Understanding AS1684

Residential Timber Framed Construction

Tie-down example

Timber recycles carbon

TIMBER QUEENSLAND
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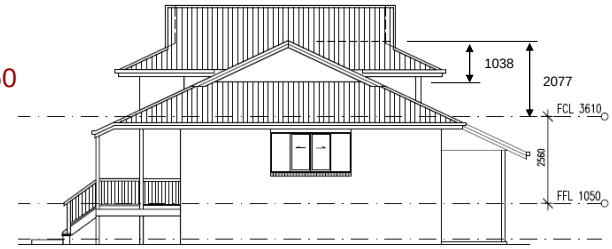
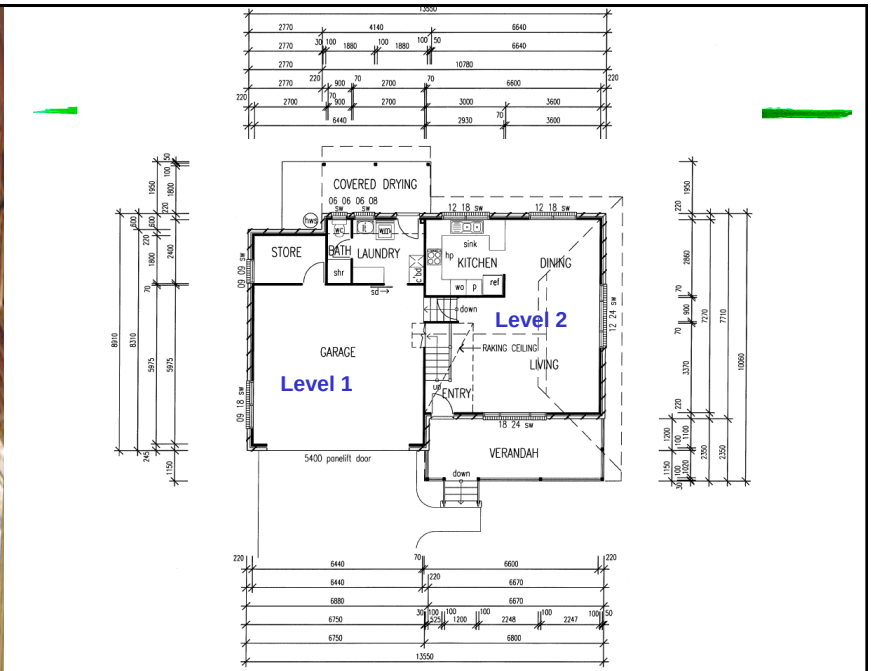
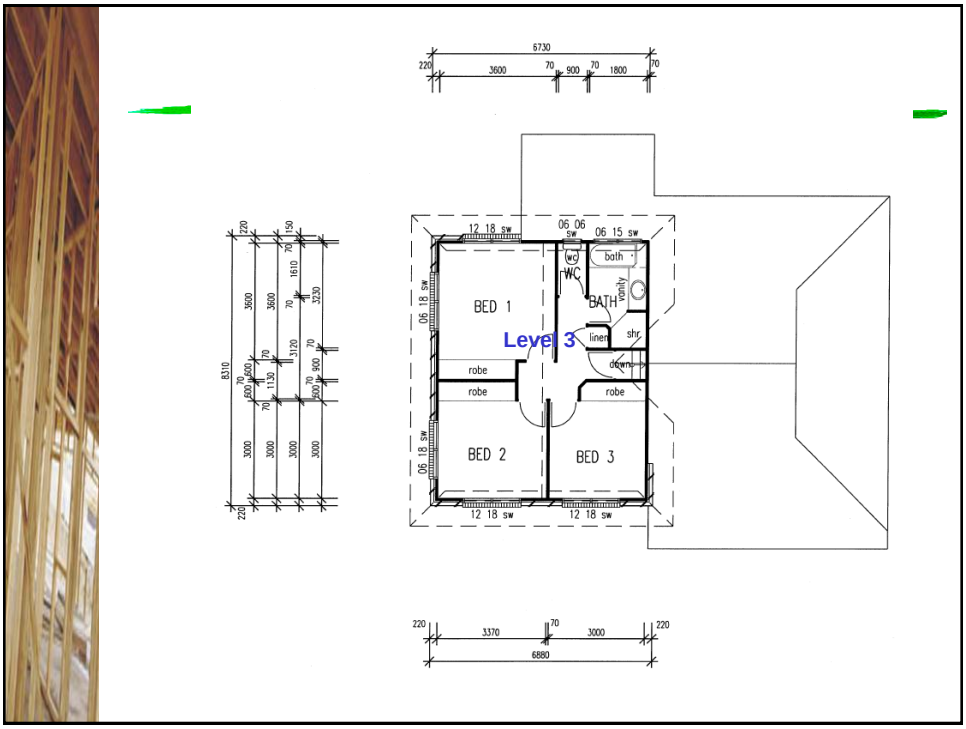
North elevation

