Government of **Western Australia**
Department of **Mines, Industry Regulation and Safety**
Building and Energy

Industry Bulletin 121

Tie-down of timber framed sheet metal clad roofs to timber frame walls and beams

This bulletin provides information to builders, building surveyors, structural engineers, truss manufacturers and others involved in the specification, design and installation of timber truss and stick framed roofs supporting light weight sheet metal roofs in non-cyclonic areas in WA.

This bulletin is in response to recent investigations into the causes of a roof failure in Perth and other construction issues identified through Building and Energy's building audit program.

The aim of this bulletin is to highlight areas where improvements can be made to assist with ensuring roof construction meets the applicable building standards.

This bulletin focuses on timber roof truss tie-down through double top plates or ribbon plates, but is equally applicable to conventional stick framed roofs, and the installation of connections between metal battens and timber trusses or rafters.

Background

Building and Energy identified a deficiency in the chain of tie-down in both timber truss and conventional stick-framed roofs.

Timber trusses are typically:

- designed using a computer program to AS 1720.5 - Timber structures Part 5: Nail plated timber roof trusses;
- manufactured in a factory to AS 4446 - Manufacture of nailplate-jointed timber products; and
- delivered to site with the manufacturer's installation instructions.

They may also be supplied with all the necessary connectors such as framing anchors and fasteners (e.g. connector nails).

The installation instructions should specify the types of connectors required for each truss to top plate connection, the roof layout and bracing requirements and required tie-downs.

Generally, trusses span between the external walls and have a clearance above the internal walls. Therefore, the perimeter connections provide all the tie-down against design uplift forces. Unfortunately, this makes truss roofs particularly vulnerable to lifting off where the perimeter connections are inadequate.

Top chord bracing

Top chord bracing is critical during construction, particularly before the roof cladding is installed, and is part of the truss installation guidance provided by the truss manufacturer.

Bracing of timber truss top chords can be improved by ensuring that the bracing is installed in accordance with AS 4440 - Installation of nailplated timber roof trusses, or other suitable approved details, paying attention to the end fixing requirements installed at the heel (exterior wall location).

Aug 2019

Tie-down through double top plate (ribbon plates)

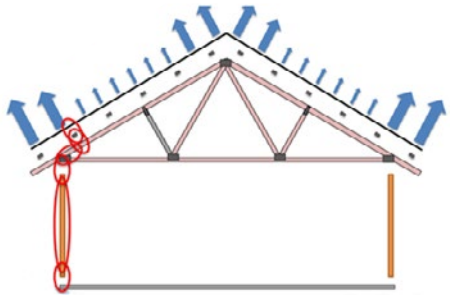


Figure 1 above, blue arrows indicate direction and relative magnitude of wind uplift, red ellipses indicate part of the tie-down 'chain'.

Building and Energy have identified a deficiency in the chain of tie-down through ribbon plates and double top plates:

- where ribbon plates (an extra timber member used as a packer on top of the top plate or beam to raise the level of the truss, so the bottom chord has the required clearance over the internal walls) have been installed (see Figures 2 and 3); and
- where either single or double top plates are installed on top of supporting timber beams such as verandah or alfresco beams.

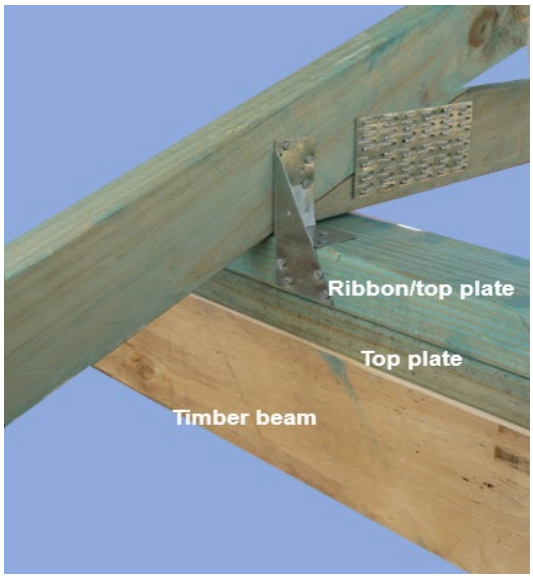


Figure 2 above shows a ribbon and top plate above a supporting timber beam. Note adequate tie-down between the truss and ribbon plate, however the chain of tie-down is not continued down into the timber beam. The tie-down system needs to ensure that it adequately ties all these elements together.

