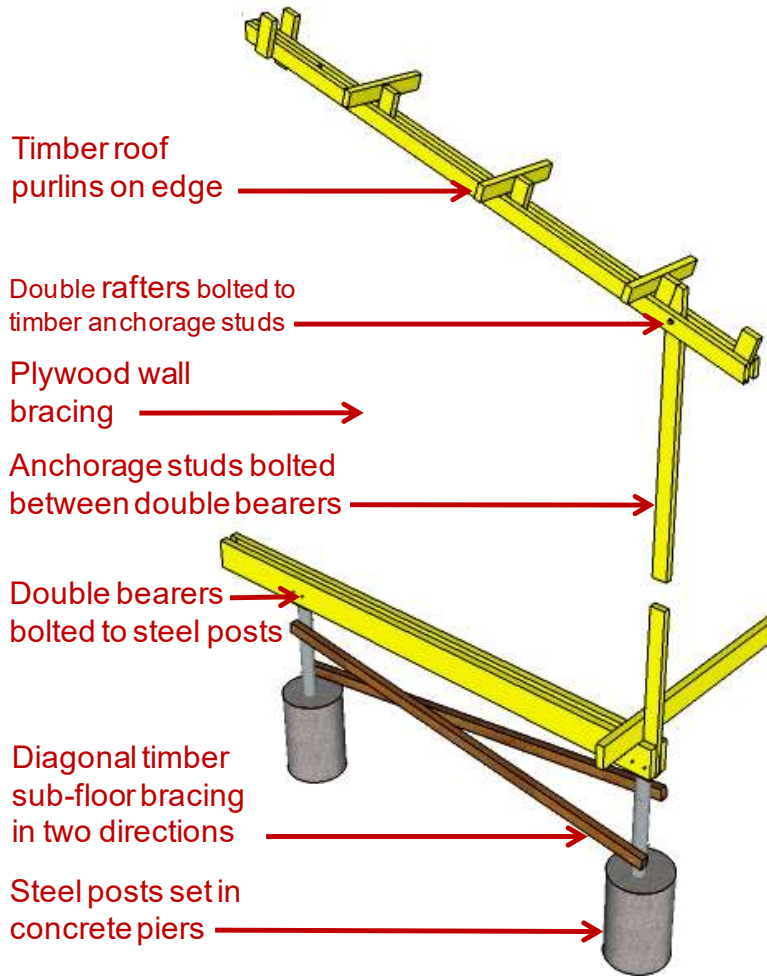


DANCER Reinforced Concrete Masonry on Concrete Slab-on-Ground

DANCER roof systems may also be used with reinforced concrete blockwork walls on concrete slab-on-ground construction. The **DANCER** Trusses (or **DANCER** Rafters) are bolted to steel cleats, which are set in the top two courses of reinforced concrete blockwork.



DANCER Rafter System



DANCER Rafter System

Purpose and Structure of This Manual

The purpose of this Manual is to provide a comprehensive reference on the background, design and detailing of the **DANCER** Building System, together with the records of its development and testing. The intention is to provide a single document in seven parts, from which other simpler or focused documentation can be extracted or developed.

Part 1 – **DANCER** Manual

Part 1 provides the background and brief description of the **DANCER** Building System, together with guidance on the use of this Manual.

Part 2 – **DANCER** Design

Part 2 provides an introduction to the **DANCER** Design Package, consisting of a Microsoft Excel workbook, which may be used to customise the design of **DANCER** buildings for particular loads and specific applications. The same workbook may be used for fabrication and construction quality assurance purposes.

Part 3 – **DANCER** Details

Part 3 provides member and connection details, material lists and timber cutting schedules for the principal components of the most common **DANCER** buildings. The **DANCER** Design Package may be used to prepare customised details, material lists and timber cutting schedules for other applications.

Part 4 – **DANCER** Specifications

Part 4 provides generic specifications for the principal components of **DANCER** buildings.

Part 5 – **DANCER** Bills of Quantities

Part 5 provides bills of quantities for the principal components of the most common **DANCER** buildings. The **DANCER** Design Package may be used to prepare customised Bills of Quantities for other applications.

Part 6 – **DANCER** Fabrication and Construction Guide

Part 6 provides guidelines on the factory prefabrication, including (when appropriate) trial erection of the system, and the construction process.

Part 7 – **DANCER** Development and Testing Program

Part 7 provides a record of the development of the system and the testing program used to refine and verify it.

Part 8 – **DANCER** Design Actions

Part 8 provides guidance on the determination of design actions for the countries of the South Pacific

Part 2 – DANCER Design

Part 2 provides an introduction to the **DANCER** Design Package, consisting of this manual, a Microsoft Excel workbook and Training Packages.

These may be used as a basis for:

- customized design of **DANCER** buildings for particular loads and specific applications;
- fabrication;
- construction; and
- quality assurance monitoring.

For a copy of the **DANCER** Design Package and information regarding its conditions of use, please contact –

Quasar Management services Pty Ltd
272 Blackwall Road, Woy Woy, NSW
Attention: Rod Johnston rod@electronicblueprint.com.au

DANCER Design Workbook

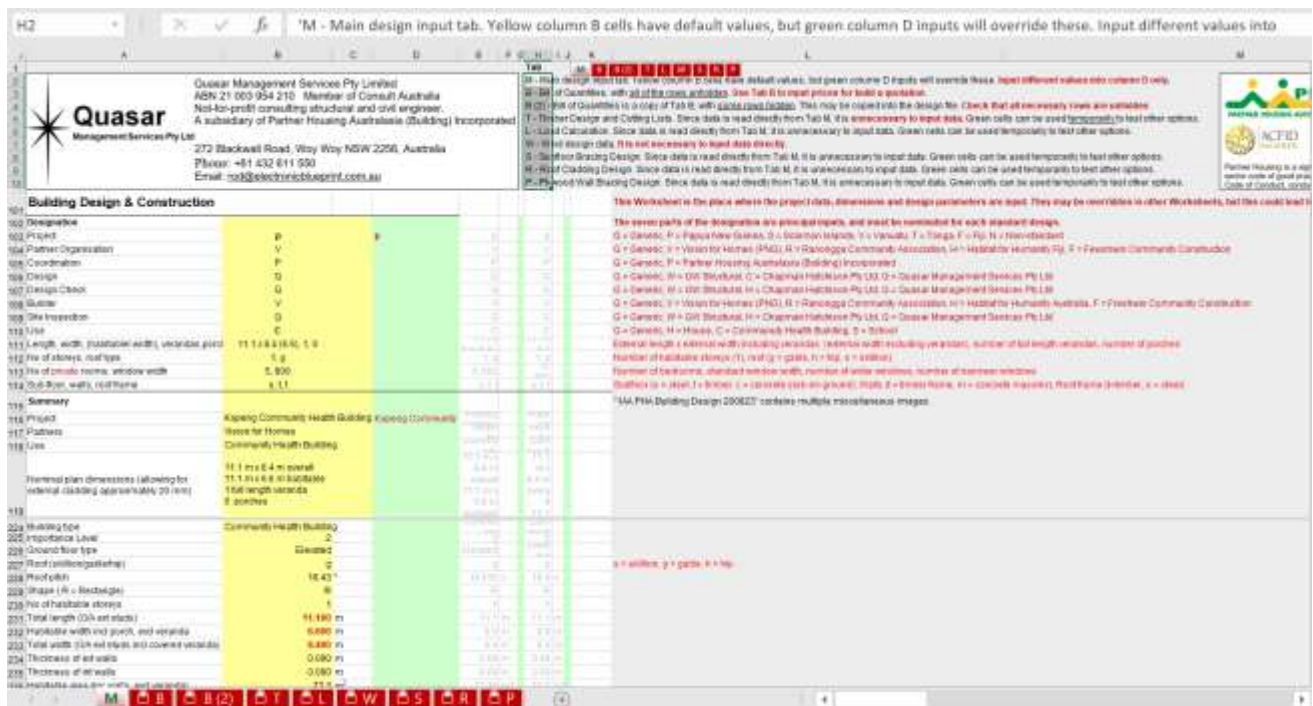
The **DANCER** Design Workbook is a Microsoft Excel workbook, which may be used to design a range of village buildings of various sizes and locations.

It is particularly useful for the rapid design of **DANCER** village buildings, although it can also be used easily for other systems.

The **DANCER** Design Workbook is available from Quasar Management services Pty Ltd.

Under normal circumstances, a design would only need to access three tabs –

- Design information is input into Tab M;
- Cost data is input into Tab B; and
- A summary of prices can be read from Tab B (2).



Screen shot of the first page of the **DANCER** Design Workbook

Tab M – Main Input

This is the main input tab for design information.

- Yellow column B cells have default values, but green column D inputs will override these.
- Input different values into column D only.
- Tab M has been set to default to the most common buildings, 11.1 x 8.4 community health building, 5.7 x 8.4 house or 5.7 x 8.4 classroom. However, all dimensions and members can be varied by amending the green cells (Column D). This generally will not be necessary for the main building dimensions, but some of the details (e.g. number of lights, area of vinyl, length of cable etc.) may need to be “tweaked”. The default is set for timber steps, although that can be changes (in green cells, column D) to be concrete steps.

Tab B – Bill of Quantities

Bill of Quantities, with all of the rows unhidden (i.e. visible).

Use Tab B to input prices for build a quotation.

- The material quantities are read directly from Tab M or Tab T into the Tab B Bill of Quantities.

- Price inputs (for PNG) can be made in columns R (lump sum prices), T (pricing information) or U (unit prices).
- Price inputs (for Vanuatu) will be made in columns AA (lump sum prices), AD (pricing information) or U (unit prices). These have not been populated yet).
- Labour could (in the future) be input in Columns O and P, although that option has not been fully developed yet.
- In the absence of local price data, (e.g. Vanuatu at the moment), a default value based on Australian unit prices multiplied by the exchange rate is used.
- The total prices are read at rows 1457 to 1471, and a “check price” based on Australian prices can be read at rows 1474 to 1488.

Tab B (2) – Bill of Quantities Copy

Tab B (2) Bill of Quantities is a copy of Tab B, with some rows hidden.

- Before using Tab B (2), check that all required rows are “unhidden”.
- Parts of this tab may be copied into the design file as a series of jpg images .

Tab T - Timber Design and Cutting Lists

Parts of this tab may be copied into the design file as a series of jpg images .

- Since data is read directly from Tab M, it is unnecessary to input data.
- Green cells can be used temporarily to test other options.

Tab L - Load Calculation

This tab is used to carry our detailed analyses for permanent load, imposed load, tsunami load, earthquake loads and wind load.

- Since data is read directly from Tab M, it is unnecessary to input data.
- Green cells can be used temporarily to test other options.

Tab W - Wind Design Data

This tab is used to determine wind loads for various locations and various part of the structure

- Wind load data is read from this file into Tab M and Tab T.
- It is not necessary to input data directly.

Tab S - Subfloor Bracing Design

This tab is used to carry our detailed analyses of subfloor bracing capacities.

- Since data is read directly from Tab M, it is unnecessary to input data.
- Green cells can be used temporarily to test other options.

Tab R - Roof Cladding Design

This tab is used to carry our detailed analyses of the roof cladding.

- Since data is read directly from Tab M, it is unnecessary to input data.
- Green cells can be used temporarily to test other options.

Tab P - Plywood Wall Bracing Design

This tab is used to carry our detailed analyses of the plywood bracing.

- Since data is read directly from Tab M, it is unnecessary to input data.
- Green cells can be used temporarily to test other options.

Design Actions

Part 8 of this Manual provides information on the design actions for the South Pacific region.

- a) The information in Part 8 has been used in the preparation of the **DANCER** standard designs set out in this manual.
- b) It may also be used to provide design input when using the **DANCER** Design Package software to produce customised designs.

Wind Action Applicable to **DANCER** Standard Buildings

This manual provides information on number **DANCER** standard buildings, which have been developed to resist failure under wind loads categorised as follows:

- “Non-Cyclonic” covers low to medium non-cyclonic wind that meet the criteria in AS 4055 for wind classifications N1, N2, N3 and N4.
- “Cyclonic” covers cyclonic wind that meet the criteria in AS 4055 for wind classifications C1, C2 and C3.

Design of buildings in AS 4055 for wind classifications N5 and N6 may be carried out by treating them as “cyclonic”.

Buildings in AS 4055 for wind classifications C4 are specifically excluded from the structural design parts of this manual, and (if required) must be designed using a more rigorous analysis process.

Other Actions Applicable to **DANCER** Standard Buildings

The ability to resist uplift and racking under the action of “non-cyclonic” or “cyclonic” wind (as described above) is the main determinant in the design process used to prepare the standard designs in this manual.

However, other actions are important and must be considered.

- Earthquake resistance is particularly important in some regions. In particular, racking resistance of reinforced concrete masonry superstructures may be the principal factor in determining the design of Reinforced Masonry **DANCER** buildings.
- Tsunami resistance may be important on sites exposed to the sea. In this case, design for the racking actions associated with cyclonic wind may provide some limited resistance to tsunamis.
- Actions resulting from permanent and imposed loads have been considered in the standard designs.
- Where standard designs include reinforced concrete slab-on-ground construction, this has been designed to resist shrinkage and expansion of reactive foundations.

Timber Applicable to **DANCER** Standard Buildings

This manual provides information on number **DANCER** standard buildings, which are based on the following assumptions regarding timber availability.

Although hardwood trusses and framing possess capacities significantly in excess of softwood components, due principally to superior behaviour at joints, the availability of hardwood cannot always be reliably predicted. For this reason, the standard designs given in this manual are all based on the use of softwood of stress grade F7 or better.

If hardwood or softwood of stress grades higher than F7 are available, they should be used, thus enhancing the reserve of strength in the trusses and frames. If they are not available, the careful use of F7 softwood, with close attention to the specified joint configurations, will result in structures of adequate strength.

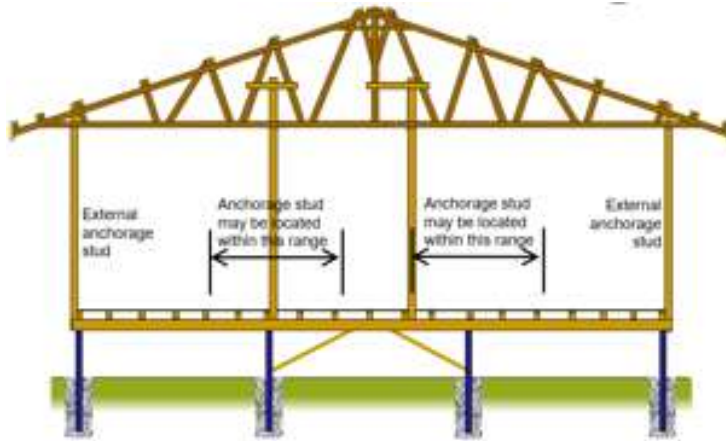
Roof Anchorage of **DANCER** Standard Buildings

The recommended roof anchorage arrangements for the most common **DANCER** standard buildings are shown on the following page.

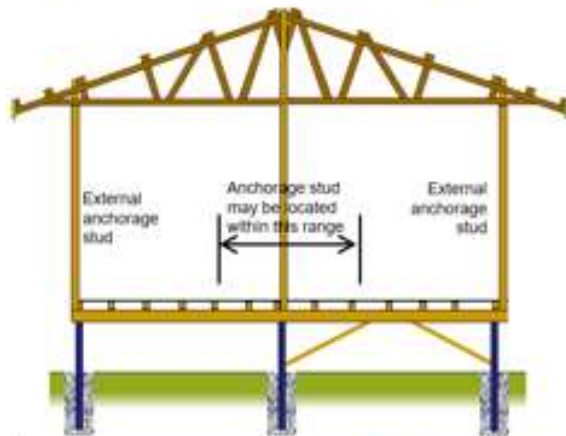
These provide broad guidance only and other arrangements may be used, provided the structural integrity of member and connections is verified during the design process.

- a) The maximum recommended roof width is 8.4 m (measured outside the external anchorage studs).
- b) To this maximum width, eaves up to a maximum of 0.9 m may be added, by extending the truss top chord.
- c) Verandas may be added, provided they are adequately supported.
- d) It is preferable to locate a veranda under the roof truss (of maximum width up to 8.4m). This means that one line of “internal” anchorage studs will be clad to form an “external” wall, with the extreme line of anchorage studs would remain unclad.
- e) Alternatively, a veranda roof may be provided by extending each truss top chord and adding an additional line of anchorage studs, which also serve as a balustrade supports. When using this method, care must be taken to ensure that headroom clearance is not compromised at the edge of the veranda.
- f) Internal anchorage studs may be located within the designated range of positions in order to form part of the internal walls.

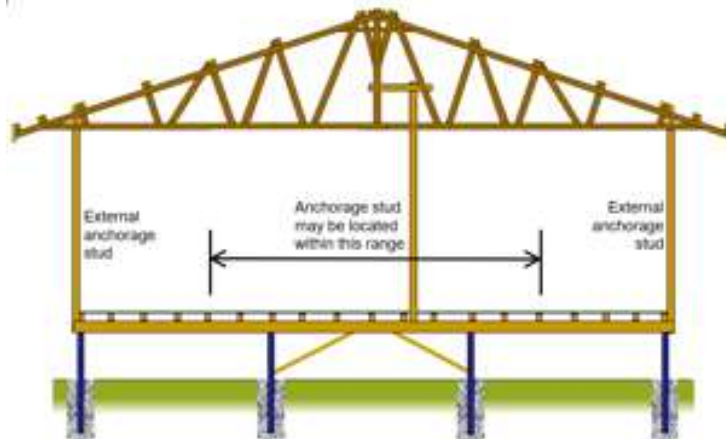
Typical Arrangements for Non-cyclonic and Cyclonic Applications



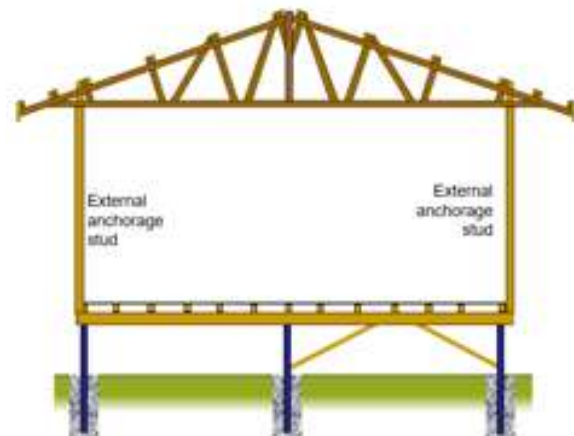
Cyclonic location
 Width over 5.7 up to 8.4 m
 Truss spacing – 900 mm
 4 anchorage studs per truss



Cyclonic location
 Width up to 5.7 m
 Truss spacing – 900 mm
 3 anchorage studs per truss



Non-cyclonic location
 Width over 5.7 up to 8.4 m
 Truss spacing – 1350 mm
 3 anchorage studs per truss



Non-cyclonic location
 Width up to 5.7 m
 Truss spacing – 1350 mm
 2 anchorage studs per truss

Fig 2.1 – Typical Arrangements for Non-cyclonic and Cyclonic Applications

DANCER Truss System

The **DANCER** Building System is fabricated from 90 x 45 seasoned softwood (Stress Grade F7, Strength Group SD6, Joint Group JD4 or better) Seasoned softwood of higher stress grades and seasoned hardwood are preferable.

To facilitate prefabrication and transport to site, trusses are manufactured in two halves, and bolted together on site, with one bolt in the top chord at the apex and one bolt in the bottom chord.

Each truss end is fixed to the Anchorage Studs by two bolts. Additional internal anchorage studs (in accordance with Fig 2.1) are required for cyclonic wind applications and for wider buildings. Fig 2.2 provides a conceptual diagram of the principal components of a **DANCER** elevated timber building.

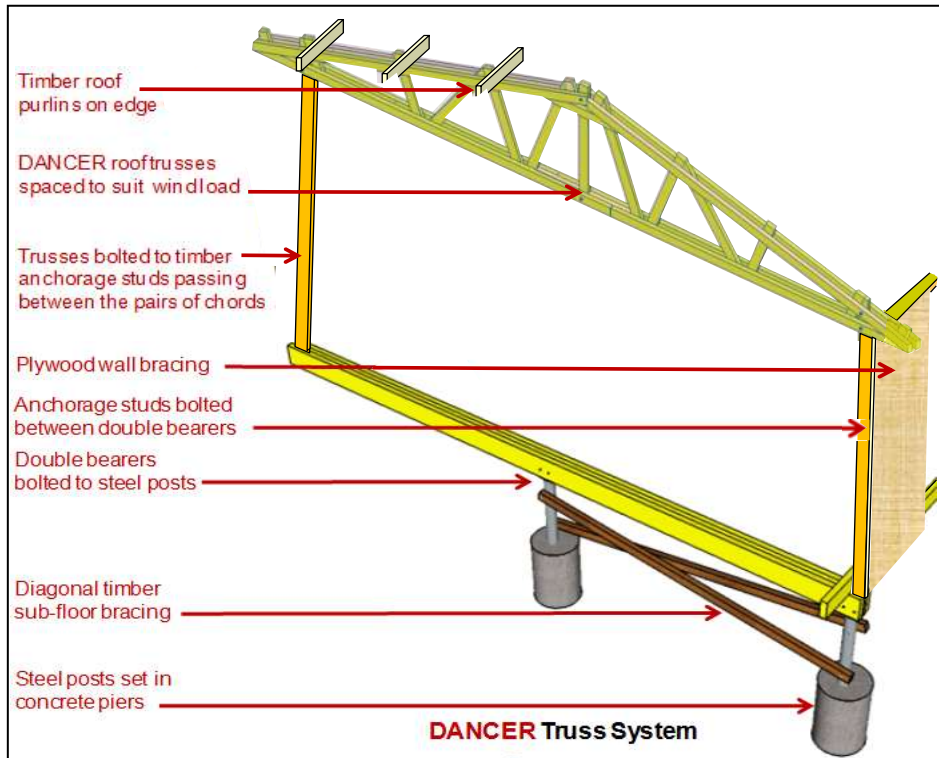
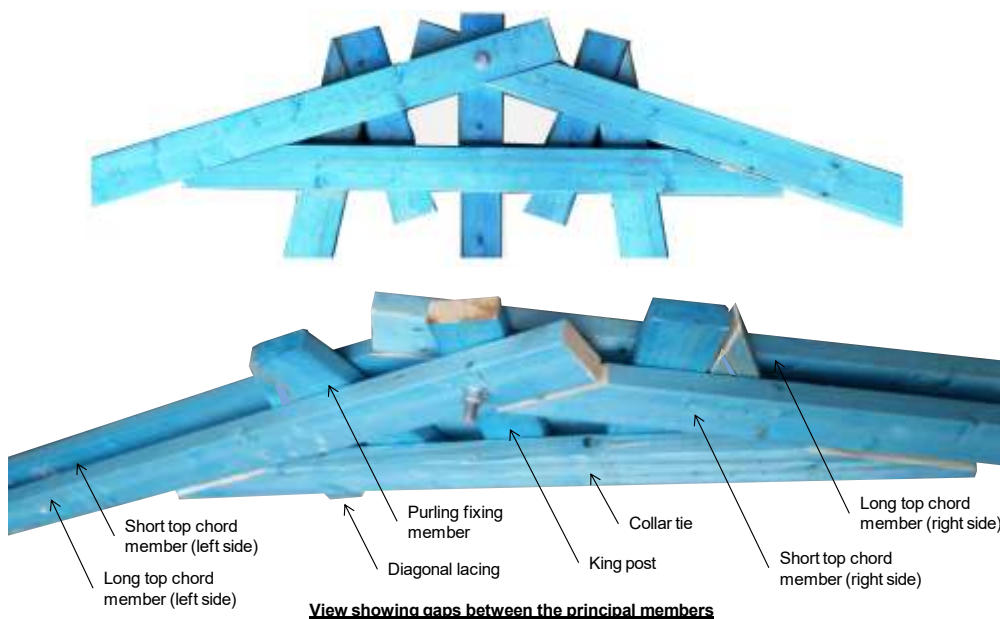


Fig 2.2 – Principal components of a **DANCER** elevated timber building



Part 3 – DANCER Details

Part 3 provides typical designs for a variety of village community health buildings, classrooms, accommodation and community buildings, including – elevated timber structures, concrete slab-on-ground and reinforced concrete masonry walls, together with a stairs, balustrades and other ancillary features. Also included are details of members and connections, material lists and timber cutting schedules for the principal components of the most common **DANCER** buildings.

The **DANCER** Design Package may be used to prepare customised details, material lists and timber cutting schedules for other applications.

The **DANCER** Building System can be safely and economically used for rectangular buildings up to 11.1 x 8.4 m, either elevated timber construction or reinforced concrete masonry construction. Roofs are generally gable roofs, although skillion and hip roofs can also be employed with some modification of the standard system.

The standard **DANCER** elevated timber buildings typically employ piers and posts on grids of 2.7 x 2.7 m grid and incorporate an additional 150 mm at each side and at each end (to the outside of the wall framing). Larger non-standard buildings can be achieved by varying this dimension.

These grids facilitate a roof purlin spacing of 900 mm.

Purpose of Standardization

All buildings (funded by PHA) shall be designed by QMS based on a standard DANCER width of 8.4 m.

This will –

- a) Shorten the design time required by QMS, enabling designs to be produced (and customized) very quickly;
- b) Provide enhanced confidence that the structural design requirements are consistently met (without having to recalculate for every project); and
- c) Facilitate prefabrication (including manufacture of key components for stock). This is a key advantage of standardization. See below.

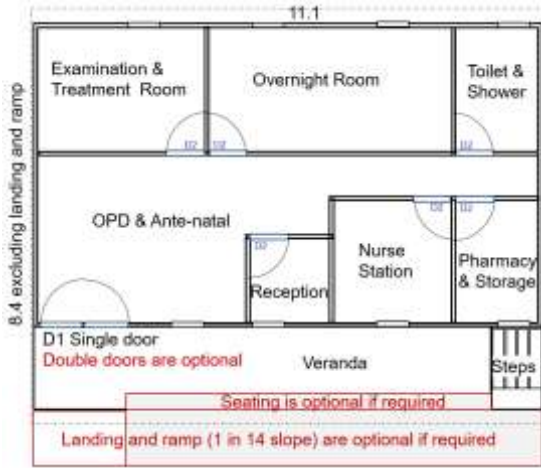
Standard DANCER 8.4 Buildings

- a) All buildings shown below are standard DANCER 8.4 buildings.
- b) Building lengths can be varied to suit –
 - Standard DANCER lengths are 5.7, 8.5, 11.1, 13.8, 16.5 and 19.2 m; or
 - Non-standard building lengths can be accommodated, although this is not preferred.
- c) DANCER 8.4 standard buildings (of standard lengths) can accommodate a wide number of alternative internal layouts, depending on the use to which the building is put (health, education, accommodation etc.)
- d) DANCER 8.4 standard buildings may be used in any of three styles –
 - Elevated timber superstructure;
 - Timber superstructure on concrete slab-on-ground; or
 - Reinforced concrete masonry superstructure on concrete slab-on-ground.
- e) DANCER 8.4 standard buildings may incorporate, as option extras, standard extended eaves, sun shades, awnings, verandas, ramps, steps, additional windows, fixed gable ventilation, ridge ventilation, etc.

Standard designs are available for these components.

- f) In addition to the simple floor plans below, more detailed designs are available. See Appendix.

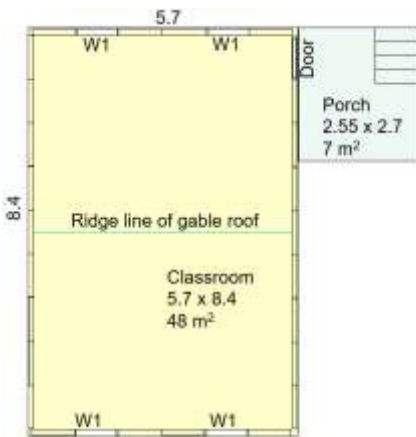
11.1 x 8.4 Community Health Building



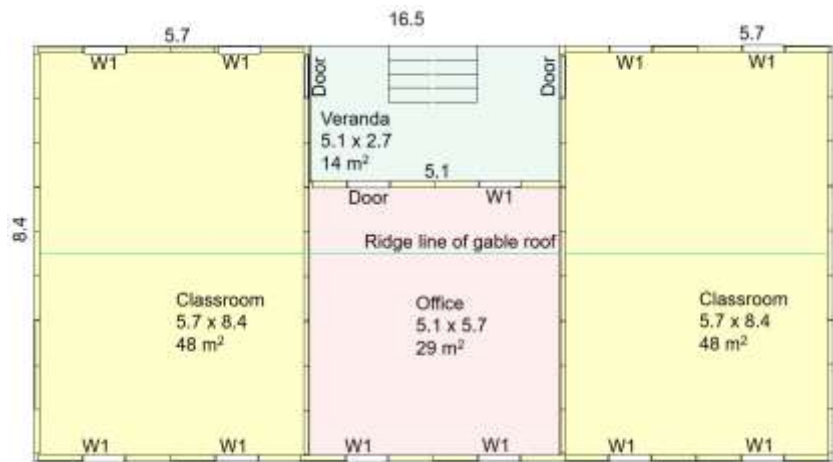
13.8 x 8.4 Extended Community Health Building



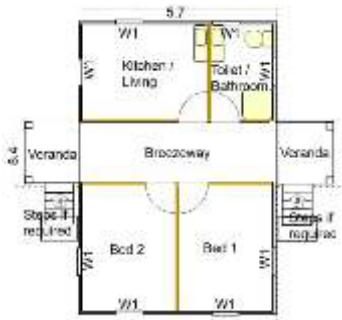
5.7 x 8.4 Single Classroom



16.5 x 8.4 Double Classroom



5.7 x 8.4 Small House



8.4 x 8.4 Medium House



11.1 x 8.4 Large House



13.8 x 8.4 Duplex House (2 units)



Prefabrication

Prefabrication involves the manufacture of building components in a central location, some time prior to their requirement on site.

The following items are recommended for prefabrication –

- a) All timber framing components that form the structure of standard (8.4 span) DANCER buildings, viz., purlins, trusses, anchorage trusses, external wall frames, ceiling joists, floor joists, bearers and subfloor bracing;
- b) Steel posts, most likely standard posts commercially available from local hardware outlets;
- c) Timber veranda rails and balustrades;
- d) Timber stairs and/or ramps; and
- e) Pre-packed bolts, nuts and washers and screws (or nails) for site erection.

Although not included in the list above, the following items could be considered for prefabrication in the future –

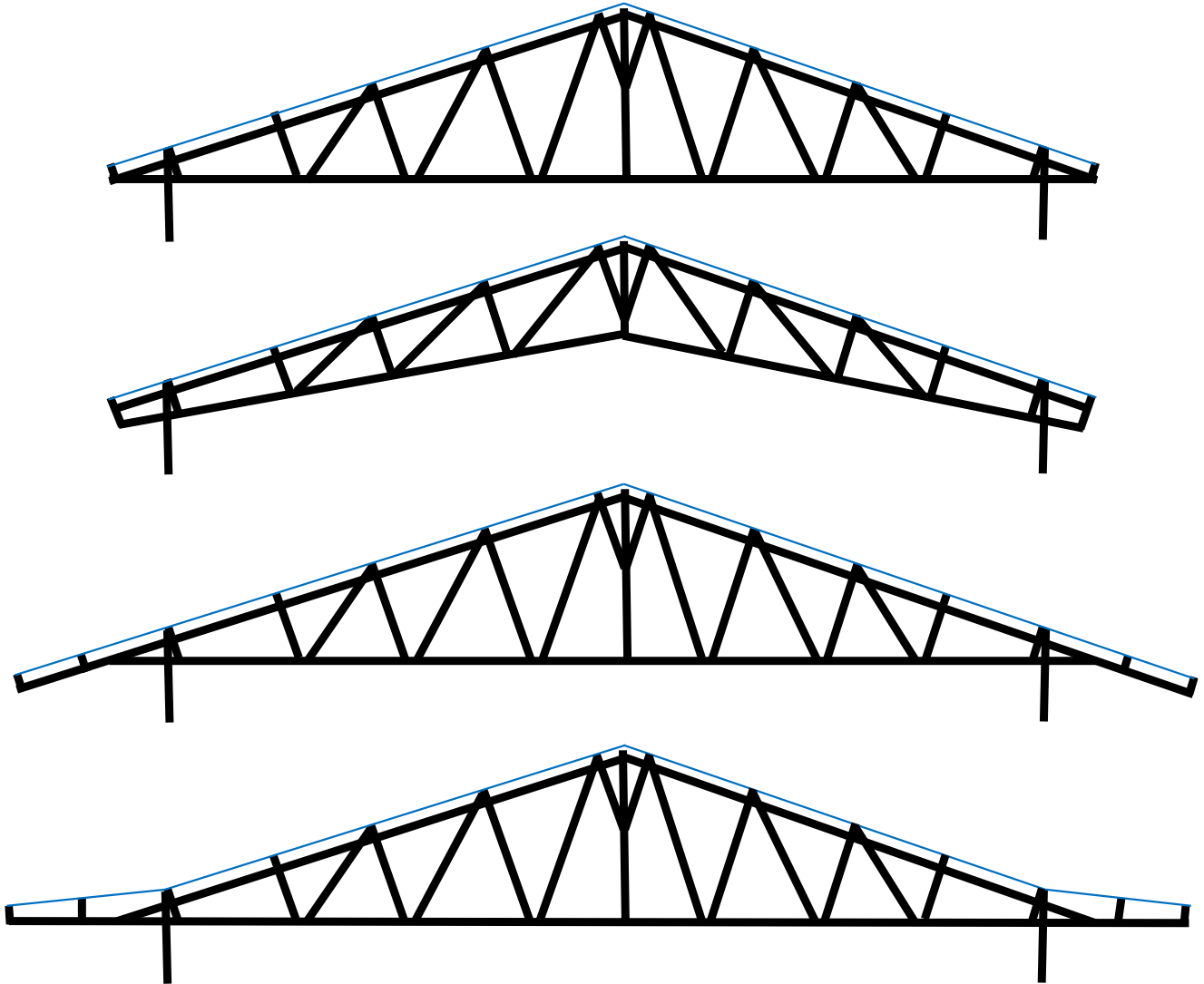
- a) Internal wall frames (Although internal wall frames could be included in the prefabrication process, this requires a high degree of accuracy in design (using CAD) and accurate fabrication (using jigs), but neither are available for internal walls at present;
- b) Cladding materials, such as flooring, roofing, cladding, ceilings, and wall linings; and
- c) Other components, such as gutters, downpipes, doors, door hardware, and louvre windows.

The key advantages of the prefabrication (of standard designs) are –

- a) Accuracy of fabrication can be monitored and closely controlled in a factory environment, thus ensuring that “site problems” and “site changes” are minimized; and
- b) Standard components (e.g., DANCER components) can be prefabricated on a continuous process, and held for future use. This is particularly advantageous for VFH, given that all buildings funded by PHA will be based on a standard DANCER width of 8.4 m. In practice –
 - PHA can confidently donate AUD 50,000 per year (PGK 120,000 approximate);
 - On receipt of this donation, VFH can confidently order timber and steel sections and employ factory staff to manufacture standard DANCER 8.4 components; and
 - VFH can store these components, confident that they will be used, no matter what type of future building (community health building, single classroom, double classroom, or house) is to be built.

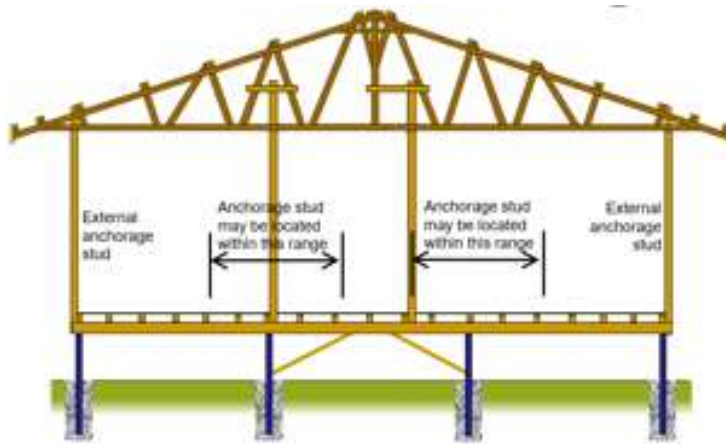
Variations of DANCER Truss Arrangements

The following diagrams show some of the many variations of roof truss shape that are possible with the **DANCER** system. This includes raked bottom chords, extended eaves and variable rake roofs.

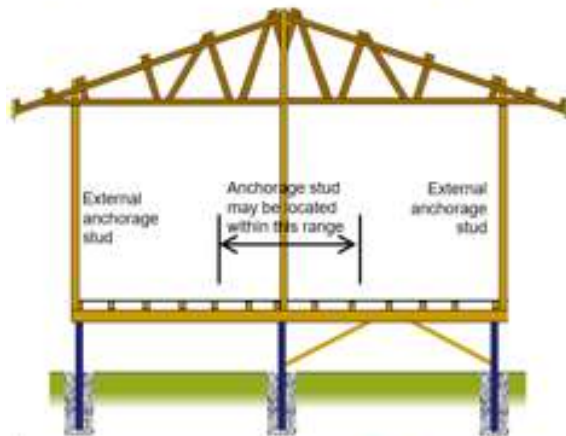


3.1 – Variations of DANCER Truss Arrangements

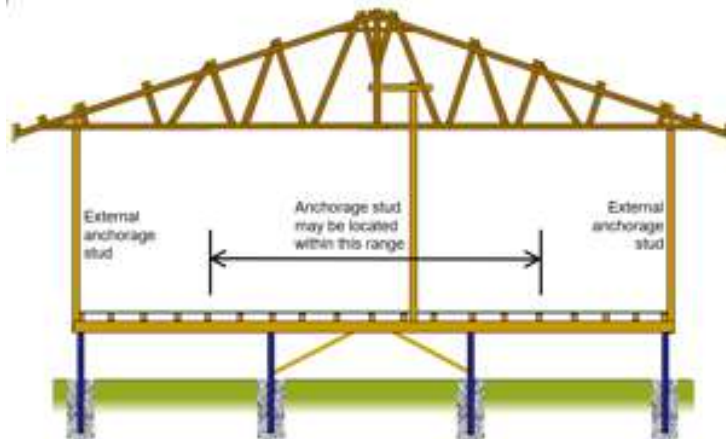
Typical Arrangements for Non-cyclonic and Cyclonic Applications



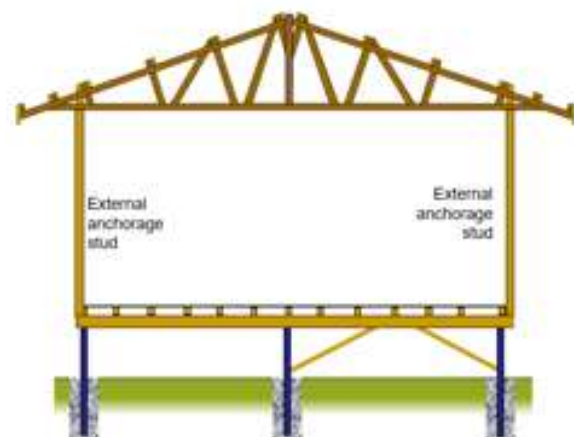
Cyclonic location
 Width over 5.7 up to 8.4 m
 Truss spacing – 900 mm
 4 anchorage studs per truss



Cyclonic location
 Width up to 5.7 m
 Truss spacing – 900 mm
 3 anchorage studs per truss



Non-cyclonic location
 Width over 5.7 up to 8.4 m
 Truss spacing – 1350 mm
 3 anchorage studs per truss

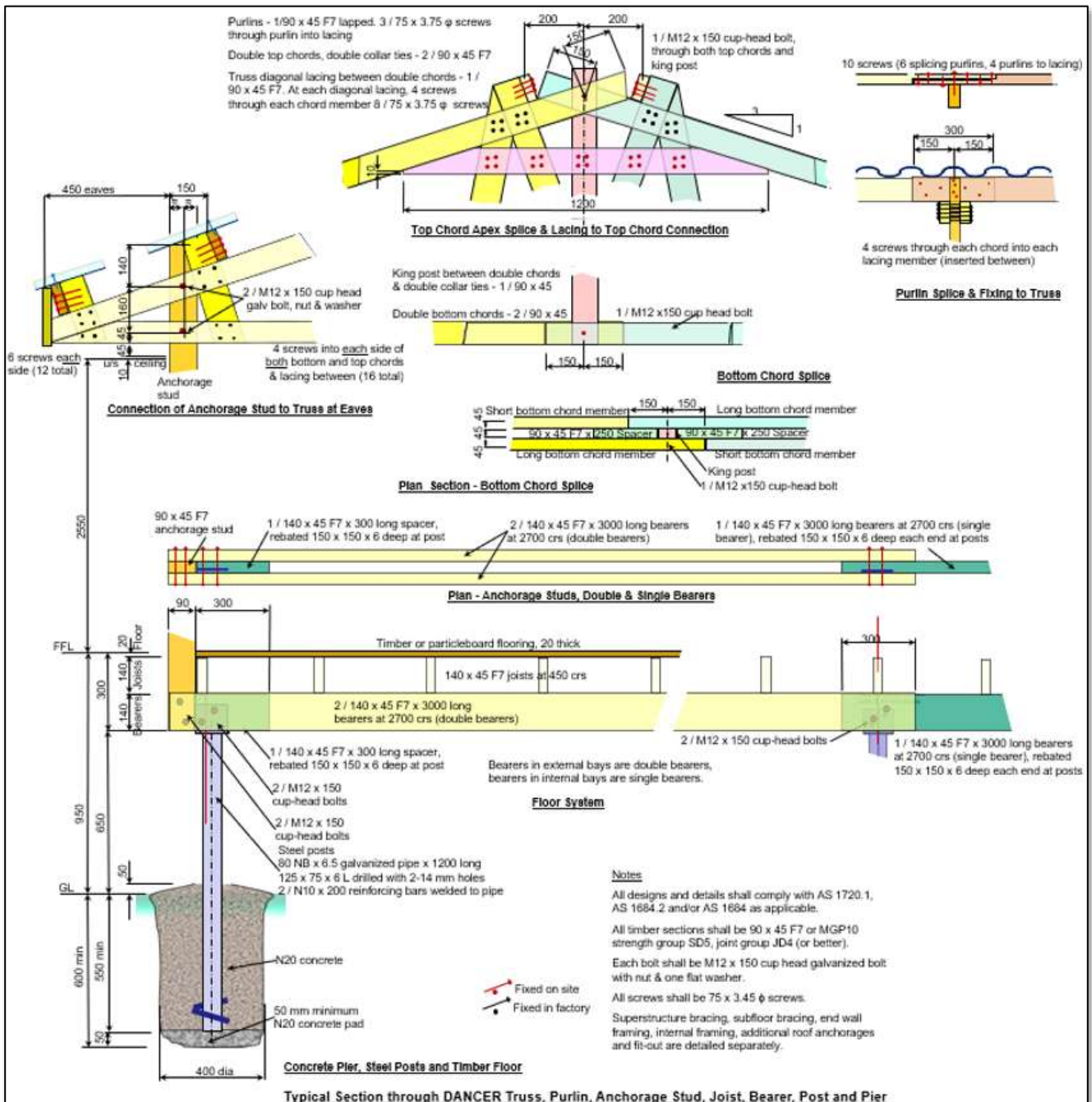


Non-cyclonic location
 Width up to 5.7 m
 Truss spacing – 1350 mm
 2 anchorage studs per truss

Fig 3.2 – Typical Arrangements for Non-cyclonic and Cyclonic Applications

Typical DANCER Details

The following drawings show the typical details of an elevated timber building incorporating the **DANCER** Building System.



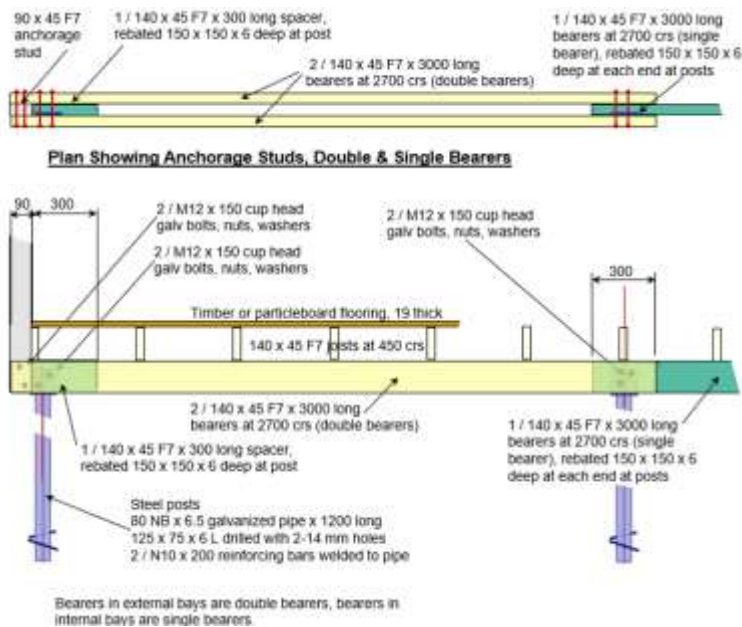
Frequently Asked Questions regarding **DANCER** Timber Superstructures

The following issues and questions have been reported as arising on DANCER construction sites

1. Should bearers be joined using a splayed splice as shown in the photo?

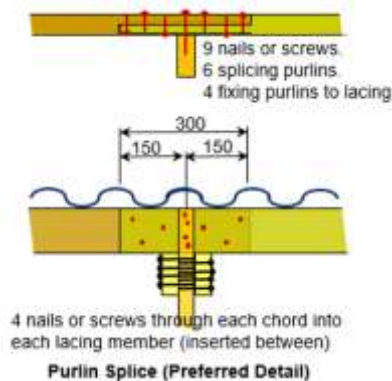


No – With this splayed double bearer connection and a standard 2-bolt post connection, it is not possible for all four members to be properly connected. Therefore, use the standard double to single arrangement as detailed in this manual.



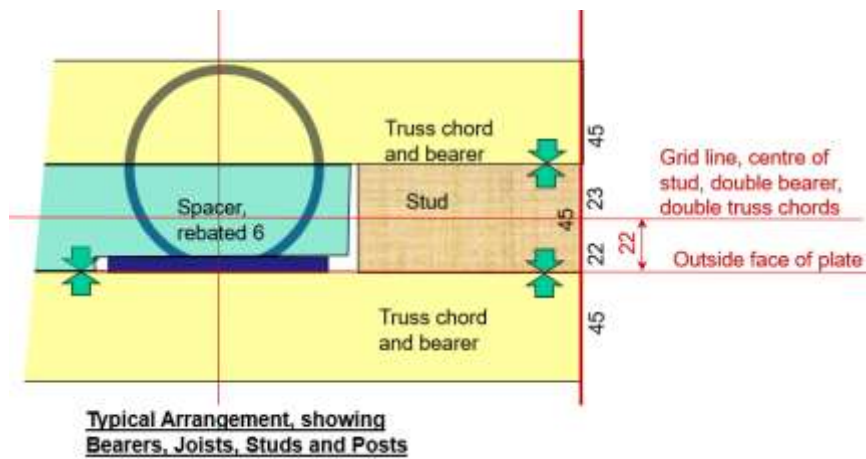
2. Should be joined using a splayed splice?

No – With a splayed purlin connection, it is not practical for both members to be properly connected. Therefore, use the standard lapped purlin connection detailed in this manual.



3. Why is the rebate in the double bearer spacer limited to 6 mm depth

The 90 x 45 mm timber spacer between the pairs of double bearer members is required to be rebated 6 mm at the steel cleat. However, if the rebate is too deep, the double bearer members will be too close together requiring the anchorage studs to be rebated (as is the case in this photo). The depth of the spacer rebate must be limited to no more than 6 mm. Not as shown in this photo.



3. How should the end wall studs be fixed ?

Fix the end wall studs into one of the double bearers by two M12 x 150 cuphead galvanized bolts through the stud. Also fix the stud to the joist by three screws.



4. Is it OK to rebate diagonal timber bracing?

No - Do not cut diagonal bracing, because it will reduce the racking resistance,

Where an internal wall meets the external wall, it does not require an extra stud in the external wall. The end stud of the internal wall may be flush with the inside face of the external wall. Not as shown in this photo.



5. How should the ceiling battens be supported?

Support the ceiling battens from the bottom chord of the trusses. This will reduce the number of separate ceiling supports required. Not as shown in this photo.



6. Are end eaves required?

For a standard DANCER design, end eaves are not required. This is intentional, because it reduces the area (and cost) of the roof sheeting. It also enables the standardisation of the roof purlins. If the building requires end wall gables, this will require a redesign and budget increase. Not as shown in this photo.