- C2
- Split level
- Dutch gable roofs
- Ceiling height 2560
- Eaves 600mm
- Roof pitch 25°



East elevation





Tie - Down Design Process

General

Prior to starting the detailed determination of tie-down connections etc, it is recommended that familiarization with Clauses 9.1 (pg 156) to 9.5 (pg 163) be obtained.

These clauses include, but are not limited to topics such as:

- **Corrosion protection**
- **Washer sizes**
- **Joining of top plates and**
- **Nominal fixings etc**

For example: See Washer sizes - next

Tie - Down Design Process

Clause 9.2.4 Steel Washers (pg 157)

9.2.4 Steel washers

The size of steel washers shall be determined from Table 9.1.

Circular washers of equivalent thickness and with the same net bearing a permitted to carry the same full design loads. For thinner washers or washers net bearing areas, the design loads shall be reduced in proportion to the thickness and net bearing area, that is, less the hole diameter.

TABLE 9.1

STEEL WASHERS

Bolt or coach screw diameter (mm)	Washer size (mm)
M10 cup-head	Standard
M12 cup-head	Standard
M16 cup-head	Standard
M10 bolt or coach screw	38 × 38 × 2.0
M12 bolt or coach screw	50 × 50 × 3.0
M16 bolt or coach screw	65 × 65 × 5.0

Tie - Down Design Process (Clause 9.3)

1. Determine if specific tie-down required	**Table 9.2 (pg 161)**
2. Determine the wind uplift load width	**Clause 9.6.2 & Fig 9.5 (pg 163- 164)**
3. Determine the uplift pressure	**Table 9.5 (pg 165)**
4. Calculate the wind uplift force	**Clause 9.6.4 (pg165)**
5. Determine the Joint Group	**Table 9.15, Fig 9.6 (pg 175 – 176)**
6. Enter the appropriate design strength & select a suitable tie-down connection	**Tables 9.16 to 9.25 (pg 177 to 203)**
7. Determine shear force	**Clauses 9.7.5 & 9.7.6 (pg 204 & 211)**
8. Enter the appropriate design strength & select a suitable shear connection	**Tables 9.27 to 9.30 (pg 205 to 212)**

1. Determine if specific tie-down required

a) Use Tables 9.2 (uplift) and 9.3(shear) to determine if Nominal and additional Specific fixings are required.

TABLE 9.2

UPLIFT

Connection	Wind classification					
	C1		C2		C3	
	Sheet roof	Tile roof	Sheet roof	Tile roof	Sheet	Tile
Roof battens to rafters/trusses — within 1200 mm of edges — general area	S S	S S	S S	S S		
Single or upper storey rafters/trusses or wall frame to floor frame or slab	S	S	S	S		
Single or upper storey floor frame to supports	S	S	S	S		
Lower storey wall frame to floor frame or slab	S	S	S	S		
Lower storey floor frame to supports	S	S	S	S	S	S

N = nominal (minimum) connection only (refer to Clause 9.5)

S = specific connection may be required for uplift forces (refer to Clause 9.6)

Specific connections required

AS1684.3 p161

1. Determine if specific shear connections are required *Cont.*

TABLE 9.3

SHEAR

Connection	Wind classification		
	C1	C2	
Bottom plate to slab	N	N at 900 mm max. centres	N at 60
Joists to bearers	N	S	
Bearers to stumps	S	S	

N = nominal (minimum) connection only (see Clause 9.5)