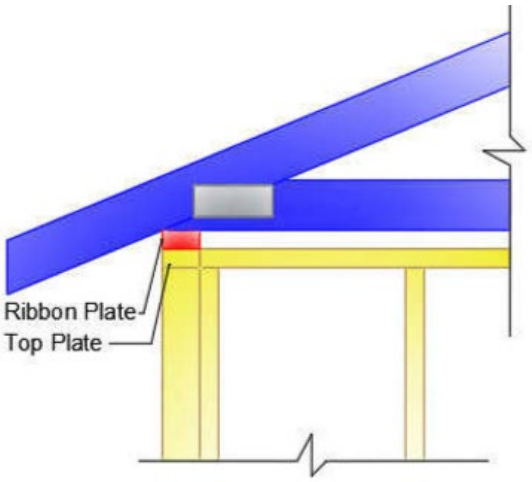


Figure 3 above shows a ribbon plate installed on top of a timber stud wall top plate to raise the level of the truss, so the bottom cord has the required clearance over the internal walls.

In many cases, ribbon plates are fastened to the top plates with only plain shank nails that are driven through both the ribbon and top plates. Failures have occurred where the trusses have been tied down to only the ribbon plate; the nails through the ribbon and top plates did not have sufficient capacity, and the trusses have lifted off the building under wind uplift; consequently, taking the ribbon plates with them.

These cases highlight the need for the truss tie-down to carry wind loads into the beams or timber wall frames rather than just the ribbon plate (see Figures 4 & 5 for examples of how this may be achieved)

To improve roof tie-down compliance, Building and Energy recommend that the chain of tie-down (refer Figure 1) be clearly detailed in the approved plans.

Suitable tie-down details could be obtained from the following sources:

- a suitably qualified and experienced structural engineer;
- applicable Australian Standards such as AS 1684.2 - Residential timber-framed construction; Part 2: Non-cyclonic areas e.g. Table 9.19;
- timber connector installation guidelines; and
- the truss manufacturer.

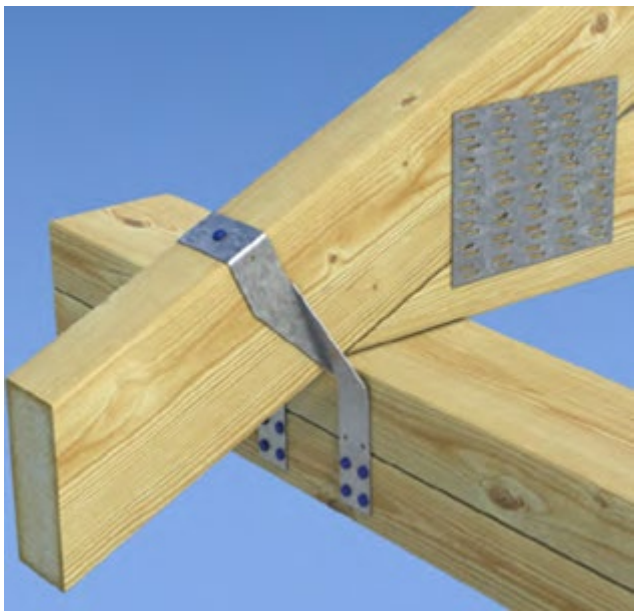


Figure 4 above shows an example of one type of an appropriate tie-down system for a timber truss that bypasses the ribbon plate and ties to the top plate. The top plate should be adequately tied down to the supporting studs (not shown). Other appropriate methods could include using a long multigrip or other suitable connectors that tie the ribbon plate and top plate together.