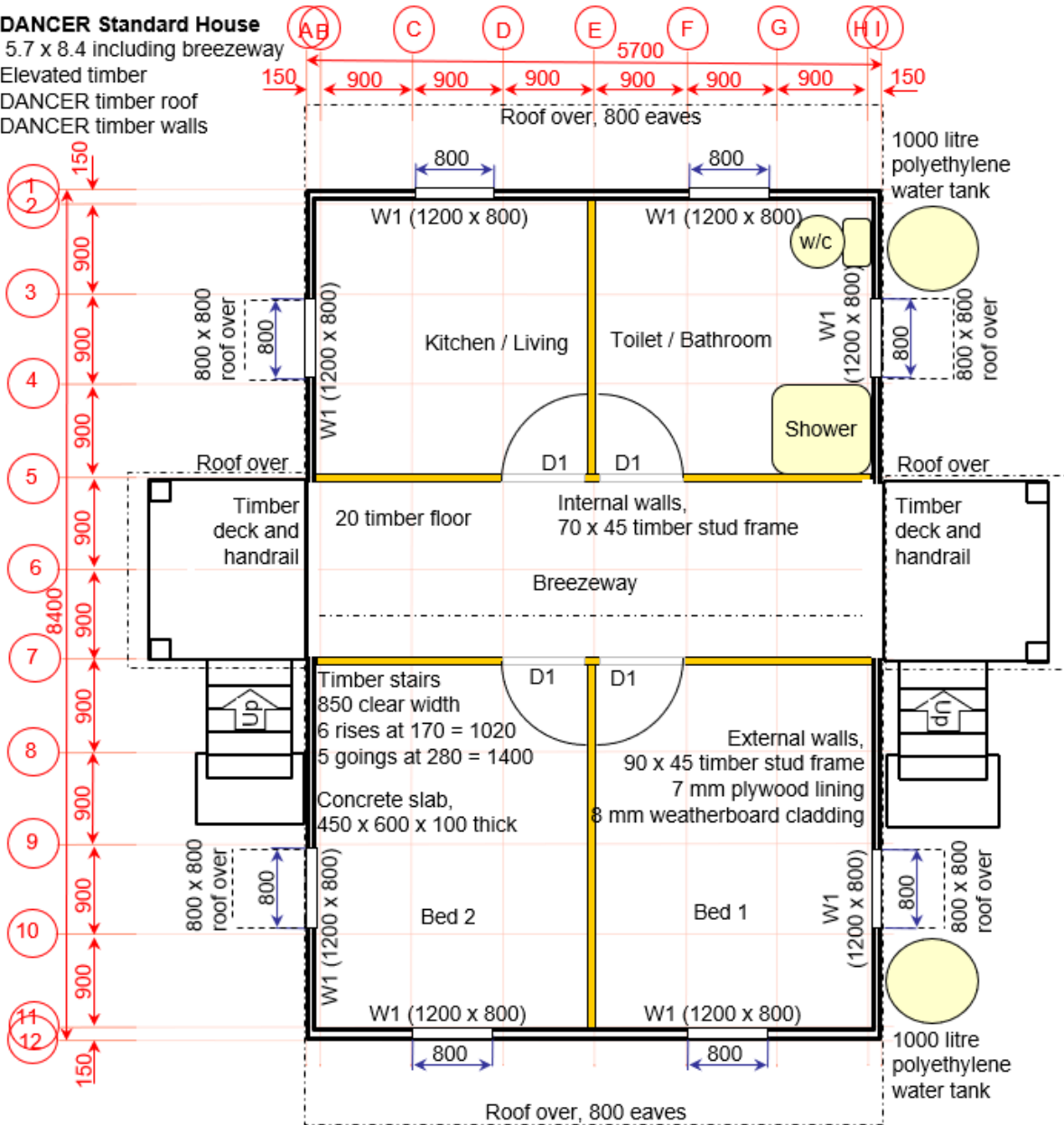


7. Are additional joists under internal walls?

Additional joists may be required under internal walls, but this should be determined on site rather than in standard designs.

Example 1 - DANCER 5.7 x 8.4 Elevated Timber House

DANCER Standard House
 5.7 x 8.4 including breezeway
 Elevated timber
 DANCER timber roof
 DANCER timber walls

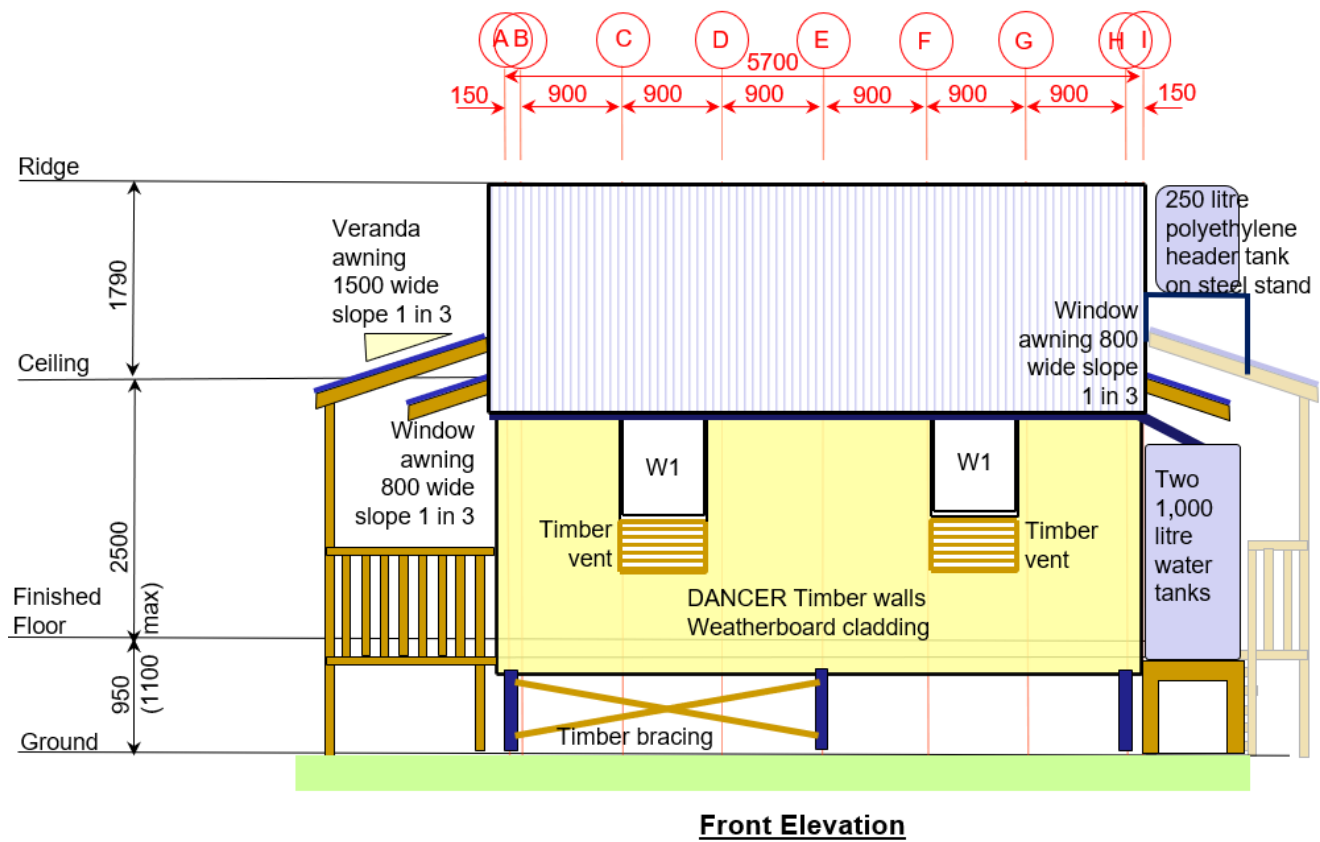
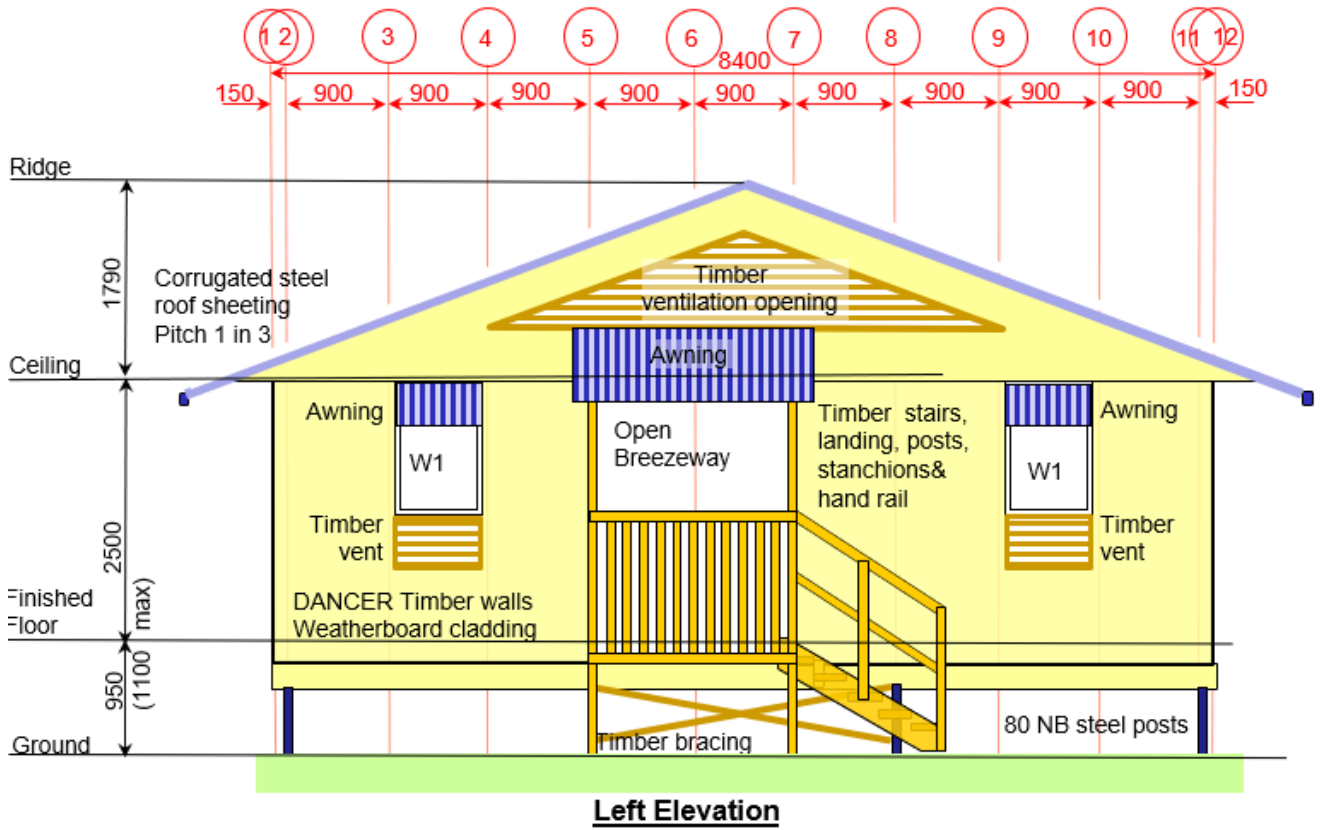


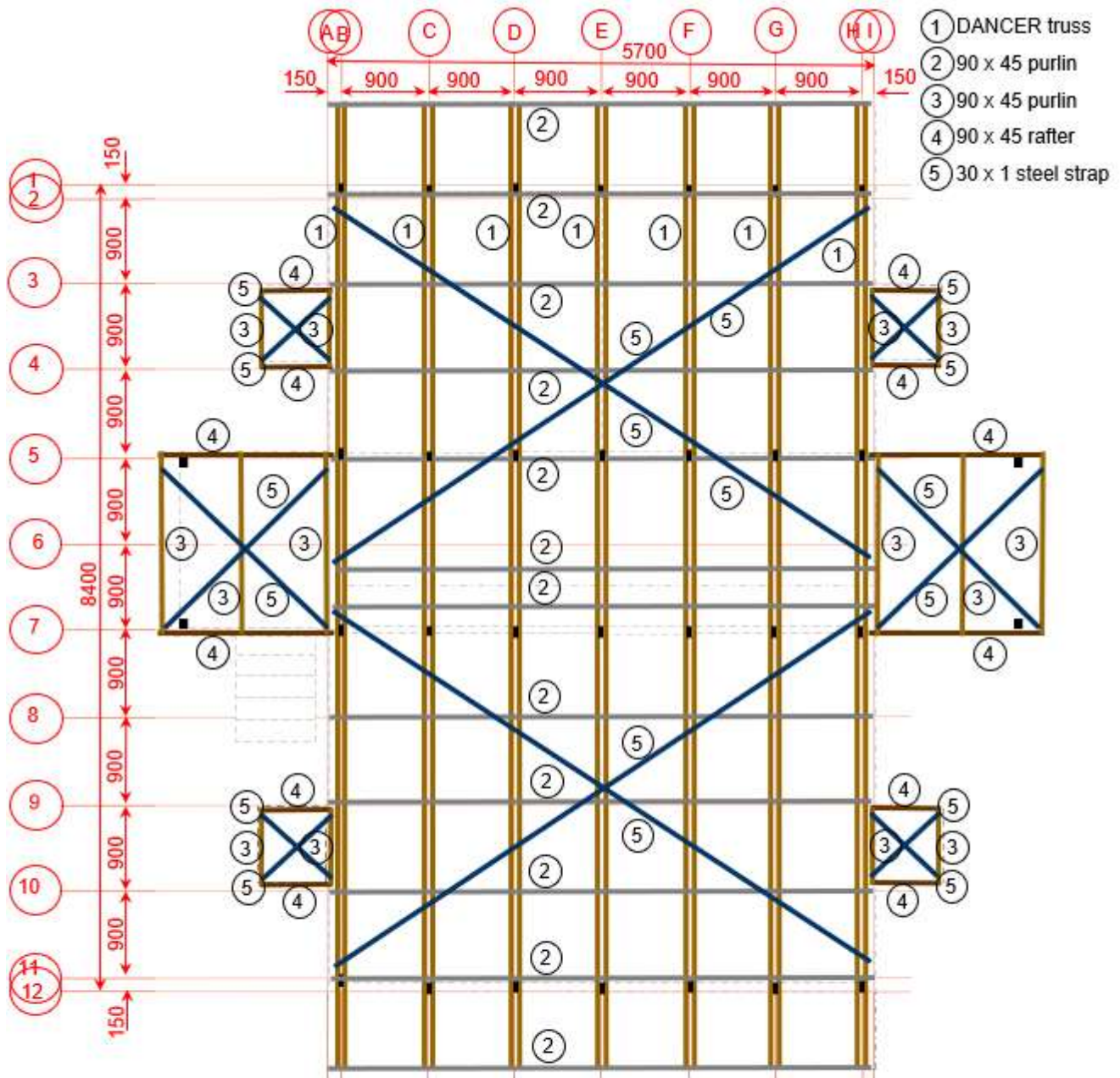
Floor Plan

This house has been designed to meet the dual criteria of cultural sensitivity and structural resistance to cyclonic wind and earthquake.

The architectural features include a breezeway, increased roof slope, roof space ventilation, window and breezeway awnings and enlarged window ventilation.

The house may easily be extended (towards the left) if required.

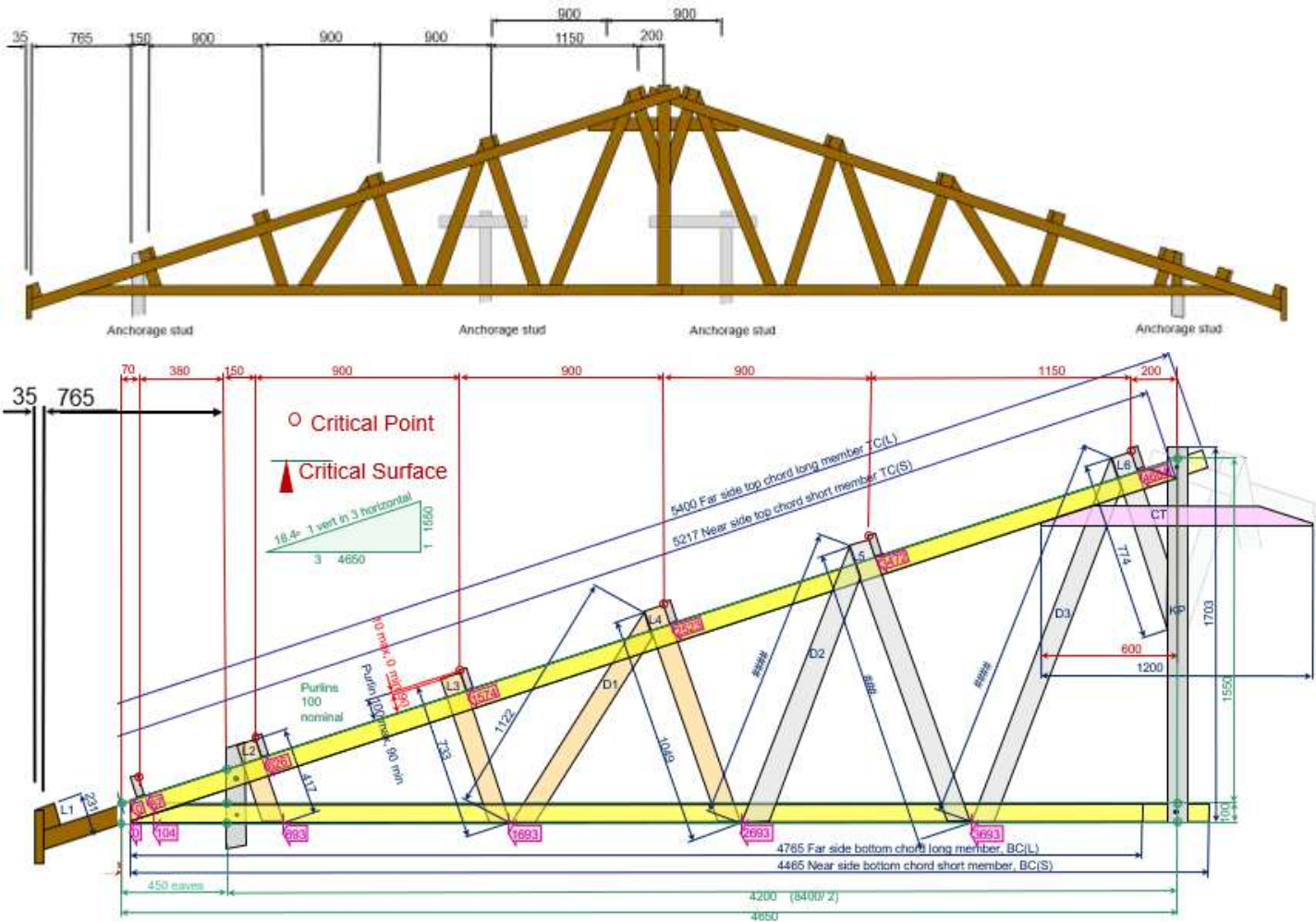




Notes:

1. All timber shall be graded F7, SD6, JD4 or stronger. Australian and New Zealand Seasoned Radiata Pine are deemed to meet this specification.
2. For all other items, substitution of other sizes must be approved by the Engineer.
3. Refer to Engineer's Details for fixings, connections and associated members.

Timber Roof Framing

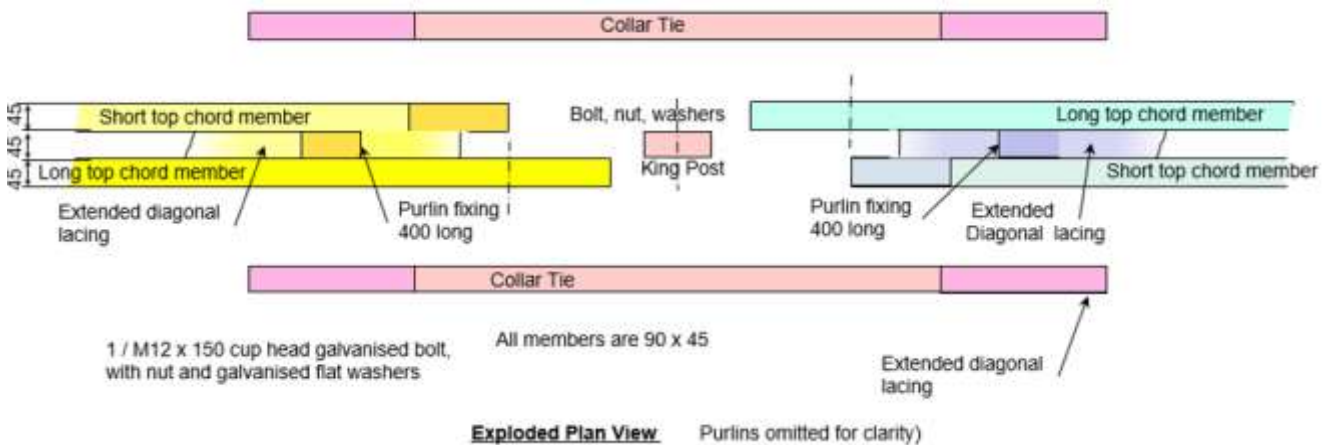
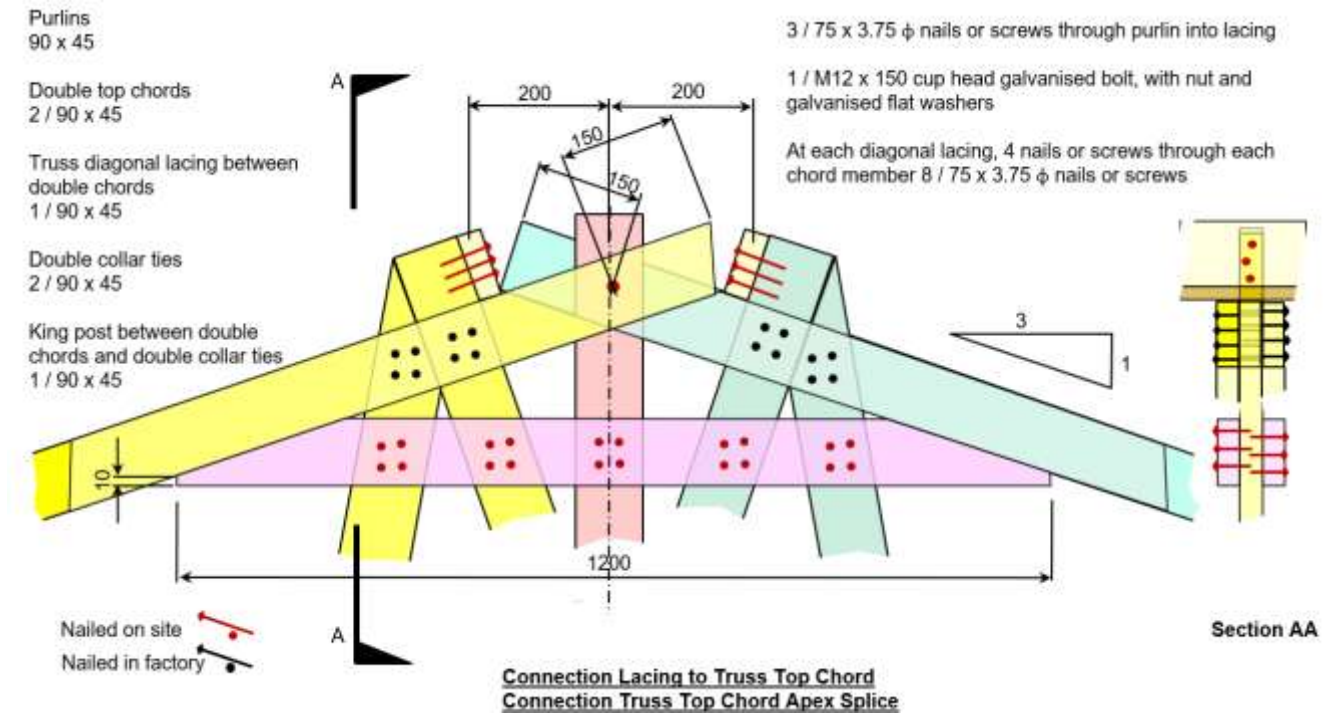


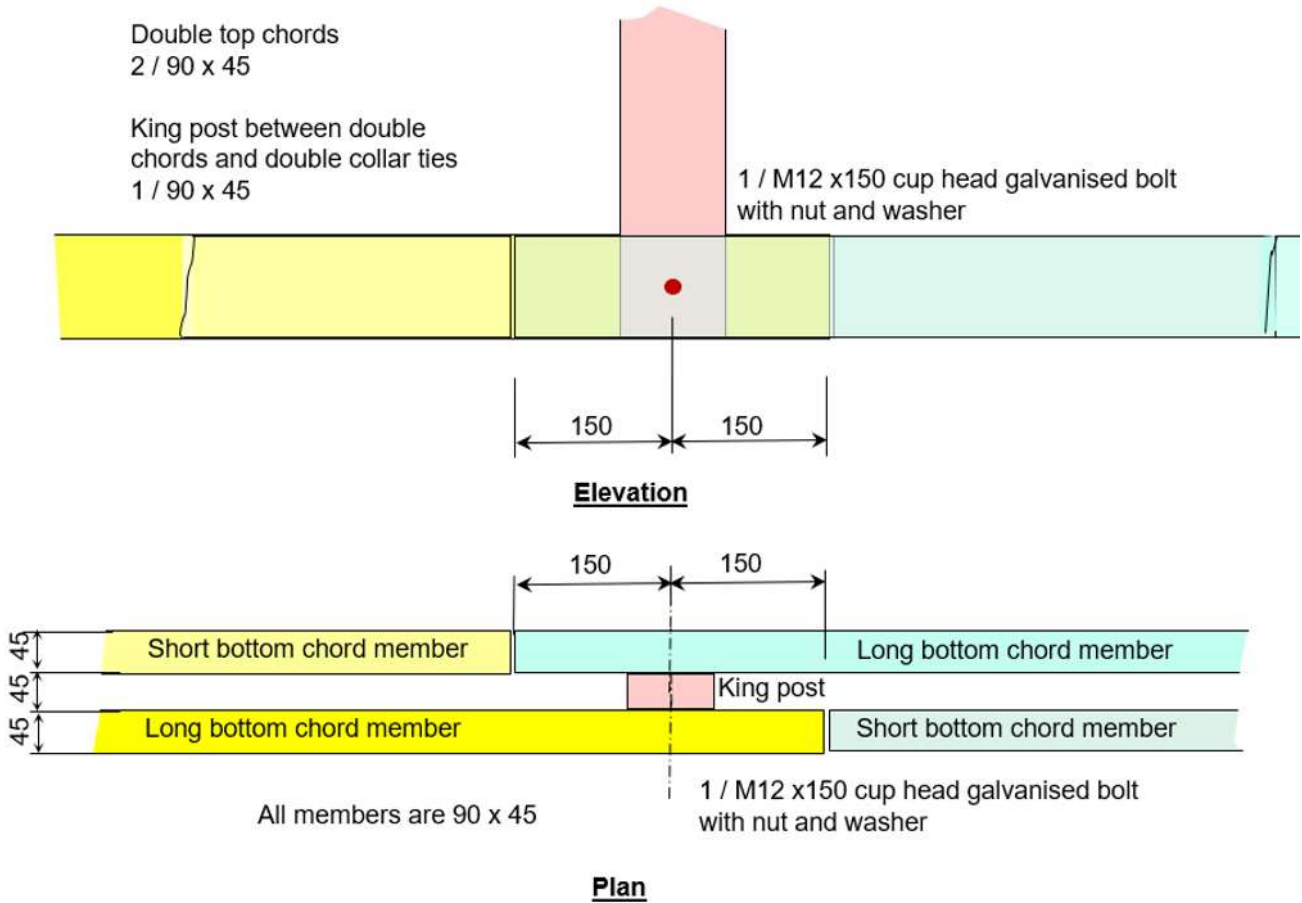
Roof Trusses		8400 span + 800 eaves			
Item	Component	Section			Length mm
		mm	x	mm	
TC(L)	Truss Top Chord (or R	90	x	45 F7	5,417
TC(S)	Truss Top Chord (or R	90	x	45 F7	5,234
BC(L)	Truss Bottom Chord (a	90	x	45 F7	4,765
BC(S)	Truss Bottom Chord (a	90	x	45 F7	4,455
CT	Collar Tie	90	x	45 F7	1,200
KP	King Post	90	x	45 F7	1,735
L1	Lacing at eaves	90	x	45 F7	232
L2	Lacing at anchorage st	90	x	45 F7	417
L3	Lacing	90	x	45 F7	734
L4	Lacing	90	x	45 F7	1,050
L5	Lacing	90	x	45 F7	1,367
L6	Lacing	90	x	45 F7	760
D1	Diagonal	90	x	45 F7	1,129
D2	Diagonal	90	x	45 F7	1,357
D3	Diagonal	90	x	45 F7	1,777

Trusses longer than 3.5 metres cannot be easily transported over significant distances.

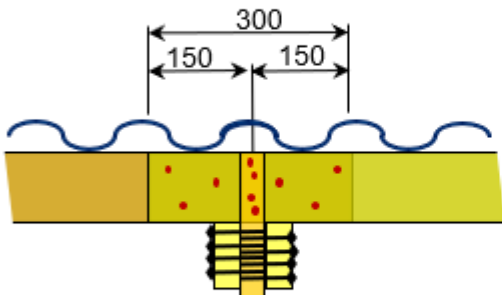
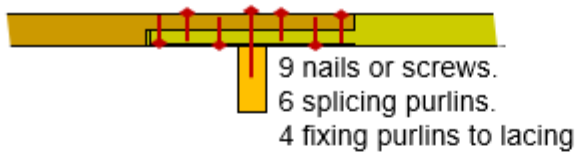
They must be fabricated in two sections and joined on site. In this case the top chords must be joined with a bolted connection, and the bottom chords must be joined by a bolted connection.

Bolted connections must not incorporate nails, since the premature failure of the nails could disrupt the timber and destroy the bolted connection before it has time to be effective.



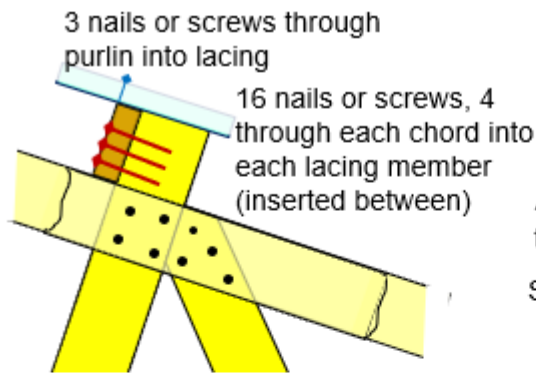


Connection Truss Bottom Chord Splice

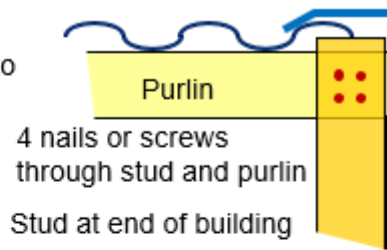


4 nails or screws through each chord into each lacing member (inserted between)



Purlin Splice (Preferred Detail)



**Connection Purlin to Double Top Chord
Connection Lacing to Double Top Chord**



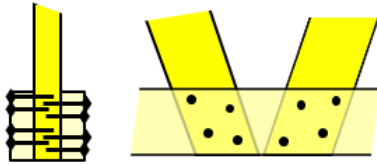
Connection Purlin to End Wall Stud

Nailed on site  Purlins, double chords and truss
Nailed in factory  diagonal lacing between double
75 x 3.75 φ nails or screws chords 90 x 45 F7 timber

Top Chord, Lacing, Purlin Fixing and Purlin Splice

75 x 3.75 φ nails or screws

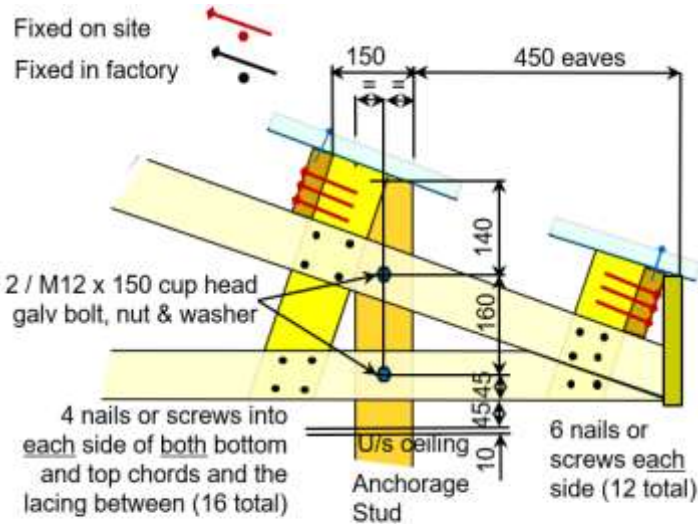
Fixed in factory



Purlins, double chords and truss diagonal lacing between double chords are all 90 x 45 F7

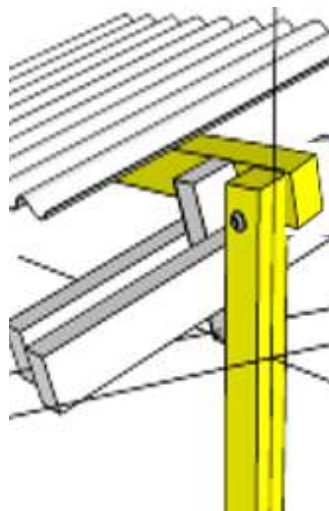
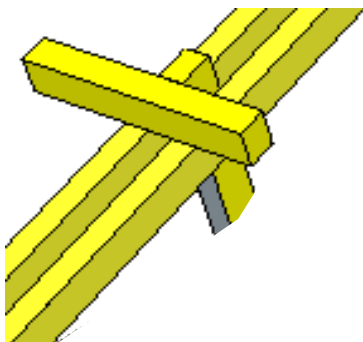
4 nails or screws through each side of both bottom chords into lacing at both lacing (16 total)

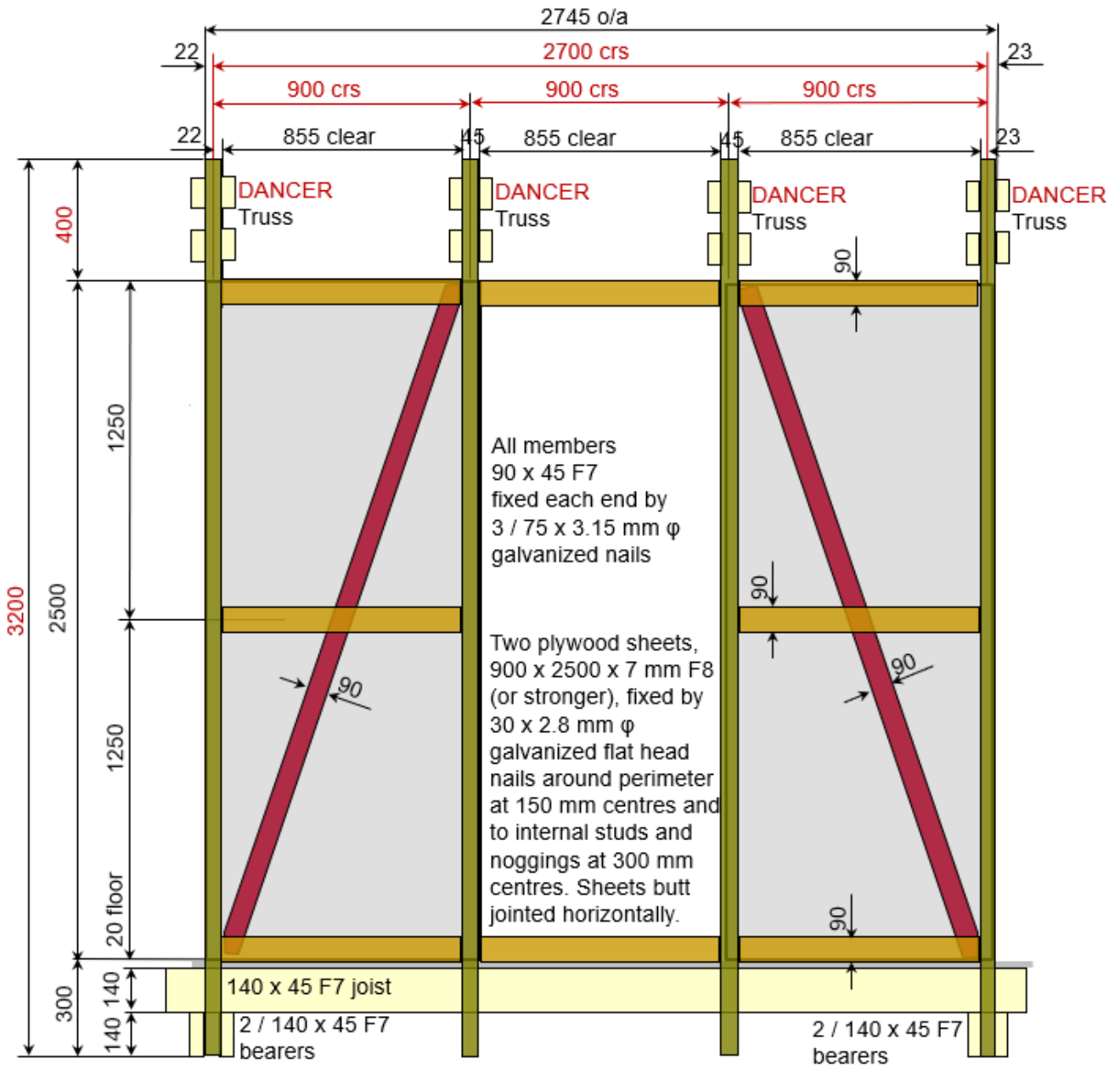
Connection of Lacing to Bottom Chords



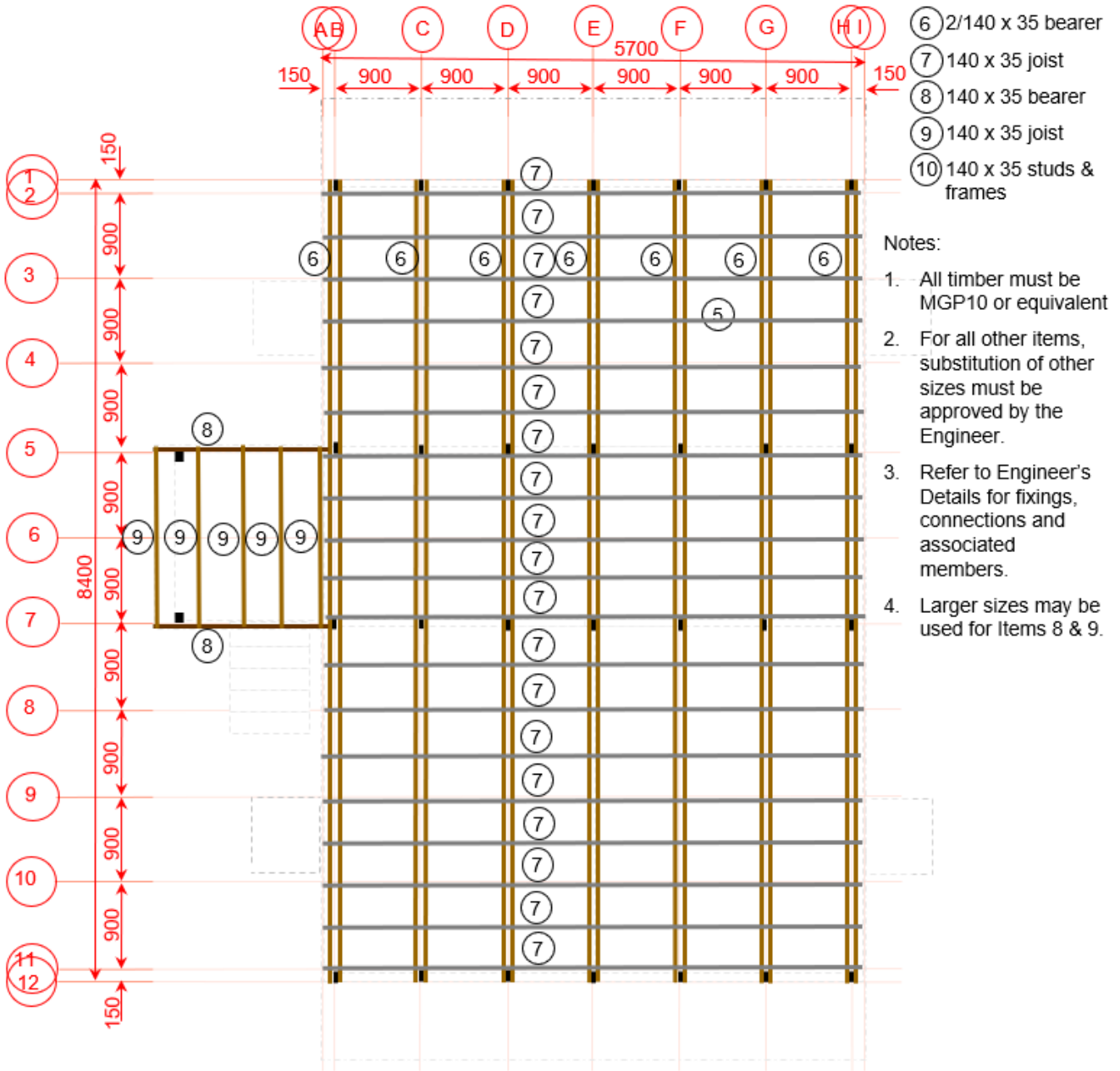
Top Chord to Bottom Chord
Top Chord to Anchorage Stud

450 Eaves



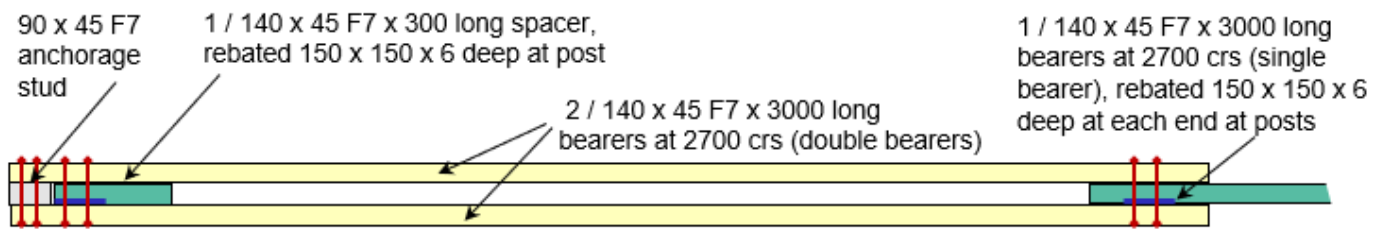


Typical Long Wall Framing, Trusses at 900 mm centres

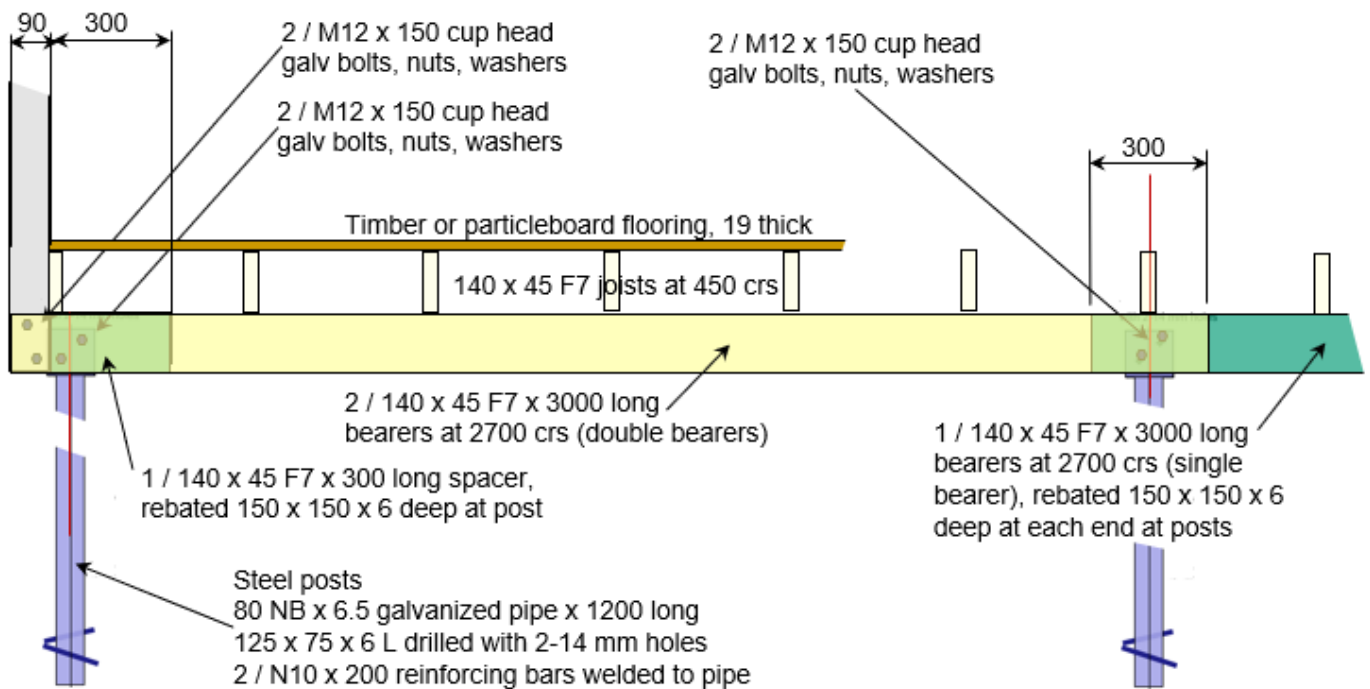


Timber Floor Framing

For standard buildings on a 2.700 x 2.700 grid with 0.150 overhangs, the bearer timbers will all be 3,000 long.



Plan Showing Anchorage Studs, Double & Single Bearers



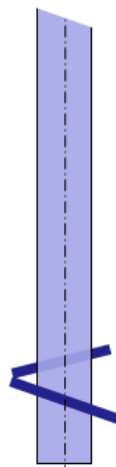
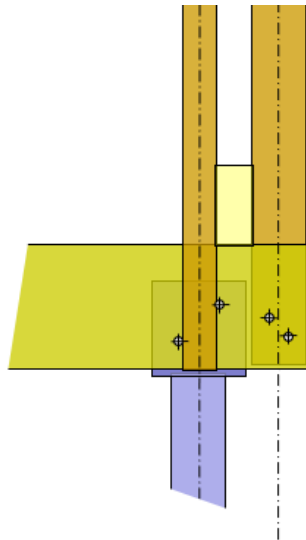
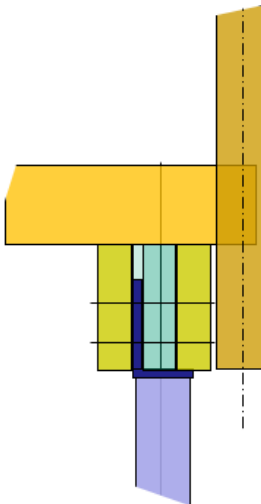
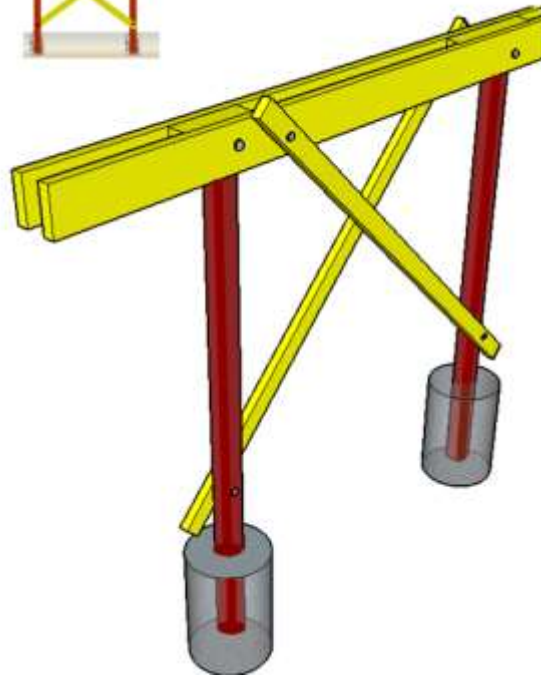
Bearers in external bays are double bearers, bearers in internal bays are single bearers.
 Except where specified otherwise in these drawings or specifications, all details shall comply with AS 1684.3

Section Showing Anchorage Studs, Joists, Double & Single Bearers and Posts

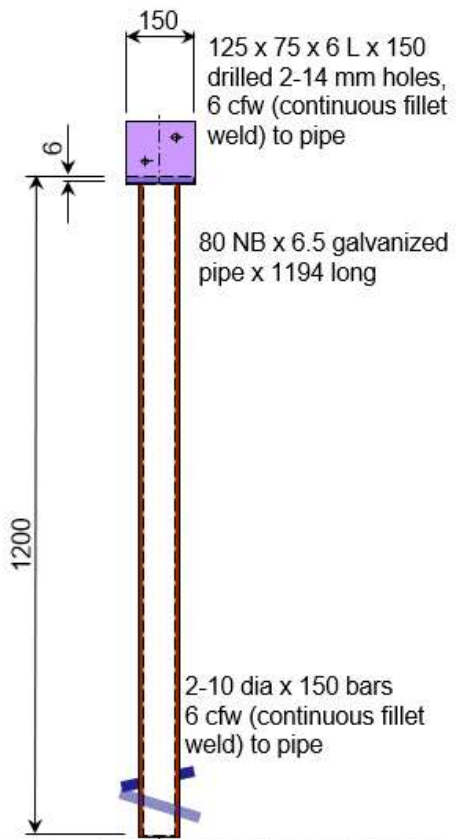
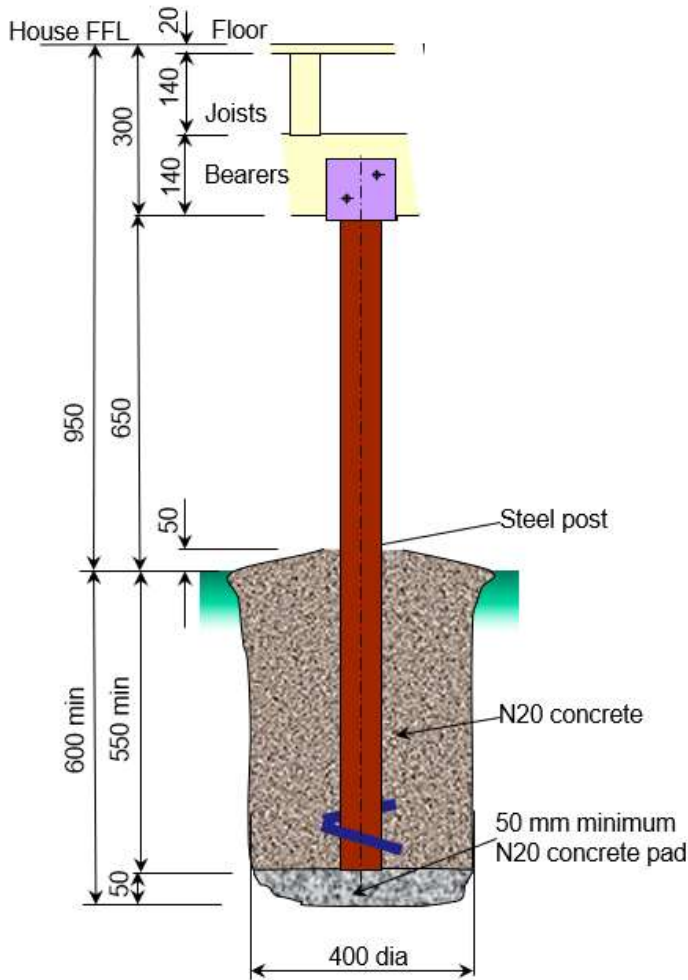
Direct Anchorage Detail
 Fix diagonal braces at the top directly to the bearers or joists (as appropriate), to provide a direct load path to the ground



Alternate Detail
 Fix bracing fixed to the steel posts both top and bottom.