S = specific connection may be required for shear forces (see Clauses 9.7.5 and 9.7.6)

Specific connections required

AS1684.3 p161

1. Determine if specific tie-down required *Cont.*

b) Determine Nominal Fixing requirements.
(Clause 9.5 & Table 9.4)

AS1684.3 p162/163

1. Determine if specific tie-down required *Cont.*

c) Determine Specific Tie-Down Requirements

In this example, specific tie-down connections will be determined for :

- roof batten to truss
- standard truss to top plate/floor frame or slab
- Dutch girder truss to floor frame
- tie-down at sides of openings
- floor frame to stumps/footings

Note: Not all tie-down connections required for the house will be covered by this worked example.

1. Determine if specific tie-down required *Cont.*

(*Roof battens to rafters/trusses)*

c) Determine Specific Tie-Down Requirements

The area to be held down via roof battens is calculated by multiplying the:

Batten Spacing x Tie - Down Spacing

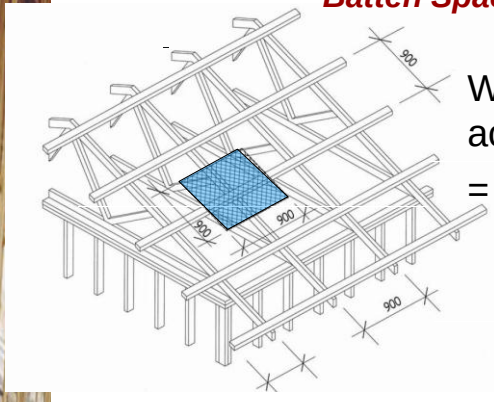
resulting in the area of roof acting on the Tie - Down connection at that point.

2. Determine the wind uplift load width/area

(*Roof battens to rafters/trusses)*

Wind uplift area =

Batten Spacing x Tie - Down Spacing



Wind uplift area of roof acting on batten tie-down:

= 0.9m x 0.9m = 0.81m²

NOTE: Whilst in this example the roof batten spacing has nominally been specified as 900mm, in high wind and cyclonic areas, manufacturers specifications for the sheet roofing may require closer batten spacing to ensure satisfactory performance of the sheeting.

Check manufacturers requirements

3. Determine the uplift pressure

(*Roof battens to rafters/trusses)*

Roof battens fall into 2 categories -

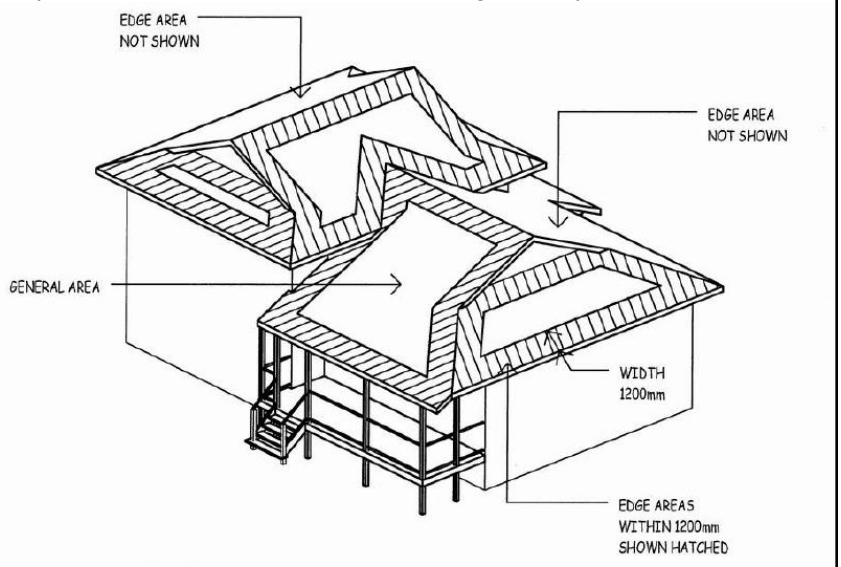
1. Within 1200 mm of edges

2. General area

A different Net Uplift Pressure is applied to each category. (Table 9.5, pg 165)

3. Determine the uplift pressure

(*Roof battens - General areas and Edge areas)*



3. Determine the uplift pressure

(Roof battens to rafters/trusses)