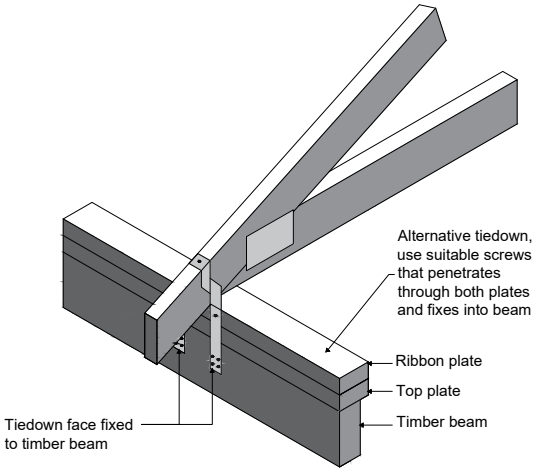


Figure 5 above gives an example of a face-fixed tie-down system that transfers the roof uplift load past the ribbon plate.

Alternatively, where the beam is to remain exposed, framing anchors could be used to connect the trusses to the ribbon plates provided a connector, such as No.14 Type 17 screws, carry the tie-down forces from the ribbon plate to the beam.

When driving screws into the top edge of the beam consideration should be given to the type and breadth of beam receiving the screw to determine if it will resist splitting.

The length, number and location of the screws as an appropriate tie-down system should be determined by a competent person and detailed in the documentation.

Installation of metal connectors

Engineering details reference Australian Standards such as AS 1684.2 and manufacturers' installation instructions typically detail the nailing configurations required for a connector to achieve its required capacity.

Building and Energy have frequently found the following issues regarding the installation of metal connectors:

- lower capacity machine driven nails have been installed instead of the hand driven connector nails specified in the manufacturer's installation guide;
- less connectors (nails or screws) than specified in the manufacturer's installation guide have been used;
- nails were spaced inappropriately i.e. spacing too large or nails grouped too closely together;
- manufacturer's installation instructions were not followed, which resulted in connector plates or straps with lower capacities than required being installed; and
- metal connectors were incorrectly orientated.

If the manufacturer's installation instructions for a metal connector are not complied with this may create a weak point in the chain of tie-down that could lead to a roof failure.

Building and Energy recommends that the tie-down system should be approved by an appropriately qualified and experienced person such as a structural engineer or truss manufacturer, and should be clearly detailed in the documentation.

Connector brackets should be fixed by suitably qualified and experienced persons in accordance with the manufacturer's installation instructions (derived by rigorous testing).

Metal batten to rafter connection

Building and Energy Industry Bulletins 49 and 117 warn against the use of nails to fix metal battens to timber rafters.

Building and Energy have seen the increasing use of hex-headed self-drilling screws to connect light gauge metal battens to timber trusses/rafters.

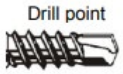
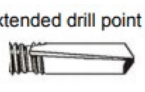
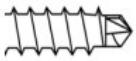
- There are a wide variety of hex-headed self-drilling screws available. However, hex-headed self-drilling screws designed for metal-to-metal connections are unlikely to achieve the required capacity when fixed to timber truss chords/rafters. This is because a metal to metal screw cuts a hole size closer to the outer screw diameter when compared to a timber screw. It also has a finer thread pitch, which means that less timber is gripped between the threads, which gives a lower capacity in timber than a timber screw. (A timber screw engages a larger plug of timber that is harder to pull out under uplift loads); and
- As metal screws have a finer thread pattern, if they are over-tightened, the screw threads break off the small plugs of timber between the threads, which can further reduce the capacity of the connection.

To be sure that the appropriate screws have been used for the metal batten to timber rafters or trusses:

- the builder could supply the correct screws for each job; or
- the work could be inspected by removing a few screws and checking for compliance before the roofing is fixed to the battens.

Table 1 below is based on Table 6.3 from NASH, and details some commonly available self-drilling screws and their recommended applications.