Connections at floor of steel posts with additional cleats

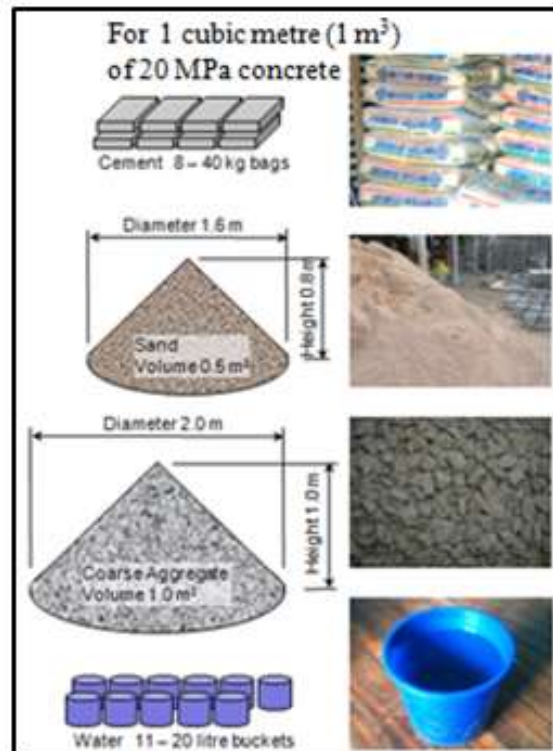


Fabricated posts meeting this specification (or similar) may be available from hardware retailers. If the length of the post is different, the height of the finished floor level and the details of the steps may need to be adjusted.

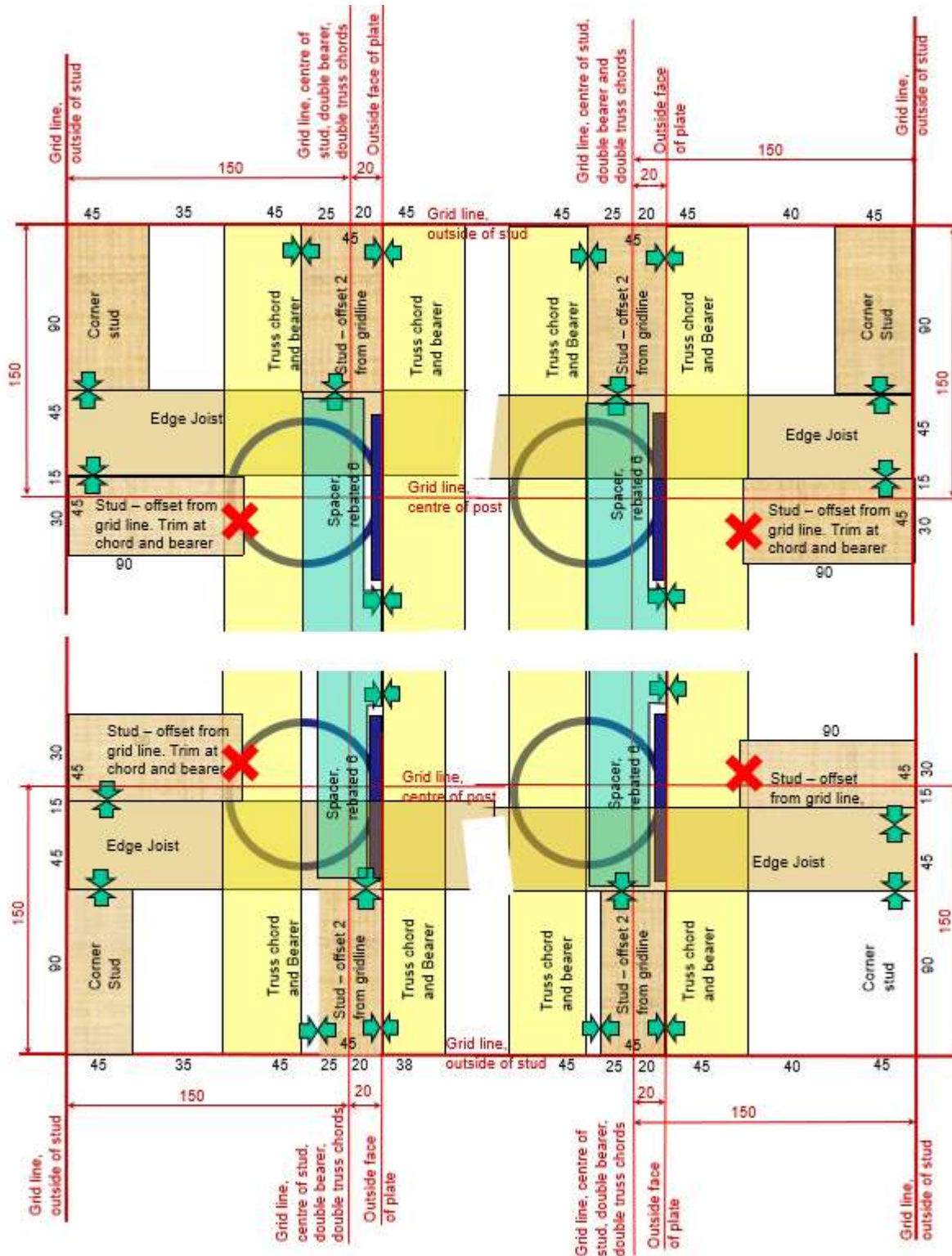
Concrete Pier, Steel Posts and Timber Floor

Steel Posts

20 MPa mix (by volume) 1 : 2 : 4		
Volume of concrete	m ³	1.0
Wastage included	%	
GP or GB cement	40 kg bags	8
Clean sharp sand	m ³	0.5
20 mm rock aggregate	m ³	1.0

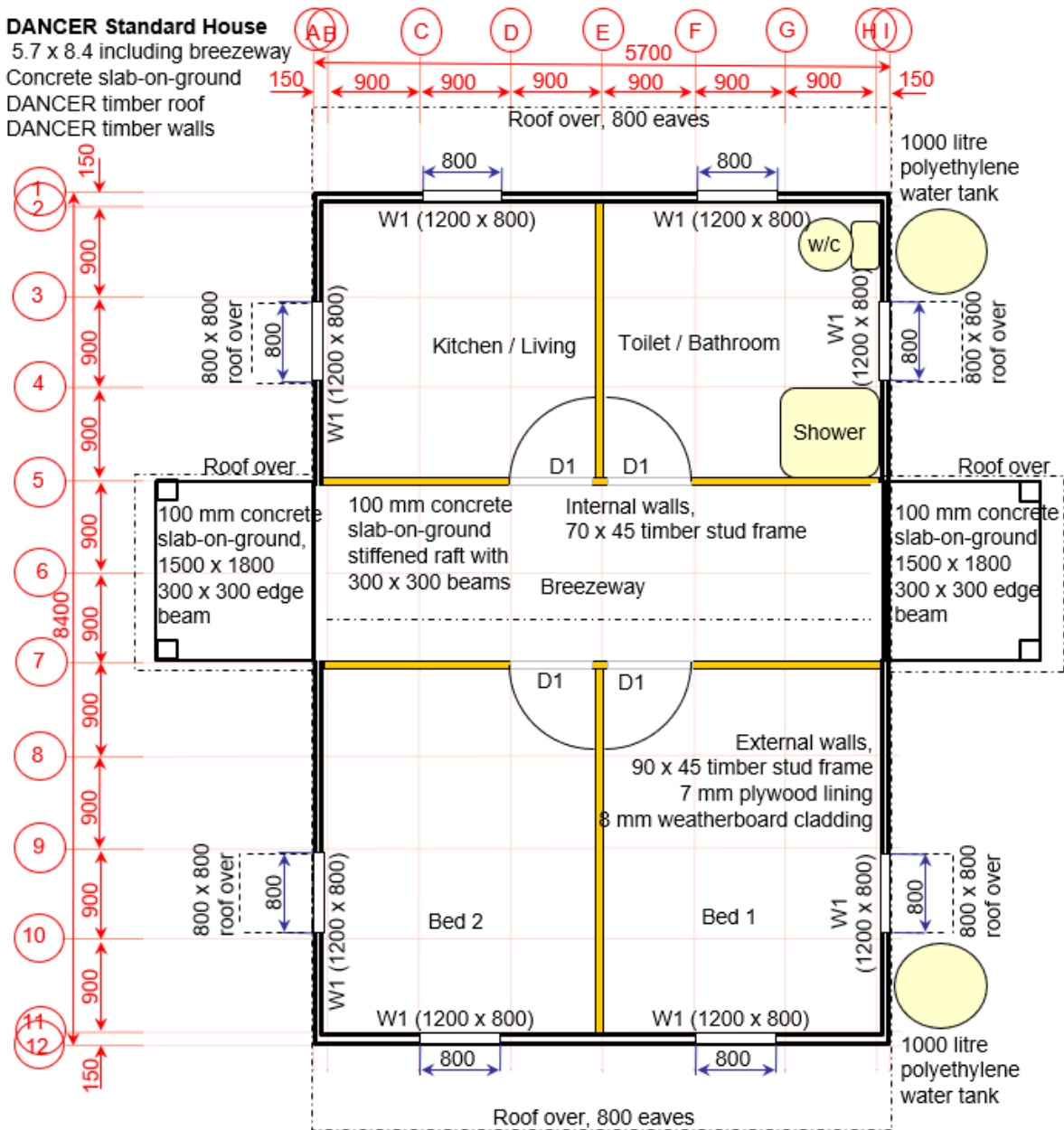


The following plan views show the relative positions of the double bearer (including the spacer), edge joist, steel post, anchorage stud and corner stud. The outside vertical face of the steel angle must be offset 20 mm from the gridline and **must be on the same side for every post**. If this is not done, prefabricated wall framing will not fit properly. The spacer timbers at the posts (shown in green) must be rebated 6 mm for a 150 mm length, to fit past the steel section. The plan (for 90 x 35 dressed timber) below is typical of the arrangement.



Arrangement at the Corner of Building for 90 x 45 studs and 140 x 45 bearers

Example 2 - DANCER 5.7 x 8.4 House with Timber Superstructure and Concrete Slab-on-Ground

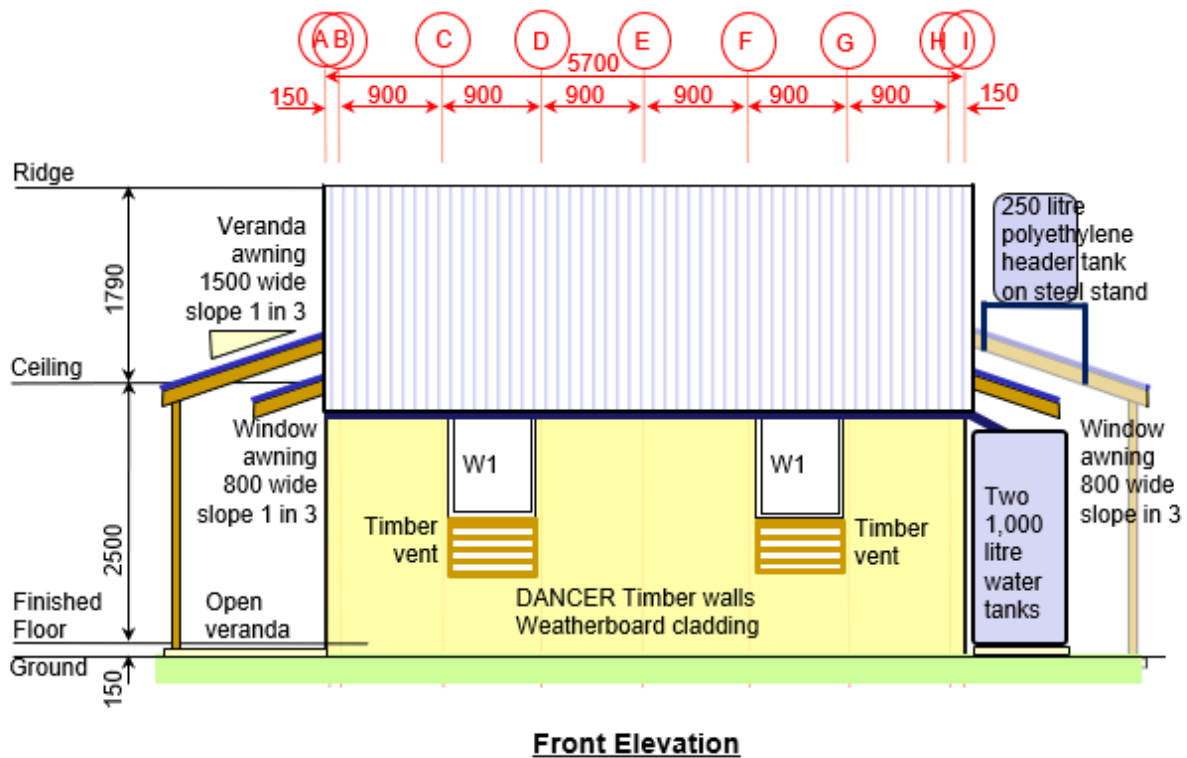
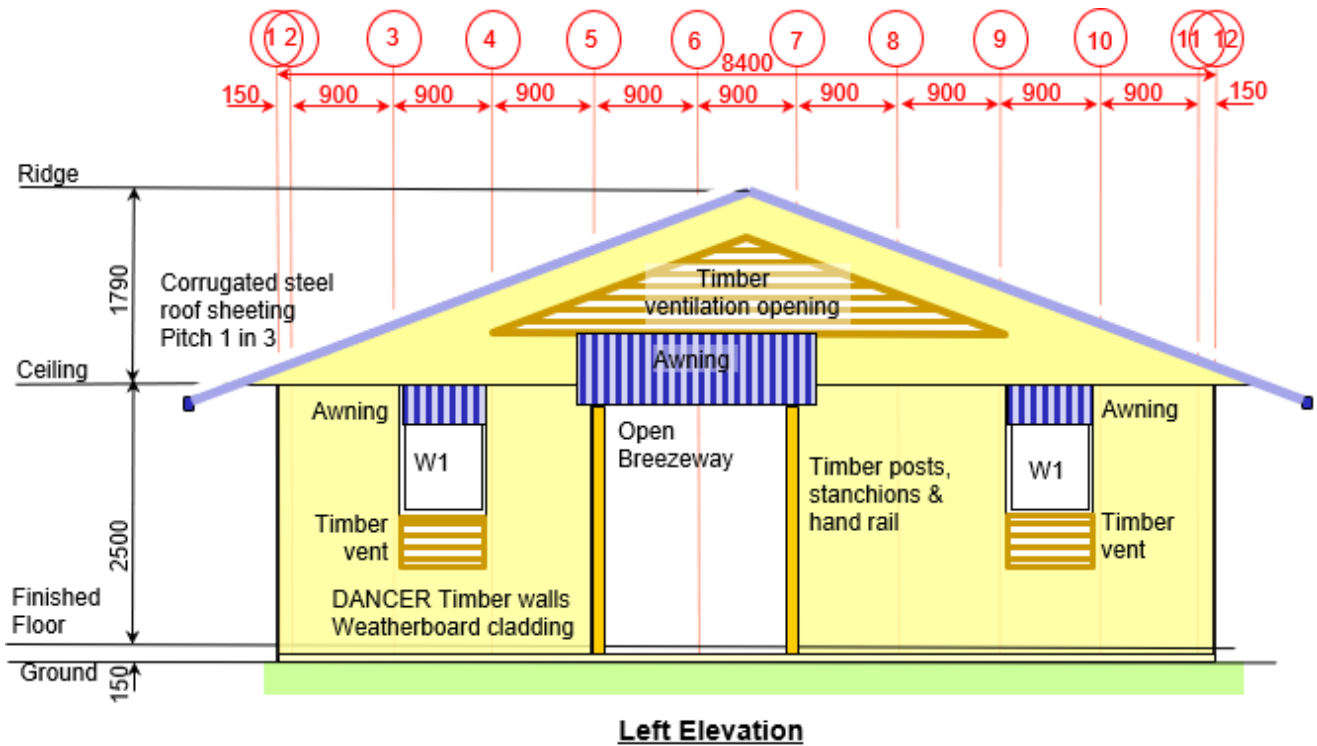


Floor Plan

This house has been designed to meet the dual criteria of cultural sensitivity and structural resistance to cyclonic wind and earthquake.

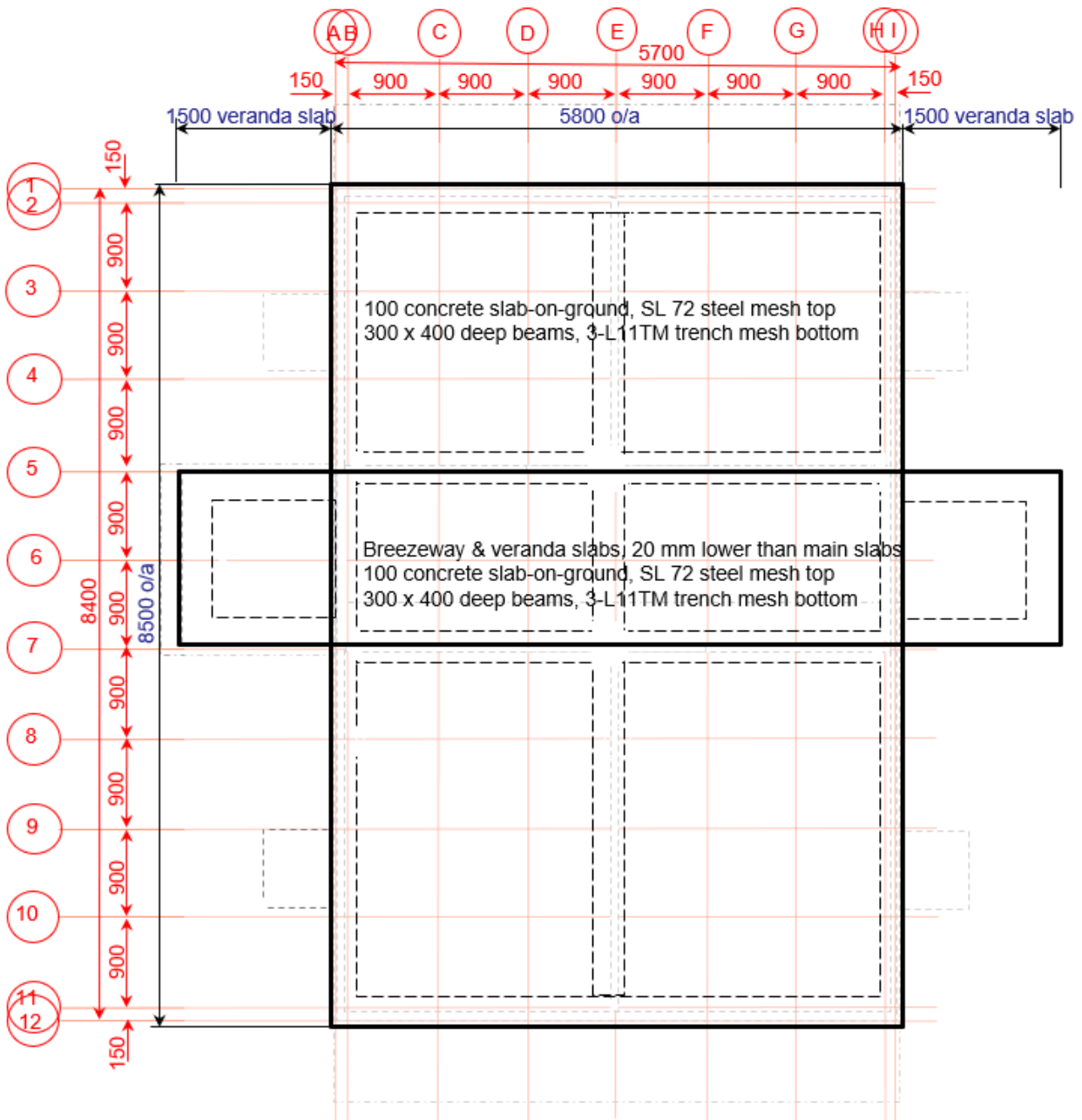
The architectural features include a breezeway, increased roof slope, roof space ventilation, window and breezeway awnings and enlarged window ventilation.

The house may easily be extended (towards the left) if required.



Timber Roof and Wall Framing

Refer to Example No 1 for details of the **DANCER** Roof Trusses and Wall Framing

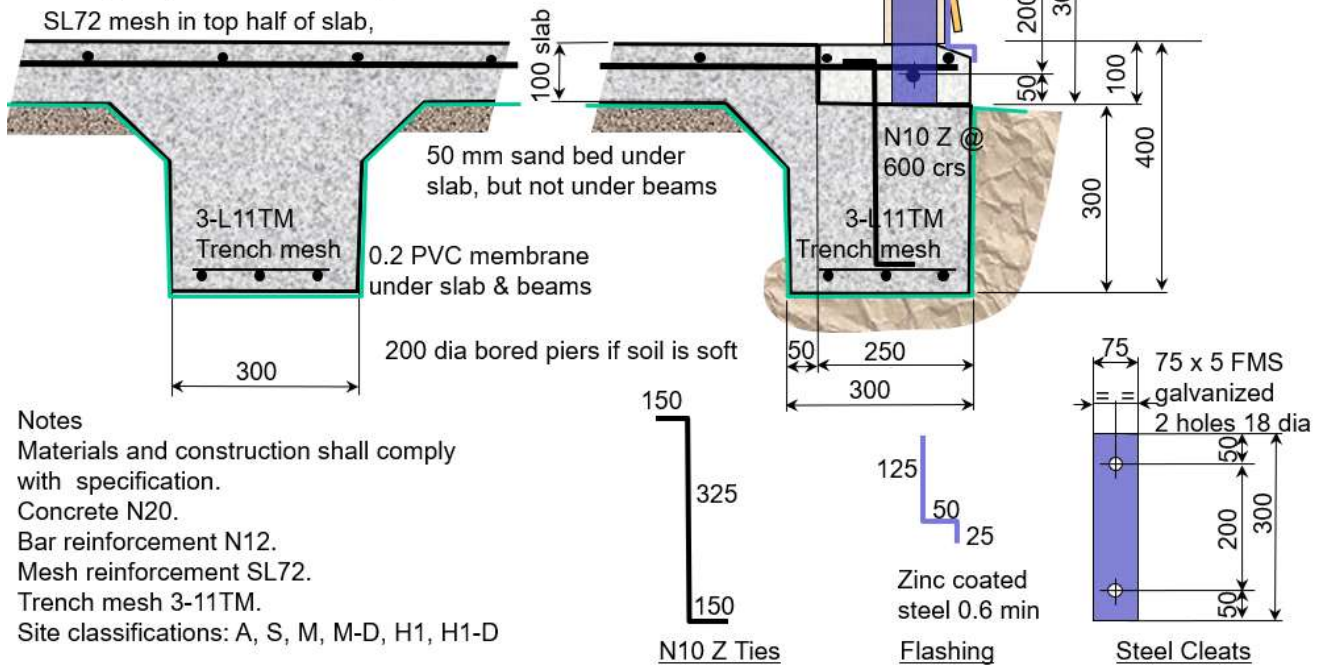


Concrete Slab-on-Ground for Timber Superstructure

Principal grid lines Roof member centre (line) Edge of Wall Edge of slab

Construction Sequence

1. Excavate and compact the soil for beams.
2. Install the 50 mm sand layer under the slab, but not under the beams.
3. Install the PVC membrane.
4. Position slab mesh, trench mesh and Z bars on bar chairs.
5. Pour, compact and finish the concrete. Apply curing compound.
6. Assemble the studs (including steel anchors and reinforcing bars), trusses and two rows of bearers.
7. Fix a 100 x 50 temporary edge form.
8. Pour, compact and finish the perimeter concrete.

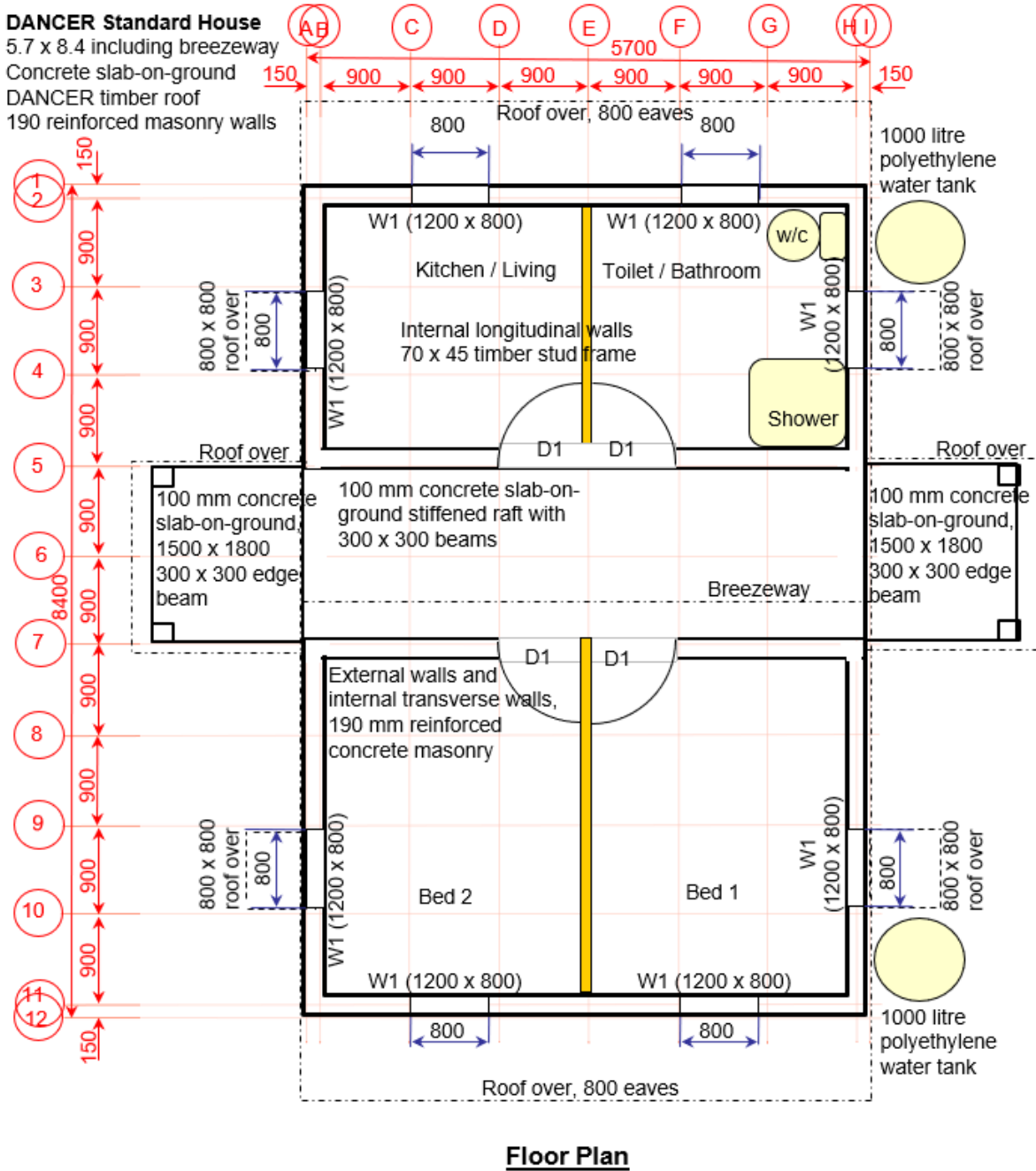


Notes

- Materials and construction shall comply with specification.
- Concrete N20.
- Bar reinforcement N12.
- Mesh reinforcement SL72.
- Trench mesh 3-11TM.
- Site classifications: A, S, M, M-D, H1, H1-D

Section through Concrete Slab-on-Ground and Stud Anchorage

Example 3 - DANCER 5.7 x 8.4 House with Reinforced Concrete Masonry Superstructure and Concrete Slab-on-Ground

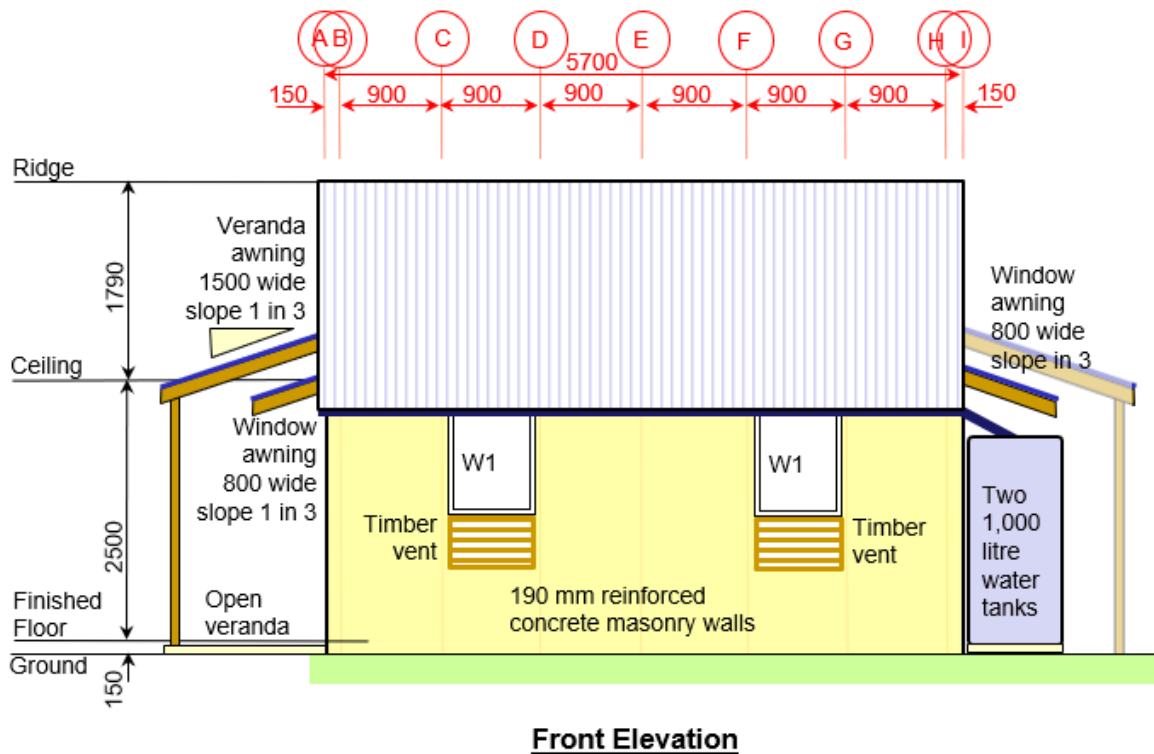
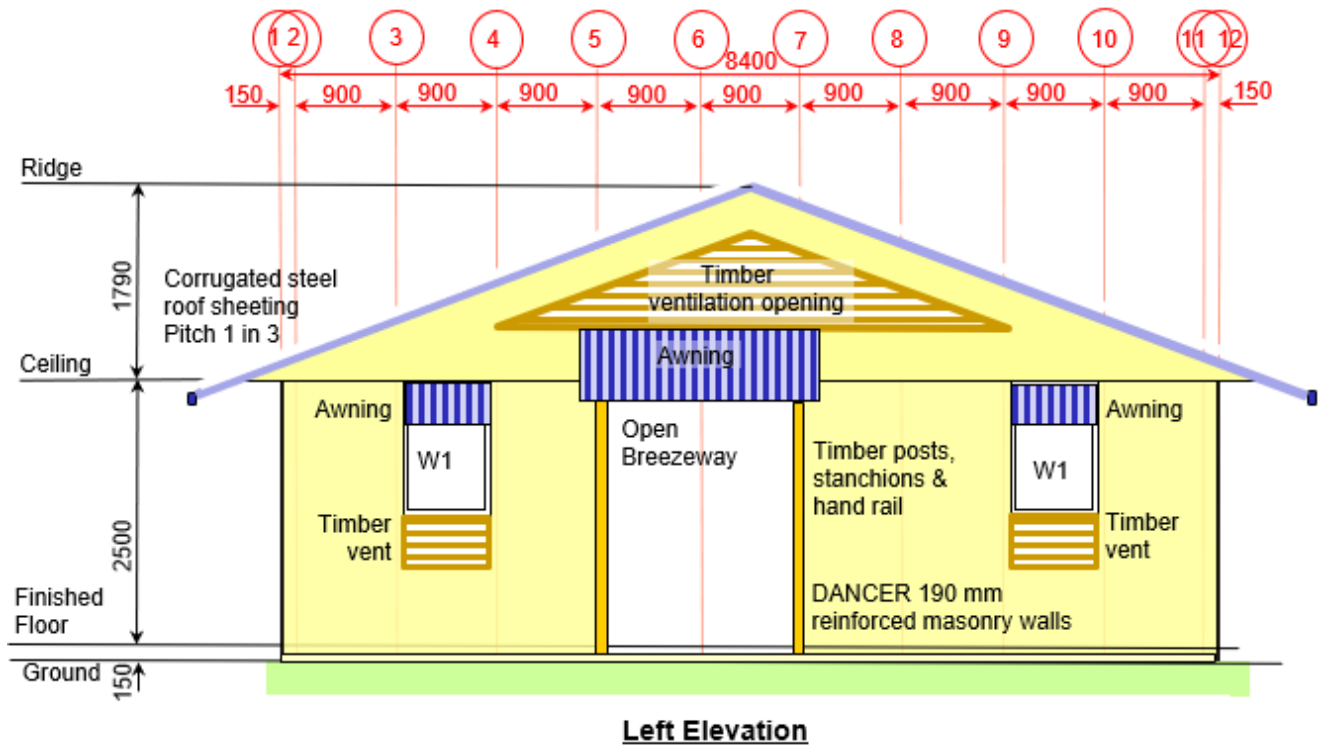


This house has been designed to meet the dual criteria of cultural sensitivity and structural resistance to cyclonic wind and earthquake.

The architectural features include a breezeway, increased roof slope, roof space ventilation, window and breezeway awnings and enlarged window ventilation.

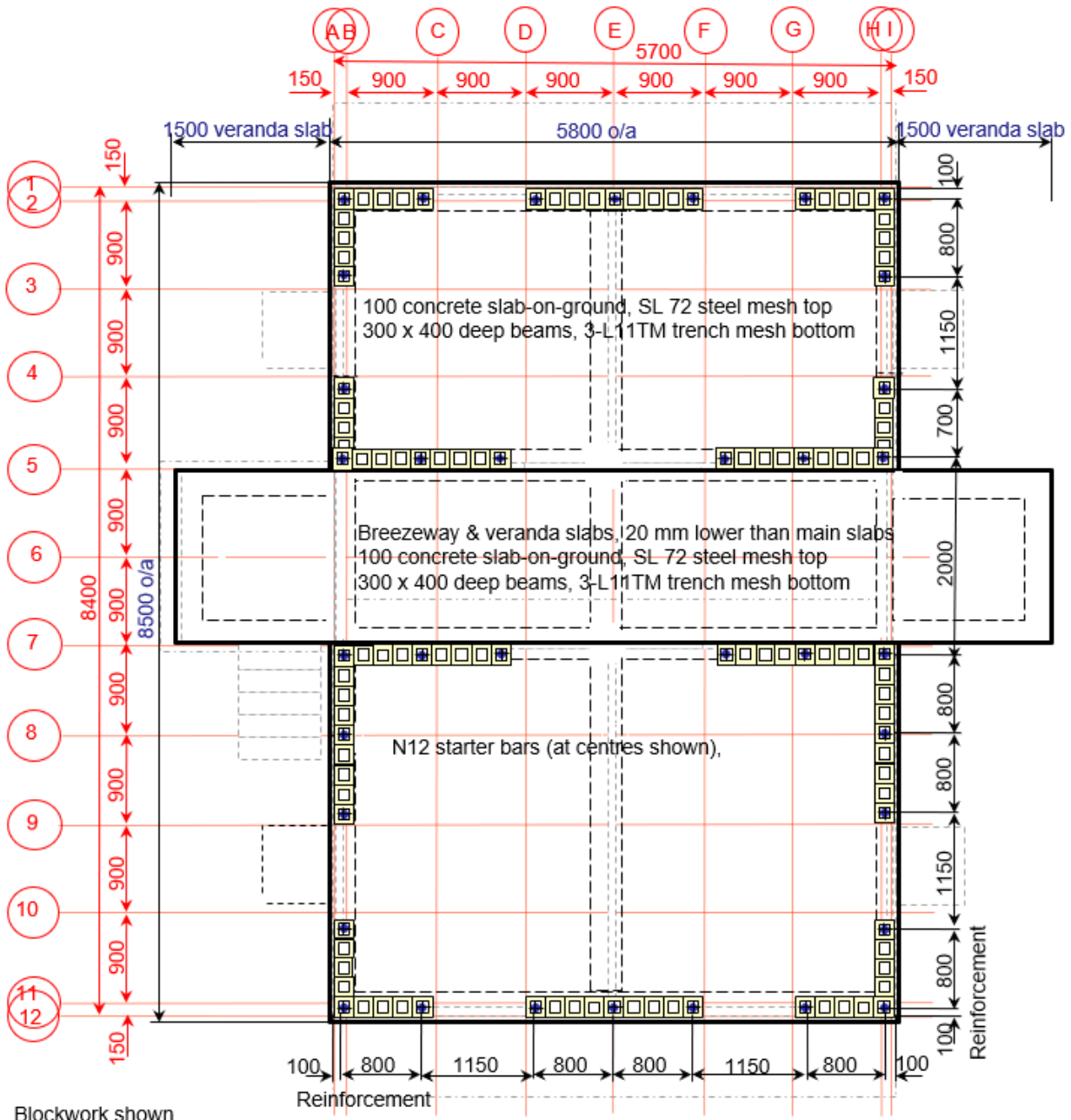
The house may easily be extended (towards the left) if required.

Elevations

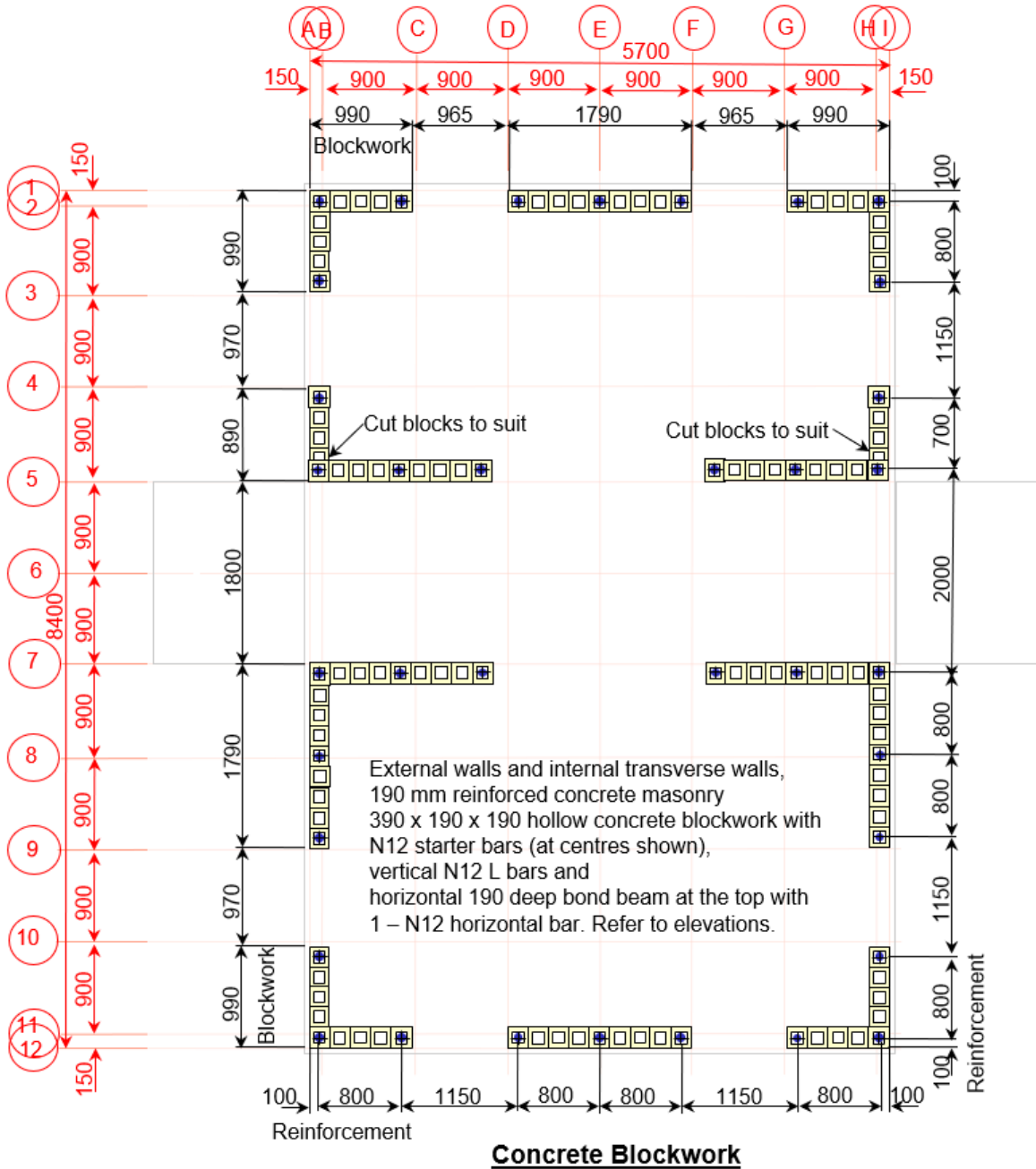


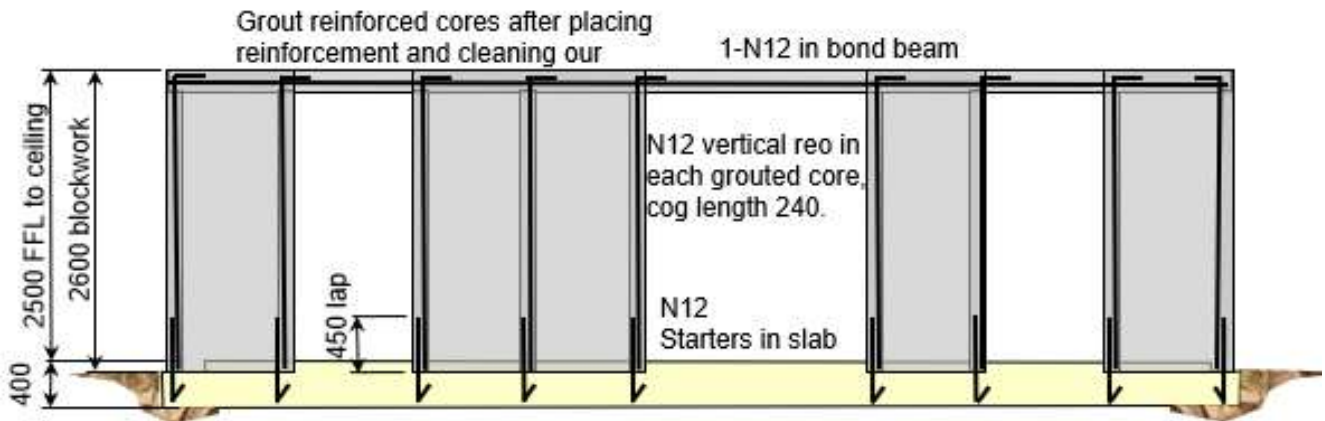
Timber Roof and Wall Framing

Refer to Example No 1 for details of the **DANCER** Roof Trusses and Wall Framing



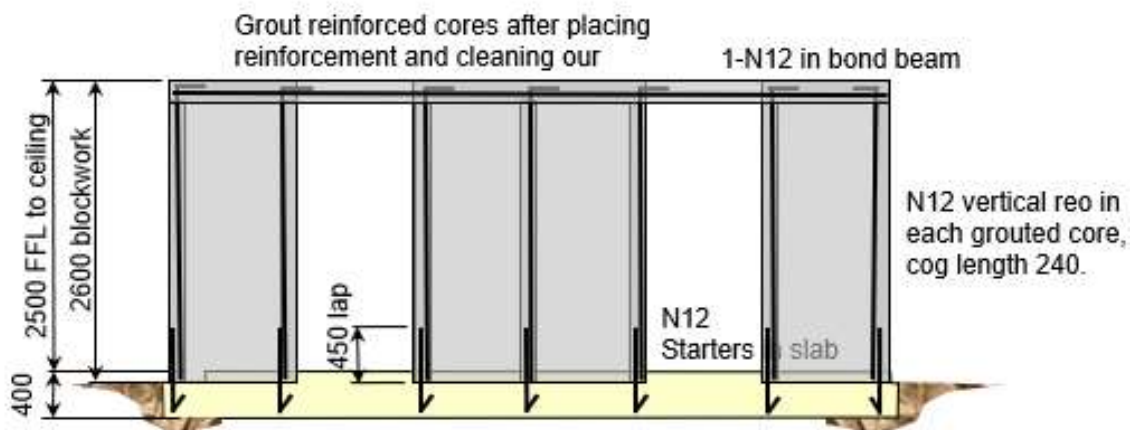
Concrete Slab-on-Ground for Reinforced Concrete Masonry Superstructure





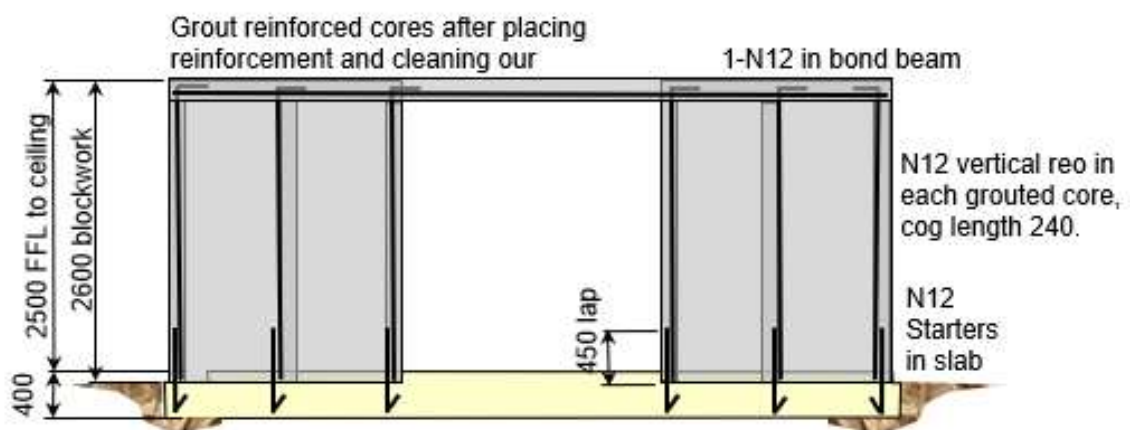
Concrete slab/beam system, including sand bed, reinforcement, membrane etc, designed to AS 2870. Edge beams and cross beams, 400 x 300 mm, 3-11TM trench mesh. 100 mm concrete slb, SL72 mesh.