TABLE 9.5

NET UPLIFT PRESSURE, kPa

Connection/tie-down position	Wind classification					
	C1		C2		C3	
	Tile	Sheet	Tile	Sheet	Tile	Sheet
Roof battens to rafters/trusses						
— within 1200 mm of edges	3.27	3.67	5.10	5.50	7.73	8.13
— general area	1.92	2.32	3.09	3.49	4.78	5.18
Single- or upper storey- rafters/trusses to wall frames and wall plates to studs, floor frame or slab	1.68	2.08	2.85	3.25	4.54	4.94
Single- or upper- storey bottom plates to floor frame or slab	1.36	1.76	2.53	2.93	4.22	4.62
Single- or upper- storey floor frame to supports	*1.0*	*1.2*	*2.0*	*2.1*	*3.8*	*3.8*
Lower storey wall frame to floor frame or slab	*1.0*	*1.2*	*2.0*	*2.1*	*3.8*	*3.8*
Lower storey floor frame to supports	*0.5*	*0.6*	*1.7*	*1.8*	*3.8*	*3.8*

NOTE: The values in italics make allowance for overturning forces, which dictate rather than direct uplift.

4. Calculate the wind uplift force

(Roof battens to rafters/trusses)

Roof battens to rafters/trusses -

Within 1200 mm of edges.

Net Uplift Force =

Wind Uplift Area of roof x Net Uplift Pressure

$0.81 m^2$ x 5.5 kPa *(kN/m²)*

= 4.46 kN

4. Calculate the wind uplift force

(Roof battens to rafters/trusses)

Roof battens to rafters/trusses -

General Area.

Net Uplift Force =

Wind Uplift Area of roof x Net Uplift Pressure

0.81m^2 x 3.49 kPa *(kN/m^2)*

= 2.83 kN

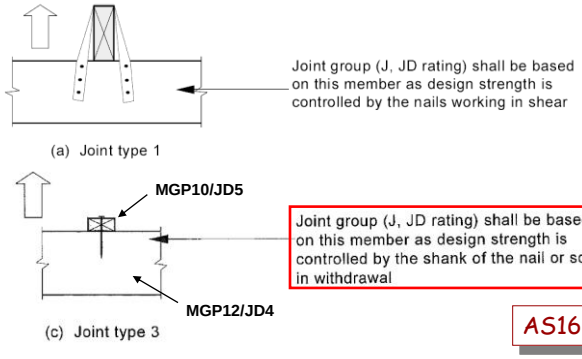
5. Determine the joint group

(Roof battens to rafters/trusses)

Select the appropriate Joint Group -

35 x 70 MGP10 seasoned pine batten (JD5) to MGP12 seasoned pine truss top chord (JD4).

Joint Group = JD4 (truss specification)



AS1684.3 p175/176

6. Select a suitable tie-down connection

(Roof battens to rafters/trusses)

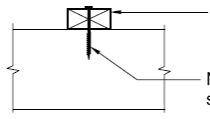
Select a Tie-down connection - [Table 9.25]

Batten to truss (within 1200mm of edges)

Uplift Capacity = 4.46 kN

Adopt - 1/75mm long, No.14 Type 17 screw

(d)



Two screws shall be used only with 75 mm wide batten

Screws (length)				JD4		
1/75 mm long	5.7	4.2	2.4	4.5	3.6	2.7
1/90 mm long	7.4	5.5	3.2	6.0	4.7	3.6
2/75 mm long	11	8.4	4.8	9.0	7.2	5.4
2/90 mm long	15	11	6.4	12	9.4	7.2

AS1684.3 p202

6. Select a suitable tie-down connection *Cont.*

(Roof battens to rafters/trusses)

Select a Tie-down connection - [Table 9.25]

Batten to truss (General Area)

Uplift Capacity = 2.83 kN

Adopt - 1/75 mm long No.14 Type 17 screw,

as there are no nailing options available that achieve the required load. Therefore use same fixing over whole roof.

6. Select a suitable tie-down connection *Cont.*

d) Determine specific tie-down requirements where appropriate.