Table 1:
Suitability of screws for metal batten to timber connections

Suitability	Point Type	Features and Application
✗	 Drill point	A metal drill point used for fastening steel from 1.0 up to 5.0mm thick. **Not suitable** for connecting metal battens to timber rafters/trusses.
✗	 Extended drill point	An extended metal drill point used for steel up to 12.5mm thick. **Not suitable** for connecting metal battens to timber rafters/trusses.
	 Universal point	Universal points are designed for drilling into both timber and metal. Product performance varies greatly depending on the manufacturer and the combination of steel and timber the product is designed for. **Confirm suitability and capacity** with the manufacturer ensure appropriate screw length and gauge is selected.
✓	 Type 17	Type 17 point can be used for drilling through metal up to 0.75mm thick. The screw has a special long sharp point fluted to assist with insertion into timber. **Suitable** for connecting metal battens to timber rafters/trusses, ensure appropriate screw length and gauge selected.
✓	 Needle point	Needle point screws are used for a wide range of fastening to timber and can be used for steel less than 0.75mm thick. **Suitable** for connecting metal battens to timber rafters/trusses, ensure appropriate screw length and gauge is selected.

Recommendations for improvement

Building and Energy suggests implementing the following strategies to ensure that timber trusses and framed roof and wall structures are appropriately constructed:

- the truss layout should clearly detail the required connectors with type and number of fixings especially between the truss and top of the wall at all support points;
- the parties involved in the design and installation of trusses should confer to ensure that the tie-down details are appropriate for the site and construction method used;
- ensure the tie-down system includes details for the options of tie-down directly to the top of a wall or beam; or past ribbon plate to the top of a wall or beam;
- clearly detail how the top chord bracing is to be installed and fixed to the trusses;
- ensure that appropriate framing anchors, straps and connectors are specified in the documentation, and the installation is consistent with those details; and
- ensure that metal roof batten to timber truss/rafter connections are detailed and constructed as per the design documentation.

Further related information

Cyclone Testing Station Technical Report No 62
Static testing of batten connections at University of Western Australia.

Building and Energy General Inspection Report One: A General Inspection into Metal Roof Construction in Western Australia https://www.commerce.wa.gov.au/publications/general-inspection-report-one-general-inspection-metal-roof-construction

Checking roof compliance on site video
https://www.youtube.com/watch?v=Nv8KtXSVFSA

Industry Bulletin 117 – Improving tie-down of timber framed sheet metal clad roofs

Industry Bulletin 109 – J-Bolt (hook rod) tie-down systems

Industry Bulletin 93 – Documentation for timber framed roof construction

Industry Bulletin 49 – Connection of roof battens

Industry Bulletin 32 – Durability of roof tie down connector straps

Queensland Building Commission; Timber Queensland; Guidance on Use of Framing Anchors for Specific Tie-Down to Multiple Top Plates (Ribbon Plate Construction).
https://www.qbcc.qld.gov.au/sites/default/files/Timber_Qld_-_TDS_-_Framing_anchors_for_specific_tie_down_to_multiple_top_plates_-_ribbonplates_guide.pdf

Queensland Building Commission; Wind Tie-Down Connections Getting it Right.
https://www.qbcc.qld.gov.au/sites/default/files/Timber_Qld_-_TDS_-_Wind_tie_down_connections.pdf

National Association of Steel-Framed Housing (NASH) *Handbook: Design of Residential and Low-rise Steel Framing.*

Building and Energy | Department of Mines, Industry Regulation and Safety
1300 489 099

8.30am – 4.30pm
Level 1 Mason Bird Building
303 Sevenoaks Street (entrance Grose Avenue)
Cannington Western Australia 6107
M: **Locked Bag 100, East Perth WA 6892**
W: **www.dmirs.wa.gov.au/building-and-energy**
E: **be.info@dmirs.wa.gov.au**

Regional Offices

Goldfields/Esperance	(08) 9021 9494
Great Southern	(08) 9842 8366
Kimberley	(08) 9191 8400
Mid-West	(08) 9920 9800
North-West	(08) 9185 0900
South-West	(08) 9722 2888

National Relay Service: 13 36 77

Translating and Interpreting Service (TIS): 13 14 50

This publication is available in other formats on request to assist people with special needs.

DMIRSAUG19_6045