Section through Longitudinal External Wall Reinforcement



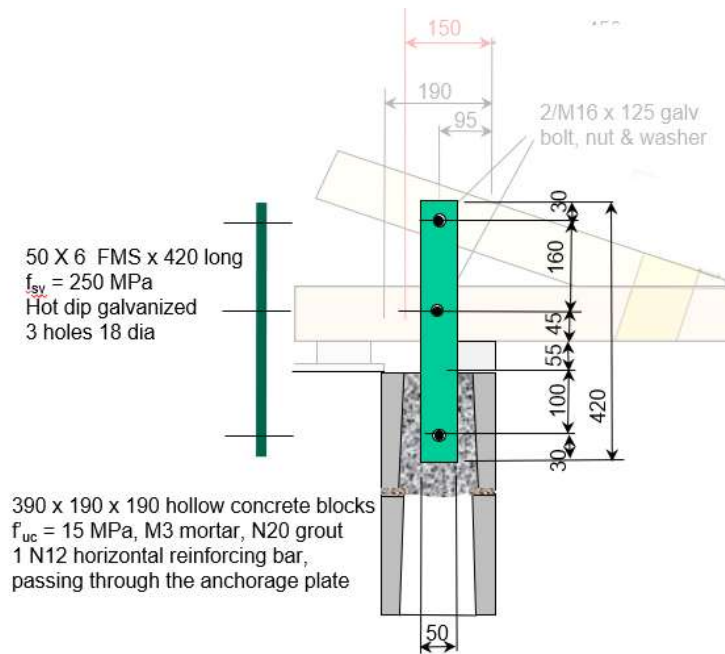
Concrete slab/beam system, including sand bed, reinforcement, membrane etc, designed to AS 2870. Edge beams and cross beams, 400 x 300 mm, 3-11TM trench mesh. 100 mm concrete slb, SL72 mesh.

Section through Transverse External Wall Reinforcement



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

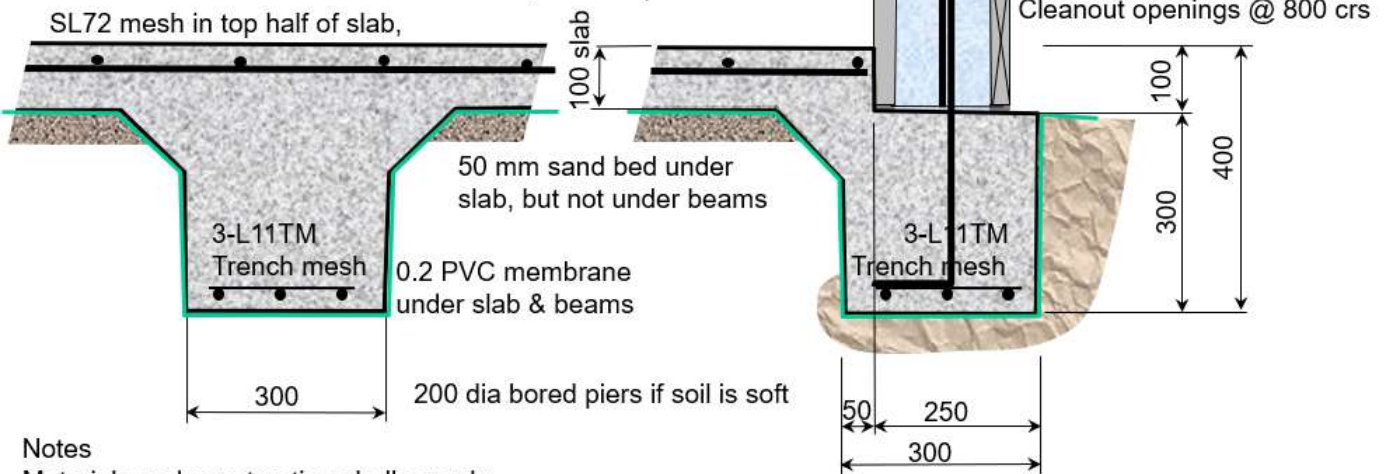
Section through Transverse Internal Wall Reinforcement



Section through Roof Anchorage to Reinforced Concrete Masonry Wall

Construction Sequence

1. Excavate and compact soil for beams.
2. Install the 50 mm sand layer under the slab, but not under beams.
3. Install the PVC membrane.
4. Fix a 100 x 50 temporary edge form to create the rebate.
5. Position slab mesh and trench mesh (or equivalent) on bar chairs.
6. Position all reinforcement, including starter bars in exact locations.
7. Pour, compact and finish the concrete. Apply curing compound.
8. Construct reinforced masonry wall, including reinforcement and grout.
9. Position PVC membrane near blockwork, and compact the soil.

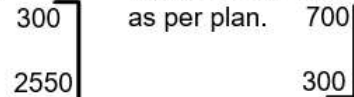


Notes

Materials and construction shall comply with specification.
 Concrete N20.
 Bar reinforcement N12.
 Mesh reinforcement SL72.
 Trench mesh 3-11TM.
 Site classifications: A, S, M, M-D, H1, H1-D

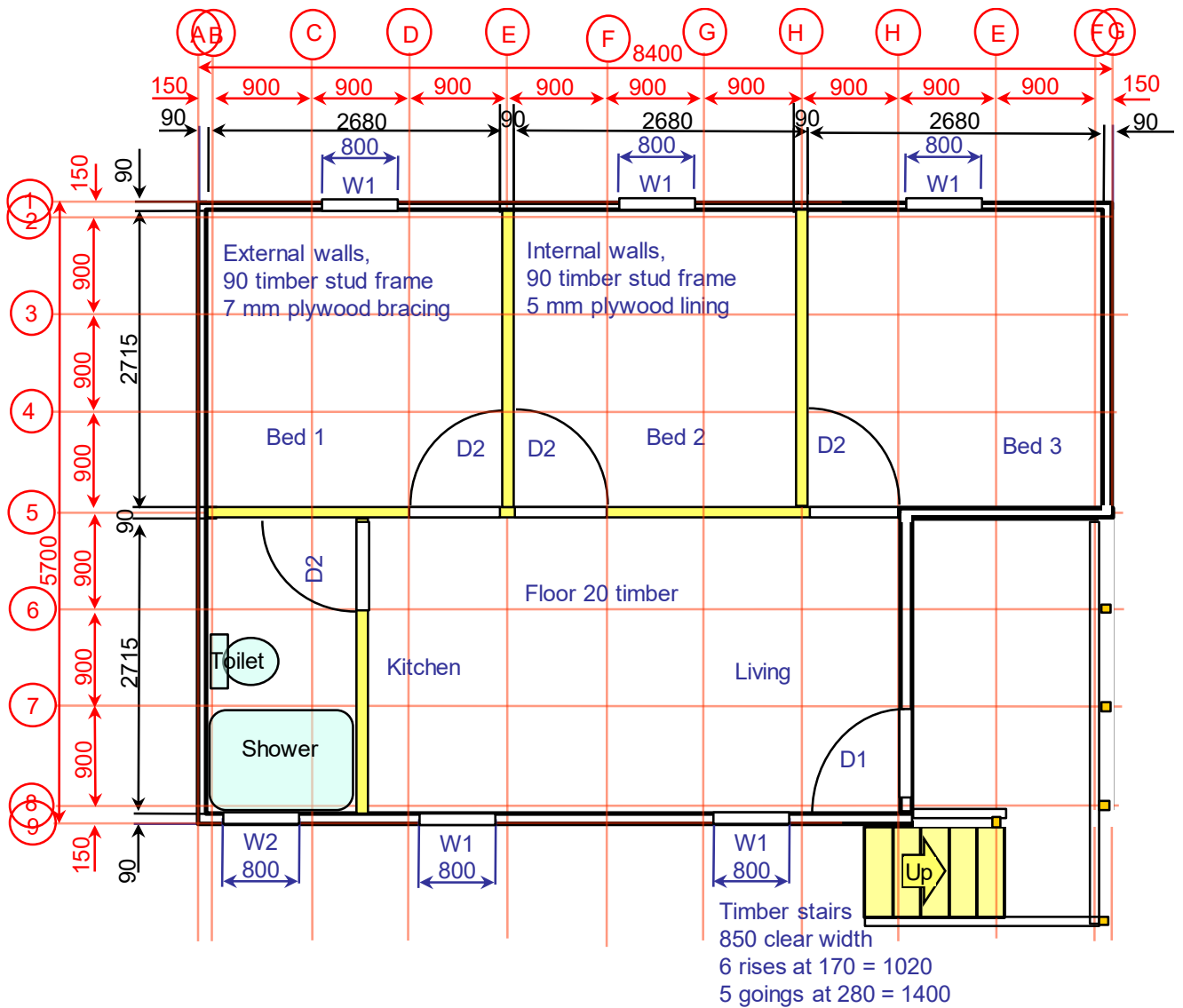
Steel vertical wall reo and grout.
 N12 L @ 800 max crs. location to match starters. Cog at top.

Steel starter
 N12 L @ 800 max crs.
 Exact location of starters as per plan.

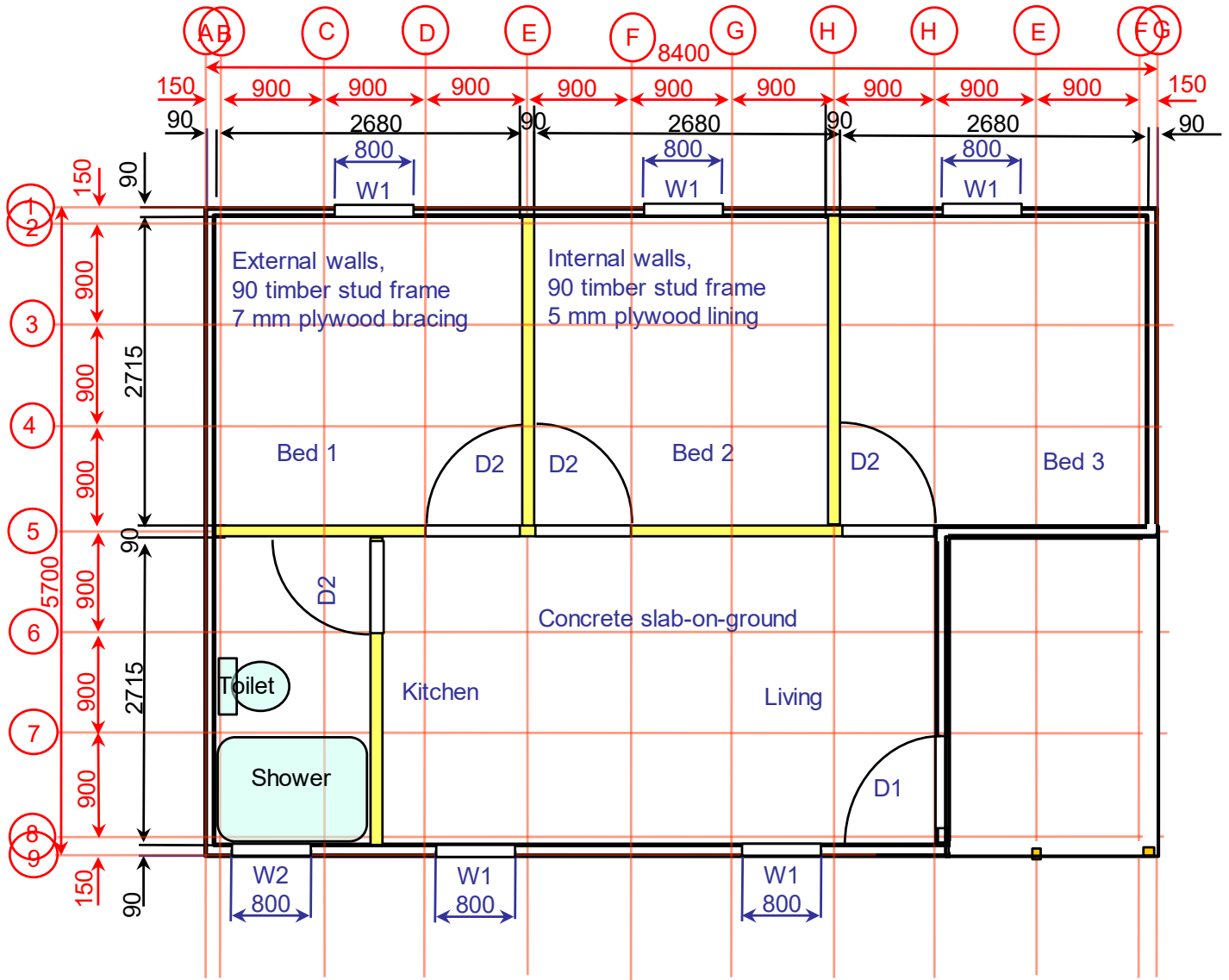


Section through Concrete Slab-on-Ground and Reinforced Concrete Masonry Wall

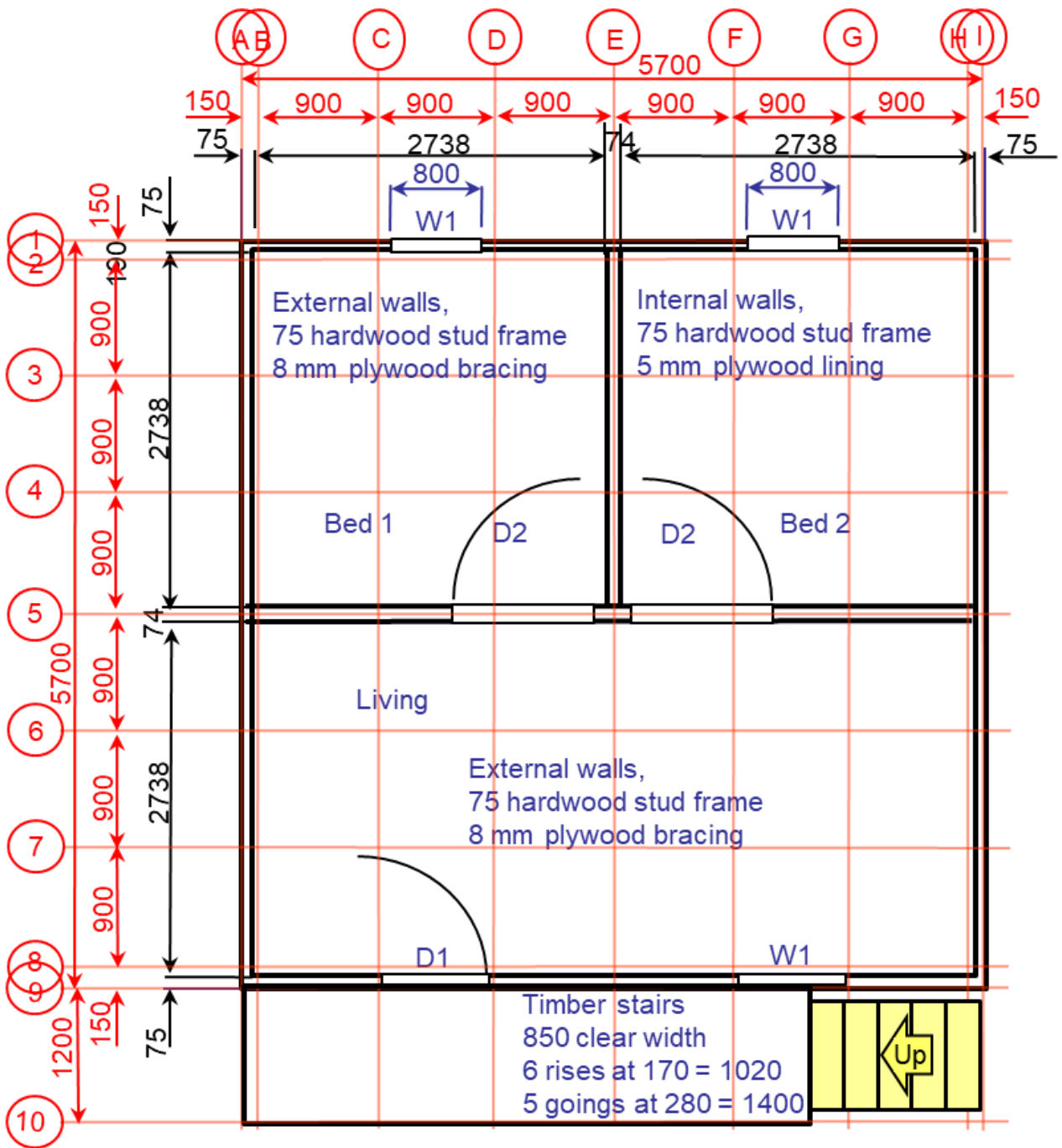
Example 4 - DANCER 8.4 x 5.7 Elevated Timber House with Porch



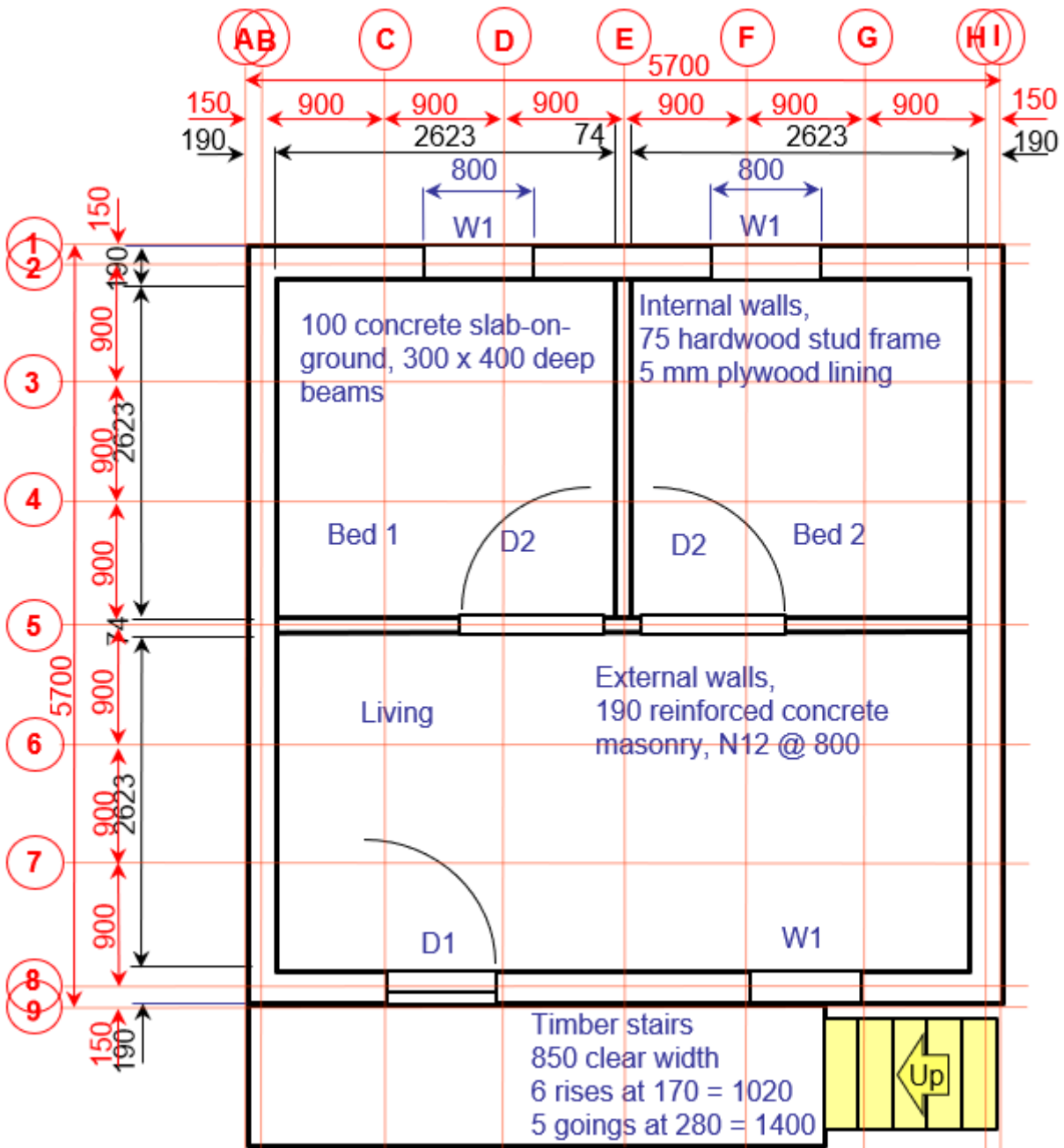
Example 5 - **DANCER** 8.4 x 5.7 Timber House with Concrete Slab-on-Ground



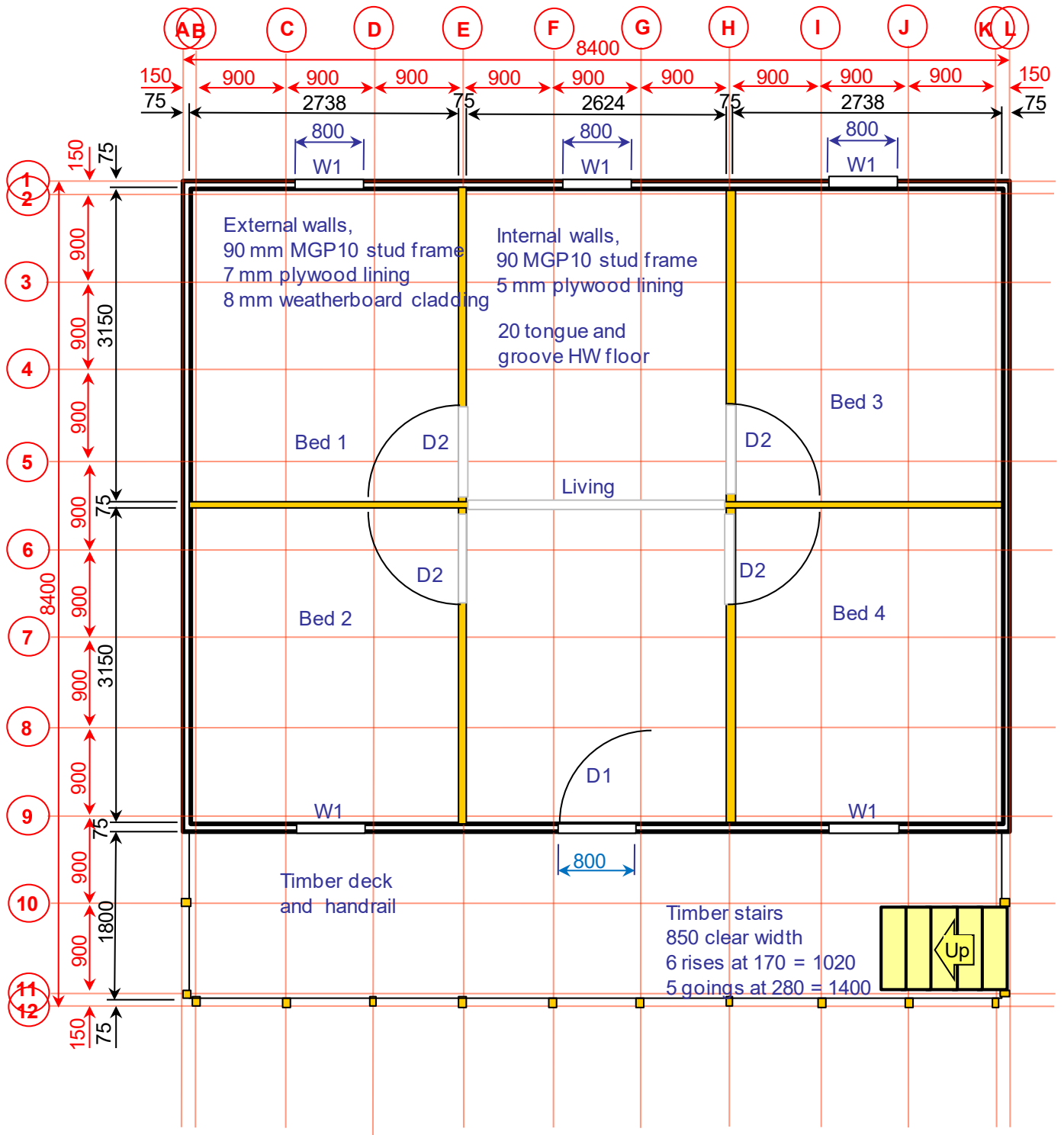
Example 6 - DANCER 5.7 x 5.7 Elevated Timber House with Veranda



Example 7 - DANCER 5.7 x 5.7 Reinforced Concrete Masonry House with Concrete Slab-on-Ground

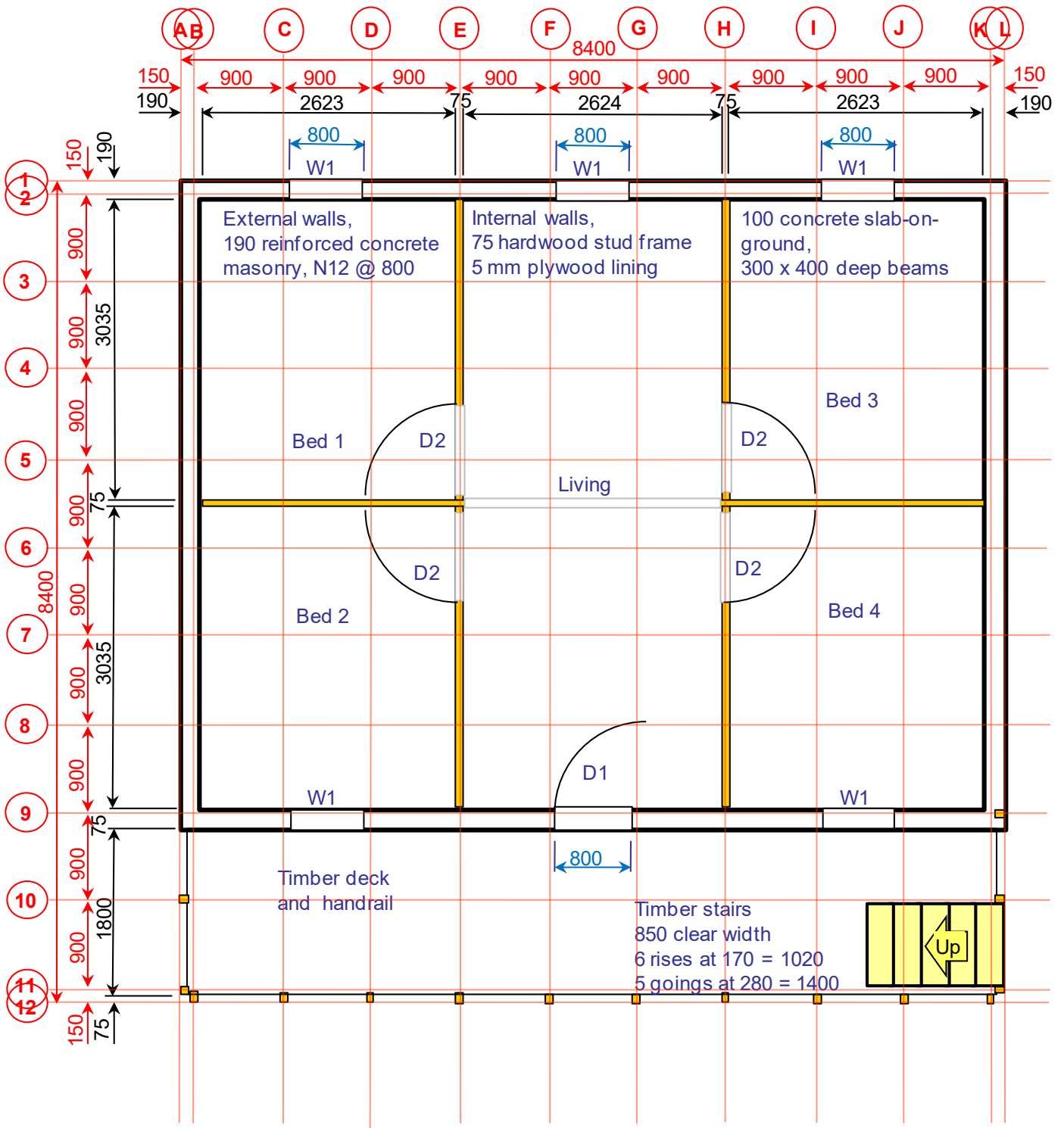


Example 8 - DANCER 8.4 x 6.6 Elevated Timber House, 1.8 Veranda



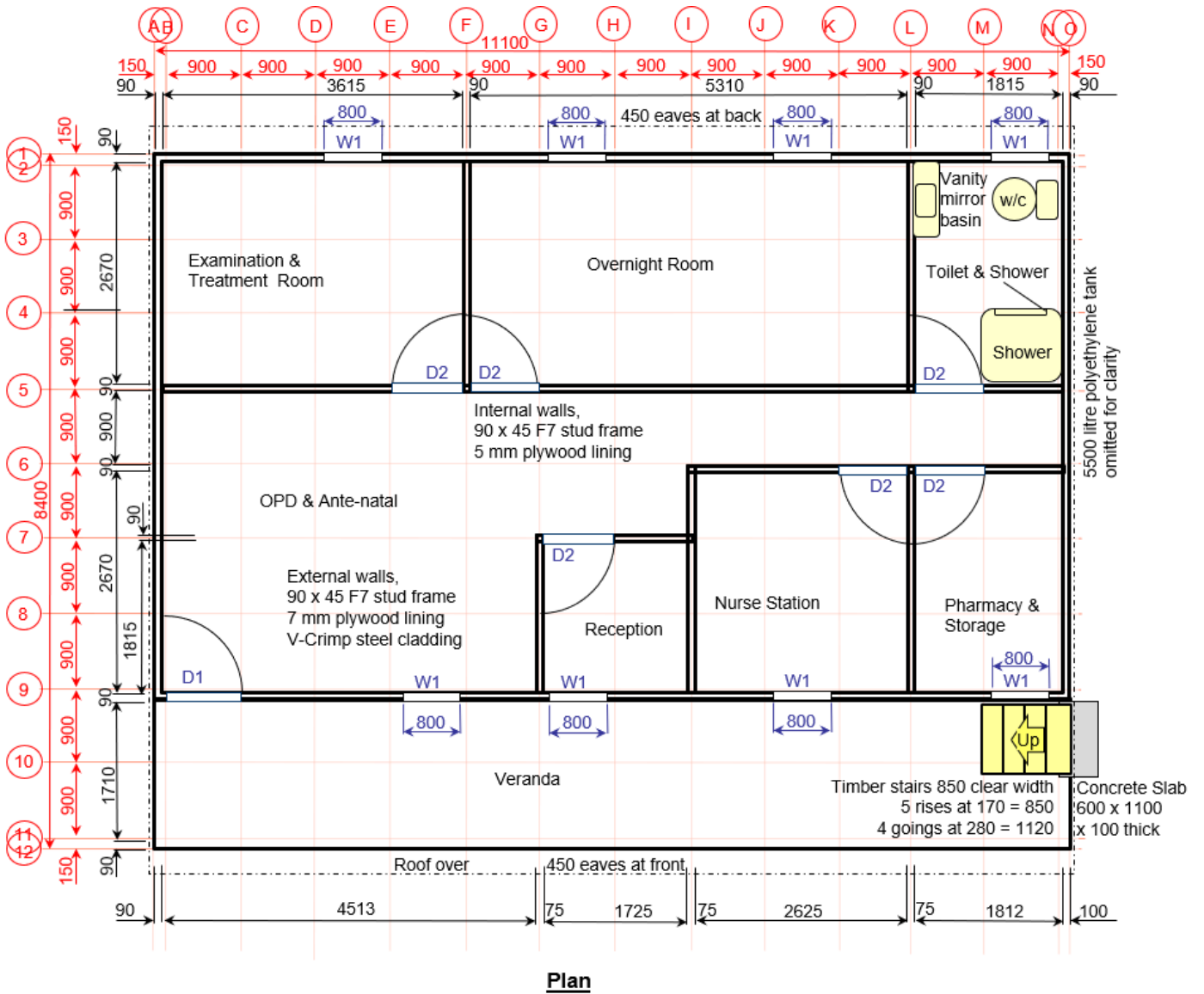
Fix Dimensions #

Example 9 - DANCER 8.4 x 6.6 Reinforced Concrete Masonry House with Concrete Slab-on-Ground and 1.8 Veranda



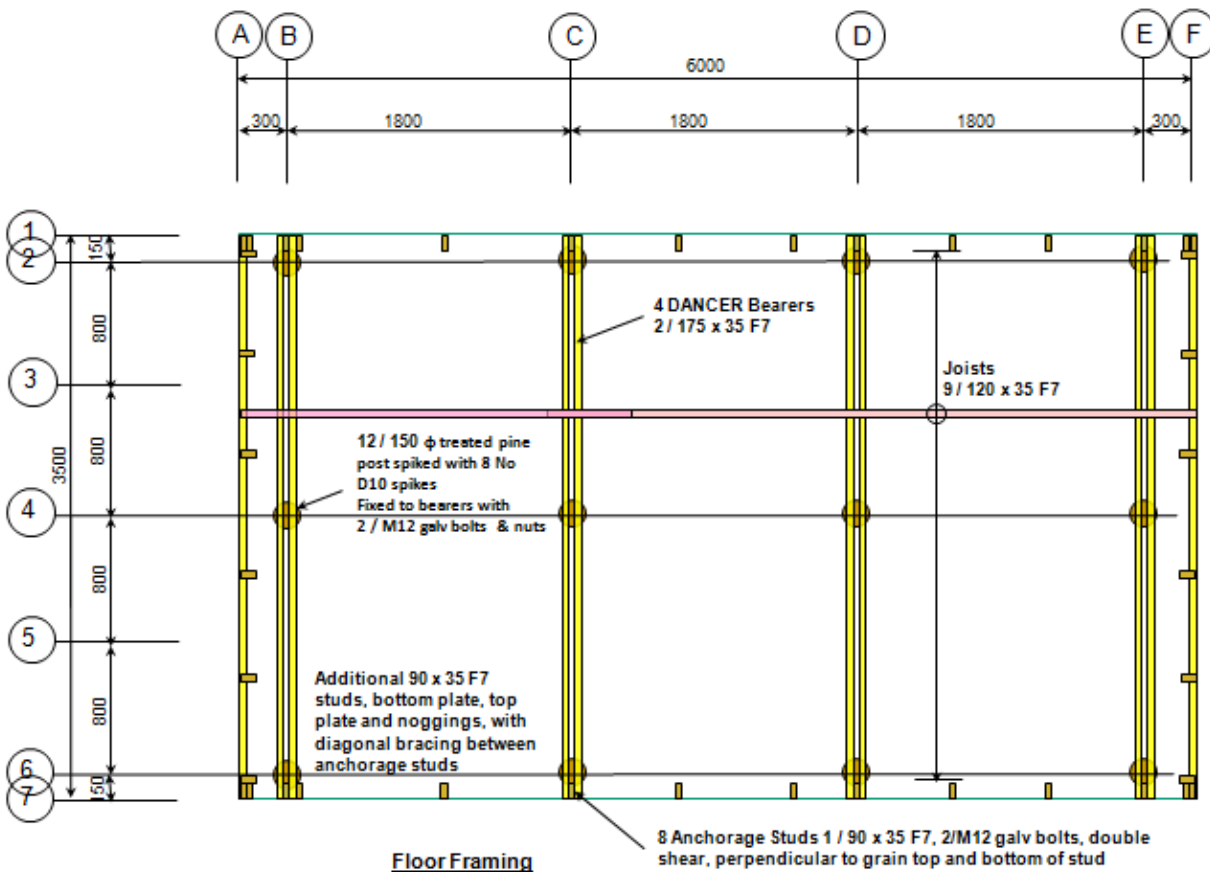
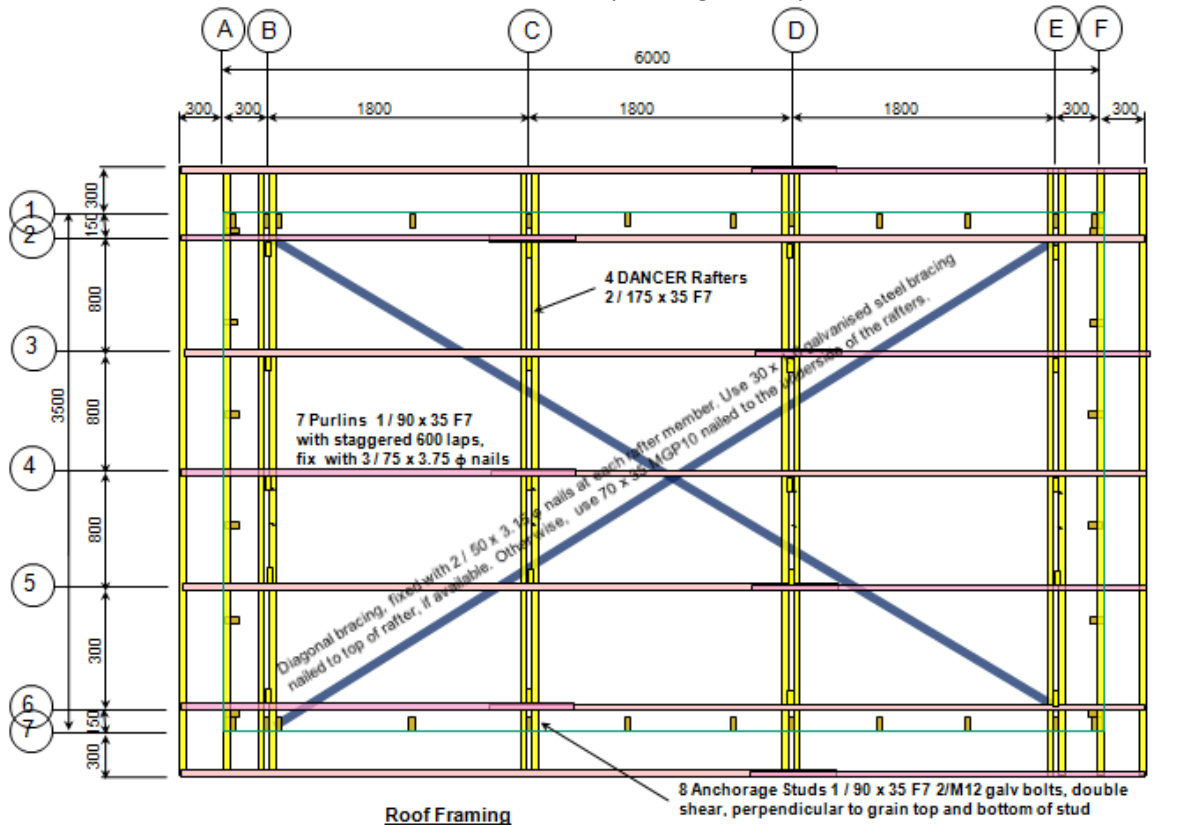
Fix Dimensions #

Example 10 - DANCER 11.1 x 8.4 Aid Post Including 1.8 Veranda



Example 11 - DANCER 6.0 x 3.6 Transition House

The **DANCER** Building System can be safely and economically used for non-standard rectangular buildings, either elevated timber or reinforced concrete masonry, with gable, hip or skillion roofs.



Concrete Slab-on-Ground Details

The following pages provide concrete-slab on-ground details suitable two superstructure systems:

- A **DANCER** roof system supporting a **DANCER** roof system supported on the concrete slab-on-ground (Option 1 and Option 2 provided); or
- Reinforced concrete masonry walls supporting a **DANCER** roof system supported on the concrete slab-on-ground.

Frequently Asked Questions regarding **DANCER** Concrete Slab-on-Ground

... In option 1, there appears to be no step down in the slab to prevent water ingress?

- a) AS 2870 requires edge rebates for masonry veneer and full masonry, but not for clad frame construction (i.e. **DANCER** is a clad frame). The relevant clause is AS 2870 5.3.4. Even single leaf masonry does not require an edge rebate, as per subclause, although perhaps it should be provided in this case.
- b) The reasons why the Standard does not require a rebate for clad frame is the difficulty finishing smoothly under the edge rebate form and the need to maximise the visible edge (75 mm for termite detection).
- c) The weather-proofing is provided by the flashing.
- d) There would also be a damp-proof-course (separate from the flashing) where the studs rest on the concrete. This has not been shown on this drawing for clarity.
- e) In addition to the weatherproofing provided by the flashing and in lieu of the rebate, the drawing shows the concrete sloping 20 mm over a 150 mm length. The reason why this is a slope and not a rebate is because of the need to maintain maximum cover on the SL72 slab mesh.

In option 2, why is the stepdown much wider than the actual wall frame?

- a) By using the wider rebate, the Option 2 slab (for **DANCER** timber clad frame walls) has identical dimensions to the slab for Reinforced Concrete Masonry walls.
- b) This facilitates the use standard drawings, standard ordering quantities and standard rebate formwork irrespective of whether the slab is intended for use with **DANCER** clad frame walls or reinforced masonry walls.

In option 2, why has the slab reinforcement appears to have entered the step down area?

- a) Each stud must resist a net uplift force in the commonly around 8 kN (0.8 tonne) in C2 cyclonic areas, and up to 50 kN (5 tonnes) for some corner studs in C4 cyclonic areas
- b) In order to provide the necessary anchorage, the full weight of the slab must be engaged.
- c) In order to engage the full weight of the slab, the anchors (horizontal reo through the bottom of the steel cleats) must be under the SL72 slab mesh, and the beam must be tied in by the N10 Z ties. For this to happen, both mesh and Z ties must be fully encased by the concrete that fills the rebate.

In Option 2, why are the holding down cleats only be embedded in the deep rebate?

- a) This is the essential difference between Option 1 and Option 2.
- b) Option 1 relies on the steel cleats being held very accurately (+, - 2 mm maximum) in the correct position while the slab is being poured, compacted and finished. This is because prefabricated wall framing is subsequently positioned between the studs. Achievement of these tolerances may be very difficult, depending on the level of supervision and control.
- c) Option 2 is more flexible from a construction point of view, because it enables the studs, wall framing and trusses to be erected before the final rebate concrete is poured.
- d) This rebate concrete is proper N20 (20 MPa) concrete the same as the rest of the slab and is held in position by the SL72 slab mesh and the N10Z ties.
- e) The embedded SL72 slab mesh engages the slab and the N10 Z bars (aided by friction on the vertical interface) engage the beam.

What are the difficulties associated with the flashings and DPCs?.

Because the steel cleats cannot pass through the flashing, the flashing should be used only to weatherproof the cladding. Studs and (if appropriate) frames may be protected by discontinuous damp-proof-courses (dpc) at point where they would otherwise be in contact with the concrete.

How deep should a step down be to enable the detection of termite intrusion?

If the step down (or edge slope) is more than (say) 20 mm, there will be insufficient clearance to the finished ground. The slab is only 100 thick and the bedding sand is no more than (and usually a lot less than) 50 mm. This means that the top of the slab is often no more than 125 to 150 above the surrounding ground. There must be at least 75 mm of visible slab edge for termite detection + (say) 25 mm turn down on the flashing for weatherproofing + (say) 25 mm that the cladding overlaps the flashing. This does not leave any room for a deep rebate.

What surface treatment should be applied to the steel cleats?

Hot-dip galvanizing is both expensive and inconvenient in many rural locations. Therefore, pre-galvanised flat mild steel, touched up with cold galvanizing paint, are suitable.

How are the steel cleats anchored to resist uplift?

The cleats have horizontal N12 x 1100 long reinforcement passing through pre-drilled holes.

In the reinforced concrete masonry walls detail, how are the N12 starter bars secured?

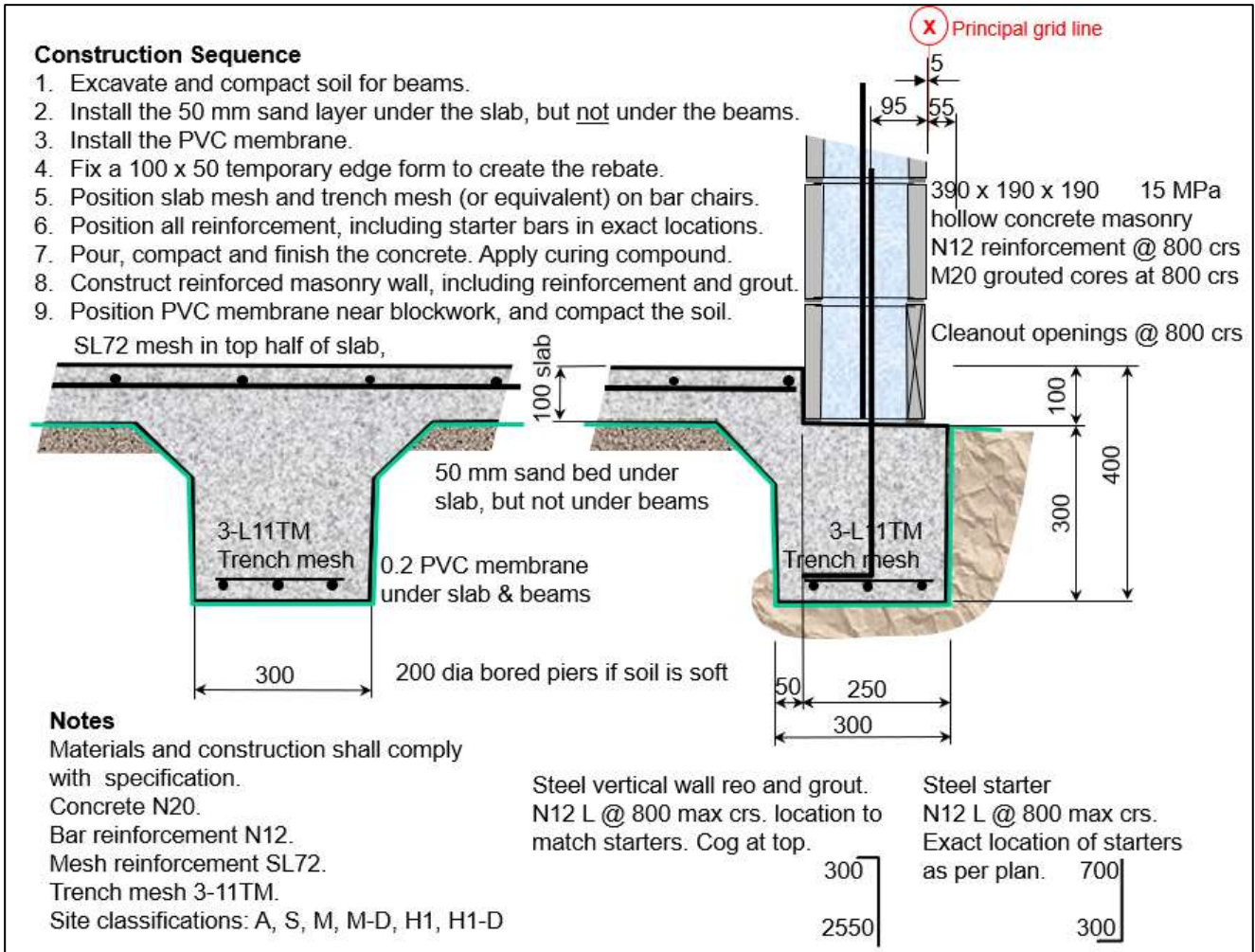
Part 4 of this **DANCER** Manual includes the following specification.

.... 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.....