For all other connections (truss to wall frame, wall frame to floor), the following inputs are required...

i) Uplift Load Width

ii) Uplift Area (or tie-down spacing)

iii) Wind Uplift Force

iv) Joint Group

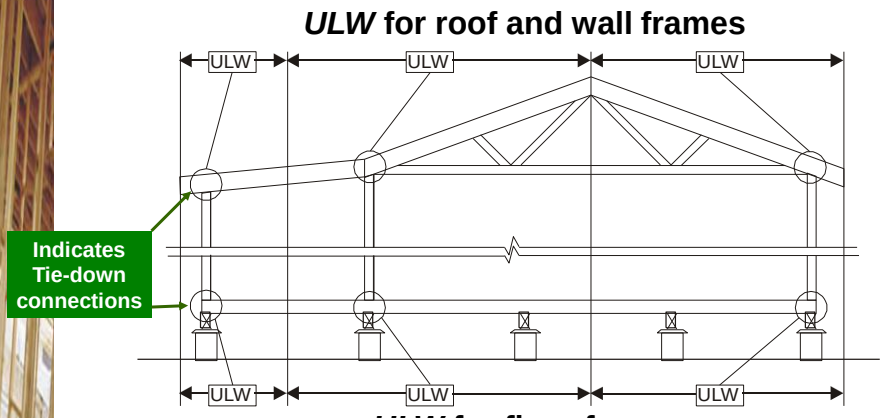
6. Select a suitable tie-down connection *Cont.*

i) Uplift Load Width. This is used to determine the tie-down requirements for each structural joint, excluding roof battens.

(Clause 9.6.2 and Figure 9.5, pages 163 & 164)

AS1684.3 p 163/164

6. Select a suitable tie-down connection *Cont.*



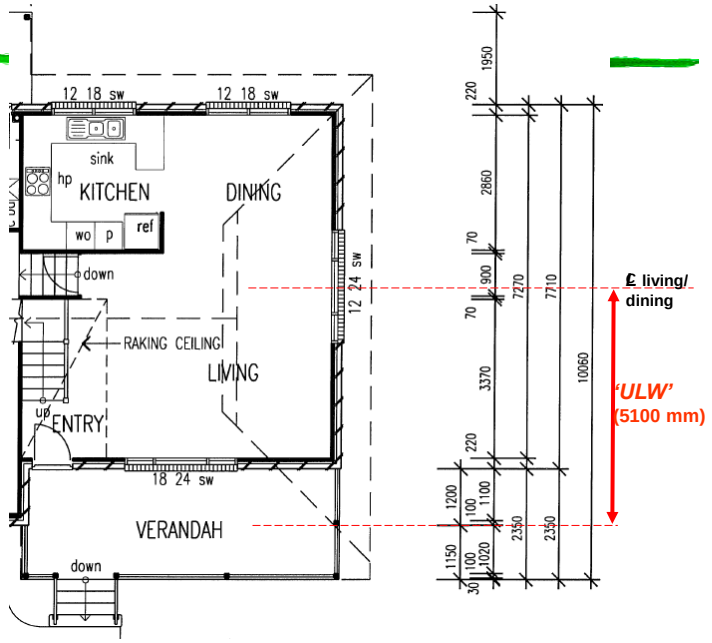
***ULW* for roof and wall frames**

***ULW* for floor frames**

(c) Roof truss construction

FIGURE 9.5 ROOF UPLIFT LOAD WIDTH *ULW*

AS1684.3 p164



6. Select a suitable tie-down connection *Cont.*

(*Roof trusses to wall frame)*

The Uplift Load Width (ULW) will be determined across the lounge/dining area of Level 2.

This is the *"worst case"* and will be applied throughout the structure for convenience.

The width is 7.710/2 m + 1.2 m (cantilevered section for verandah)