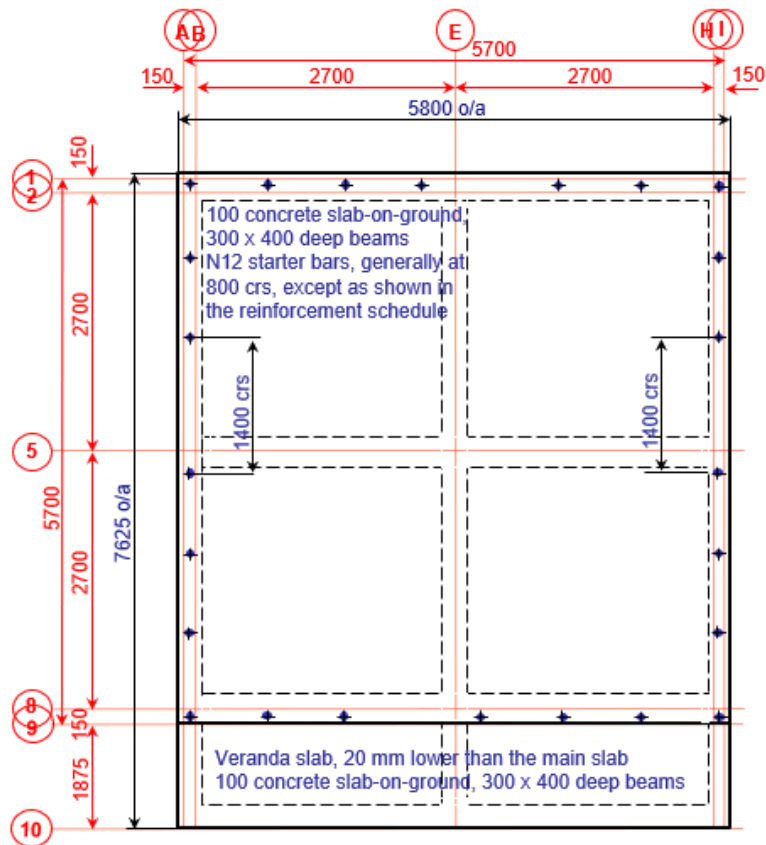
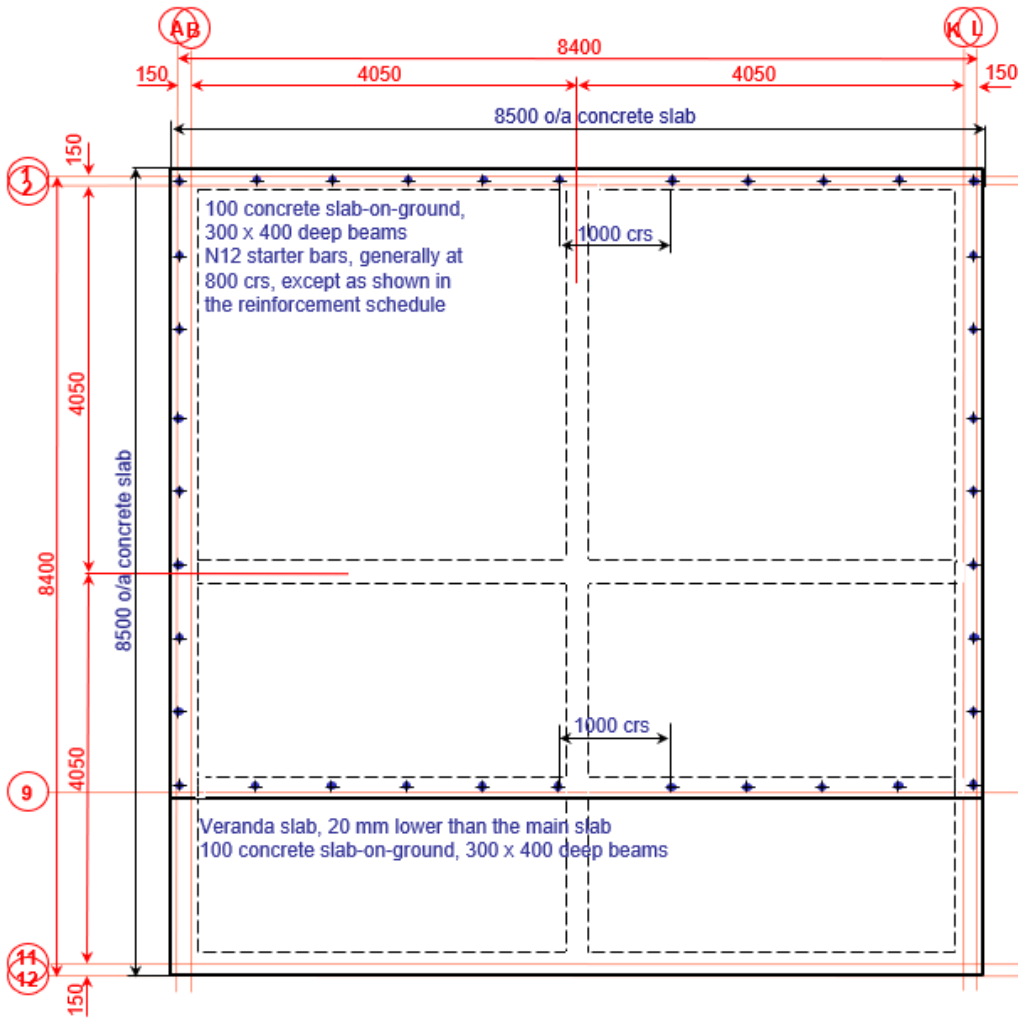
Concrete Slab-on-Ground, **DANCER** Walls, **DANCER** Roof

DANCER Roof and Walls on Concrete Slab-on-ground					
Spacing of DANCER Trusses				900	mm
Distance from end truss to outside walls				150	mm
Concrete slab overall length	Concrete edge to stud	Walls overall length	Walls inside dimension	No of DANCER trusses	Truss spacing at ends
8,700	50	8,600	8,400	10	1000
8,600	50	8,500	8,300	10	950
8,500	50	8,400	8,200	10	900
8,400	50	8,300	8,100	10	850
8,300	50	8,200	8,000	10	800
8,200	50	8,100	7,900	10	750
8,100	50	8,000	7,800	10	700
8,000	50	7,900	7,700	9	1100
7,900	50	7,800	7,600	9	1050
7,800	50	7,700	7,500	9	1000
7,700	50	7,600	7,400	9	950
7,600	50	7,500	7,300	9	900
7,500	50	7,400	7,200	9	850
7,400	50	7,300	7,100	9	800
7,300	50	7,200	7,000	9	750
7,200	50	7,100	6,900	9	700
7,100	50	7,000	6,800	8	1100
7,000	50	6,900	6,700	8	1050
6,900	50	6,800	6,600	8	1000
6,800	50	6,700	6,500	8	950
6,700	50	6,600	6,400	8	900
6,600	50	6,500	6,300	8	850
6,500	50	6,400	6,200	8	800
6,400	50	6,300	6,100	8	750
6,300	50	6,200	6,000	8	700
6,200	50	6,100	5,900	7	1100
6,100	50	6,000	5,800	7	1050
6,000	50	5,900	5,700	7	1000
5,900	50	5,800	5,600	7	950
5,800	50	5,700	5,500	7	900
5,700	50	5,600	5,400	7	850
5,600	50	5,500	5,300	7	800
5,500	50	5,400	5,200	7	750
5,400	50	5,300	5,100	7	700
5,300	50	5,200	5,000	6	1100
5,200	50	5,100	4,900	6	1050
5,100	50	5,000	4,800	6	1000
5,000	50	4,900	4,700	6	950
4,900	50	4,800	4,600	6	900
4,800	50	4,700	4,500	6	850
4,700	50	4,600	4,400	6	800
4,600	50	4,500	4,300	6	750
4,500	50	4,400	4,200	6	700
4,400	50	4,300	4,100	5	1100
4,300	50	4,200	4,000	5	1050
4,200	50	4,100	3,900	5	1000
4,100	50	4,000	3,800	5	950
4,000	50	3,900	3,700	5	900

Concrete Slab-on-Ground, Reinforced Concrete Masonry Walls, DANCER Roof



Concrete Slab-on- Ground, Reinforced Concrete Masonry Walls, **DANCER** Roof



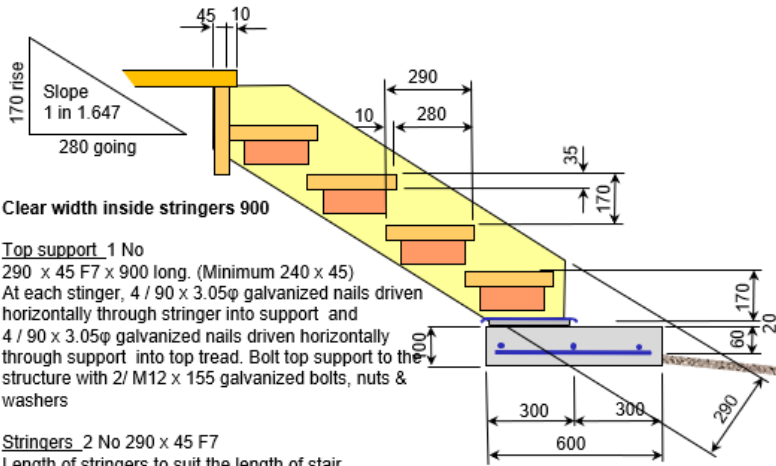
Concrete Slab-on- Ground, Reinforced Concrete Masonry Walls, DANCER Roof

DANCER Roof on Concrete Masonry Walls on Concrete Slab-on-ground									
Length of concrete block		390	mm						
Width of concrete block		190	mm						
Mortar joint thickness		10	mm						
Nomimal spacing of starter bars		800	mm						
Spacing of DANCER Trusses		900	mm						
Distance from end truss to ouside blockwork		150	mm						
Concrete slab overall length	Concrete edge to block	Walls overall length	Walls inside dimension	No of DANCER trusses	Truss spacing at ends	Distance to first & last starter	Number of starters along edge	Starter spacing at wall cente	No of blocks
8,700	55	8,590	8,210	10	995	150	11	1,200	21.5
8,500	55	8,390	8,010	10	895	150	11	1,000	21.0
8,300	55	8,190	7,810	10	795	150	11	800	20.5
8,100	55	7,990	7,610	10	695	150	10	1,400	20.0
7,900	55	7,790	7,410	9	1045	150	10	1,200	19.5
7,700	55	7,590	7,210	9	945	150	10	1,000	19.0
7,500	55	7,390	7,010	9	845	150	10	800	18.5
7,300	55	7,190	6,810	9	745	150	9	1,400	18.0
7,100	55	6,990	6,610	8	1095	150	9	1,200	17.5
6,900	55	6,790	6,410	8	995	150	9	1,000	17.0
6,700	55	6,590	6,210	8	895	150	9	800	16.5
6,500	55	6,390	6,010	8	795	150	8	1,400	16.0
6,300	55	6,190	5,810	8	695	150	8	1,200	15.5
6,100	55	5,990	5,610	7	1045	150	8	1,000	15.0
5,900	55	5,790	5,410	7	945	150	8	800	14.5
5,700	55	5,590	5,210	7	845	150	7	1,400	14.0
5,500	55	5,390	5,010	7	745	150	7	1,200	13.5
5,300	55	5,190	4,810	6	1095	150	7	1,000	13.0
5,100	55	4,990	4,610	6	995	150	7	800	12.5
4,900	55	4,790	4,410	6	895	150	6	1,400	12.0
4,700	55	4,590	4,210	6	795	150	6	1,200	11.5
4,500	55	4,390	4,010	6	695	150	6	1,000	11.0
4,300	55	4,190	3,810	5	1045	150	6	800	10.5
4,100	55	3,990	3,610	5	945	150	5	1,400	10.0
3,900	55	3,790	3,410	5	845	150	5	1,200	9.5

Concrete Slab-on- Ground, Reinforced Concrete Masonry Walls, **DANCER** Roof

DANCER Roof on Concrete Masonry Walls on Concrete Slab-on-ground										
Length of concrete block		390	mm							
Width of concrete block		190	mm							
Mortar joint thickness		10	mm							
Nominal spacing of starter bars		800	mm							
Spacing of DANCER Trusses		900	mm							
Distance from end truss to outside blockwork		150	mm							
Concrete slab overall length	Concrete edge to block	Walls overall length	Walls inside dimension	No of DANCER trusses	Truss spacing at ends	Distance to first & last starter	Number of starters along edge	Starter spacing at wall centre	No of blocks	
8,700	55	8,590	8,210	10	995	150	11	1,200	21.5	
8,500	55	8,390	8,010	10	895	150	11	1,000	21.0	
8,300	55	8,190	7,810	10	795	150	11	800	20.5	
8,100	55	7,990	7,610	10	695	150	10	1,400	20.0	
7,900	55	7,790	7,410	9	1045	150	10	1,200	19.5	
7,700	55	7,590	7,210	9	945	150	10	1,000	19.0	
7,500	55	7,390	7,010	9	845	150	10	800	18.5	
7,300	55	7,190	6,810	9	745	150	9	1,400	18.0	
7,100	55	6,990	6,610	8	1095	150	9	1,200	17.5	
6,900	55	6,790	6,410	8	995	150	9	1,000	17.0	
6,700	55	6,590	6,210	8	895	150	9	800	16.5	
6,500	55	6,390	6,010	8	795	150	8	1,400	16.0	
6,300	55	6,190	5,810	8	695	150	8	1,200	15.5	
6,100	55	5,990	5,610	7	1045	150	8	1,000	15.0	
5,900	55	5,790	5,410	7	945	150	8	800	14.5	
5,700	55	5,590	5,210	7	845	150	7	1,400	14.0	
5,500	55	5,390	5,010	7	745	150	7	1,200	13.5	
5,300	55	5,190	4,810	6	1095	150	7	1,000	13.0	
5,100	55	4,990	4,610	6	995	150	7	800	12.5	
4,900	55	4,790	4,410	6	895	150	6	1,400	12.0	
4,700	55	4,590	4,210	6	795	150	6	1,200	11.5	
4,500	55	4,390	4,010	6	695	150	6	1,000	11.0	
4,300	55	4,190	3,810	5	1045	150	6	800	10.5	
4,100	55	3,990	3,610	5	945	150	5	1,400	10.0	
3,900	55	3,790	3,410	5	845	150	5	1,200	9.5	

Timber Stairs



Clear width inside stringers 900

Top support_1 No

290 x 45 F7 x 900 long. (Minimum 240 x 45)
At each stinger, 4 / 90 x 3.05φ galvanized nails driven horizontally through stringer into support and 4 / 90 x 3.05φ galvanized nails driven horizontally through support into top tread. Bolt top support to the structure with 2/ M12 x 155 galvanized bolts, nuts & washers

Stringers_2 No 290 x 45 F7

Length of stringers to suit the length of stair.

Treads – Number of treads to suit length of stair

290 x 45 F7 x 920 long. Slot the treads into rebates, 10 mm deep in the stringers to give 900 clear width. At each stinger, 2 / 90 x 3.05φ galvanized nails driven horizontally through stringer into tread and 2 / 90 x 3.05φ galvanized nails driven vertically through stringer into support

Tread supports –

2 per tread. 90 x 45 F7 x 260 long
3 / 90 x 3.05φ galvanized nails driven horizontally through support into stringer

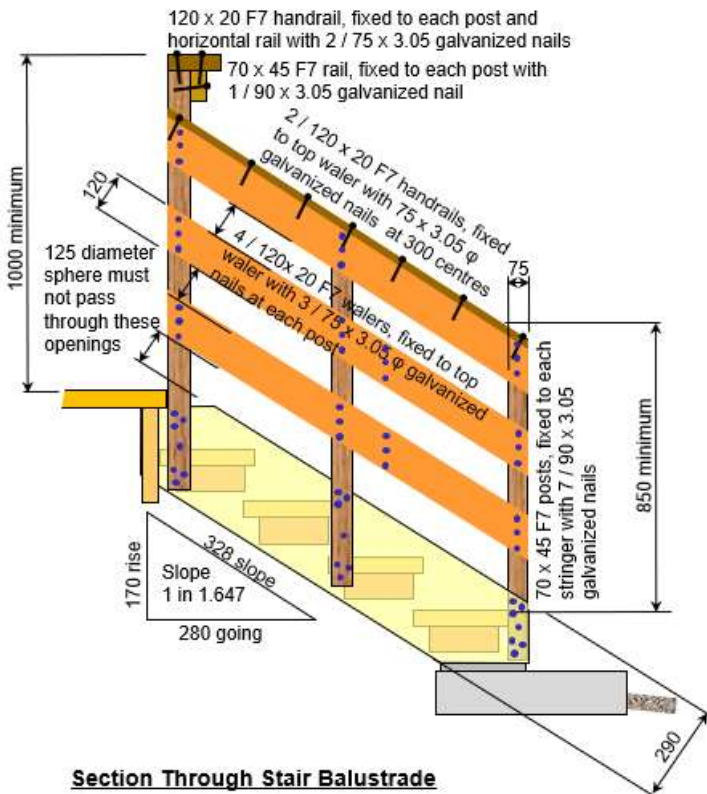
Termite shield – 2 / 100 x 3 x 350 galvanized steel strips, folded down 20 mm around edges, nailed to the underside of the stair stringer and kept clear of debris.

Concrete Pad – 1,200 x 600 x 100 mm thick
3 / N10 x 550 reinforcing bars and 3 / N10 x 950 reinforcing bars
Top surface of slab nominally 60 mm above ground level. If the slab surface is low, grout (up to a maximum thickness of 20 mm) under both stringers to make up required height. If the slab surface is high, trim the bottom surface of the stringers.

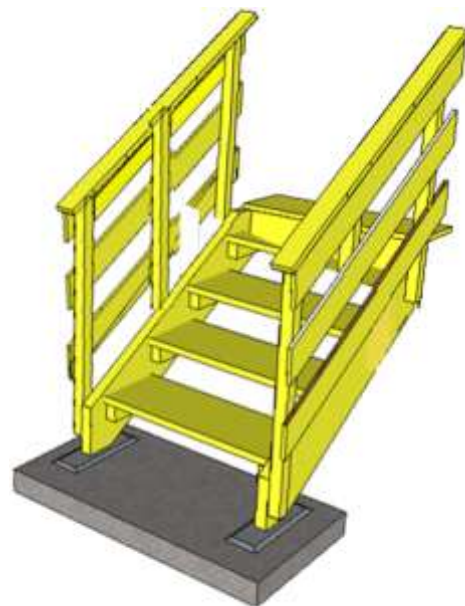
Stair Dimensions				
Stair going	280	mm		
Stair rise	170	mm		
Grout thickness	0	mm		
Height of slab above ground	80	mm		
No of Rises	No of Goings	Stair Rise	Stair Going	Veranda Height
5	4	850	1120	930

Stair Dimensions				
Stair going	280	mm		
Stair rise	170	mm		
Grout thickness	0	mm		
Height of slab above ground	80	mm		
No of Rises	No of Goings	Stair Rise	Stair Going	Veranda Height
18	17	3060	4760	3140
17	16	2890	4480	2970
16	15	2720	4200	2800
15	14	2550	3920	2630
14	13	2380	3640	2460
13	12	2210	3360	2290
12	11	2040	3080	2120
11	10	1870	2800	1950
10	9	1700	2520	1780
9	8	1530	2240	1610
8	7	1360	1960	1440
7	6	1190	1680	1270
6	5	1020	1400	1100
5	4	850	1120	930
4	3	680	840	760
3	2	510	560	590
2	1	340	280	420
1	0	170	0	250

Section Through Timber Stairs

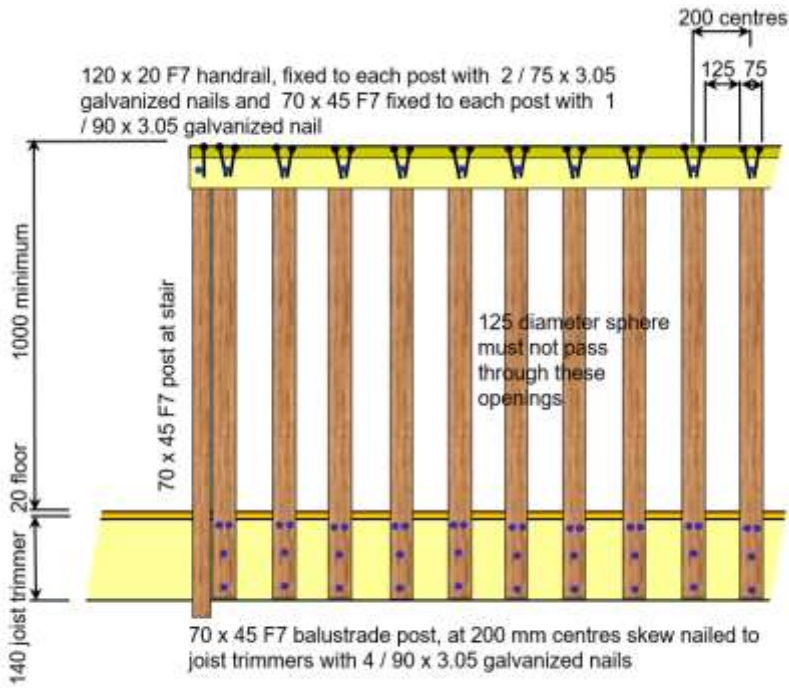


Section Through Stair Balustrade

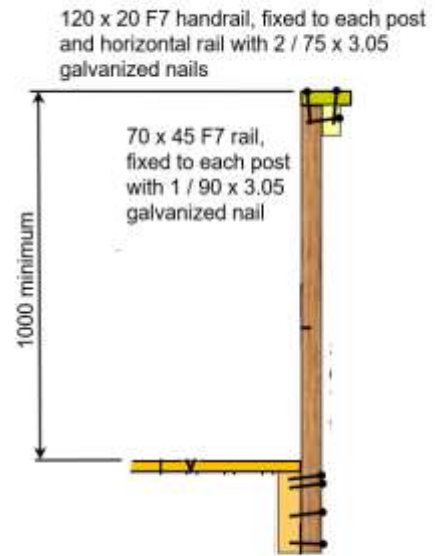


Typical Timber Stairs – 5 Rises

Timber Veranda Balustrades

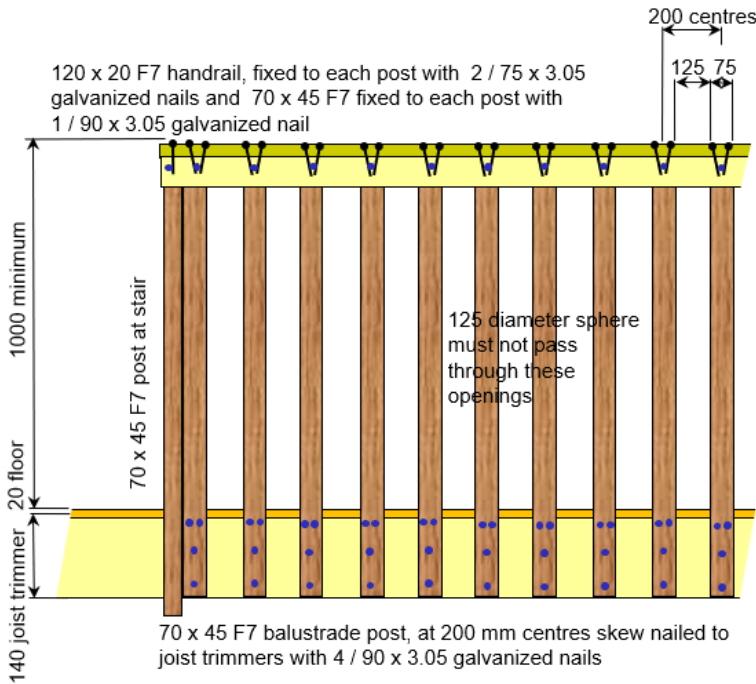


Elevation of typical Veranda Balustrade

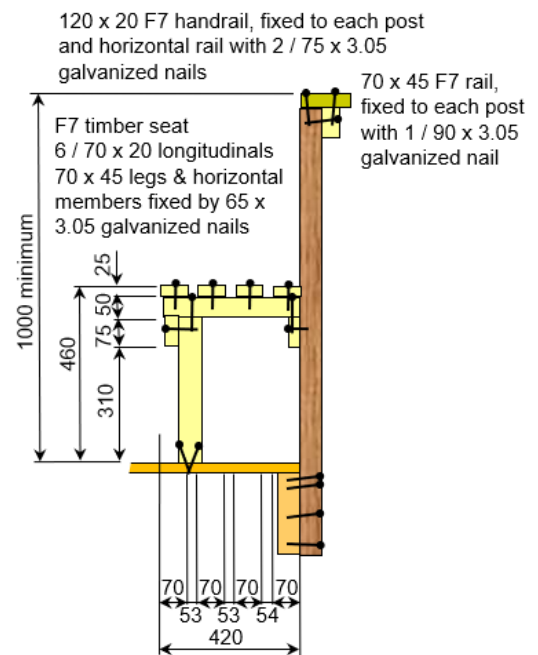


Section through Veranda Balustrade

Timber Veranda Balustrades with Seat



Elevation of Typical Veranda Balustrade

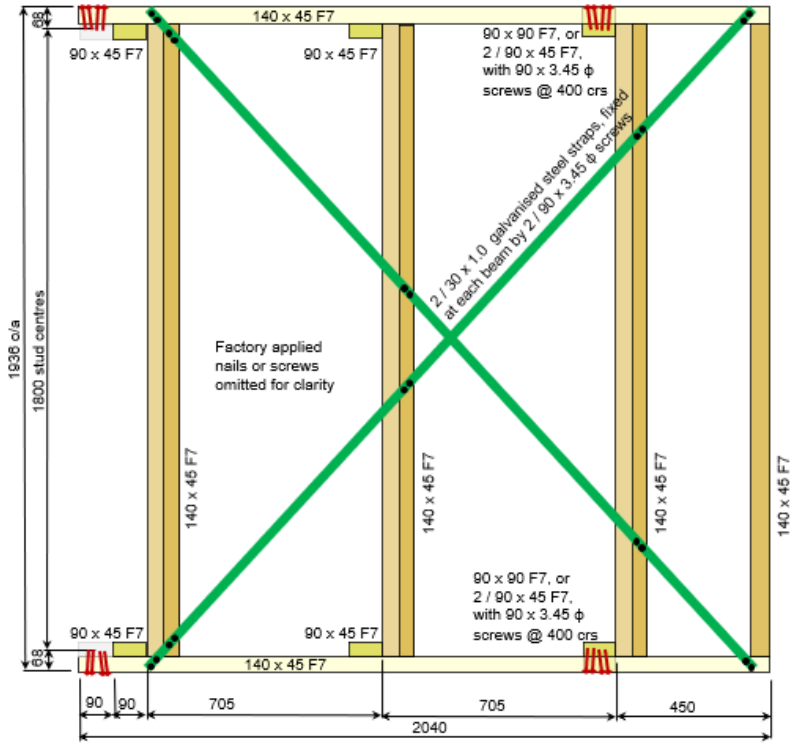


Section through Veranda Balustrade

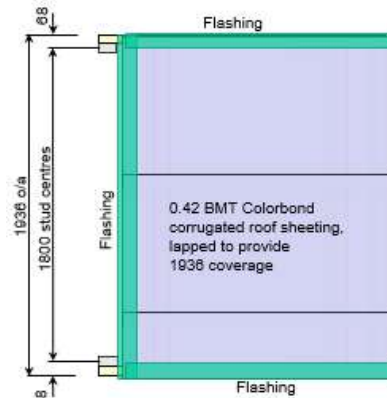
Porch Awning for Timber Superstructure

All timber members shall be fixed at each end by –
 6 / 90 x 3.45 φ screws. If screws cannot be used,
 substitute 6 / 90 x 3.75 φ nails

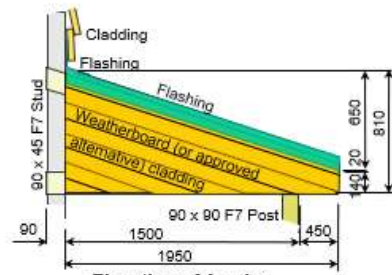
Nailed or screwed on site
 Nailed or screwed in factory



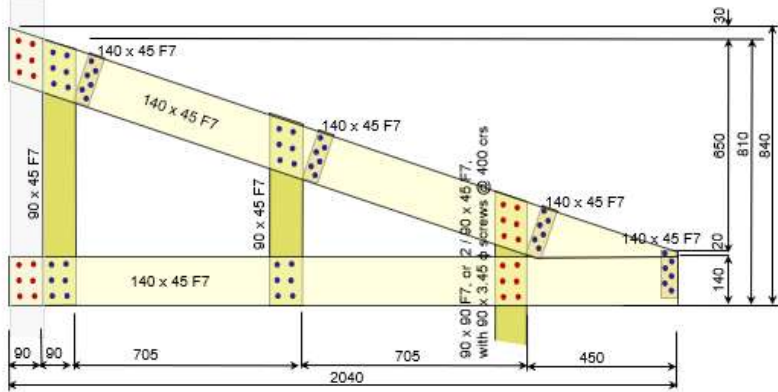
Plan of Awning Frame



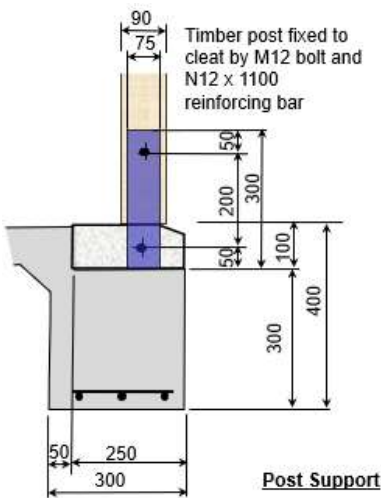
Plan of Awning



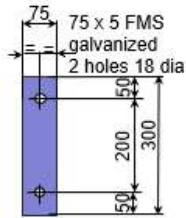
Elevation of Awning



Elevation of Awning Frame



Post Support



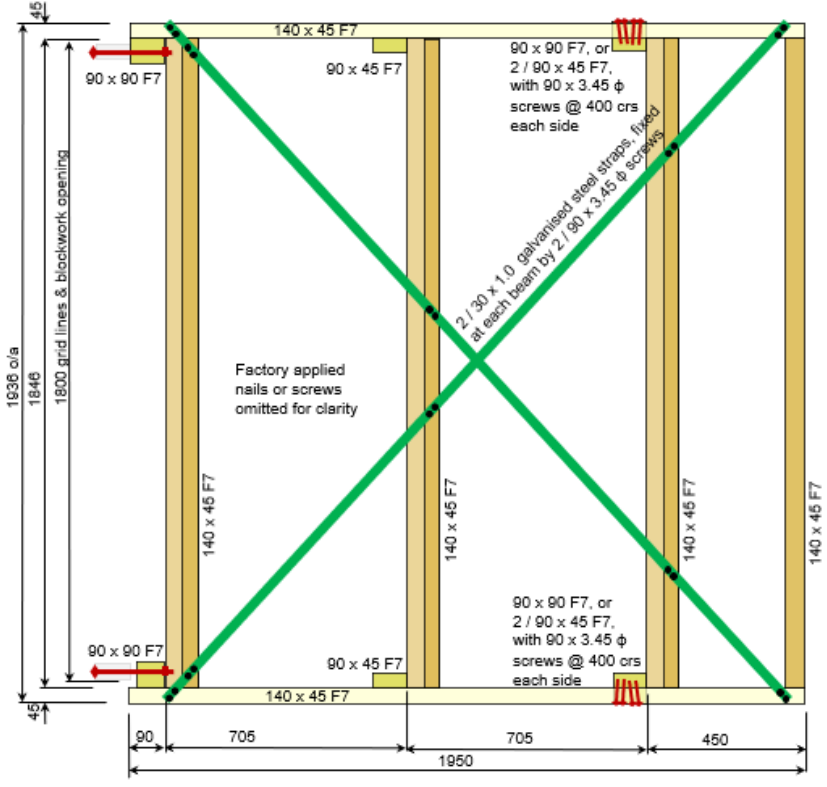
Steel Cleats

Zinc coated steel 0.6 min

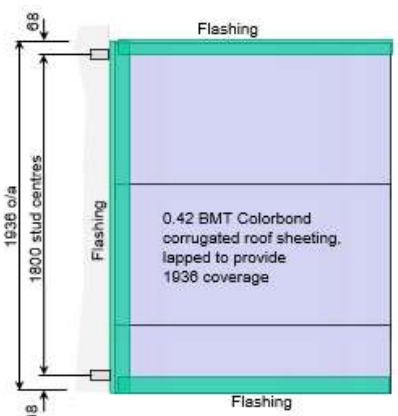
Porch Awning for Masonry Superstructure

All timber members shall be fixed at each end by -
 6 / 90 x 3.45 φ screws. If screws cannot be used,
 substitute 6 / 90 x 3.75 φ nails

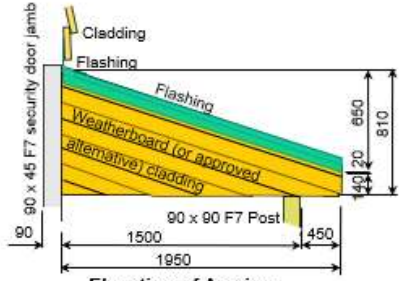
Nailed or screwed on site
 Nailed or screwed in factory



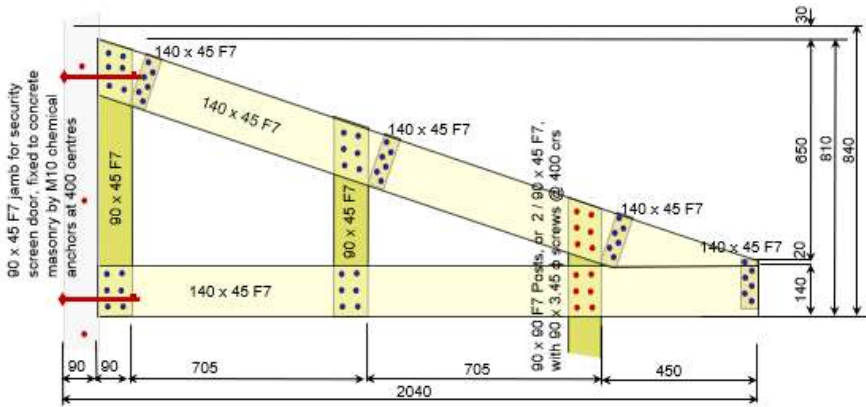
Plan of Awning Frame



Plan of Awning

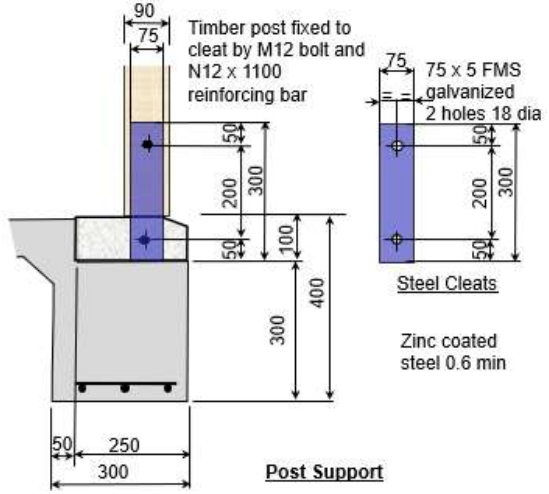


Elevation of Awning



Elevation of Awning Frame

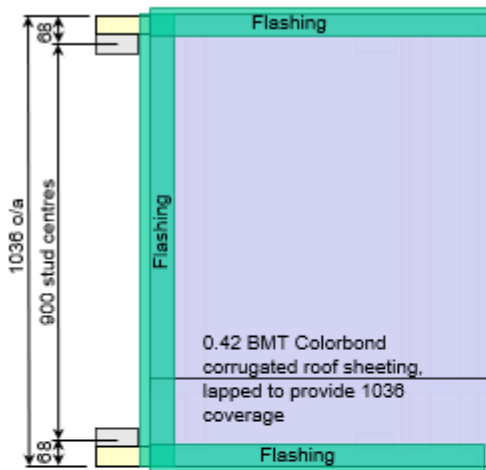
Base of posts supported on steel brackets set in concrete



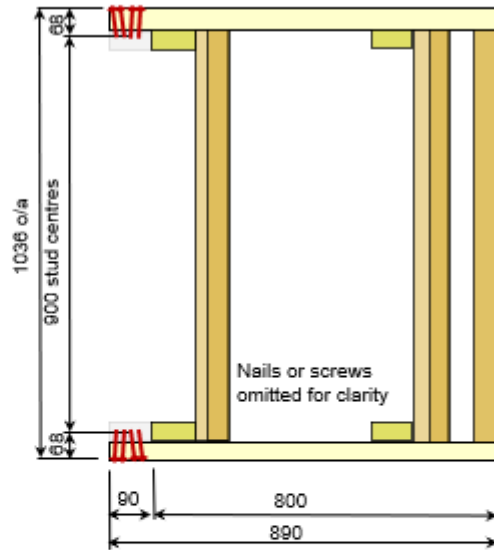
Post Support

Window Shades for Timber Superstructure

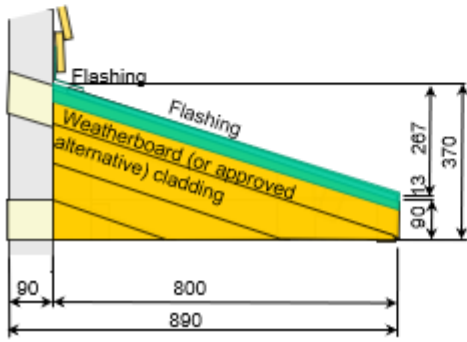
All timber members 90 x 45 F7,
 fixed at each end by – Nailed or screwed on site
 4 / 90 x 3.45 φ screws, or Nailed or screwed in factory
 4 / 90 x 3.75 φ nails



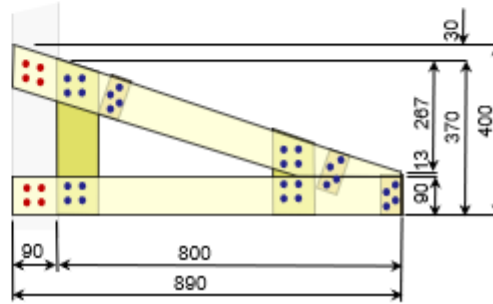
Plan of Window Shade



Plan of Window Shade Frame



Elevation of Window Shade

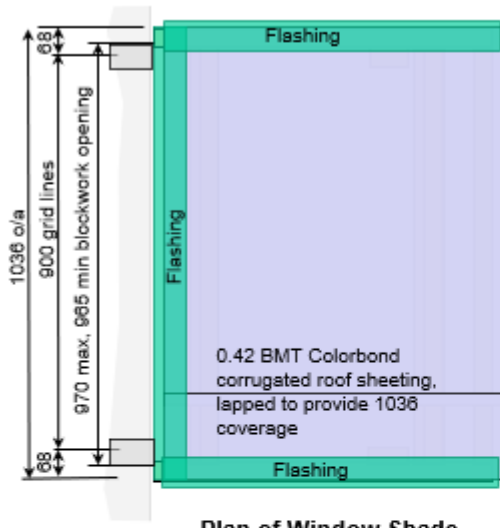


Elevation of Window Shade Frame

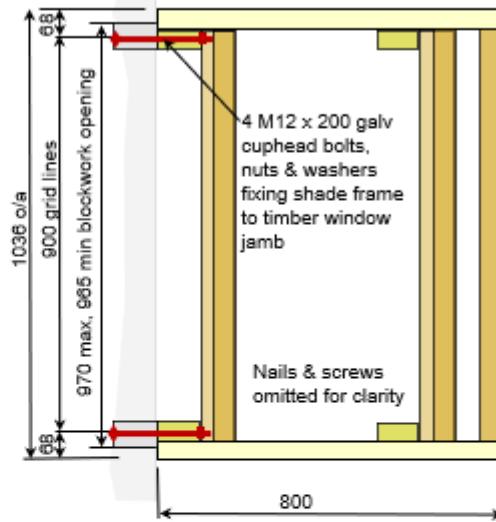
Window Shades for Masonry Superstructure

All timber members 90 x 45 F7,
 fixed at each end by –
 4 / 90 x 3.45 φ screws, or
 4 / 90 x 3.75 φ nails

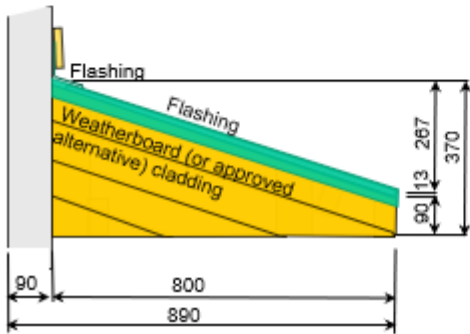
Nailed or screwed on site
 Nailed or screwed in factory



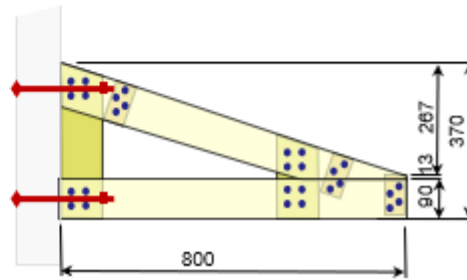
Plan of Window Shade



Plan of Window Shade Frame



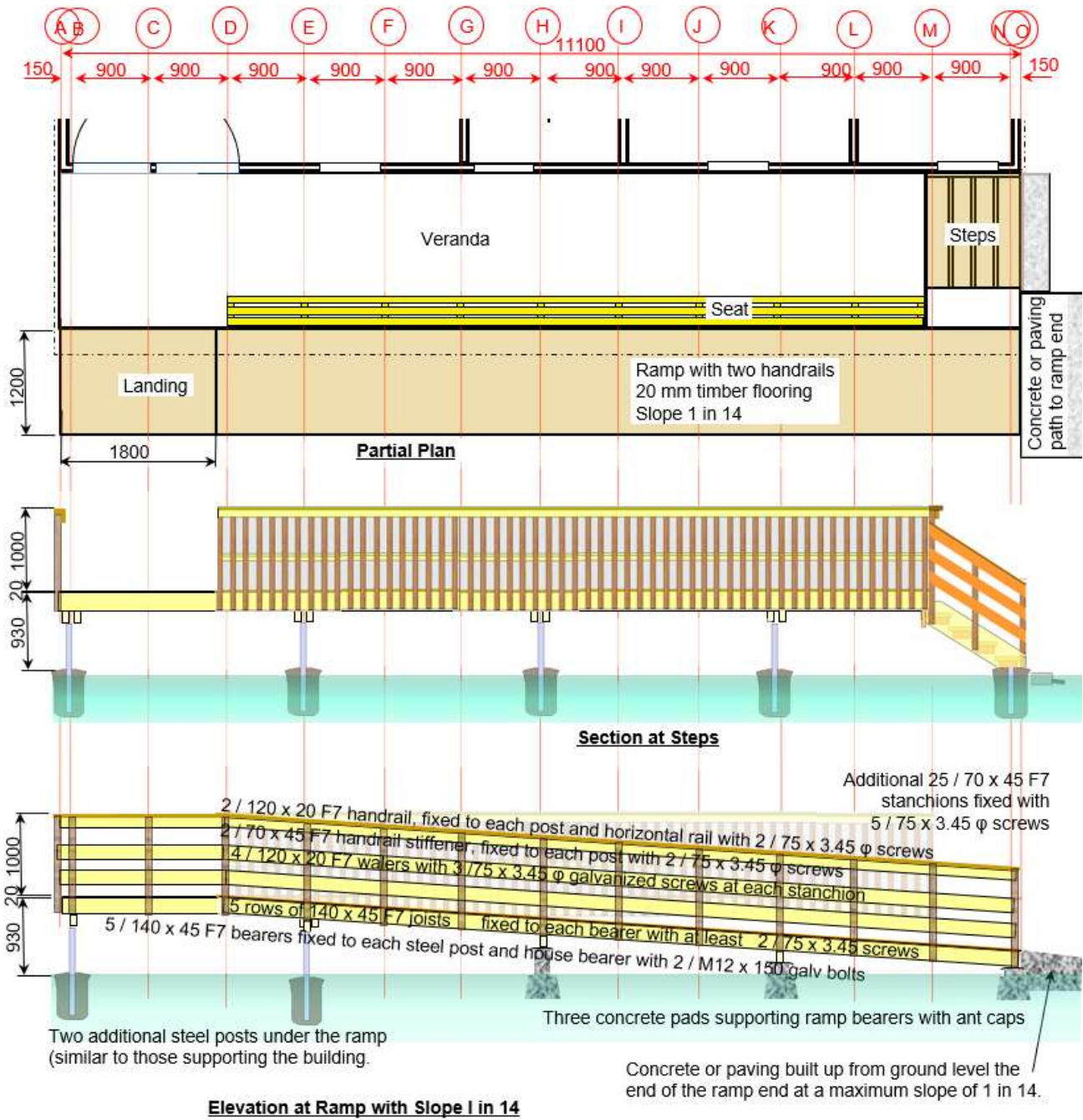
Elevation of Window Shade



Elevation of Window Shade Frame

Ramp with Maximum Slope of 1 in 14

This ramp is an optional addition to the standard DANCER 11.1 x 8.4 Community Health Building.

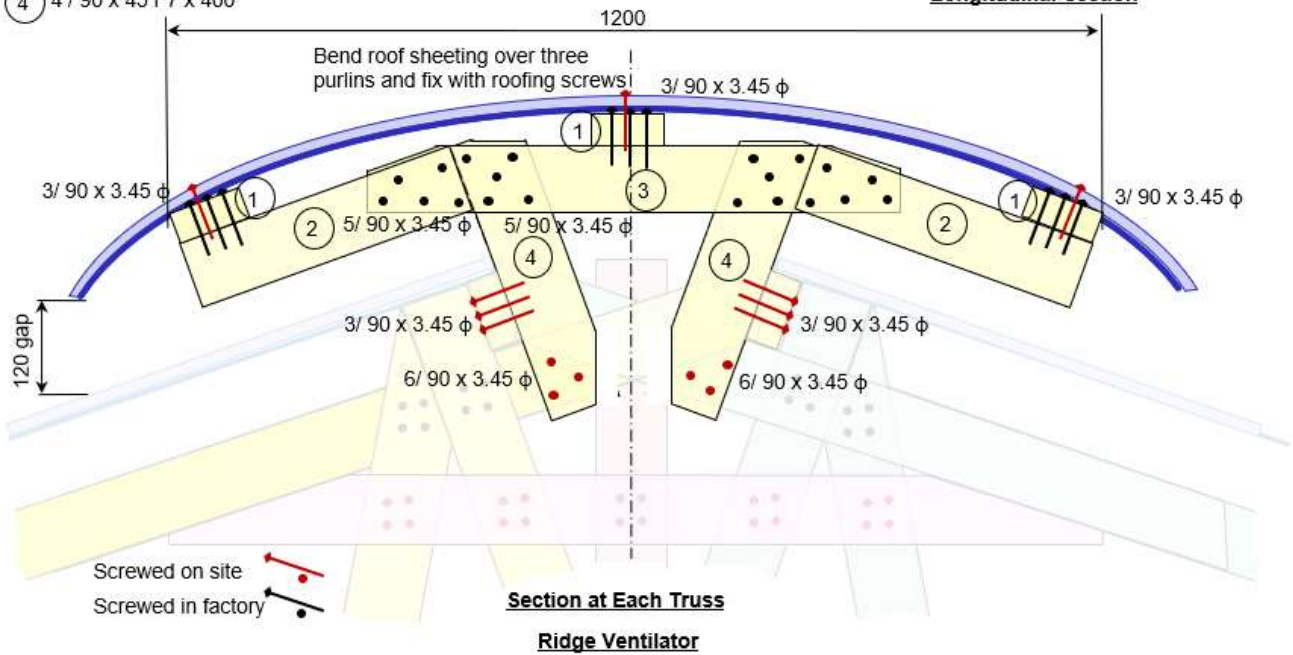
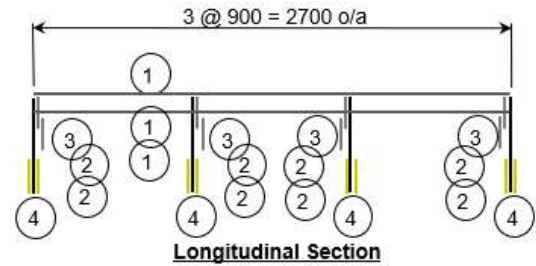


Ridge Ventilator

A ridge ventilator, when used in combination with gable ventilators and/or a breezeway (without a ceiling), will provide cooling. It will also relieve internal roof wind pressure, and thus reduce the risk of structural failure in strong winds. Details for one ridge ventilator, 2.7 m long (fixed to four trusses at 900 mm crs). The ventilators are prefabricated, transporter to site, and positioned by slipping the legs (Item 4) between the truss top chords of four trusses. They are screwed in position by 3 screws from each side and three screws through the purlin.

The overall length of each ventilator is 2700 mm, such that ventilators can be erected in adjacent bays without interfering with each other. Items 2 and 3 must be within the 2.7 m length. Item 4 is shared with adjacent ventilators.

- ① 3 / 90 x 45 F7 x 2700 All screws shall be 90 x 3.45 ϕ
- ② 8 / 90 x 45 F7 x 400 Flash the exposed ends of each ventilator to prevent rain from entering.
- ③ 4 / 90 x 45 F7 x 700
- ④ 4 / 90 x 45 F7 x 400



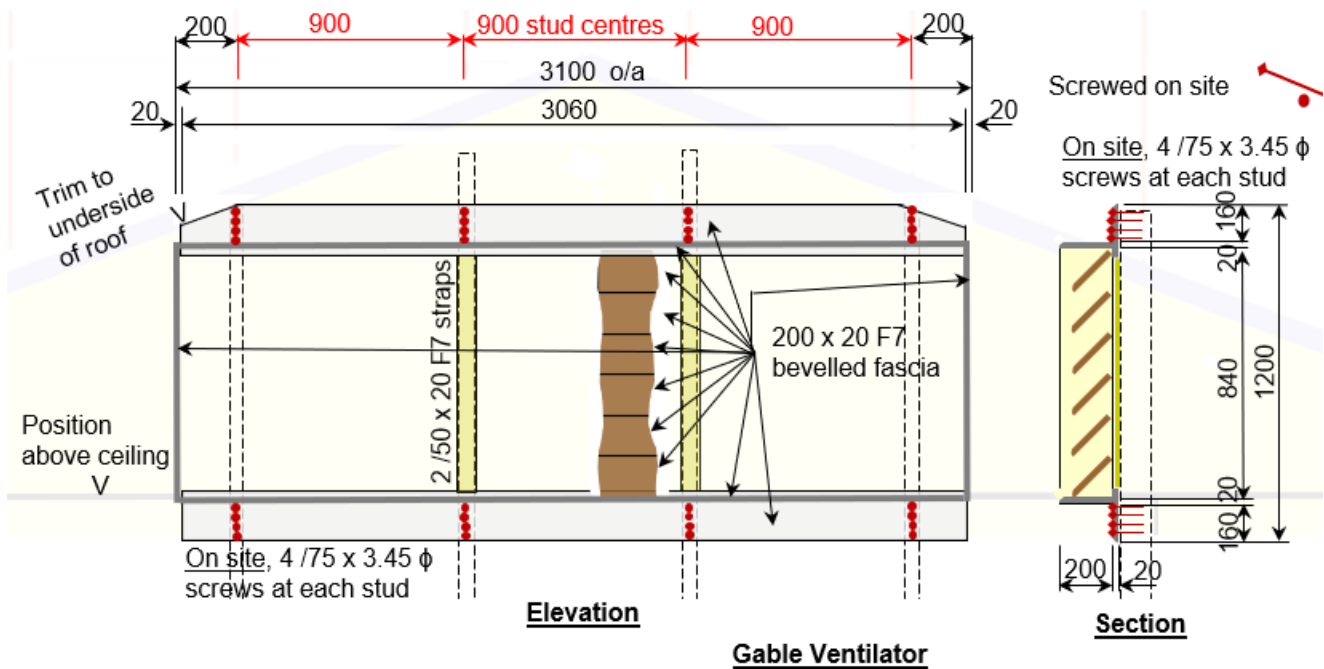
Gable Ventilator

Gable ventilators, when used in combination with a ridge ventilator and/or a breezeway (without a ceiling), will provide cooling. They will also relieve internal roof wind pressure, and thus reduce the risk of structural failure in strong winds. The opening area of each ventilator is 1.53 m².

Details are for one gable ventilator, 3.100 m long (fixed in one gable).
The ventilator may be prefabricated, transported to site, positioned by fixing to the end studs and weatherproofed by flashing.

Framing – 200 x 20 F7 bevelled fascia board
Slats – 200 x 20 F7 bevelled fascia board
Straps – 50 x 20 F7
Screws – 75 x 3.45 ϕ

In the factory, the 6 / 200 x 20 F7 bevelled fascia frame members are fixed by 75 x 3.45 ϕ screws at 200 mm centres. The 6 / 200 x 20 F7 bevelled fascia slats are inserted at 45° slope, and fixed at each end by 5 / 75 x 3.45 ϕ screws. Two 50 x 20 F7 straps may also be screwed to each slat to provided additional rigidity.



Part 4 – DANCER Specifications

Part 4 provides generic specifications for the principal components of **DANCER** buildings.

These specifications are limited to timber, concrete and masonry. If required, a comprehensive specification for other aspects of building is available.

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.

Timber

Scope

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

Relevant Standards

AS 1684.1 Residential Timber Framed Construction – Design Criteria
AS 1684.2 Residential Timber Framed Construction – Non – cyclonic areas
AS 1684.3 Residential Timber Framed Construction – Cyclonic areas
AS 1720.1 Timber structures - Part 1 Design methods
AS 1720.2 Timber structures - Part 2 Timber properties
AS 1604 Timber – Preservative treated – Sawn and round
AS 2209 Timber – Poles for overhead lines
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

Levels, Dimensions, Square 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, square and setting out.

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.

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.

Preservatives

Timber in exposed applications shall be treated with pyrethroid-and metal-based light organic solvent preservatives (LOSPs) to minimize fungal decay and attack by insects.

Health Warnings and Precautions

Precautions shall be in accordance with the requirements of the relevant Regulations and, where applicable, the recommendations of the following reference *RIC Good Wood Project & the Good Wood Advisory Centre, Victoria, Preservatives*.

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 to increase its ability to repel water.
- 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.

Although previously in use, the following timber preservatives shall not be used.

- (a) *Creosote*: Creosote gives off a vapour that irritates the eyes and skin; and is therefore not recommended.
- (b) *Pigment Emulsified Creosote (PEC)*: PEC is a combination of coal tar, with a heavy metal pigment used to stabilize it. PEC is not suitable for normal building applications.
- (c) *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.
- (d) *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 shall not 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.
- (e) Ammoniacal copper quaternary (ACQ)
 - (f) Copper azole
 - (g) Boron

Design and Construction

Timber structures shall comply with the Drawings, Building Regulations and relevant Standard (AS 1684 [residential applications], AS 1720 [general applications]).

Minimum Strength Grade

Timber used for structural framing purposes shall have a strength grade not less than F11 or MGP10 as applicable.

Timber Type, Properties, Preservation and Application

Timber and timber products 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.

1. The following tables are 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.
6. Lyctid Susceptible: S = Susceptible, N = Not susceptible, R = Rarely susceptible

Timber and Timber Products for Use Below Found Level

Timber and timber products shall not be used in direct contact with the ground.

If timber is required to be embedded below ground level, it shall be painted with high-build latex paint to a height 100 mm above the concrete surface and fully encased in Grade N20 concrete (20 MPa) of sufficient thickness to provide not less than 50 mm cover to all parts of the timber.

Timber and Timber Products for Above-ground External Exposed Framing

Standard Trade Name	Preservative Requirement	Available	Strength Group Seasoned	Durability Class	Lyctid Susceptible	Tangential Shrinkage %	Early Fire Hazard Ignitability
Group (Mixed Queensland & North NSW Hardwoods)	O	R	SD3	3	S		
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	
Radiata Pine	P	R	SD6	4	N	5.1	14
Kwila (Merbau)	O	L	SD3	2	S	2.5	
Red Mahogany	O	L	SD3	2	N	6.3	
Keruing	P	L	SD3	4	S	9.5	

Timber and Timber Products for Above-ground Internal Protected Framing

Standard Trade Name	Preservative Requirement	Available	Strength Group Seasoned	Durability Class	Lyctid Susceptible	Tangential Shrinkage %	Early Fire Hazard Ignitability
Group (Mixed Queensland & North NSW Hardwoods)	O	R	SD3	3	S		
Douglas Fir (Oregon)	O	R	SD5	4	N	4.0	14
Hoop Pine	S	R	SD5	4	N	3.8	14
Slash Pine	S	R	SD5	4	N	4.2	
Radiata Pine	S	R	SD6	4	N	5.1	14
Group (Hemfir)	O	R	SD7	4	N		
Group (Australian mixed softwoods)	O	R	SD7	4	N		
Group (Spruce Pine Fir [SPF])	O	R	SD7	4	N		
Group (Unidentified imported softwoods)	O	R	SD8	4	N		
Kwila (Merbau)	O	L	SD3	2	S	2.5	
Keruing	O	L	SD3	4	S	9.5	

Concrete

Scope

This section covers the construction of the following concrete members for small to medium sized buildings:

- Concrete footings
- Concrete ground beams
- Concrete slab-on-ground
- Concrete piers.

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 3600 Concrete Structures

AS 3610 Formwork for concrete

AS 3660.1 Termite management – New Building work

AS 3660.2 Termite management – In and around existing buildings and structures – Guidelines

AS 3660.3 Termite management – Assessment criteria for termite management systems

AS 1379 Specification and supply of concrete

AS 1478.2 Chemical admixtures for concrete, mortar and grout

AS 2870 Residential slabs and footings - Construction

AS 3799 Liquid membrane-forming curing compounds for concrete

AS 4200.1 Pliable building membranes and underlays - Materials

AS/NZS 4671 Steel reinforcing materials

Definitions

Site Classifications (based on AS 2870)

Class A – Most sand and rock sites with little or no ground movement from moisture changes

Class S – Slightly reactive clay sites with only slight ground movement from moisture changes

Class M – Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes

Class H – Highly reactive clay sites, which can experience high ground movement from moisture changes

Class E – Extremely reactive sites, which can experience extreme ground movement from moisture changes

Class P – Filled sites including soft or unstable foundation, soils, such as soft clay or silt or loose sands, landslip, mine subsidence, collapsing soils, soils subject to erosion, reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise.

Note: For deep-seated movements, typical of dry climates and corresponding to a design depth of suction change equal to or greater than 3 metres, the classification Classes M, H and E shall be modified to M-D, H-D or E-D.

Sand Bedding

A bedding sand layer 50 to 100 mm in thickness shall be placed over the compacted soil base to the level of the underside of the slab.

Vapour Barrier

The vapour barrier shall be installed immediately beneath the concrete slab-on-ground and footings. The vapour barrier shall not be punctured. Laps shall be 200 mm at joints. Plumbing penetrations shall be taped or sealed with a close-fitting sleeve. Where shallow bulk piers are used, the vapour barrier shall line the pier hole to enable the piers and footings to be poured integrally.

Reinforcement

Reinforcement shall be placed in accordance with the drawings such that the following laps and cover are achieved. Three N12 corner bars 2.0-metre long shall be placed at all re-entrant corners.

Reinforcement Minimum Required Laps

Bars	500 mm
Fabric	2 cross wires overlapping
Trench mesh	500 mm

Bar chairs shall be placed at one metre centres both ways. Bar chairs shall incorporate wide bases and be placed on metal bases that do not puncture the vapour barrier. Where fabric with 7 mm bars at 200 mm centres (SL72), or lighter, is used, the bar chair spacing shall be reduced to 800 mm. Bar chairs shall be placed to give the following clear cover.

- 40 mm in concrete in contact with unprotected ground
- 40 mm in concrete exposed externally
- 30 mm to a sealed vapour barrier
- 20 mm to the internal surface

Placing Concrete

Trenches and footing excavations shall be dewatered and cleaned prior to concrete placement so that no softened or loosened material remains.

All concrete shall be compacted by mechanical immersion vibrator.

Notes

1. Formwork - Edge forms for suspended concrete slabs are often difficult to secure and keep straight. When permanent steel sheet formwork is used, preformed metal edge forms may also be screwed to the sheeting by short metal straps.
2. Reinforcement Cover - The lapping of welded fabric reinforcement in the top face of a slab will significantly increase the thickness of reinforcement and reduce the cover. The slab thickness shall be such as to provide both sufficient cover and sufficient effective depth.

Finishing Concrete

Concrete surfaces shall be finished as noted below unless specified otherwise.

- Floor slabs - Steel float.
- External paths, driveways and parking areas at less than 10% slope - Fine broomed steel float.
- External paths, driveways and parking areas at greater than 10% slope - Coarse broomed steel float.
- Vertical surfaces exposed in the completed building - Rubbed back to fill all voids and provide smooth surface.

- Vertical surfaces not exposed in the completed building - Off form finish.

Curing Concrete

All concrete shall be cured using a sprayed curing compound. Wax-based compounds shall not be used in areas requiring the subsequent application of curing adhesives.

Notes

1. The Builder shall apply and maintain the curing system; or ensure that the Contractor correctly applies and maintains the curing system.
2. Sprayed emulsions require less attention than moistening and covering the slab.

Stripping Formwork

Unless adverse weather or the use of retarders delays the hardening of concrete, the minimum stripping time for formwork shall be 3 days.

Maintenance

The building owner is responsible for the building and site maintenance as detailed in the CSIRO Pamphlet 10-19 *Guide to Home Owners on Foundation Maintenance and Footing Performance*.

Bedding Sand Bedding

Bedding sand shall comply with the Drawings, Building Regulations and relevant Standard (AS 2758.1). Unless stated otherwise, sand shall be clean, free from salts, vegetable matter and impurities, and with the following grading:

Sieve	Percent Passing
4.75 mm	90 to 100
2.36 mm	60 to 100
1.18 mm	30 to 85
0.600 mm	15 to 60
0.300 mm	5 to 30
0.150 mm	0 to 15
0.075 mm	0 to 10

Vapour Barrier

Vapour barriers shall comply with the Drawings, Building Regulations and relevant Standard (AS 4200). Unless stated otherwise, vapour barriers shall be not less than medium impact resistance polyethylene vapour barrier 0.2 mm thick.

In areas of known salt damp, a damp-proofing membrane with high impact resistance is required.

Adhesive tape shall be PVC for normal applications, or polyethylene tape for fixing to higher strength or thicker membranes.

Bar Chairs

Bar chairs shall comply with the Drawings, Building Regulations and relevant Standard. Unless stated otherwise, properties shall such that:

- Reinforcement is positioned in the top half of the concrete slab
- Reinforcement in footings has 40 mm in concrete in contact with unprotected ground and 30 mm to a sealed vapour barrier

Reinforcement

Reinforcement shall comply with the Drawings, Building Regulations and relevant Standard (AS 4671, AS 2870). Unless stated otherwise, properties shall be not less than:

- Deformed bars - 500 MPa, normal ductility (N)
- Square fabric, rectangular fabric and trench mesh - 500 MPa, low (L) or normal (N) ductility ribbed wires
- Fitments -500 MPa, low (L) or normal (N) ductility ribbed wires
- Round bar (e.g. R250 N10 for dowels) - 250 MPa round

Concrete

Concrete shall comply with the Drawings, Building Regulations and relevant Standard (AS 3600 or AS 2870). Unless stated otherwise, properties shall be not less than:

- Characteristic compressive strength of 20 MPa (Strength grade N20) for residential ground slabs and footings to AS 2870
- Characteristic compressive strength of 25 MPa (Strength grade N25) for other structures to AS 3600
- Maximum aggregate size of 20 mm
- Of sufficient slump to facilitate the nominated means of placement
- Subject to plant control testing.

Site-mixed 20 MPa concrete shall comply with the following specification. For each cubic metre of concrete, mix

- 320 kg of portland or blended cement (8 No 40 kg bags or 16 No 20 kg bags);
- 0.5 cubic metres of clean sharp sand;
- 1.0 metre of coarse 20 mm rock aggregate; and
- 220 litres (11 No 20 litre buckets) of drinkable water.

Formwork

Formwork shall comply with the Drawings, Building Regulations and relevant Standard (AS 3610).

Curing Compounds

Curing compounds shall comply with the Drawings, Building Regulations and relevant Standard (AS 3799). Unless stated otherwise, curing compounds shall be hydrocarbon, solvent-based acrylic, water-based acrylic or wax-based acrylic. Wax-based compounds shall not be used in areas requiring the subsequent application of curing adhesives.

Joint Material

Joint material shall comply with the Drawings, Building Regulations and relevant Standard (AS 2870). Unless stated otherwise:

- Backing rod for control joints, expansion joints and articulation joints shall be expanded polystyrene tube or bead or, rigid steel backing profile with closed cell foam adhered to the metal profile face.
- Joint sealant shall be gun grade multi-purpose polyurethane sealant.

Concrete Jointing Accessories

Concrete jointing accessories shall comply with the Drawings, Building Regulations and relevant Standard (AS 2870). Unless stated otherwise, concrete jointing accessories shall have appropriate properties to ensure they fulfil their intended function and can be accurately installed.

Dowel Cradles shall provide accurate horizontal and vertical alignment of dowels.

Crack Inducers shall provide an adequate crack to relieve contraction stresses.

Rebate Moulds shall be constructed of a rigid PVC material and form a true square or rectangular rebate.

Dowel Sleeves shall include provision for longitudinal expansion in the ends of all sleeves, stiffening ribs to minimise distortion, end clips to ensure correct alignment during pour and end closures to prevent entering of slurry.

Expansion Caps shall fit a variety of dowel sizes and provide internal compression pins for longitudinal expansion.

Permanent Flexible Plastic Capping shall be UV treated PVC material and provide a bevelled edge to the joint.

Removable Capping shall be PVC material and provide a bevelled edge to the joint.

Foam Filler compression strips shall be closed cell polyethylene foam.

Key Joint Joiners shall provide accurate alignment of key joints in both horizontal and vertical directions without interrupting the capping line.

Masonry

Scope

This section covers the construction of partially reinforced hollow concrete blockwork used as the walls of buildings constructed on concrete slab-on-ground..

Relevant Standards

- AS 3700 Masonry structures
- AS 3700 Supplement 1 Masonry Structures – Commentary
- AS 4773.1 Masonry in small buildings – Design
- AS 4773.2 Masonry in small buildings – Construction
- AS/NZS 4455 Masonry units and segmental pavers
- AS/NZS 4456 Masonry units and segmental pavers - Methods of test
- AS/NZS 2904 Damp-proof courses and flashings
- AS/NZS 2699.1 Built-in components for masonry construction - Wall ties
- AS/NZS 2699.2 Built-in components for masonry construction - Connectors and accessories
- AS/NZS 2699.3 Built-in components for masonry construction - Lintels and shelf angles (durability requirements)
- AS 3972 Portland and blended cements
- AS 2758.1 Aggregates and rock for engineering purposes - Concrete aggregates
- AS 3660.1 Termite management – New Building work
- AS 3660.2 Termite management – In and around existing buildings and structures - Guidelines
- AS/NZS 4671 Steel reinforcing materials
- AS 3600 Concrete structures
- AS 2870 Residential slabs and footings – Construction

Mortar

For general applications (except as listed for M4 or M2), 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)
- 1 part GP or GB cement, 5 parts sand plus water thickener

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)
- 1 part GP or GB cement, 4 parts sand plus water thickener
- 1 part GP or GB cement, 0-0.25 parts lime, 3 parts sand (water thickener optional)

This applies to:

- 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.

Damp-Proof Course

Damp-proof-courses shall be built into the masonry in accordance with the Drawings, Building Regulations and relevant Standard (AS 3700). Unless stated otherwise, damp-proof-courses shall be:

- Placed under walls to provide a continuous damp-proof barrier around the building
- Lapped not less than 150 mm at joints
- Projecting through the entire width of the masonry and project beyond the external face of the masonry
- Stepped at changes of floor level
- Positioned (if applicable) under the coping of any parapet more than 300 mm above adjoining roof cladding
- Positioned (if applicable) in chimney stacks, 150 mm to 300 mm above the highest junction of roof and chimney
- At least 75 mm above finished surface level of adjacent paved, concreted or landscaped areas that slope away from the wall
- At least 50 mm above finished paved or concreted areas sloping at least 50 mm over the first 1 m from the building and protected from the direct effects of the weather by a carport, verandah or similar
- At least 150 mm above the adjacent finished ground in all other cases.

Flashings

- Flashings shall be built into the masonry in accordance with the Drawings, Building Regulations and relevant Standard (AS 3700). Unless stated otherwise, flashings shall be:
- Fixed with clouts to timber studs or built into an inner leaf of masonry as applicable
- Built into the external leaf of walls exposed to weather, extending across the cavity,
- Turned up 150 mm and nailed to the frame or built 30 mm into an inner leaf of masonry,
- Positioned at openings (unless they are protected by an overhang), where they shall extend 100 mm past the end of opening and be turned up to prevent leakage.

Termite Protection

Masonry walls in buildings shall incorporate termite protection. Refer to the separate specification on Termite Protection in "Concrete".

Mortar Joints

Mortar joints shall comply with the Drawings, Building Regulations and relevant Standard (AS 3700). Unless stated otherwise, mortar joints shall comply with the following:

- Mortar joint 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.

Provision for Timber Shrinkage

In masonry veneer construction, a gap in accordance with schedule below shall be left between the timber frame and the top of the masonry, and at window sills, to accommodate timber shrinkage.

Location in timber framed buildings	Minimum Clearances (mm)
-------------------------------------	-------------------------

	Unseasoned hardwood frame	Other timber frame
Sills of lower or single storey windows	10 mm	5 mm
Roof overhangs of single storey buildings	16 mm	8 mm
Sills of second storey windows	20 mm	10 mm
Roof overhangs of two storey buildings	24 mm	12 mm

Reinforced Masonry Construction (Excluding Retaining Walls)

All construction of reinforced concrete masonry shall comply with the Drawings, Building Regulations and relevant Standard (AS 3700). Unless stated otherwise, the following shall apply:

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 Double U or H blocks. It shall be held in position by steel ties or plastic clips. Cover to horizontal steel in lintel blocks shall be maintained by the use of wheel type plastic clips.

The minimum cover (from the edge of the steel reinforcement to the inside face of the block core) shall be 20 mm, except where specified otherwise. In severe marine environments, saline or contaminated water including tidal and splash zones, and within 1 km of an industry in which chemical pollutants are produced, the minimum cover to the inside face of the block core shall be 30 mm.

For houses (and similar buildings) consisting of partially reinforced concrete masonry on concrete slab-on-ground, control joints shall not be built in.

For other reinforced concrete masonry applications, control joints shall be built into reinforced concrete masonry at all points of potential cracking and at the locations shown on the drawings. The spacing of control joints should not exceed 8.0 metres, except that the spacing of control joints may be increased in reinforced masonry walls meeting the following criteria:

- Consisting of at least 190 mm hollow concrete units,
- Built less than 3.0 metres high,
- Incorporating a top reinforced bond beam,
- Incorporating N16 horizontal reinforcement at not greater than 400 mm centres,
- On a site with rock or slightly reactive foundations,
- With a reinforced concrete footing of adequate stiffness.

Hollow Concrete Masonry Units

Hollow concrete masonry units shall comply with the Drawings, Building Regulations and relevant Standard (AS/NZS 4455.1) and the following properties:

- Dimensional Category DW4;
- General Purpose Salt Attack Resistance Grade (except for applications requiring Exposure Grade including 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);
- Characteristic Compressive Strength not less than a value specified by the Engineer or 15 MPa (measured using face shell bedding), whichever is the lesser;

- Characteristic Lateral Modulus of Rupture not less than 0.8 MPa;
- Mean Coefficient of Residual Drying Contraction not more than 0.6 mm/m.
- When intended for face applications and exposed to the weather:
 - Permeability not more than 2 mm/minute
 - Efflorescence Potential of Nil or Slight
 - Colour and texture within an agreed range.
- If units are intended to incorporate both horizontal and vertical reinforcement and are not protected both sides by a waterproof membrane, they shall be “H” or “Double U” configuration such that:
- Units may be fully grouted and may be reinforced both vertically and horizontally;
- Cores such that concrete grout may flow easily around and enclose the reinforcement in all cores; and provide cover is consistent with the requirements for durability, strength and fire resistance as appropriate.

Cement

Cement shall be Type GP portland cement or GB blended cement complying with the relevant Standard.(AS 3972).

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

Concrete Grout

Concrete grout shall comply with the Drawings, Building Regulations and relevant Standard (AS 3700). Unless stated otherwise, properties shall be:

- 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.

Flashings

Flashings shall comply with the Drawings, Building Regulations and relevant Standard (AS 3700, 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)

Unless stated otherwise flashings shall consist of one of the following options:

- Flashing in Concealed Locations (e.g. cavity flashings) shall be one of the following:
- Uncoated annealed lead having a mass not less than 10 kg/m² in lengths not exceeding 1.5 m, but shall not be used on any roof that is used to catch potable water;
- Uncoated copper having a mass not less than 2.8 kg/m² 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 with a thickness not less than 0.6 mm;
- Embossed/quilted polyethylene sheet with an average thickness not less than 0.5 mm

Flashings in Exposed Locations (e.g. flashings from the roof to masonry wall) shall be one of the following:

- Uncoated annealed lead having a mass not less than 20 kg/m² in lengths not exceeding 1.5 m, but shall not be used on any roof that is used to catch potable water;
- Uncoated copper having a mass not less than 2.8 kg/m² 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

Damp Proof Course

Damp-proof courses (DPCs) shall comply with the Drawings, Building Regulations and relevant Standard (AS 3700, AS/NZS 2904). Unless stated otherwise damp-proof courses (DPCs) shall consist of one of the following options.

- A material complying with the Standard AS/NZS 2904;
- Embossed black polyethylene film of high impact resistance and low slip, with a nominal thickness of 0.5 mm prior to embossing, and meeting the requirements of the relevant Standard (Clause 7.6 of AS/NZS 2904);
- Polyethylene coated metal damp proof courses with an aluminium core not less than 0.1 mm thick, shall be coated both sides with bitumen adhesive enclosed in polyethylene film not less than 0.1 mm thick on each face, and has a nominal total thickness of not less than 0.5 mm prior to embossing;
- Termite shields (with no penetrations) continuous throughout the wall or pier.

Notes:

Metal and metal-cored damp-proof courses and termite shields shall not be used in locations with saline ground water or subject to rising salt damp.

Termite Barriers Consisting of Woven Stainless Steel Mesh

Woven stainless steel mesh acting as a termite barrier shall comply with the Drawings, Building Regulations and relevant Standard (AS 3660.1). Unless stated otherwise, properties shall be not less than the following:

- Mesh shall be woven wire from a fine wire loom.
- Wire shall be stainless steel grade 304 or 316 (AS 1449).
- Wire diameter shall be not less than 0.18 mm.

- Aperture size shall be not greater than 0.66 mm × 0.45 mm, except in those locations where a very small species of *heterotermes vagus* is present (e.g. parts of northern Australia), the aperture shall be reduced to a maximum of 0.40 × 0.40 mm

Pipe collars, manufactured from woven stainless steel mesh with a 50 mm annulus, shall be attached to any penetrating service by a stainless steel clamp. Such collars shall be:

- Embedded in concrete; or
- Clamped and parged to the top surface of the slab and protected from damage by covering with a tile mortar bed or false floors of cupboards or vanities. The clamp shall be sealed with the parging mix.

Termite Barrier Parging Material for Woven Stainless Steel Mesh

Parging material, for woven stainless steel mesh acting as a termite barrier, shall comply with the Drawings, Building Regulations and relevant Standard (AS 3660.1). Unless stated otherwise, parging material shall be a highly modified cementitious grout of a water-dispersed copolymer with a dry mixture of Type GP portland cement and sieved aggregate of a size that passes readily through the woven stainless steel mesh.

Hardened parging material shall provide:

- Termite resistance, when in contact with soil and termite workings;
- Bond strength (mesh to substrate) of not less than 1 kN/m at 28 days for a temperature range of 10°C to 30°C at a relative humidity range of 10%RH to 70%RH; and for at least 60 freeze-thaw cycles in saline solution between -15°C and 18°C.

Termite Barriers Consisting of Composite Fibre Blanket and Plastic Membrane with Termiticide Impregnation

Termite barriers, consisting of composite fibre blanket and plastic membrane with termiticide impregnation, shall comply with the Drawings, Building Regulations and relevant Standard (AS 3660.1).

Unless stated otherwise, properties shall be not less than:

- Internal non-woven fibre blanket, not less than 200 grams per square metre,
- Impregnated with termiticide of pyrethroid deltamethrin crystals to a loading of not less than 1 gram per square metre (low toxicity to warm blooded animals which both strongly repels and kills termites),
- Bonded to a top moisture vapour barrier of low density polyethylene (LDPE), not less than 200 microns thick,
- Bonded to a bottom membrane of low density polyethylene (LDPE) not less than 50 microns thick, to prevent the termiticide leaching into soil.

Part 5 – DANCER Cost Comparisons and Bills of Quantities

Part 5 provides bills of quantities for the principal components of the most common **DANCER** buildings. The **DANCER** Design Package may be used to prepare customised Bills of Quantities for other applications.

DANCER Cost Comparisons

Background

The **DANCER** building System provides structural framing in which the uplift and racking forces due to wind, earthquake and tsunami are efficiently transmitted to the foundations via the timber frame itself, rather than through separate steel anchors and ties.

In this way, **DANCER** differs from a conventional timber house framing (designed to AS 1684), which relies on steel anchors and ties to secure the roof structure through the walls and floor system to the sub-floor.

Notwithstanding any cost differences, the advantages of the **DANCER** system are that it has a simple site construction method that does not rely on tensioning straps and it does not use steel components that are difficult to source in remote areas.

Scope of Cost Comparisons

1. The cost comparisons in this section deal only with the cost differences between the **DANCER** framing above the sub-floor and conventional timber house framing above the sub-floor.
2. The roof cladding, wall cladding, flooring, subfloor, windows, doors, internal walls, ceiling, internal lining and fit-out can be (and in most cases would be) identical in both systems and are therefore not included in the cost comparisons below.

Assumptions

1. Designs complying with AS 1684 can utilize a number of solutions, depending on the sub-floor post and pier spacing. So too, the **DANCER** system could adopt different arrangements for sub-floor post and pier spacing. To enable reasonable cost comparisons to be made, both systems have been based on the same sub-floor arrangement.
2. The roof systems described in AS 1684 consist of rafters, ridge beams, collar ties, struts, underpurlins, hanging beams, ceiling joists and the like, sometimes referred to as a "cut roof". This system relies on load bearing walls for support at various intermediate points and is not favored in modern design.
3. Most modern buildings would incorporate a trussed roof (designed to AS 1720.5) in preference to the cut roof described in AS 1684. Therefore, the costs are based on a truss system.
4. The designs of both systems vary depending on the building geometry, wind exposure, earthquake risk and availability of structural timber.
5. The following combinations are assumed for both systems for the cost comparisons.
 - (a) In non-cyclonic regions (such as Papua New Guinea Highlands), a wind classification of N2 and an availability of unseasoned hardwood of stress grade F11 and joint type J2 are assumed. For this combination, a post and pier grid of 2.7 x 2.7 m has been used.
 - (b) In cyclonic regions (such as Solomon Islands, Vanuatu, Fiji and Tonga), a wind classification of C2 and an availability of seasoned softwood of stress grade MGP10 and joint type JD4 are assumed. For this combination, a post and pier grid of 1.8 x 1.8 m has been used.
6. Notwithstanding the assumption listed above, the design of individual structures will depend on availability of local materials and the local exposures.

Cost Comparison 5.7 x 5.7 Building, Cyclonic Wind C2, Timber MGP 10

Building: 5.7 x 5.7 m with a small porch

Subfloor: Steel posts arranged on a 1.8 m x1.8 m grid

Timber: Seasoned pine, MGP10, Joint Type JD4

DANCER Trusses, Purlins and External Wall Frames

No of trusses	10			
<u>Bolts, nuts and washers</u>				
M12 x 150 gal bolt nuts	80	M12	x 150	\$ 2.07 each \$ 165
M12 galv flat washers	160	M12		\$ 0.20 each \$ 31
M16 x 150 gal bolt nuts	20	M16	x 150	\$ 3.41 each \$ 34
M16 galv nuts	40	M16		\$ 0.33 each \$ 13
				\$ 244
<u>Timber</u>				
Studs, Plates, Noggings	1.501	m ³		\$ 1,022 m ³ \$ 1,535
Roof trusses	1.443	m ³		\$ 1,022 m ³ \$ 1,475
Roof Purlin (or Roofing B:	0.299	m ³		\$ 1,022 m ³ \$ 306
Other timber	1.355	m ³		\$ 1,022 m ³ \$ 1,386
Total timber	4.599	m ³		\$ 4,702
Total costs				\$ 4,946

Conventional Trusses, Battens and External Wall Frames

No of trusses	10			
<u>Bolts, nuts and washers</u>				
M10 screwed galv rod	14	M10	x 2700	\$ 9.20 each \$ 129
M10 galv nuts	28	M10		\$ 0.20 each \$ 6
M10 galv flat washers	56	M10	x 3.0	\$ 0.15 each \$ 8
				\$ 143
<u>Truss components</u>				
Galvanised knuckle plate	320			\$ 1.20 each \$ 384
Galvanised knuckle plate	40			\$ 2.14 each \$ 86
				\$ 470
<u>Strapping for tie-downs</u>				
30 x 1.0 mm steel strap	120	30	x 1.0 x 0.545 m	\$ 1.07 m \$ 121
<u>Timber</u>				
Studs, Plates, Noggings	1.626	m ³		\$ 1,022 m ³ \$ 1,662
Roof trusses	1.271	m ³		\$ 1,022 m ³ \$ 1,299
Roof Purlin (or Roofing B:	0.233	m ³		\$ 1,022 m ³ \$ 238
Other timber	1.355	m ³		\$ 1,022 m ³ \$ 1,386
Total timber	4.484	m ³		\$ 4,585
Total costs				\$ 5,054
Difference				\$ 109

Example 1 – BOQ for DANCER 5.7 x 8.4 Elevated Timber House

Following is a sample BOQ (Bill of Quantities) that has been generated using the **DANCER** Building System Design Package (MS Excel workbook).

Bill of Quantities	
Project	Vanuatu Government
Partners	Freshwin Community Construction
Use	House
Nominal plan dimensions (allowing for external cladding)	5.7 m x 8.4 m overall
	5.7 m x 8.4 m habitable
	1 full length internal breezeway
	0 porches
External elevation	One habitable storey, gable roof
Internal arrangement	2 bedrooms, 1 kitchen/living room, 1 bathroom/toilet, 1 breezeway
Sub-floor, walls, roof	Steel posts, anchored timber wall & cladding, anchored timber roof
Country	Vanuatu
Location	Coastal
Tsunami exposure	0
Earthquake hazard, z	0.4
Cyclonic / Non-cyclonic	Cyclonic
Wind classification	C2
Return period	500 years
Basic wind speed	69 m/s
Details	
Building designation	Small detached village house
Importance Level	1
Ground floor type	Elevated
Roof (skillion/gable/hip)	g
Roof pitch	18.4 o
Shape (R = Rectangle)	R
No of habitable storeys	1
Length (O/A ext studs)	5.700 m
Width (O/A ext studs)	8.400 m
Total width incl verandas	8.400 m
Thickness of ext walls	0.090 m
Thickness of int walls	0.090 m
Area (inc walls, excl veranda)	47.9 m ²
Area of habitable rooms	44.3 m ²
FFL to U/S ceiling	2.500 m
Top storey height FFL to ceiling	0.000 m
Bottom storey height FFL to ceiling	2.500 m
Minimum sub-floor FFL	0.950 m
Eaves overhang (length)	0.000 m
Eaves overhang (width)	0.450 m
Is roof truss over verandas?	No
Plan length of roof	5.700 m
Plan width of roof	9.300 m
Is there a ceiling?	Yes
Is there eaves lining?	Yes

Bottom bolt to top bolt	0.160	m
Bottom bolt to u/s chord	0.045	m
Ceiling joist depth	0.045	m
Ceiling depth+ allowance	0.004	m
Roof rise ceiling to purlins top	1.781	m
External wall height	3.450	m
Total height to ridge	5.231	m
U/S Ceiling to FFL above	0.950	m
Front veranda length (incl posts)	0.000	m
Front veranda width (incl posts)	0.000	m
Back veranda length (incl posts)	0.000	m
Back veranda width (incl posts)	0.000	m
Rise of stairs	0.950	m
Number of external doors	4	
Number of internal doors	0	
Number of windows	8	
Area of windows	8.16	m ²
Length of internal walls	11.8	m
Roof sheeting	Steel sheet	
Roof structure	Direct Anchorage Timber	
External walls	Clad timber frame	
Internal walls	Timber frame	
Footings for building	Concrete piers	
Footings for steps	Concrete pad footings	
Subfloor post type	Steel	
Is subfloor post embedded?	Yes	
Floor	Elevated timber	

Site Establishment			
Item	1	No	Lump sum for all partts of site establishment
Earthworks & Site Drainage			
Clear site	1	No	12 x 14 = 168 m ² Clear the site of vegetation for a distance of 3.0 m around the building.
Construct site drainage	1	No	12 = 11.7 m Construct a drain and bund (200 mm high) around top side of site if necessary.
Excavate for concrete piers	12	No	.

Concrete									
Notes:									
<u>Installation</u>									
Place concrete in piers and pad footings									
<u>Materials</u>			Depth	x	Width	x	Length	Total	Wasteage
			mm		mm		mm	m	%
N20 concrete in piers	12	No	600	x	400	dia		1.0	m ³ 10%
<u>Components of concrete</u>									
Cement in concrete	8		40kg bag					318	kg
Sand in concrete								0.50	m ³
Gravel in concrete								1.00	m ³
N20 concrete in stair pad	1	No	1,200	x	600	x	100	0.079	m 10%
<u>Components of concrete</u>									
Cement in concrete	1		40kg bag					25	kg
Sand in concrete								0.04	m ³
Gravel in concrete								0.08	m ³
Reinforcement in Stair Pad	6	No	N10					5.610	m 10%

Steel Posts

Notes:

Installation

Erect steel posts

Fabricated Steel Posts	12	No	80NB galvanized medium pipe, 125 x 75 x 6 L x 130, 2 holes 13 dia				12.0	No
------------------------	----	----	---	--	--	--	------	----

The abovementions Fabricated Steel Posts are available from hardware outles and consist of the following:

Steel Post	12	No	80 NB	galv med wall p	1,200	14.4	m	0%
	12	No	125 x 125 x 6 L	x	130	1.6	m	0%
	12	No	N12	x	300	3.6	m	0%

Timber Framing

Notes:

Installation

Construct timber framing

Materials

Timber Specification	Seasoned	F7	Softwood	Volume	7.557	m ³					
Number of trusses	7	No					Depth mm	Width mm	Length mm	Total m	Wasteage
Bracing for Steel Posts	8	No	90	x	45	x	2,957	26.0	m	10%	
Floor Bearer	15	No	140	x	45	x	3,000	49.5	m	10%	
Floor Joist	40	No	140	x	45	x	3,000	132.0	m	10%	
Floor Trimmer Joist	4	No	140	x	45	x	2,850	12.5	m	10%	
Floor Joist Blocking	0	No	0	x	0	x	0	0.0	m	10%	
Studs, Plates, Noggings	326	No	90	x	45			759.7	m	10%	
Roof trusses	203	No	90	x	45			462.5	m	10%	
Ceiling Batten	40	No	45	x	90	x	2,700	108.0	m	0%	
Veranda Rafter	7	No	90	x	45	x	-35	-0.3	m	10%	
Veranda Beam	0	No	0	x	0	x	200	0.0	m	10%	
Roof Bracing	4	No	25	x	1	x	4,993	22.0	m	10%	
Fascia Board	4	No	240	x	35	x	2,850	12.5	m	10%	
Barge Board	6	No	240	x	35	x	3,331	22.0	m	10%	
Roof Purlin	28	No	90	x	45	x	3,000	92.4	m	10%	
Stair Stringer	2	No	290	x	45	x	1,586	3.5	m	10%	
Stair Tread	4	No	290	x	45	x	920	4.0	m	10%	
Tread support	8	No	70	x	45	x	260	2.3	m	10%	
Stair stringer support	1	No	290	x	45	x	920	1.0	m	10%	
Stair post	6	No	90	x	45	x	975	6.4	m	10%	
Stair walers	6	No	120	x	20	x	1,586	10.5	m	10%	
Stair hand rail	2	No	120	x	20	x	1,586	3.5	m	10%	
Veranda Balustrade Post	0	No	90	x	45	x	1,120	0.0	m	10%	
Front Veranda Balustrade	0	No	120	x	20	x	0	0.0	m	10%	
Front Veranda Balustrade	0	No	120	x	20	x	0	0.0	m	10%	
Back Veranda Balustrade	0	No	120	x	20	x	0	0.0	m	10%	
Back Veranda Balustrade	0	No	120	x	20	x	0	0.0	m	10%	
Front Veranda Stinger	0	No	70	x	45	x	0	0.0	m	10%	
Front Veranda Stringer	0	No	70	x	45	x	0	0.0	m	10%	
Back Veranda Stringer	0	No	70	x	45	x	0	0.0	m	10%	
Back Veranda Stringer	0	No	70	x	45	x	0	0.0	m	10%	
Seat & Stingers	0	No	0	x	0	x	0	0.0	m	10%	
Seat support	0	No	0	x	0	x	420	0.0	m	10%	
Seat leg	0	No	0	x	0	x	310	0.0	m	10%	

<u>Bolts, Nuts, Washers, Screws and Nails</u>			
Bolts fixing bearers to posts	26	No	M12 x 150 cuphead galv bolts & nuts
Bolts fixing subfloor bracing to posts	18	No	M12 x 150 cuphead galv bolts & nuts
Bolts fixing subfloor bracing to bearers	7	No	M12 x 150 cuphead galv bolts & nuts
Bolts fixing subfloor bracing to joists	11	No	M12 x 150 cuphead galv bolts & nuts
Bolts fixing anchorage studs to bearers	31	No	M12 x 150 cuphead galv bolts & nuts
Bolts fixing top chord to anchorage stud:	15	No	M12 x 150 cuphead galv bolts & nuts
Bolts fixing bottom chords to anchorage	15	No	M12 x 150 cuphead galv bolts & nuts
Bolts fixing stairs to joist	2	No	M12 x 150 cuphead galv bolts & nuts
Washers	125	No	M12 galv flat washers
Washers	0	No	M16 galv flat washers
Screws	20	kg	Screws
Screws	0	kg	Screws
Jolt head nails	20	kg	100 x 4.5 ϕ jolt head bright nails
Jolt head nails	20	kg	75 x 3.75 ϕ jolt head bright nails
Jolt head nails	20	kg	50 x 4.5 ϕ jolt head bright nails
Jolt head nails	8	kg	25 x 3.75 ϕ jolt head galv nails
Steel strap bracing	2		30m r 25 x 0.8 x 30 m galvanised steel strap

Cornice, skirting, cupboards and other joinery			
Notes:			
<u>Installation</u>			
Install cornice, skirting, cupboards and other joinery.			
<u>Materials</u>			
Timber cornice	22	No	25 x 25 75.8 m 10%
Timber skirting	22	No	50 x 20 67.8 m 10%
Cupboards with sink over	3	No	. 0%

Flooring			
Notes			
<u>Installation</u>			
Install flooring			
<u>Materials</u>			
19mm particleboard	49.9	m2	
15mm compressed fibre-cement sheet	0.0	m2	
90 x 20 timber T&G flooring	0.0	m2	
<u>Fixings</u>			
Screws	0.0	kg	
Screws	0.0	kg	
Screws	0.0	kg	

Doors

Notes

Installation

Instal doors and door furniture as listed below.

<u>Door D1</u>	External Door	
No	4	No
Height	2040	mm
Width	820	mm
Thickness	35	mm
Material	Solid core external	
Butt hinge set (100mm, 3)	4	No
Lock set (single deadbold cylinder lock)	4	No
Closer	4	No
<u>Door D2</u>	Internal Door	
No	0	No
Height	2040	mm
Width	820	mm
Thickness	0	mm
Material		
Butt hinge set (75mm, 3)	0	No
Lock set (single deadbold cylinder lock)	0	No
Closer	0	No

Windows

Notes

Installation

Instal windows & screens

<u>Window W1</u>	1200 x 850 louvres	
No	7	
Frame Height	1190	mm
Frame Length	842	mm
Clear opening height	1200	mm
Clear opening Length	855	mm
Vertical clearance	10	mm
Horizontal clearance	13	mm
Frame material	Aluminium	
Frame operation	Louvre	
Latch	Single lever	
Lock	Key lock	
Glass blade type	Clear float glass, 2 sides polished bevel	
Glass blade thickness	5	mm
Glass blade width	150	mm
Glass blade length	762	mm
Glass blade coverage	140	mm
No of blades per window	8	
Total No of blades	56	
No of flyscreens	7	
Width each flyscreen mesh	910	mm
Length each flyscreen mesh	1190	mm
Total length flyscreen mesh	8.33	m
Wastage	10%	
Order length flyscreen mesh	9.163	m

No security screens (4 mm wires welded)	7		
Width of welded mesh sheets (4 mm wires)	2000	mm	
Length of welded mesh sheets (4 mm wires)	3000	mm	
No in width of one sheet	1	No	
No in length of one sheet	3	No	
No flyscreen mesh sheets	3	No	
<u>Window W2</u>			
	780 x 850 louvres		
No	1		
Frame Height	770	mm	
Frame Length	842	mm	
Clear opening height	780	mm	
Clear opening Length	855	mm	
Vertical clearance	10	mm	
Horizontal clearance	13	mm	
Frame material	Aluminium		
Frame operation	Louvre		
Latch	Single lever		
Lock	Key lock		
Glass blade type	Clear float glass, 2 sides polished bevel		
Glass blade thickness	5	mm	
Glass blade width	150	mm	
Glass blade length	762	mm	
Glass blade coverage	140	mm	
No of blades per window	5		
Total No of blades	5		
No of flyscreens	1		
Width each flyscreen mesh	910	mm	
Length each flyscreen mesh	770	mm	
Total length flyscreen mesh	0.770	m	
Wastage	10%		
Order length flyscreen mesh	0.847		
No security screens (4 mm wires welded)	1		
Width of welded mesh sheets (4 mm wires)	2000	mm	
Length of welded mesh sheets (4 mm wires)	3000	mm	
No in width of one sheet	2	No	
No in length of one sheet	3	No	
No flyscreen mesh sheets	1	No	
<u>Window Consumables</u>			
Louvre screws (8g x 30mm)	2	Packs	
Crack filler	4	Packs	
Sealant	2	Packs	
Roof Cladding			
Notes:			
<u>Installation</u>			
Install roof cladding			
<u>Materials</u>			
Total area	53.0	m ²	
Corrugated steel roof sheeting, 0.42 BMT, zincalume	762	mm	50.4 m 29%
Corrugated steel roof sheeting, 0.42 BMT, zincalume	762	mm	50.4 m 0%
12-11x50 T17 HD/TG HH Class 3	Top-lock hex galv roofing screws & plastic washers		1,037 20%

Roof Sarking and Insulation

Notes:

Installation

Instal sarking & insulation

Roof Sarking

Roof sarking type	Double sided reflective insulation	
Roof area	50.5	m2
Wasteage	10%	
Sarking area	55.5	m2

Roof Blanket Insulation

Roof blanket insulation type	R1.8 reflective foil & glass fibre blanket	
Roof area	0.0	m2
Wasteage	10%	
Sarking area	0.0	m2

Ceiling insulation type

Ceiling insulation type	R2.5 glass fibre batts or blanket	
Ceiling area	0.0	m2
Wasteage	10%	
Sarking area	0.0	

Roof Plumbing

Notes:

Installation

Instal roof plumbing

Materials

Colorbond 100 quad eaves gutter	14.6	m	Eaves gutter
Colorbond 100 quad stop ends	4	No	Eaves gutter stop-ends
Colorbond 100 quad brackets	21	No	Eaves gutter brackets
12-11x50 T17 HD/TG HH Class 3	84	No	Eaves gutter screws
DN80 PVC RWDP	5.8	m	RWDPs (Rainwater downpipes)
DN80 PVC inlet	1	No	RWDP inlets
DN80 PVC 88 bend	2	No	RWDP bends
Colorbond DN80 clip saddles	2	No	RWDP brackets
12-11x50 T17 HD/TG HH Class 3	5	No	RWDP bracket screws
Colorbond steel 0.6 mm thick	7.0	m	Ridge flashing
Colorbond steel 0.6 mm thick	22.0	m	Barge moulds
Galv roofing nails 65 x 3.75mm x 500g	11	kg	Flashing & barge fixings
Jolt head nails 125 x 5.6mm x 500g	3	kg	Flashing & barge fixings

External Wall Cladding

Notes

Installation

Install external wall cladding

Cladding

90 x 20 F7 timber weather boards	123.5	m2
0.40mm BMT zinalume steel sheet (6 m)	0.0	m2
0.35mm BMT zinalume steel sheet (10 m)	0.0	m2

Fixings

12-11x50 T17 HD/TG HH Class 3 roofing	1123	No
12-11x50 T17 HD/TG HH Class 3 roofing	0	No
12-11x50 T17 HD/TG HH Class 3 roofing	0	No

Fixed Louvres in Gable Ends

Notes

Installation

Install fixed louvres in gable ends

Timber fixed louvres

Timber fixed louvre type	90 x 20 F7 timber triangular frame, 90 x 20 F7 timber horizontal slats at 50 centres at 45 degrees	
Length 90 x 20 F7 timber	82	m
12-11x50 T17 HD/TG HH Class 3 fixings	302	

Ceiling and Wall Linings

Notes

Installation

Install ceiling lining

Install wall lining

Install eaves lining

Ceiling Lining

Plywood Ceiling Lining

Plywood thickness	4	mm
Plywood sheet length	2.4	m
Plywood sheet width	1.2	m
Plywood wall area	44.6	m2
Wasteage	5%	
No of plywood sheets	17	No

Plasterboard Ceiling Lining

No

Plasterboard thickness	10	mm
Plasterboard sheet length	2.4	m
Plasterboard sheet width	1.2	m
Plasterboard wall area	0	m2
Wasteage	0.05	0
No of plasterboard sheets	0	No

Ceiling Fixings & Consumables

0

Ceiling fixings	0	0
Ceiling consumables	0	0
Ceiling consumables	0	0

Internal Wall Lining

Plywood Wall Lining		
Plywood thickness	4.0	mm
Plywood sheet length	2.400	m
Plywood sheet width	1.200	m
Plywood wall area	211.9	m2
Wasteage	5%	
No of plywood sheets	78	No

Plywood at Wet Areas

Plywood thickness	17.0	mm
Plywood sheet length	2.400	m
Plywood sheet width	1.200	m
Plywood wall area	7.74	m2
Wasteage	5%	
No of plywood sheets	5	No

Plasterboard Wall Lining

Plasterboard thickness	10.0	mm
Plasterboard sheet length	2.400	m
Plasterboard sheet width	1.200	m
Plasterboard wall area	0.0	m2
Wasteage	5%	0
No of plasterboard sheets	0	No

Internal Wall Fixings & Consumables

Wall fixings	0	0
Wall consumables	0	0

Eaves

Fibre-cement Eaves Lining	Yes	
Eaves lining thickness	4.5	mm
Eaves lining sheet length	2.400	m
Eaves lining sheet width	1.200	m
Eaves lining wall length	12.3	m
Wasteage	10%	
No of fibre-cement sheets	6	No

Eaves Fixings & Consumables

Eaves fixings	0	0
Eaves consumables	0	0
Tie wire	10	kg

Painting

Notes:

Installation

Paint all exposed surfaces where specifi

Required primer volume

External walls (timber)	4.0	litres	Latex wood primer	10A
External barge, fascia, gables (timber)	4.0	litres	Latex wood primer	10A
External eaves (timber, fibre-cement)	4.0	litres	Latex wood primer	10A
External doors & other (timber)	4.0	litres	Latex wood primer	10A
External metalwork (steel)	4.0	litres	Metal primer for zinc-coated surfaces	11
Internal walls (plywood, plasterboard)	8.0	litres	Latex plasterboard sealer	16
Internal ceilings (plywood, plasterboard)	4.0	litres	Latex plasterboard sealer	16
Internal doors (timber)	4.0	litres	Latex plasterboard sealer	16
Internal windows & other (timber)	4.0	litres	Latex plasterboard sealer	16
Internal metalwork (steel, aluminium)	4.0	litres	Metal primer for zinc-coated surfaces	11

Required top-coat volume

External walls (timber)	8.0	litres	Semi-gloss washable exterior latex	8
External barge, fascia, gables (timber)	4.0	litres	Semi-gloss washable exterior latex	8
External eaves (timber, fibre-cement)	4.0	litres	Semi-gloss washable exterior latex	8
External doors & other (timber)	4.0	litres	Gloss washable exterior latex	9
External metalwork (steel)	4.0	litres	Gloss washable exterior latex	9
Internal walls (plywood, plasterboard)	16.0	litres	Semi-gloss mould resistant latex	8
Internal ceilings (plywood, plasterboard)	4.0	litres	Semi-gloss mould resistant latex	8
Internal doors (timber)	4.0	litres	Solvent-borne gloss interior	9
Internal windows & other (timber)	4.0	litres	Solvent-borne gloss interior	9
Internal metalwork (steel, aluminium)	4.0	litres	Solvent-borne gloss interior	9

Painting Consumables

Paint roller tray kit	2	No
Paint brushes (100 mm)	3	No
Paint brushes (75 mm)	3	No
Paint brushes (50 mm)	3	No
Paint brushes (38 mm)	3	No
Turps (4 litres)	1	No

Electrical Installation

Note: Inclusion of electrical installation is subject to instruction by the client.