and therefore the truss ULW is 5.055, say 5.1 m

6. Select a suitable tie-down connection *Cont.*

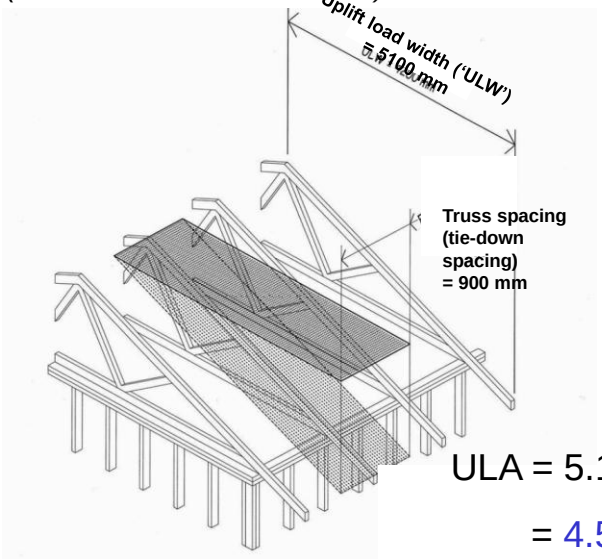
(*Roof trusses to wall frame)*

ii) Uplift Load Area. This is calculated by multiplying -

ULW x Tie - Down Spacing = ULA

6. Select a suitable tie-down connection *Cont.*

(Common trusses to wall frame)



ULA = 5.1 m x 0.9m

= 4.59 m²

6. Select a suitable tie-down connection *Cont.*

(Roof trusses to wall frame)

iii) Wind Uplift Force. We now require a pressure to use in selecting the connection.

This can be determined by multiplying the -

Uplift Load Area x Net Uplift Pressure (Table 9.5)

for the joint in question.

(Clause 9.6.4 and Figure 9.5)

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6. Select a suitable tie-down connection *Cont.*

(Roof trusses to wall frame)

TABLE 9.5

NET UPLIFT PRESSURE, kPa

Connection/tie-down position	Wind classification					
	C1		C2		C3	
	Tile	Sheet	Tile	Sheet	Tile	Sheet
Roof battens to rafters/trusses — within 1200 mm of edges — general area	3.27 1.92	3.67 2.32	5.10 3.09	5.50 3.49	7.73 4.78	8.13 5.18
Single- or upper storey- rafters/trusses to wall frames and wall plates to studs, floor frame or slab	1.68	2.08	2.85	3.25	4.54	4.94
Single- or upper- storey bottom plates to floor frame or slab	1.36	1.76	2.53	2.93	4.22	4.62
Single- or upper- storey floor frame to supports	*1.0*	*1.2*	*2.0*	*2.1*	*3.8*	*3.8*
Lower storey wall frame to floor frame or slab	*1.0*	*1.2*	*2.0*	*2.1*	*3.8*	*3.8*
Lower storey floor frame to supports	*0.5*	*0.6*	*1.7*	*1.8*	*3.8*	*3.8*

NOTE: The values in italics make allowance for overturning forces, which dictate rather than direct uplift.

6. Select a suitable tie-down connection *Cont.*

(Roof trusses to wall frame)

Wind Uplift Force:

= Uplift Load Area x Net Uplift Pressure

Rafters/Trusses to wall frames - Top and bottom plates to studs.

Wind Uplift Force =

4.59 m^2 x 3.25 kN/m^2 (kPa) = 14.9 kN

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6. Select a suitable tie-down connection *Cont.*

iv) Joint Group. This is the rating assigned to a piece or parcel of timber to indicate the design capacity appropriate to that timber for a range of connectors. (Clause 9.6.5 & Table 9.15)

F5/MGP10 seasoned softwood framing is likely to contain pith, MGP12 seasoned softwood framing should be free of pith.

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TABLE 9.15

JOINT GROUPS

Species or species group		Joint group
Seasoned softwood (radiata, slash and other plantation pines)	Seasoned—Free of pith	JD4
	Seasoned—Pith-in	JD5
Australian hardwood (non-ash type from Qld, NSW, WA, etc.)	Unseasoned	J2
	Seasoned	JD2
Australian hardwoods (ash type eucalyptus from Vic, TAS, etc.)	Unseasoned	J3
	Seasoned	JD3
Cypress	Unseasoned	J3
Douglas fir (Oregon) from North America	Unseasoned	J4
	Seasoned	JD4
Douglas fir (Oregon) from elsewhere	Unseasoned	J5
	Seasoned	JD5
Spruce pine fir (SPF)	Seasoned	JD6
Hem-fir	Seasoned	JD5

NOTES:

1 The appropriate joint group for a single timber species can be determined by reference to Appendix H, or AS 1720.2.

2 For timber with a joint group of JD2 or JD3, the values given in this Standard for J2 may be used.

6. Select a suitable tie-down connection *Cont.*

Where a timber joint is comprised of two or more different species, the joint group allocated to that joint shall, in general, be that appropriate to the weakest material in that joint (Clause 9.6.5)

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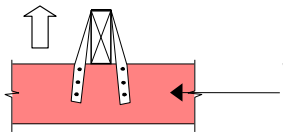
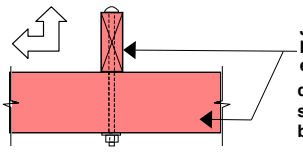


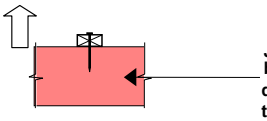
Joint group (J, JD rating) shall be based on this member as design strength is controlled by the nails working in shear

(a) Joint type 1



Joint group (J, JD rating) shall be based on the weakest of either member as design strength is controlled by shear or bearing of the bolt in both members

(b) Joint type 2



Joint group (J, JD rating) shall be based on this member as design strength is controlled by the shank of the nail or screw in withdrawal

(c) Joint type 3

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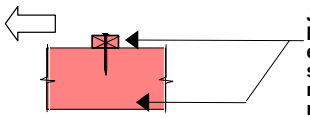
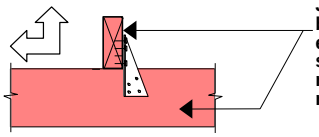


Joint group (J, JD rating) shall be based on the weakest of either member as the design strength is controlled by the nails or screws in shear in both members

(d) Joint type 4



Joint group (J, JD rating) shall be based on the weakest of either member as the design strength is controlled by the nails working in shear in both members

(e)

Large arrows indicate direction of load.

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6. Select a suitable tie-down connection *Cont.*

d) Select tie-down connections.

6. Select a suitable tie-down connection *Cont.*

Discussion

When selecting a suitable tie-down system for the trusses/rafters to the floor frame or slab, a decision is required on whether:

1. **a direct tie-down system will be used**
   - **connect trusses direct to floor frame or slab or**
   - **connect trusses to top plate and then within 100 mm of truss, connect top plate to floor frame or slab**

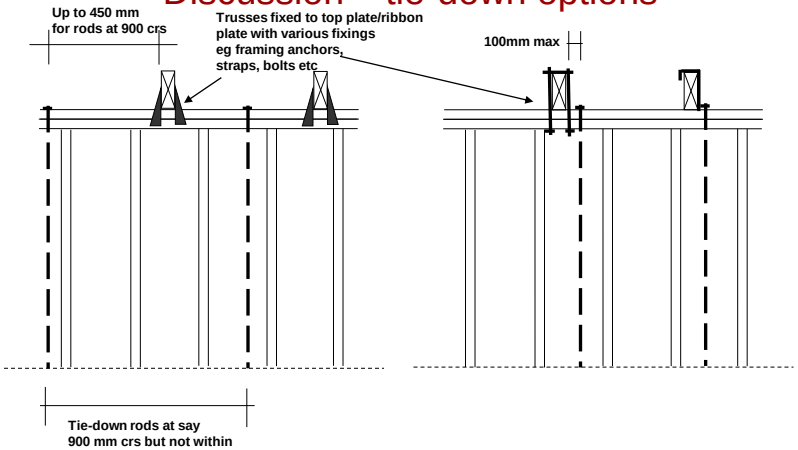
   OR

2. **Indirect tie-down by connecting trusses to top plate and then top plate to floor frame or slab located anywhere i.e. not within 100 mm of truss to top plate connection.**

For option 1. the top plate is not required to resist the wind uplift bending forces, and may be sized accordingly.
For option 2. the top plate must be sized to account for uplift bending so tie-down spacing becomes important.