Installation

Install electrical system
Connect to electrical mains
Connect solar hot water

Building Wiring

Meter box	1	No	Meter box 300 x 300 x 250 mm
Load centre	1	No	PVC 6 Pole Load Centre (PVC Modern)
Circuit breaker 63 A (Main)	1	No	Circuit Breaker Single Pole 63A Tesla MCB1P63
Circuit breaker 16 A (Power)	1	No	Circuit Breaker Single Pole 16A (Power) MCB16
Circuit breaker 10 A (Light)	1	No	Circuit Breaker 1 Pole 10A (Light) MCB10
Cable (mains)	20	m	Cable Mains Twin & Earth 10 mm
Cable (GPOs)	20	m	Cable Twin & Earth 2.5 mm
Cable(Lights)	20	m	Cable Twin+ECC 1.5 mm TPS 'DN 100mt
Cable	20	m	Cable Twin Active TPS 1.5 mm PR LM
Cable (Earthwire)	20	m	Earthwire Yellow& Green Stripe
Single GPO outlets	0	No	Single GPO 10A 250V ED(EDWGPO1)
Double GPO outlets	4	No	Double GPO2 10A Tesla
Switch single power point	5	No	Switch single power point 10A AS 314
External weatherproof switch	0	No	Weatherproof 10A 2 Gang Surf/Switch
Internal light switch	1	No	Wall light switch 2 Gang (AS314)
Security light switch	0	No	Switch Eye Day Light 10A (Natec)
Lights (1 x 18W, 613 x 26mm bare batte	0	No	Light Fittings 1 x 18 Watt (Davis LPB118)
Lights (1 x 36W, 1222 x 26mm bare bat	6	No	Light Fittings 1 x 36 Watt (Davis LPB136)
Lights (2 x 18W, 613 x 26mm bare batte	0	No	
Lights (2 x 36W, 1222 x 26mm bare bat	0	No	
Stud brackets	20	No	DN Stud Brackets Vertical & Horizontal
Wire connectors	20	No	Connectors Single Screw Loose
Hex head screws (10-16x 16 mm)	255	No	Hex head screws (10-16x 16 mm)
Insulation tape	2	No	PVC Electrical Insulation Tape 18mmx 20m Red

Mains Supply

J Hook	1	No	Mains Entry Box 2 way single phase
Dead ends	2	No	Dead ends with rubber 10-16mm DIS 80610
Copper earth stake	1	No	Copper earth stake 13mmx1.4 m E/CLIP

Floor & Wall Tiling

Note: Inclusion of tiling is subject to instruction by the client.

Installation

Install floor tiles
Install floor tiles
Install miscellaneous tiling

Floor Tiling

Length bathroom floor	1.8	m
Width bathroom floor	2.7	m
Length kitchen floor	0	m
Width kitchen floor	0	m
Length other floor	0	m
Width other floor	0	m
Total area	4.9	m ²
Half total perimeter	4.5	m
Tile length	300	mm
Tile width	300	mm
Area wastage	5%	
Perimeter wastage	5%	
Pack size	12	No
Number of tiles	72.5	No
No of tile packs	7	No
Adhesive coverage	2.408	kg/m ²
Adhesive pack size	20	kg
Number of adhesive packs	1	No
Grout coverage	0.56	kg/m ²
Grout pack size	20	kg
No of grout packs	1	No
Additional adhesive packs	18	No

Wall Tiling

		0
Height shower wall	1.8	m
Length shower wall	3.6	m
Height toilet wall	1.2	m
Length wall wall	0.9	m
Height splash-back	0.2	m
Length splash-back	0.9	m
Total area	7.74	m ²
Half total perimeter	8.6	m
Tile length	200	mm
Tile width	200	mm
Area wastage	5%	
Perimeter wastage	5%	
Pack size	25	No
Number of tiles	248.325	No
No of tile packs	10	No
Adhesive coverage	2.408	kg/m ²
Adhesive pack size	20	kg
Number of adhesive packs	1	No
Grout coverage	0.56	kg/m ²
Grout pack size	20	kg
No of grout packs	1	No

Plumbing

Notes:

Installation

Install plumbing furniture

Install cold water

Install hot water

Install solar hot water

Install tanks

Toilet

WC Toilet seat	1	No
WC Pan & P trap	1	No
WC Cistern (Dual 6L / 3L)	1	No
DWV Pan collar 100 mm Adjustable M&	1	No
Mini-cistern set tap & flexible connector	1	Set
Mini-cistern 15mm tap	0	No (loose)
Flexible connector 15mm x 600 mm :	0	No (loose)
Wall plate 15mm chrome	1	No
DN50 uPVC pipe (DWV vent stack)	3.9	m
DN50 uPVC cowl (DWV vent stack)	1	No
Roof penetration & flashing	1	No
DN100 uPVC pipe	2	No
DN100 uPVC FF elbow	11.6	m
DN100 uPVC FFF tee	2	No
DN 80/100 reducer	1	No
DN 80 floor waste	1	No

Shower

Shower tray (900 x 900 mm, white)	1	No
Shower tap set (2 taps & spout)	1	No
Shower pipe combination (200 x 300 tail)	1	No
Shower rose set (15mm, white)	1	No
Wall stop (easy clean anti-vandal)	2	No
Shower waste (80 x 50mm, chrome plat	1	No

Additional Plumbing Fixtures

Sink	1	No
Sink tap set (2 taps & spout)	1	No
Sink pipe combination	1	No

Basin

Wall mounted basin	1	No
Basin tap set (2 taps & spout)	1	No
Basin pipe combination	1	No

Additional Plumbing Fixtures

Sink	1	No
Sink tap set (2 taps & spout)	1	No
Sink pipe combination	1	No

External Taps

External taps	1	No
Compression unions	1	No
Compression elbows	1	No
Compression tees	1	No

Cold Water Copper Pipe

Copper pipe specification	DN15 copper tube	
Brass fittings specification	DN15 brass fittings	
Wasteage	10%	
Pipe length	17.27	m
Brass FF unions	9	No
Brass FF elbows	9	No
Brass FFF tees	9	No

Hot Water Copper Pipe

Copper pipe specification	DN15 copper tube	
Brass fittings specification	DN15 brass fittings	
Wasteage	10%	
Pipe length	13.31	m
Brass FF unions	9	No
Brass FF elbows	9	No
Brass FFF tees	9	No

Cold & Hot Water Plumbing Consumable

PTFE Tape Seal	2	No
----------------	---	----

DVW Plumbing Consumables

Priming fluid (250 ml pack)	1	No
Glue Blue (250 ml pack)	1	No

Solar Hot Water Service

Notes: Default pricing is based on SolarHart 300 litre

Installation

Install solar hot water system, including pipework to bathroom and kitchen taps, roof fixings and electrical connection

Materials

Solar hot water system specification	SolarHart 300 litre	
Solar hot water capacity	300	litres
No of solar hot water systems	1	No

Rainwater tank specification

Notes:

Installation

Instal rainwater tank, header tank, pipev

Materials

Rainwater tank specification	Polyethylene rainwater tank
Rainwater tank volume	5500 litres
Number of rainwater tanks	1 No
Header tank specification	Polyethylene header tank with roof support
Header tank volume	200 litres
Number of header tanks	1 No
Electric pump specification	Centrifugal 1400 W, 240 V electric pump and contoller
Electric pump capacity	60 l/m
Number of electric pumps	0 No
Hand pump specification	Mini rotary hand pump
Hand pump capacity	30 l/m
Number of hand pumps	1 No
Pipes tanks/pump to header tank	DN80 uPVC pipe
Pipes tanks/pump to header tank	DN32 HDPE pipe
Pipes header tank to appliaces	DN15 copper pipe

Rainwater uPVC Pipe (roof gutter to ta

uPVC pipe specification	DN80 uPVC pipe
uPVC fittings specification	DN80 uPVC fittings
Wasteage	10%
uPVC pipe length	7.6 m
uPVC FF elbows	2 No
uPVC gutter inlet	1 No

Rainwater HDPE Pipe (tanks & pump to

Pipe specification	DN32 HDPE pipe
Fittings specification	DN32 HDPE & brass fittings
Wasteage	10%
Pipe length	14.6 m
Unions	8 No
Elbows	10 No
Tees	0 No
Valves (brass FF gate valves)	4 No
Other fittings	0 No

Rainwater Copper Pipe (into building)

Copper pipe specification	DN15 copper pipe
Brass fittings specification	DN15 brass fittings
Wasteage	10%
Pipe length	8.4 m
Brass FF unions	5 No
Brass FF elbows	5 No
Brass FFF tees	5 No

Rainwater Plumbing Consumables

PTFE Tape Seal	2 No
Nylon compression olives (15mm)	5 Packs

DVW Rainwater Plumbing Consumables

Priming fluid (250 ml pack)	1 No
Glue Blue (250 ml pack)	1 No

Part 6 – DANCER Fabrication and Construction Guide

Part 6 provides guidelines on the factory prefabrication, including (when appropriate) trial erection of the system, and the construction process.

DANCER Prefabrication Procedure

1. A set of permanent steel posts in concrete piers, set out accurately to the 2.7 x 2.7 m gridlines (in noncyclonic regions) or 1.8 x 1.8 m gridlines (in cyclonic regions) shall be constructed at the prefabrication workshop. It is recommended that sufficient posts and piers be installed for buildings up to 8.4 x 8.4 m (allowing for and 150 mm at each side and each end).
2. One jig for each type of frame, truss, pier and floor member shall be manufactured and stored permanently at the prefabrication workshop. Initially these jigs will be manufactured from timber. As they prove to be accurate, the timber jigs may be replaced by steel jigs. Refer to Part 3 of this Manual.
3. Once the permanent posts and the jigs are complete, fabrication of all timber components may commence.
4. All timber shall be ordered from the Material Lists and cut in accordance with the Cutting Lists. The Cutting Lists make provision for wastage due to cutting 10% oversize.
5. Once fabrication is complete, the building shall be erected in the prefabrication workshop on the permanent posts and bolted together. Any nailing should only be temporary.
6. All items shall be marked (by Grid Location and Item Number).
7. The structure shall be disassembled, packed and transported to the construction site.
8. The structure shall be reassembled, bolted and permanently nailed. All bracing, sheeting, cladding and the like shall be permanently fixed.

DANCER Trusses – Setting Out Assumptions

1. Because the dressing of timber affects the depth and thickness, the design is based on only one set of dimensions for the jig (template). i.e. the undressed dimensions 100 x 38.
2. The critical surfaces for fabrication will be:
 - the top surface of the top chords,
 - the bottom surface of the bottom chords, and
 - the interfaces between the lacing and the purlins at position of the roof sheeting
3. The fascia is assumed to be 35 thick.
4. This means that one jig will be used for all sizes of timber, provided the timbers are positioned hard against the critical surfaces. 100 x 38 will be suitable for 100 x 38, 90 x 35, 75 x 50, 70 x 45 and so on.
5. Purlins of depth less than 100 mm may need to be packed up from the critical surface (top surface of the top chord). Alternatively the top end of the lacing could be trimmed.
6. For fascias thicker than 35, the dimension over the eaves will be very slightly oversized (6 mm overall), but this is not a problem.

DANCER – Jig for Prefabrication of Standard Trusses

Principle

Production trusses may be prefabricated in a factory rather than on site where it is difficult to control the accuracy and the effectiveness of connections.

To facilitate factory-based prefabrication, the member of production trusses should be cut to length and the ends trimmed to the appropriate angles using templates, before being assembled in a jig.

Definitions

Production Truss – The roof trusses intended to be used in particular projects. The span and eaves length may vary depending on the project, but for standard **DANCER** projects the roof slope should be kept constant at 1 (vertical) to 3 (horizontal)

Production Half Truss – Half of a Production Truss. The **DANCER** Truss system is used for spans in the range 4.8 m to 8.4 m. Allowing for at least a 450 mm eaves overhang, the range of overall dimensions effectively becomes 5.7 to 9.3 m (or more). It is impractical to handle and transport full trusses in this range. Therefore, trusses are fabricated and transported to site in two halves, which are bolted together on site during erection. A feature of the **DANCER** Truss System is that both half trusses are usually identical. i.e. There is no requirement for a left-hand and a right-hand half (often called “As drawn” and “Opposite Hand”). Therefore, the Jig need only cater for a single half of a full truss, called a Production Half Truss.

Template – A timber or steel member, the exact shape as the members of the production trusses. The templates may (if required) be fitted with guides.

Jig – A timber or steel template, essentially the same plan shape as a Production Half Truss, fitted with guides and stops to enable the Production Truss members (chords and lacing) to be accurately positioned before being permanently connected with nails or screws.

Top Chord – The sloping top member of a roof truss. Each half truss of the **DANCER** system has a double top chord, consisting of one long top chord member, TC(L), and one short top chord member TC(S).

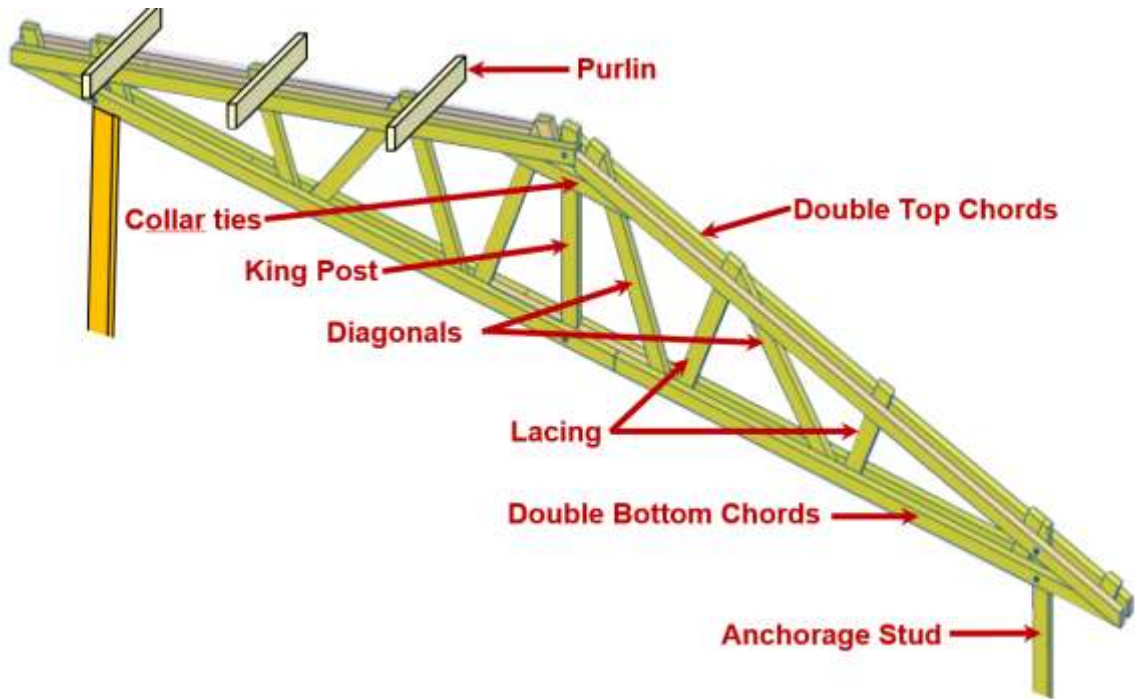
Bottom Chord – The bottom member of a roof truss. The bottom chord is usually horizontal, but in some systems it can be sloping. Each half truss of the **DANCER** system has a double bottom chord, consisting of one long bottom chord, BC(L), and one short bottom chord member BC(S). The bottom chords of the standard **DANCER** trusses are horizontal, although non-standard sloping bottom chords of various configurations may also be designed.

Lacing – The diagonal members of a roof truss that join the top and bottom chords. Lacing members (L1 to L6) are sometimes called webbing. In the **DANCER** system, lacing members are fixed between the double top chords and the double bottom chords, are perpendicular to the top chord, and protrude above the top surface of the top chord so that the purlins can be fixed to them.

Diagonals – The diagonal members of a roof truss that join the top and bottom chords. Diagonals (D1 to D3) are also sometimes called webbing. In the **DANCER** system, diagonal members are fixed between the double top chords and the double bottom chords, but in a diagonal direction that connects the bottom on one lacing member to the top of the next lacing member. They also protrude above the top surface of the top chord to maximise the end clearance of fixings.

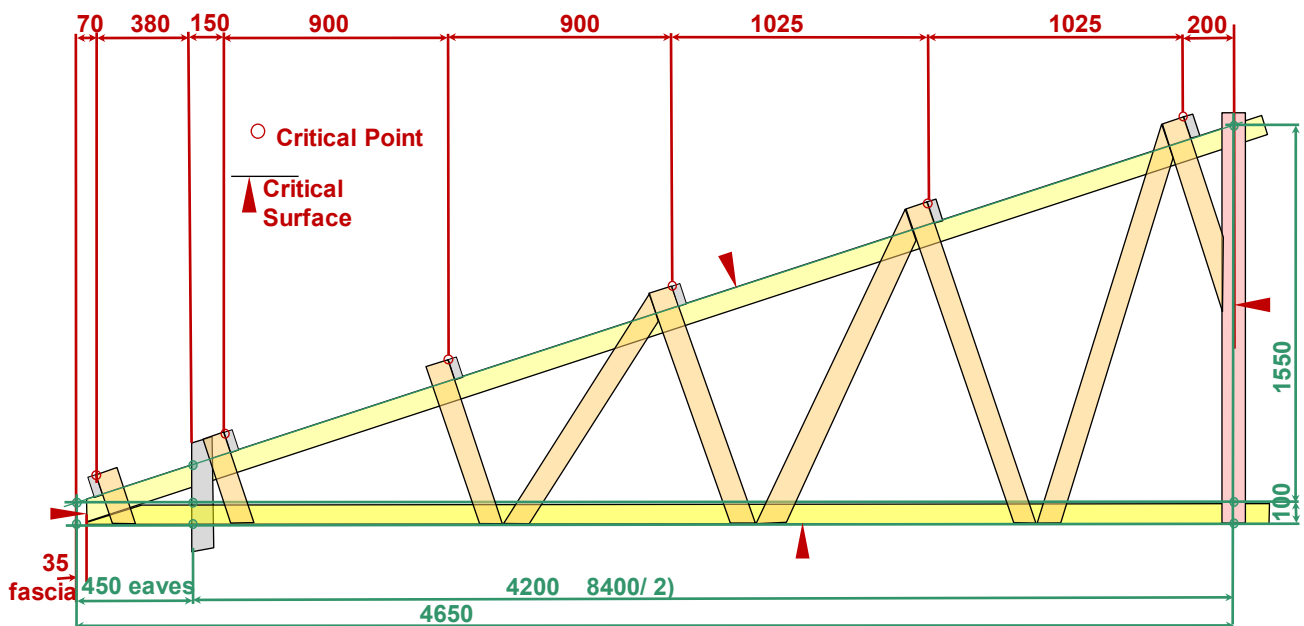
Purlin – The horizontal member to which the roof sheeting is fixed. Purlins are sometimes called battens. In timber “cut” roof systems, the term “purlin” may refer to different members.

Anchorage Stud – A vertical post to which the **DANCER** trusses are bolted, which transmit roof uplift forces down to the lower parts of the structure. For describing the **DANCER** system, the span is measured to the outside of the studs.



Critical Surfaces for a Multipurpose Jig

1. Adherence to the following principles will enable the standard jig to be used to manufacture trusses employing members of several different cross sections within the range 100 x 38 to 90 x 35 mm. Thicker members may also be used if non-standard trusses are required.
2. Because the dressing of timber affects the depth and thickness, the design is based on only one set of dimensions for the jig and templates. i.e. the undressed dimensions 100 x 38.
3. The critical surfaces (shown below) for fabrication will be:
 - the top surface of the top chords,
 - the bottom surface of the bottom chords, and
 - the inside face of the fascia, which is assumed to be 35 thick
 - the centreline of the truss
 - the interfaces between the lacing and the purlins at position of the roof sheeting.



- This means that one jig will be used for all sizes of timber, provided the timbers are positioned hard against the critical surfaces. 100 x 38 will be suitable for 100 x 38, 90 x 35, 75 x 50, 70 x 45 and so on.
- Purlins of depth less than 100 mm may need to be packed up from the critical surface (top surface of the top chord). Alternatively, the top end of the lacing could be trimmed.
- For fascias thicker than 35, the dimension over the eaves will be very slightly oversized (6 mm overall), but this is not a problem.

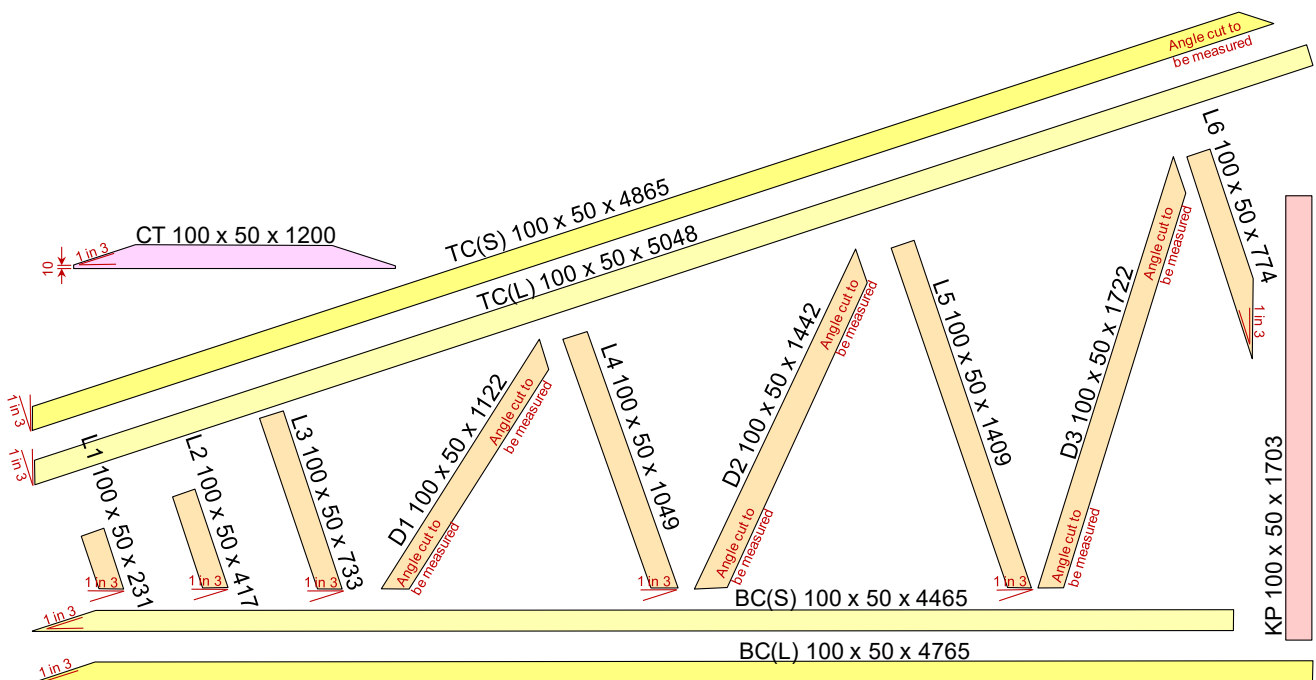
Manufacturing a Jig

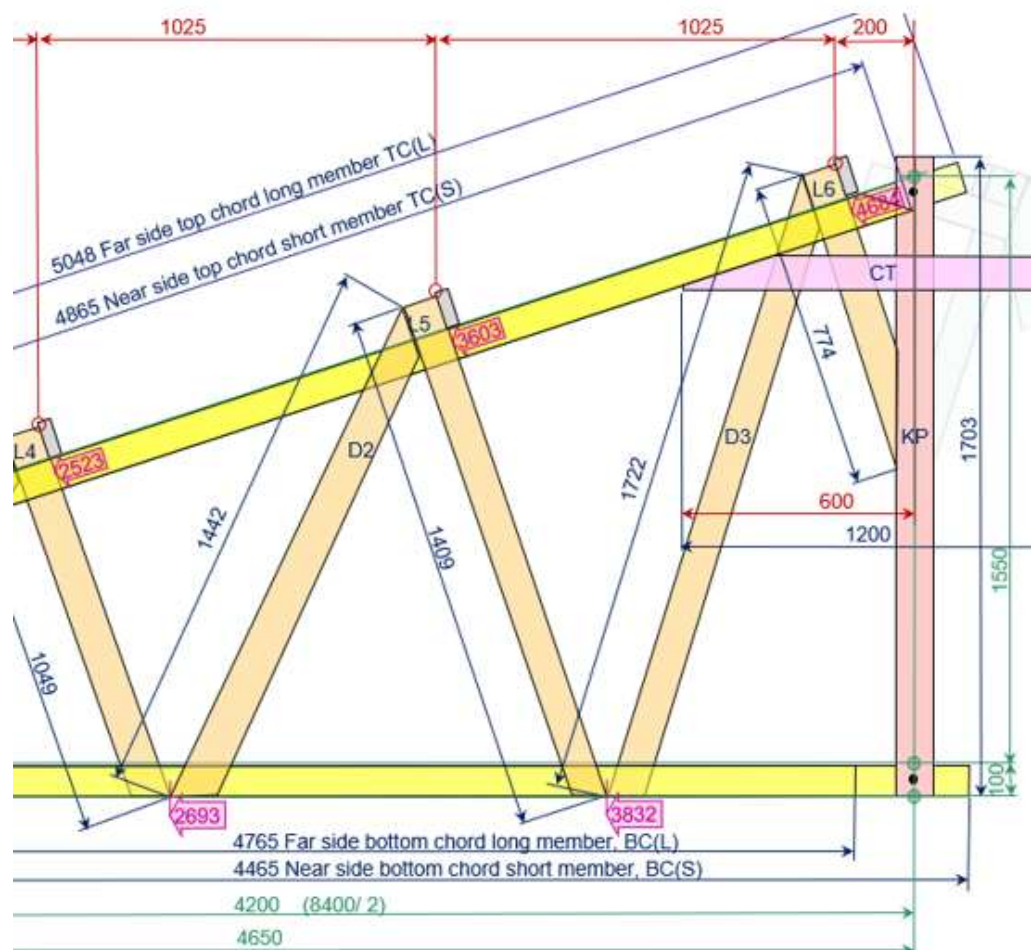
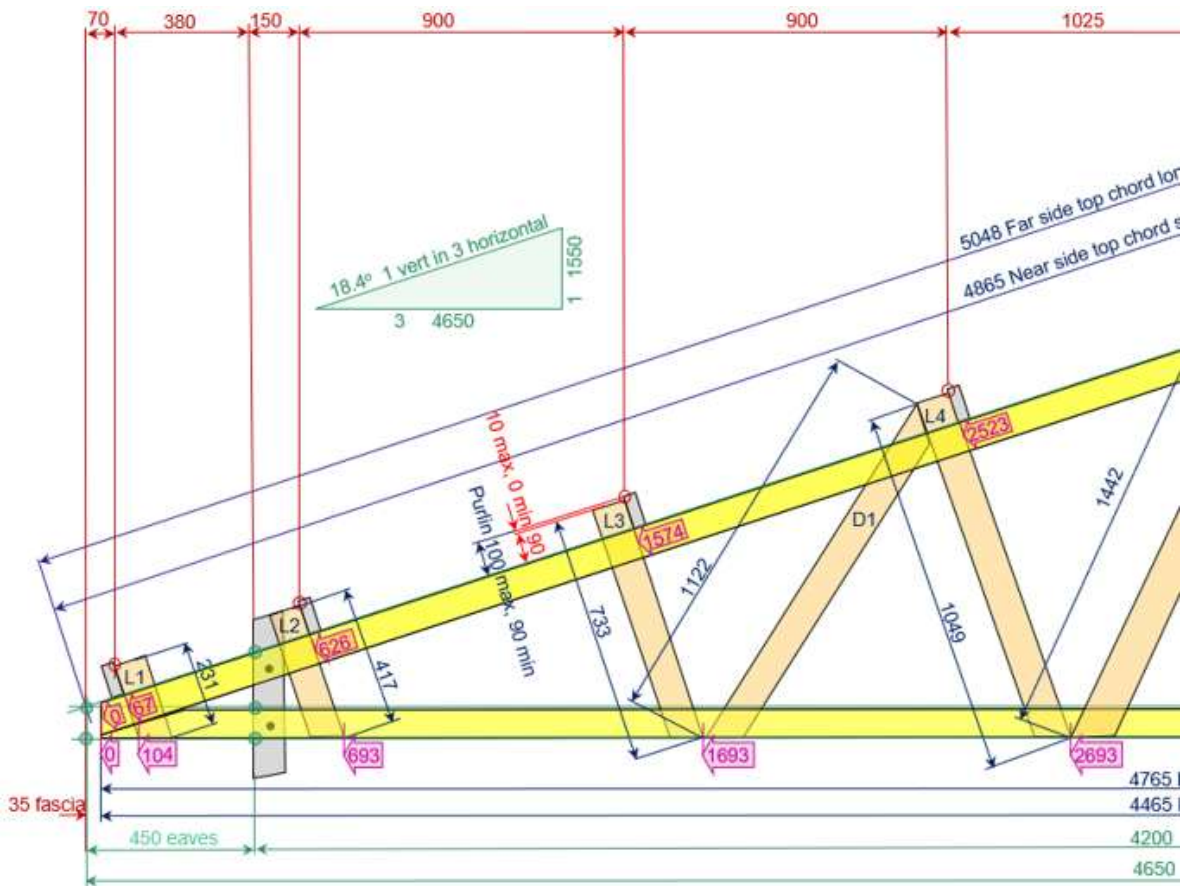
- Types: The Jig may be manufactured of timber (easy to make) or hollow steel sections (long lasting).
- Materials: Use either 100 x 38 milled timber; or 100 x 38 (or 100 x 50) RHS hollow steel sections.
- Manufacture a Production Half Truss to the following plan dimensions. Include a collar tie (CT), a King Post (KP) and a short piece of Anchorage Stud. The dimensions below are for a **DANCER** Half Truss, overall span 5.7 m, slope of 1:3, and 450 mm eaves.

Cutting Members

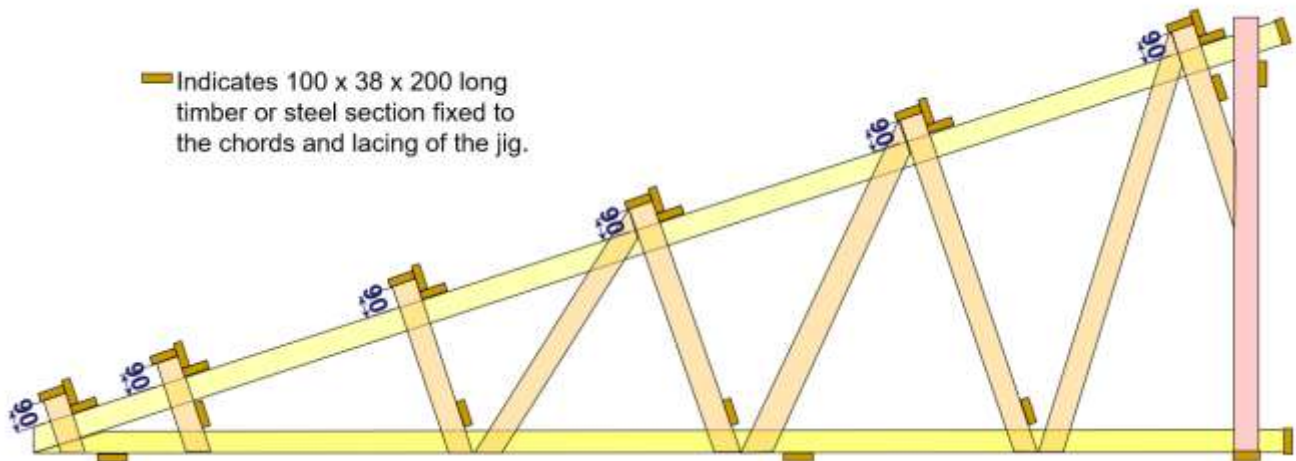
Cut two sets of the members for one half truss.

- One set of members will be used as templates for cutting the members of the production truss.
- The second set of members will be assembled to for the jig.
- Members TC(S), BC(S) and CT are not required for the jig.
- The following dimensions are for a standard **DANCER** Truss, width 8.4 m outside the studs, 1 in 3 slope and 450 mm eaves.





2. Fit 100 x 38 x 200 mm timber or steel guides as shown to form a Standard **DANCER** 8.4 Half Truss Jig.
 - a) By positioning the guides as shown in the drawing, it is easy to slide the cut members into position against the critical dimensions.
 - b) Lacing protrudes only 90 mm above the top chord top surface, thus enabling the use of purlins of depth 90 mm or more.
 - c) By leaving the left-hand end of the jig open (no guide), longer top chord members can be used to accommodate extended eaves.

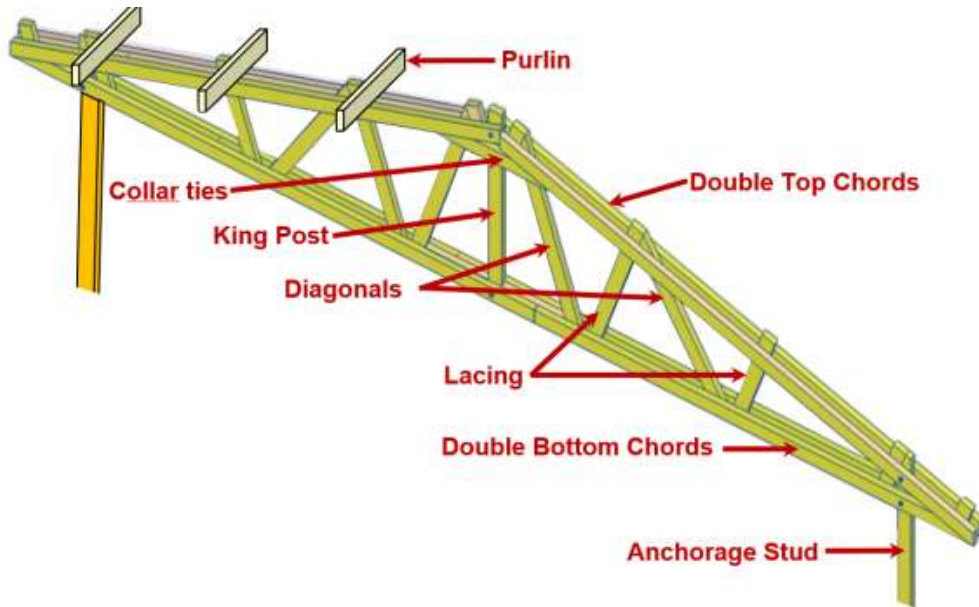


3. Mount the jig on a table or on legs of convenient height. The top surface of the jig should be approximately 800 mm above the ground.
4. The jig described above is suitable to the **DANCER** 8.4 Standard Half Truss.
 - a) The left-hand end of the jig (up to and including lacing member L4) remains unchanged for shorter spans, but the right-hand end is modified by inserting new end guides at the appropriate distance from the left-hand end.
 - b) The following shall be fixed to the top and bottom chords at the appropriate positions:
 - New King Post and King Post Guides;
 - New Lacing L6 and Lacing L6 Guides.
 - c) Lacing L5 is only required in trusses of span greater than 6.6 m (outside studs)
 - d) Diagonal D3 is only required in trusses of span greater than 6.3 m (outside studs)

Principle

1. Production trusses may be prefabricated in a factory rather than on site where it is difficult to control the accuracy and the effectiveness of connections.
2. A number of prefabricated production trusses may be trial erected and part of the quality assurance process before being sent to site.

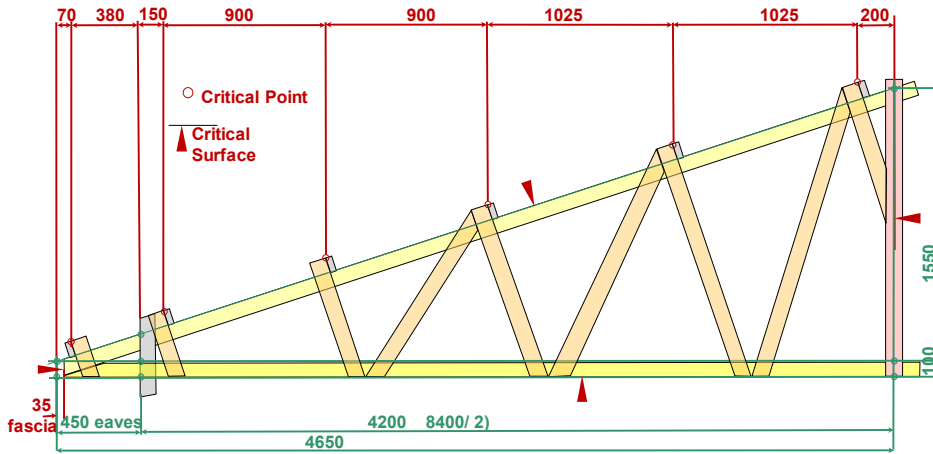
Both practices minimise inaccuracies and confusion on site regarding the dimensions.



Critical Surfaces for a Multipurpose Jig

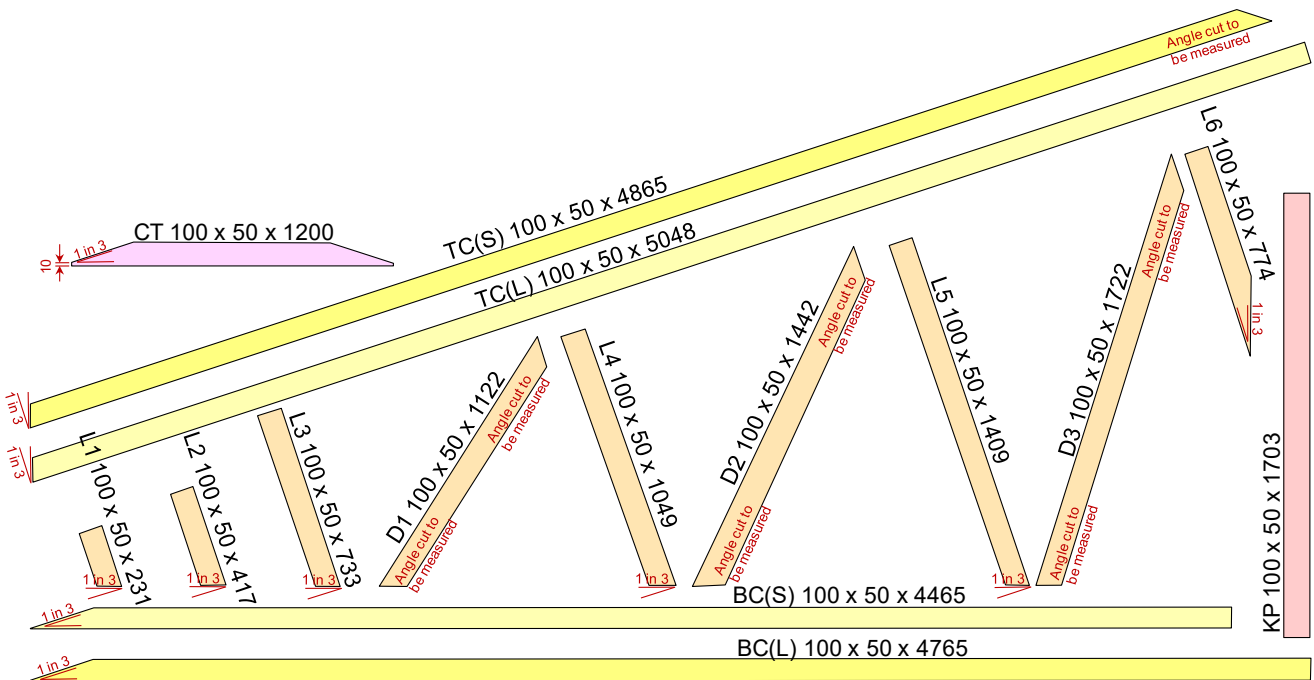
Adherence to the following principles will enable the standard jig to be used to manufacture trusses employing members of several different cross sections within the range 100 x 38 to 90 x 35 mm. Other members (75 x 50, 70 x 45 etc.) may also be accommodated if non-standard trusses are required. The critical surfaces (shown below) for fabrication will be:

- the top surface of the top chords,
- the bottom surface of the bottom chords, and
- the inside face of the fascia, which is assumed to be 35 thick
- the centreline of the truss
- the interfaces between the lacing and the purlins at position of the roof sheeting.



Cutting Members

Cut the members using the templates. The following dimensions are for a standard **DANCER** 8.4Truss, width 8.4 m outside the studs, 1 in 3 slope and 450 mm eaves.



The following dimensions are for all standard **DANCER** Trusses in the range 4.8 m to 8.4 m outside the studs, 1 in 3 slope and 450 mm eaves.

Note: Dimensions allow for 450 mm eaves

		4.800	5.100	5.400	5.700	6.000	6.300	6.600	6.900	7.200	7.500	7.800	8.100	8.400
Item	Component	Length mm	Length mm	Length mm	Length mm	Length mm	Length mm	Length mm	Length mm	Length mm	Length mm	Length mm	Length mm	Length mm
TC(L)	Truss Top Chord	3,151	3,309	3,467	3,625	3,784	3,942	4,100	4,258	4,416	4,574	4,732	4,890	5,048
TC(S)	Truss Top Chord	2,968	3,126	3,284	3,442	3,600	3,758	3,916	4,075	4,233	4,391	4,549	4,707	4,865
BC(L)	Truss Bottom Chord	2,965	3,115	3,265	3,415	3,565	3,715	3,865	4,015	4,165	4,315	4,465	4,615	4,765
BC(S)	Truss Bottom Chord	2,665	2,815	2,965	3,115	3,265	3,415	3,565	3,715	3,865	4,015	4,165	4,315	4,465
CT	Collar Tie	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
KP	King Post	1,103	1,153	1,203	1,253	1,303	1,353	1,403	1,453	1,503	1,553	1,603	1,653	1,703
L1	Lacing at eaves	231	231	231	231	231	231	231	231	231	231	231	231	231
L2	Lacing at anchorage	417	417	417	417	417	417	417	417	417	417	417	417	417
L3	Lacing	733	733	733	733	733	733	733	733	733	733	733	733	733
L4	Lacing	1,049	1,049	1,049	1,049	1,049	1,049	1,049	1,049	1,049	1,049	1,049	1,049	1,049
L5	Lacing	0	0	0	0	0	0	0	1,278	1,304	1,330	1,357	1,383	1,409
L6	Lacing	774	774	774	774	774	774	774	774	774	774	774	774	774
D1	Diagonal	1,122	1,122	1,122	1,122	1,122	1,122	1,122	1,122	1,122	1,122	1,122	1,122	1,122
D2	Diagonal	0	0	1,275	1,389	1,511	1,640	1,169	1,206	1,247	1,291	1,339	1,389	1,442
D3	Diagonal	0	0	0	0	0	0	1,436	1,409	1,467	1,528	1,591	1,656	1,722

Assembly of Truss

1. Ensure that production truss members are positioned hard against the critical surfaces.
2. Position the lacing and the diagonals first.
3. Position the long top and bottom chord members, TC(L) and BC(L) over the lacing and diagonals; and fix with the specified number of nail or screws.
4. Remove the truss from the jig, turn it over so that the lacing and diagonals are on top and place it on a flat surface.
5. Position the short top and bottom chord members, TC(S) and BC(S) over the lacing and diagonals; and fix with the specified number of nail or screws.

Part 7 – DANCER Development and Testing Program

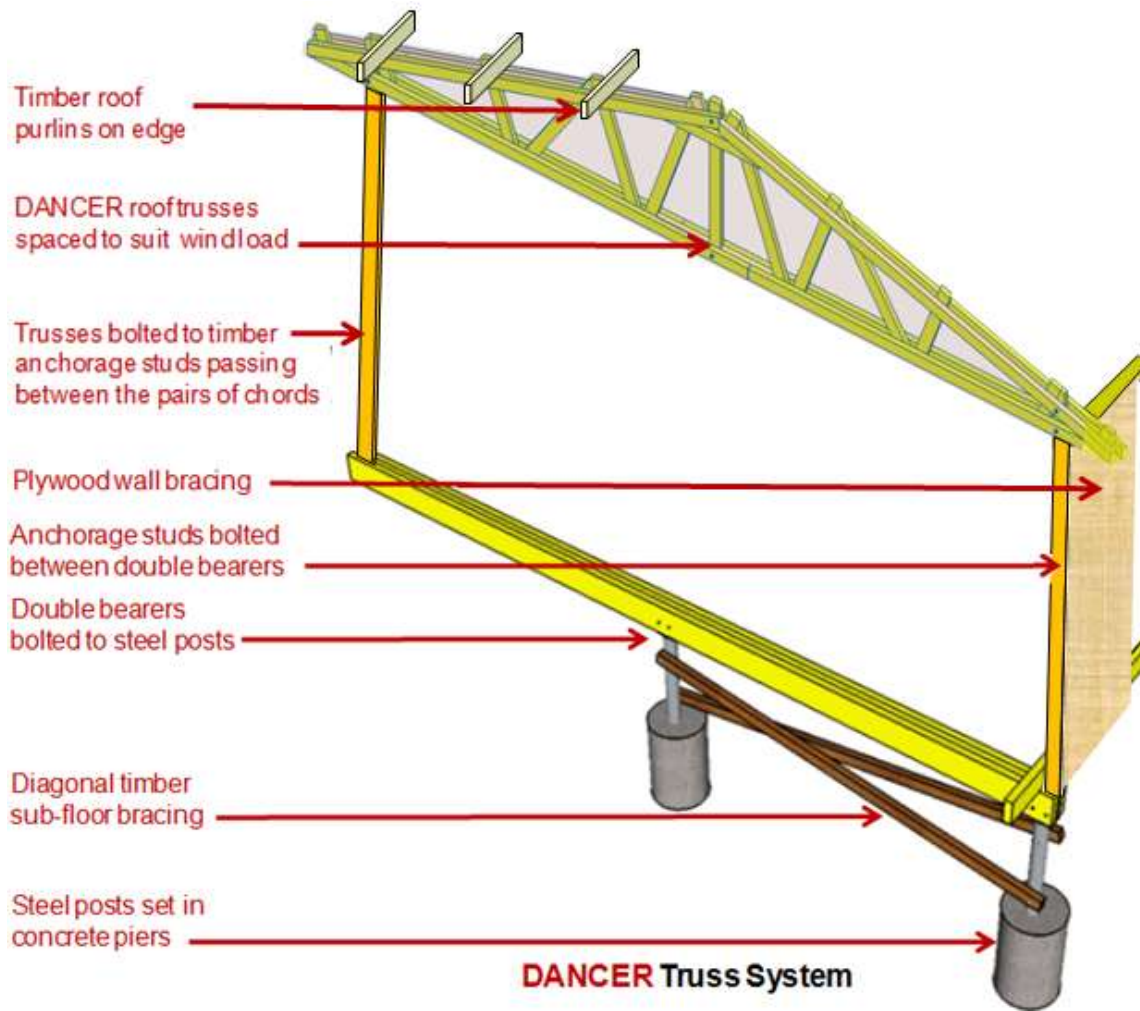
Part 7 provides a record of the development of the system and the testing program use to refine and verify it.

Background

The **DANCER** Building System is a simple timber framed building system, for South Pacific village applications, incorporating sawn timber framing fixed by bolts and nuts, steel (or timber) posts, a small quantity of concrete for piers (if available), steel (or leaf) roof cladding, sawn timber flooring and local or imported wall cladding. The cyclone/earthquake/tsunami resistance is economically achieved by orienting the timber purlins such as to maximize the truss or rafter spacing and ensure that the uplift loads are transmitted to the ground via bolted connections directly between rafter/truss, anchorage studs, double bearers and posts.

The **DANCER** building system consists of the following:

- Timber roof purlins, on edge (to maximize the span) are nailed horizontally to timber lacing members that are fixed between the double truss chords (or double rafters, as appropriate). They are fixed at 900 mm maximum centres to support corrugated steel roof sheeting.
- **DANCER** Trusses (or **DANCER** Rafters) consisting of double top chords and double bottom chords (enabling the lacing/purlin cleats to be nailed between from both sides and the anchorage studs bolted in double shear between).
- The **DANCER** Trusses (or **DANCER** Rafters) are bolted to timber Anchorage Studs between both pairs of chords.
- The timber Anchorage Studs are bolted in double shear between the Double Bearers, providing a direct load path from the roof system to the floor and subfloor
- Double Bearers are bolted to steel (or timber) posts, which are set in concrete piers.
- Plywood wall bracing and diagonal timber sub-floor bracing provide racking resistance.



Purpose

The product development and testing program described in this report deal with:

- (a) the principles underlying the **DANCER** Building System,
- (b) the determination (by test and by structural analysis) of the ultimate strength capacities of key components of the **DANCER** Building System under simulated wind uplift,
- (c) the practical issues associated detailing and constructing the system, and
- (d) the suitability of using AS 1720.1 for designing the **DANCER** Building System in real buildings.

Summary of Principal Conclusions

Although the conclusions and recommendations are located throughout this report, the principal conclusions and recommendations are summarised below.

1. The combined results of the tests indicate that the ultimate capacities of the **DANCER** Building System components can be confidently predicted using AS 1720.1.
2. Therefore, the design of particular **DANCER** buildings and their components may be based on AS 1720.1, rather than design based on prototype testing.
3. In other words, the testing program should not be considered as “prototype” testing (as described in AS/NZS 1170.0 Appendix B). Rather, it should be considered as a “reality check” and for “product development” and used to refine the system. The capacities are measured means (best estimates), to be used with assumed variability. Used for this purpose, the results do not need to be modified to reflect the number of tests. This point is further explained in the section where the results are analyzed.
4. It is acknowledged that a more comprehensive testing program could be undertaken. However, if practical building design is carried out in accordance with Point 2 (i.e. design to AS 1720.1) and the current tests are used for the purpose stated in Point 3 (i.e. as a “reality check” and for “product development”), the testing program is considered to be adequate.

Exclusions

The following must be carried out by a suitably qualified and experienced civil/structural engineers, architects and builders with the authority and responsibility for the design and construction of particular buildings. These activities are specifically excluded from the scope of this report.

- Architectural design;
- Determination of building importance and the corresponding probabilities of exceedance for the design actions listed herein;
- Determination of permanent design actions;
- Determination of imposed design actions;
- Determination of wind design actions, including (but not limited to) basic velocity, building height, terrain category, shielding, topography, ultimate wind design gust velocity, free-stream gust pressure and other factors listed in AS/NZS 1170.2 and AS 4055;
- Determination of seismic actions, including (but not limited to) hazard factor, soil classification and other factors listed in AS 1170.4;
- Determination of site classification (for soil properties);
- Drainage assessment;

- Structural design and specification of specific structures based on the points listed above; and
- Construction supervision, inspection and certification of particular buildings.

Basis of Testing and Analysis

The testing program, analysis and recommendations described herein are consistent with:

- The principles of structural mechanics for strength, stability and serviceability;
- Current versions of Australian Standards listed in the herein.

Product Development Process

The development of the **DANCER** Building System involved the following iterative process over several years.

1. Concept development, project initiation and preliminary design.
2. Development (and on-going refinement) of comprehensive software for design, material lists, cutting schedules and bills of quantities.
3. Preparation (and on-going refinement) of standardised component and connection details.
4. Establishment of a prefabrication facility in Papua New Guinea by Vision for Homes, with assistance from Partner Housing Australasia.
5. Design and construction of Kalolo Clinic using an early version of what later evolved into the **DANCER** building system.
6. Refinement of the design; and construction of a demonstration house at Mt Hagen and five houses at Mul-Baiyer.
7. Testing program investigating a number of design options:
 - Testing to failure full- scale purlin/truss/stud/bearer assemblies, observing the progressing failure of various components.
 - Testing to failure five different apex connections.
 - Testing to failure a sample of typical nailed connections.
8. Design and construction of Kumbereta High School house.
9. Based on the lessons learned at each of these stages, final refinement of the design, design software, and details.
10. Preparation of this comprehensive Manual and training material.

Description of Test Program

The testing program consisted of:

1. Testing to failure five Nailed Joint Connections.
2. Testing to failure four full-scale Purlin/Truss/Stud/Bearer Assemblies (two different timber sections), observing the progressing failure of various components.
3. Testing to failure five types of apex connections.

Materials use for Test Specimens

Materials Source

All principal materials were purchased from Bunnings Warehouse, West Gosford.

Sourcing from one large supplier was done intentionally to minimise (to a significant degree) the variability that could result from sourcing from several smaller suppliers. Although not a valid practice in prototype testing program, this is an important consideration in a product development program.

Additional variability in materials properties, which results from sourcing materials for particular buildings from various suppliers, is accounted for in the capacity reduction factors (ϕ) specified in AS 1720.1.

Because of unplanned extensions to the testing program, three separate purchases were made. Although they were supposed to be identical, the second and third purchases appeared (anecdotally) to be a little more brittle than the first.

- a) The first purchase covered the four trusses T70-1, T90-1, T90-2 and T90-3 (together with the associated, purlins, studs, double bearers), Apex Connection B and the nailed specimens, N1 to N5.
- b) The second purchase covered Apex Connections A1, A2, A3, B and C.
- c) The third purchase covered Apex Connection D.

Timber Specification

To minimise variability in the tests, all materials were MGP10 treated pine from a single source.

MGP10 was chosen because it is at the lower end of the strength and joint group spectra that are likely to be present in real buildings. For example, MGP10, with a characteristic bending capacity 17 MPa, approximates F7 with a characteristic bending capacity 18 MPa.

In other words, the timber for testing was selected to be at the lower end of the strength spectrum, but with the minimum variability.

Considering the points above, the selection of MGP10 treated pine for the testing program should not be interpreted as a recommendation that it necessarily be used for the design of particular buildings.

Bolt Specification

Bolts were M12 x 150 mm, 4/4 galvanised with galvanised flat washers under both the bolt head and the nut, except in Apex Connection D, where the bolt was M16 x 150 mm.

Nail Specification

Nails for Trusses T70-1, T90-1, T90-2, T90-3 and Apex Connection B were 75 x 3.75 ϕ bright nails.

Nails for Nailed Connections N1 to N5 and Apex Connections B, A1, A2, A3, C and D were 75 x 3.75 ϕ galvanized nails.

Timber Member Dimensions

With the exception truss T70-1 and the double bearers (which provide bottom anchorage), all tested components were fabricated from 90 x 35 MGP10.

One truss (T70-1) was fabricated from 70 x 45 MGP10.

The double bearers were manufactured from 190 x 45 MGP10.

Nailed Joint Connection Tests

Details

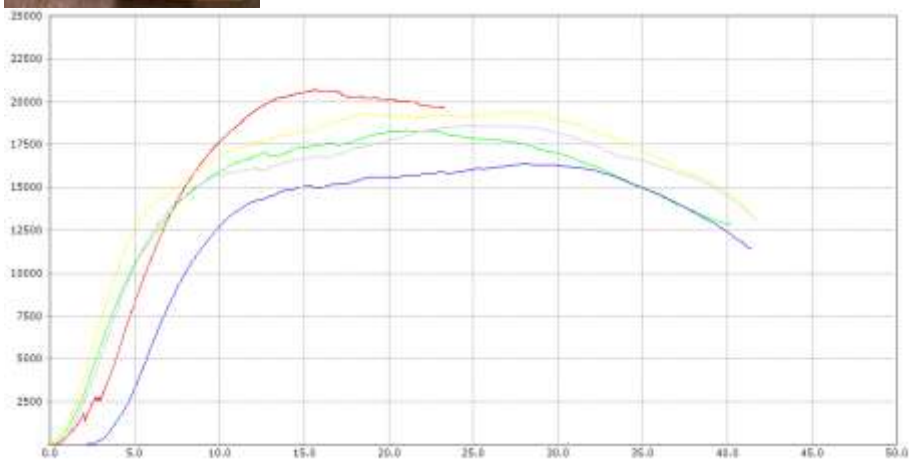
Five 10-nail Tee Joint shear specimens, each consisting of 3 / 90 x 35 MGP10 members, one sandwiched between the other two and secured with 5 / 75 x 3.75φ galvanized nails from each side, were tested with the nails in shear.

Fabrication and Testing

Fabricated 14/6/17 and tested 16/6/17 at Smithfield.

Failure

The mean ultimate capacity of the nails in single shear was 1.87 kN per nail.



Tests of 10-Nail Joints

Date 16/06/2017

Location Mahaffey Associates, Unit 8, 108-110 Percivale Street, Smithfield NSW 2164

Tee-shaped triplets from 3 / 90 x 35 MGP10.

10 / 75 x 3.76 galvanized nails in single longitudinal and transverse shear (5 on each side)

1. Ultimate capacities are at very high deflections.
2. Ultimate capacities are for uniform shear across 10 nails (5 nails from each side).

Ultimate Shear Capacities	Test No	Ultimate shear capacity 10 nails		Deflection at Ultimate	
	N1	20.7	kN	16	mm
	N2	18.3	kN	21	mm
	N3	16.4	kN	23	mm
	N4	19.4	kN	27	mm
	N5	18.6	kN	25	mm
Mean ultimate shear capacity of 10 nails	Mean	18.67	kN		
Number of nails in shear		10	kN		
Mean ultimate shear capacity of each nail		1.87	kN		

Full-scale Purlin/Truss/Stud/Bearer Assembly Tests

Details

Pairs of **DANCER** Purlin/Truss/Stud/Bearer systems were positioned side-by-side 2.7 metres apart and connected by timber purlins (on edge). They were then loaded in the upwards direction load through a loading truss by.

Fabrication and Testing

Fabricated 5/4/17 and tested 7/4/17 at Wamberal.

Details

Four full-scale Purlin/Truss/Stud/Bearer specimens were constructed and tested as follows:

- Truss T70-1 consisted of 70 x 45 MGP10 **DANCER** Trusses and Anchorage Studs, bolted to Double Bearers by 2 M12 bolts at each truss/stud connection and each stud/bearer connection. The truss halves were connected at top and bottom chords by nailed splices;
- Truss T90-1 consisted of 90 x 45 MGP10 **DANCER** Trusses and Anchorage Studs, bolted to Double Bearers by 2 M12 bolts at each truss/stud connection and each stud/bearer connection. The truss halves were connected at top and bottom chords by nailed splices.
- The two trusses were positioned 2.7 m apart and connected by 90 x 35 MGP10 purlins-on-edge, nailed to each truss by 4 / 75 x 3.75φ bright nails to the extended diagonal lacing members.

- A loading truss was positioned midway between the two loaded trusses on two jacks (at the stud positioned) to push upwards against the purlins. The loading truss was significantly strengthened by sheet bracing to minimize its deflection.



Exploded View of the Typical Apex of Trusses
90-1, 90-2, 90-3 Before Assembly



Two Test Trusses Pushed
Up By Loading Truss

Equipment

The following equipment was used:

- a. Two 5 tonne hydraulic jacks, connected in parallel to a hand pump.
- b. One load cell.
- c. Data logger.
- d. Two timber jack supports.
- e. One central "strong" loading truss
- f. Support framing

Loading Runs

Run 1: In the purlin nearest to the stud (P2) and the eaves purlin (P1), the four nails securing one end of the purlins began to loosen at a total load of 12 KN and pulled out of the extended stud at a total load of 22 KN.

Run 2: The failed purlins were then secured and Trusses T70-1 and T90-1 were both loaded. The run was terminated at a total load of 14 KN.

Run 3: Trusses T70-1 and T90-1 were both subject to loading at the apex, and T70-1 failed at 9.9 kN.

Run 4: Trusses T90-1 was subject to loading at the apex, and had not failed when the test was terminated at 12 kN total load (at the apex).

Deflection and Loads for Load Runs 1 to 4 for T70-1 and T90-1

Deflection at centreline of truss							
	Run 1		Run 2		Run 3		Run 4
Load Truss	Truss 70-1	Truss 90-1	Truss 70-1	Truss 90-1	Truss 70-1	Truss 90-1	Truss 90-1
kN	mm	mm	mm	mm	mm	mm	mm
1.0							
2.0							
3.0	0.8		1.2	1.2	7.0	3.2	4.6
4.0	1.3	1.3	2.0	1.9	10.4	5.3	6.5
5.0	2.0	1.7	2.7	2.3	12.1	6.1	6.6
6.0	2.6	2.1	3.5	2.6	13.9	6.9	11.0
7.0	3.8	2.4	4.3	2.9	18.2	9.3	13.1
8.0	4.5	2.8	5.2	3.3	22.1	11.3	15.1
9.0	5.2	3.2	5.8	3.4	30.2	12.7	17.1
10.0	5.9	3.7	6.5	4.8	61.0	18.5	19.5
11.0	6.6	4.4	7.4	5.3			23.0
12.0	7.4	4.8	8.2				28.0
13.0	8.3	5.4	9.1				
14.0	8.2	6.3	10.1				
15.0	10.2	6.9					
16.0	10.9	7.5					
17.0	11.8	8.4					
18.0	12.9	9.0					
19.0	14.8	10.4					
20.0	16.8	11.5					
21.0	20.9	13.1					

The deflection of Truss T70-1(70 x 45 MGP10 members) was at all times significantly greater than the deflection of Truss T90-1 (90 x 35 MGP10 members).

Effects of Truss Deflection During Test

During the loading of the central loading truss, initially a uniform vertical uplift was applied through the purlins to the two loaded trusses, as was intended.

However, as the test progressed and the load increased, the two loaded trusses deflected significantly at the centre (relative to the very small deflections at the stud supports). This had the effect of causing the applied load to shed towards the studs.

Visual evidence of this phenomenon was provided by the purlins closest to the studs exhibiting the greatest deflection, the next closest purlins exhibiting the next greatest deflection, and so on until the purlins closest to the apex exhibited the least deflection.

This infers that the purlins closest to the studs experienced the greatest load, the next closest purlins experienced the next greatest load, and so on until the purlins closest to the apex experienced the least load.

For the following analysis, it is assumed that 80% of the loading truss stud reaction is applied through the first purlins and each side for total loads in excess of 10 kN (5 kN reaction per stud)

Nailed Purlin Connection

Failure of the nails connecting the purlin closest to the stud to the extended lacing occurred at:

- a total applied load of 15.0 kN at each end of the loading truss;
- corresponding to 12.0 kN point load at the centre of the first purlin;
- corresponding to 6.0 kN at nailed at each end of the purlin, where it fixed to the and the lacing.

Each nailed connection consisted of 4 / 75 x 3.75φ bright nails.

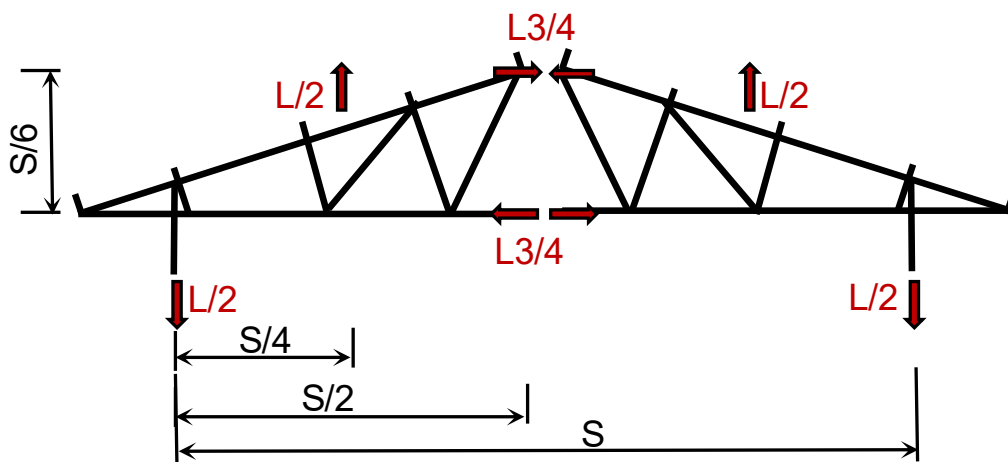
Apex Connection Tests

Based on the outcome of the full-scale truss tests, it was determined that improvement of the apex connection was required.

Five possible arrangements were tested.

- Trusses 90-1, 90-2 and 90-3 (with nailed apexes) were joined successively back-to-back in a horizontal position (joined at the studs) and pushed apart by a ram at the apex. These tests were performed in the Wamberal workshop.
- Isolated Apex Connections, A (three specimens), B (one specimen), C (one specimen) and D (one specimen) were constructed and tested in the Smithfield laboratory.

The tension in the top chord at the apex splice (and compression in the bottom chord splice) approximately equal 0.75 times the total uplift load. i.e. 1.5 times the reaction in the studs.



A more accurate analysis of the standard 5.7 m **DANCER** Building System geometry (accounting for the distance between the top and bottom chord bolts at the studs) indicates that the tension in the top chord apex connection (and compression in the bottom chord splice connection) is 0.70 (not 0.75) times the total uplift load. i.e. 1.4 times the reaction in the studs. This is the basis to the loading in the apex tests.

Trusses 90-1, 90-2, 90-3 Loaded at the Apex

Do not use this detail

Details

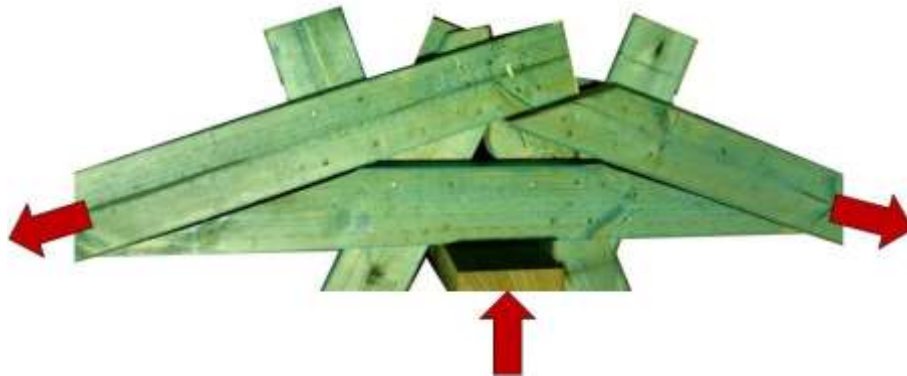
For Runs 5, 6 and 7, Trusses 90-1, 90-2, 90-3 were each laid in pairs in a horizontal position, joined at the ends by common studs and loaded by jacking apart at the apexes. Although tested under different conditions from the other apex connection tests (reported below) the test is essentially similar, and the results may be considered together with the apex connection tests. Trusses 90-1, 90-2, 90-3 consisted of 90 x 35 MGP10 members, joined as shown at the apex by lapping the chords and nailing as shown. Apex joint, 2 x 5 / 75 x 3.75φ galvanized nails in each lapped top chord with spacer. Two nailed collar ties, 4 / 75 x 3.75φ galvanized nails in each tie at each lacing and purlin cleat.

Failure

Vertical Load Capacity:	Truss 90-1	7/4/17	Run 7	13.81	kN
	Truss 90-2	7/4/17	Run 6	13.80	kN
	<u>Truss 90-3</u>	7/4/17	Run 5	<u>12.48</u>	<u>kN</u>
	Mean			13.8	kN

Fabrication and Testing:

Fabricated 5/4/17 Tested 7/4/17 at Wamberal.



Apex of Trusses 90-1, 90-2, 90-3 Arrangement Showing Directions of Loads (Runs 5, 6, 7)



Exploded View of the Typical Apex of Trusses
90-1, 90-2, 90-3 Before Assembly



Two Test Trusses Being
Pushed Apart

Apex Connection A

Do not use this detail

Details

90 x 35 MGP10

Apex joint, 3 / 75 x 3.75φ galvanized nails in each lapped top chord with king post.

One bolted and nailed collar tie, 1 / M12 and 2 x 4 / 75 x 3.75φ galvanized nails in each end of each tie plus at 2 x 4 / 75 x 3.75φ galvanized nails in each lacing.

Fabrication and Testing

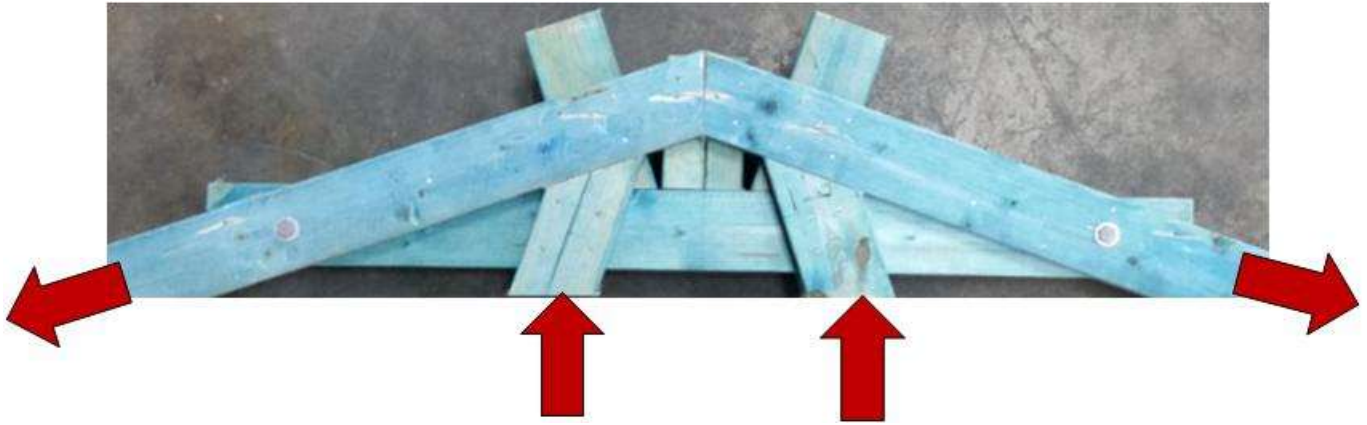
Fabricated 14/6/17 and tested 16/6/17 at Smithfield.

Failure

Ultimate failure was assumed when the collar tie timber failed at the nails due to in-plane moment. This then caused timber failure at the bolts. This occurred in all three specimens at approximately the same load (12 kN) and at similar deflections (41 to 54 mm).

Vertical Load Capacity:

A1	13.40 kN at a deflection of 45.1 mm
A2	10.90 kN at a deflection of 54.2 mm
<u>A3</u>	<u>11.60 kN</u> at a deflection of 41.1 mm
Mean	12.0 kN



Apex Connection B

Do not use this detail

Details

90 x 35 MGP10

Apex joint, M12 bolt, lapped top chords with king post. Two nailed collar ties, 4 / 75 x 3.75φ galvanized nails in each tie at each lacing and purlin cleat.

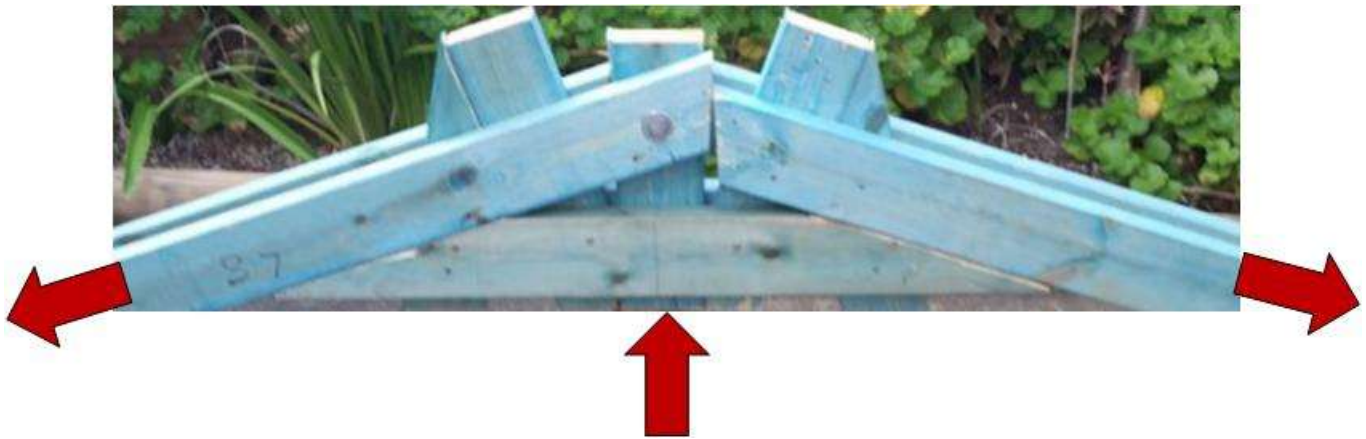
Fabrication and Testing

Fabricated 5/6/17 and tested 16/6/17 at Smithfield.

Failure

There had been no significant failure when the test terminated due to the ram reaching its limit of movement. This provides reasonable capacity, although the detail is complicated.

Vertical Load Capacity in excess of 21.1 kN



Apex Connection C

Do not use this detail

Details

90 x 35 MGP10

Apex joint consisted of one M12 bolt, tongue and clevis joint. No collar tie.

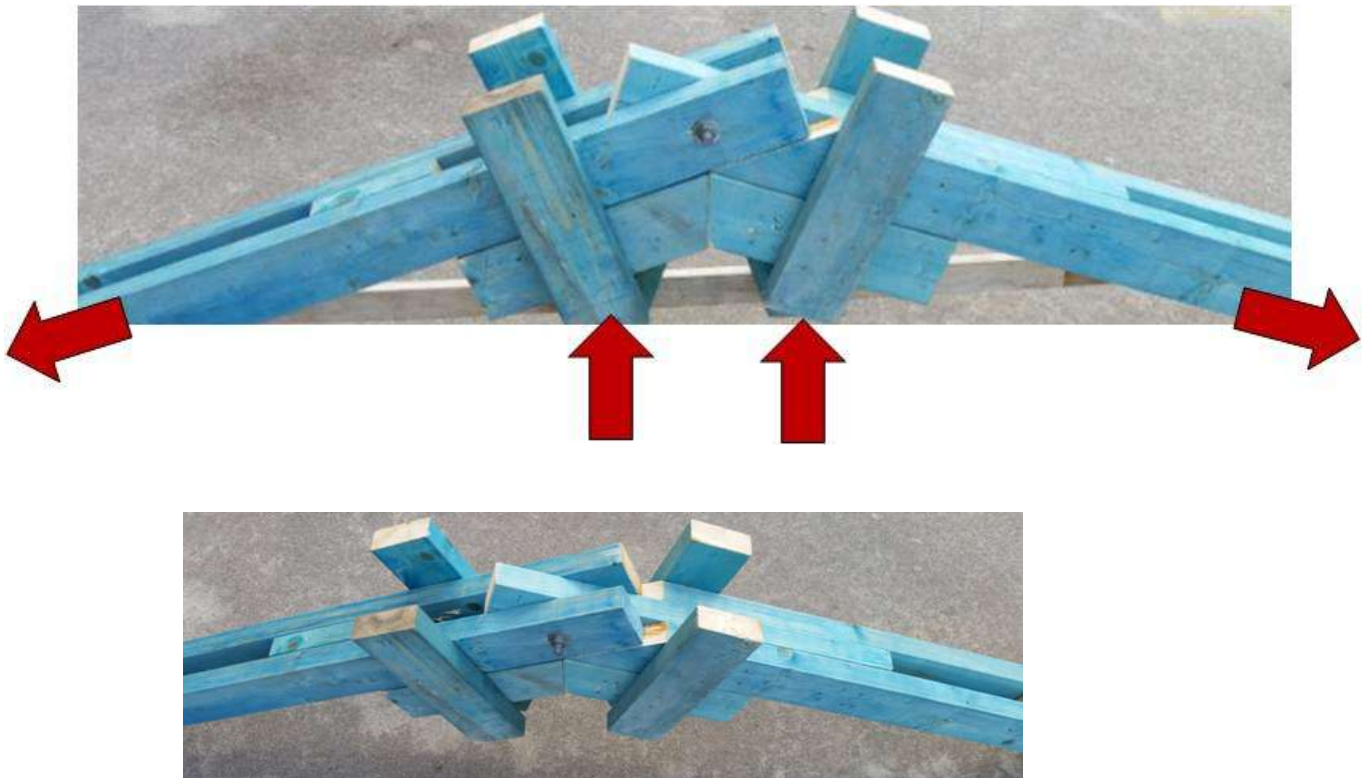
Fabrication and Testing

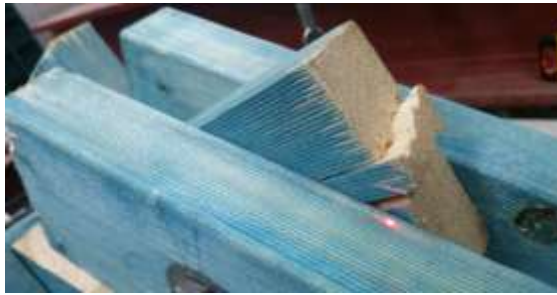
Fabricated 21/6/17 and tested 16/6/17 at Smithfield.

Failure

Timber longitudinal double shear failure at bolt. This is the simplest detail, although the fixing of the first purlin is complicated.

Vertical Load Capacity 14.0 kN when the timber in front of bolt failed in longitudinal shear.





Apex Connection D

This is the detail that is recommended for the DANCER Truss System

Details

90 x 35 MGP10

The apex joint consisted of 1 / M16 bolt, lapped top chords with a king post.

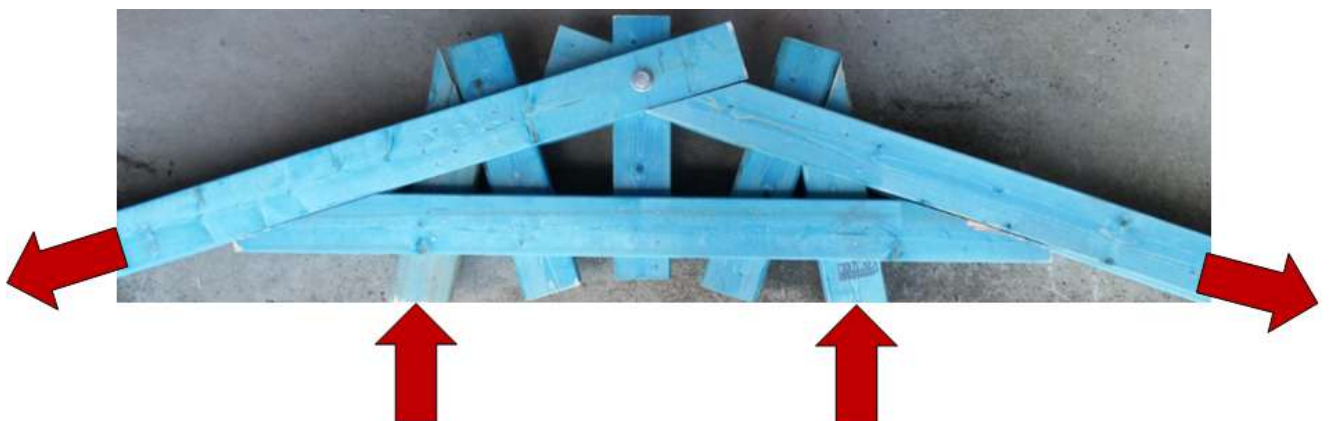
Two nailed collar ties, each fixed by 4 / 75 x 3.75φ galvanized nails in each tie at each loaded lacing member and unloaded and purlin cleat.

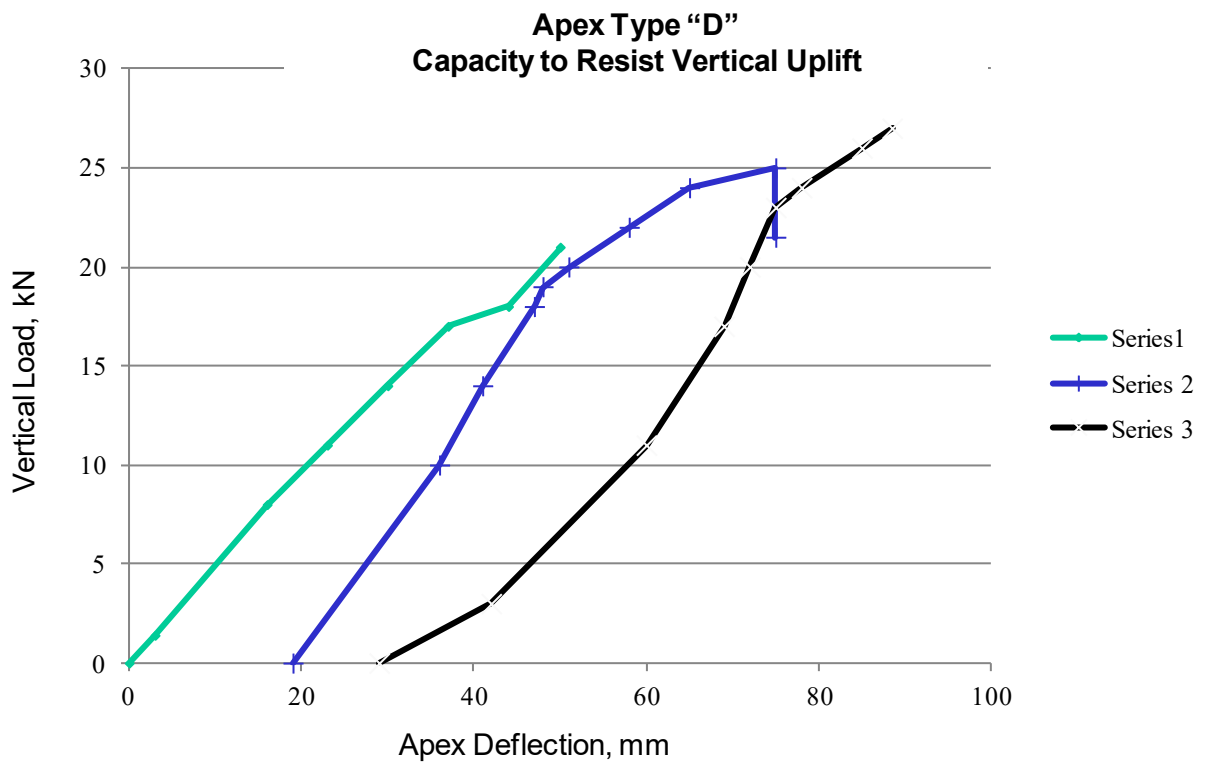
Fabrication and Testing

Fabricated 14/9/17 and tested 18/9/17 at Smithfield.

Failure

Ultimate failure occurred when the far-side collar tie bending failure. The ear-side collar tie split but still transmitted load. The M16 bolted connection rotated a little, with the washer compressing the timber, but was still transmitting load. Refer to the following detailed description.





1. Loads were applied evenly to the two diagonal lacing member stubs in the vertical direction, upwards positive.

2. Deflection of the apex was measured vertically, upwards positive.
3. Due to limited travel of the ram, load was applied in three separate series, the ram packing being adjusted twice, (between Series 1 and 2, and between Series 2 and 3)
4. In Load Series 1, no failure had occurred at 21 kN, when the ram reached its limit of travel. When the load was reduced to zero, a permanent deflection of 19 mm remained. This is probably due to the closing of some gaps between mating timber surfaces and bending of the bolts at the chord supports.
5. In Load Series 2, no failure had occurred at 25 kN when the ram reached its limit of travel. At a load 24 kN, horizontal cracking in the near-side collar tie was initiated and at 25 kN the cracking became more severe, although the load carrying ability remained. The load was maintained for a period in excess of 5 minutes. During this time, a further small creep deflection caused the applied load to reduce and stabilise at 21.5 kN. When the load was finally reduced to zero, there remained a permanent deflection of 29 mm, i.e. an additional 10 mm had occurred during Load Series 2 and the during period when the load was maintained at 21.5 kN.
6. In Load Series 3, bending rupture of the far-side collar tie occurred at 27 kN, causing resistance to diminish significantly. This was considered to be the ultimate failure capacity of the connection.
7. When the tested were terminate, the far-side collar tie had ruptured in bending (ultimate failure), the near-side collar tie had cracked significantly but still transmitted load (serviceability failure), the M16 bolted connection has rotated noticeably due to the washer compressing the timber (serviceability failure). One of the loaded lacing member stubs had split before the commencement of the test, but remained intact and transmitting load throughout the test.

Summary of Apex Connection Tests

Test detail, timber type and description of apex connection and collar tie connection	Specimen	Test	Measured vertical capacity kN	Vertical Deflection mm	Notes
70 x 45 MGP10. <u>Full truss test</u> . Apex joint, 2 x 4 / 75 x 3.75φ galv nails in each lapped top chord with spacer. Two nailed collar ties, 4 / 75 x 3.75φ galv nails in each tie at each lacing and purlin cleat.	Truss 70-1	7/4/17 #1, #2	9.9	Not recorded	Premature failure of trusses fabricated from 70 x 45 MGP10.
90 x 35 MGP10. <u>Full truss test</u> . Apex joint, 2 x 5 / 75 x 3.75φ galv nails in each lapped top chord with spacer. Two nailed collar ties, 4 / 75 x 3.75φ galv nails in each tie at each lacing and purlin cleat.	Truss 90-1	7/4/17	12.51	Not recorded	Nailed apex connection failure.
	Truss 90-2	7/4/17	12.50		
	Truss 90-3	7/4/17	12.48		
	Mean 90		12.5		
90 x 35 MGP10. Apex joint, 3 / 75 x 3.75φ galv nails in each lapped top chord with king post. One bolted and nailed collar tie, 1 / M12 and 2 x 4 / 75 x 3.75φ galv nails in each end of each tie plus at 2 x 4 / 75 x 3.75φ galv nails in each lacing.	A1		13.40	45.1	Ultimate failure was assumed when the collar tie timber failed at the nails due to in-plane moment. This then caused timber failure at the bolts.
	A2		10.90	54.2	
	A3		11.60	41.1	
	Mean A		12.0		
90 x 35 MGP10. Apex joint, M12 bolt, lapped top chords with king post. Two nailed collar ties, 4 / 75 x 3.75φ galv nails in each tie at each lacing and purlin cleat.	B		21.8	35.4	No significant failure when the test terminated. This provides the best resistance, although the detail is complicated.
90 x 35 MGP10. Apex joint, M12 bolt, tongue and clevis joint. No collar tie.	C		14.0	48.9	Timber longitudinal double shear failure at bolt. This is the simplest detail, although the fixing of the first purlin is complicated.
90 x 35 MGP10. Apex joint, 1/M16 bolt, lapped top chords with king post. Two nailed collar ties, 4 / 75 x 3.75φ galv nails in each tie at each lacing and purlin cleat.	D		27.0	89.0	Far-side collar tie bending failure, near-side collar tie cracked but still transmitted load, M16 bolted connection rotated (washer compressing the timber).

Interpretation of Tests

1. The standard **DANCER** designs in this manual are based on **90 x 45 F7** Softwood. Although other sizes and grades of timber are sometimes available, the supply and gradings are not necessarily consistently reliable.
2. The tested **DANCER** Trusses fabricated from 90 x 35 Softwood have approximately 26% greater potential resistance to uplift than the tested **DANCER** Trusses fabricated from 70 x 45 Softwood.

Justification

The mean resistance of Truss Tests T90-1, T90-2 and T90-3 (13.8 kN) is 26% higher than the recorded resistance of Truss Test 70.1 (9.9 kN).

3. 90 x 45 members are significantly stronger than 90 x 35 members and 70 x 45 members which have been used in the testing program.

Area

$$90 \times 45 \text{ mm} = 4,050 \text{ mm}^2$$

$$90 \times 35 \text{ mm} = 3,150 \text{ mm}^2 \quad (1.29) \qquad 70 \times 45 \text{ mm} = 3,150 \text{ mm}^2 \quad (1.29)$$

$$100 \times 38 \text{ mm} = 3,800 \text{ mm}^2 \quad (1.07) \qquad 75 \times 50 \text{ mm} = 3,750 \text{ mm}^2 \quad (1.08)$$

Section Modulus

$$\text{Section modulus} \quad 45 \times 90^2 / 6 = 60,750 \text{ mm}^3$$

$$\text{Section modulus} \quad 35 \times 90^2 / 6 = 47,250 \text{ mm}^3 \qquad 70 \times 45^2 / 6 = 36,750 \text{ mm}^3$$

$$\text{Section modulus} \quad 100 \times 38^2 / 6 = 63,333 \text{ mm}^3 \qquad 75 \times 50^2 / 6 = 46,875 \text{ mm}^3$$

4. **DANCER** Trusses fabricated from 90 x 45 Softwood have up to 29% greater potential resistance to uplift than the tested **DANCER** Trusses fabricated from 90 x 35 Softwood.

Justification

This is an approximation based on the relative areas of the two sections.

5. Apex Connection A will not be used.

It is inadvisable to provide additional nails in bolted joints, particularly those subject to rotation due to applied bending moment.

Justification

Apex Connection Tests A1, A2 and A3 consisted of 90 x 35 MGP10 members, one collar tie (with M12 bolt and 2 x 4 / 75 x 3.75φ galvanized nails) in each end of each tie plus at 2 x 4 / 75 x 3.75φ galvanized nails in each lacing. In addition, the apex joint was nailed with 3 / 75 x 3.75φ galvanized nails in each lapped top chord with king post. Ultimate failure occurred when the collar tie timber failed at the nails due to in-plane moment. This then caused timber failure at the bolts.

6. Apex Connection “B” will not be used.

Justification

Apex Connection Tests B consisted of 90 x 35 MGP10 members, apex joint of one M12 bolt, lapped top chords with king post. Two nailed collar ties, 4 / 75 x 3.75φ galvanized nails in each tie at each lacing and purlin cleat.

Apex Connection Test B did not fail, although the test was terminated at a vertical load of 21.8 kN and a deflection of 35 mm, when the ram reached its limit of travel.

Although the connection did not fail, the bolt clearance parallel to the grain did not meet the detailing requirements of AS 1720.1.

7. Apex Connection “C” will not be used.

Justification

Apex Connection Tests C consisted of 90 x 35 MGP10 members, apex joint of 1 / M12 bolt, tongue and clevis joint, with no collar tie. The timber of the tongue failed in longitudinal double shear failure at bolt.

Although this is a simple apex detail, the fixing of the first purlin is necessarily complicated.

8. Apex Connection “D” will be used with 1 / M12 and not less than 90 x 45 F7 softwood.

Justification

Apex Connection Tests C consisted of 90 x 35 MGP10 members, apex joint with 1 / M16 and a double collar tie nailed at the lacing stub and at the purlin cleat member.

The far-side collar tie failed in bending, while the near-side collar tie split, but still transmitted load. The M16 bolted connection twisted a little (with the washer compressing the softwood).

For high wind uplift, the use of hardwood will improve the bending capacity of the collar ties (the members that failed in the test).

9. AS 1720.1 will be used for the design and detailing of the **DANCER** Building System.

Justification

Based on the following analysis, the test results are consistent with design based on AS 1720.1.

- (a) The tests have been used for product development and to provide a “reality check” of designs that are based on AS 1720.1.
- (b) The tests have not been used for design based on prototype testing. Therefore, the method set out in AS/NZS 1170.0 Appendix B is not applicable.
- (c) Based on Points (a) and (b), the mean of the test results that are available results will be considered to be the “best estimate”. This infers a 50% confidence limit, not the 75% confidence limit implicit in the reduction factors set out in AS/NZS 1170.0 Table B1.
- (d) It is assumed that:
 - the coefficient of variation of joints in timber approximates 30%
 - the joint capacities follow a log-normal (or normal) distribution

- the capacity reduction factor from AS 1720.1 is 0.85
- a “load duration on laterally loaded joints” factor, k_1 , of 1.14 is applicable.

- (e) The relationship between mean strength and the design value for connections in timber is as follows:

$$\begin{aligned}\phi Q &= \phi k_1 Q [1 - 1.65 V] \\ &= 0.85 \times 1.14 Q [1 - 1.65 \times 0.3] \\ &= 0.49 Q\end{aligned}$$

i.e. the factored design capacity would be approximately half the mean of the tested strengths.

- (f) In trusses with a top chord slope of 1 in 3, subject to a vertical load (applied through purlins), the horizontal load in the top chord (at the apex connection) and in the bottom chord (at the splice) is 3 times the vertical load at each stud. i.e. .1.4 times the total vertical load applied to the truss. (See previous explanation)

- (g) In the Apex Connection test with a top chord slope of 1 in 3, subject to a vertical load (applied through the lacing members), the horizontal load in the top chord (at the apex connection) is 1.5 times the total vertical load applied on both lacing member stubs.

- (h) The following analysis applies to in M12 bolt in 90 x 35 MGP10 timber in Apex Connection C. It demonstrates that the tested samples behaved significantly better than AS 1720.1 would indicate.

- (i) The total vertical test load of 14 kN, corresponds to a load in the connection of 21 kN. A mean strength (one specimen) of 21 kN corresponds to a factored design load of 10.5 kN.
- (ii) Based on AS 1720.1, the capacity of a single M12 bolt, parallel to the grain in 35 mm seasoned softwood is:
 - 5.9 kN for Joint Group JD5 (56% of the value the test suggests); or
 - 7.5 kN for Joint Group JD4 (71% of the value the test suggests).
- (iii) The timber used in the test is more likely to be JD4 than JD5.

- (i) The following analysis applies to 10 / 75 x 3.75φ galvanized nails, shear, side grain in 90 x 35 MGP10 timber Tee pieces in Nailed Joint Connection Tests.

- (i) A mean strength (five specimens) of 18.67 kN corresponds to a factored design load of 9.33 kN.
- (ii) Based on AS 1720.1, the capacity of 10 / 75 x 3.75φ galvanized nails, shear, side grain in 90 x 35 MGP10 timber is:
 - 8.87 kN in Joint Group JD5 (95% of the value the test suggests); or
 - 10.76 kN in Joint Group JD4 (116% of the value the test suggests).The timber used in the test could be either JD4 or JD5

- (j) The following analysis applies to 4 / 75 x 3.75φ bright nails, shear, side grain in 90 x 35 MGP10 timber purlins and extended lacing.
- (i) Failure of the nails connecting the purlin closest to the stud to the extended lacing occurred at a total applied load of 15.0 kN at each end of the loading truss, corresponding to 12.0 kN point load at the centre of the first purlin and 6.0 kN at the nailed connection. A test strength of 6.0 kN corresponds to a factored design load of 3.0 kN.
 - (ii) Based on AS 1720.1, the design capacity of 4 / 75 x 3.75φ galvanized nails, shear, side grain in 90 x 35 MGP10 timber is:
 - 3.55 kN in Joint Group JD5 (18% of the value the test suggests); or
 - 4.30 kN in Joint Group JD4 (143% of the value the test suggests).

Given the restricted geometry of the connection and the inability to achieve the AS 1720.1 edge distances, it is recommended that the maximum number of nails at each purlin connection be limited to three, and the AS 1730.1 design capacity for nails in shear in the side grain be discounted by 25%.

Based on 75% of the AS 1720.1 value, the design capacities are:

- $0.75 \times 3.30 = 2.47$ kN shear for 3 / 75 x 3.15φ galvanized nails , side grain in Strength Group J2 hardwood;
- $0.75 \times 4.51 = 3.38$ kN shear for 3 / 75 x 3.75φ galvanized nails , side grain in Strength Group J2 hardwood;

- $0.75 \times 2.35 = 1.76$ kN shear for 3 / 75 x 3.15φ galvanized nails , side grain in Strength Group JD4 softwood;
- $0.75 \times 2.27 = 1.70$ kN shear for 3 / 75 x 3.75φ galvanized nails, side grain in Strength Group JD4 softwood.