6. Select a suitable tie-down connection *Cont.*

Discussion – tie-down options



In-direct tie-down
Top plate designed to resist uplift, by tie-down spacing required

Direct tie-down
Top plate size not governed by tie-down spacing

6. Select a suitable tie-down connection *Cont.*

(Common trusses to top plate)

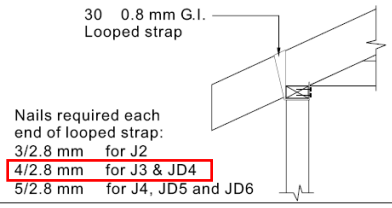
(see Table 9.21)

Required uplift capacity = 14.9 kN

Joint Group = JD4 (assume MGP12 softwood wall framing)

Adopt – Two looped straps with 4/2.8 ø nails to each end. (25 kN)

TABLE 9.21 *(continued)*

Position of tie-down connection	Uplift capacity (kN)					
	Unseasoned timber			Seasoned timber		
Rafters/trusses to wall frame or floor frame	J2	J3	J4	JD4	JD5	JD6
(e) 	No. of looped straps					
1	13	13	13	13	13	13
2	25	25	25	25	25	25

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6. Select a suitable tie-down connection *Cont.*

(Common trusses to wall frame alternative tie-down)

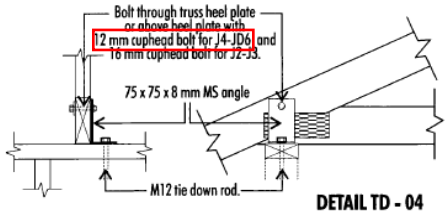
(A range of additional tie-down options is available for high wind areas - also, see manufacturers or industry published literature such as from the Timber Queensland Data Sheet below)

Required uplift capacity = 14.9 kN

Joint Group = JD4 (assume MGP12 softwood wall framing)

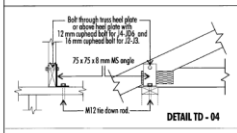
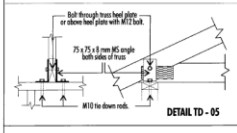
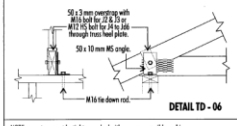
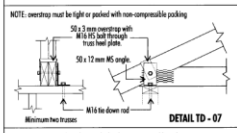
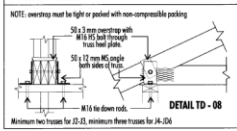
Adopt – 12 mm cuphead bolt through angle bracket plus M12 tie-down rod.

UPLIFT CAPACITY OF TRUSS TIE-DOWN CONNECTIONS

TIE-DOWN DETAILS	BOLTS	UPLIFT CAPACITY (kN) JOINT GROUP					
		J2	J3	J4	JD4	JD5	JD6
 DETAIL TD - 04	12 mm Cuphead Bolt	8	8	8	16	12	8
	16 mm Cuphead Bolt	17	12	8	16	12	8

Timber Queensland Tech Data Sheet

UPLIFT CAPACITY OF TRUSS TIE-DOWN CONNECTIONS

TIE-DOWN DETAILS	BOLTS	UPLIFT CAPACITY (kN) JOINT GROUP J2	J3	J4	JD4	JD5	JD6
 DETAIL TD - 04	12 mm Cuphead Bolt	8	8	8	16	12	8
	16 mm Cuphead Bolt	17	12	8	16	12	8
 DETAIL TD - 05	M12 Bolt	17	12	8	16	12	8
 DETAIL TD - 06	M12 HS Bolt	15	15	15	24	18	12
	M16 Bolt	33	24	15	24	18	12
 DETAIL TD - 07	M16 HS Bolt	50	42	27	35	28	21
 DETAIL TD - 08	M16 HS Bolt	71	51	33	51	42	29

NOTES: TD - (TRADAC DETAIL)
HS - High strength steel bolt (Class 8.8)

Issued: December 2000

Timber Queensland (TRADAC) Tech Data Sheet

6. Select a suitable tie-down connection *Cont.*

(Wall top plate to bottom plates/slab)

(see Table 9.19, pg 186)

Required uplift capacity = 14.9 kN @ 900 crs

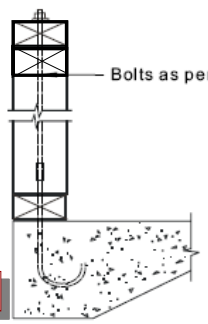
Joint Group = JD4 (softwood)

Adopt – M10 tie-down bolt with 38 x 38 structural washers at 900mm crs (see Table 9.1 [pg 157] for washer size) capacity 15 kN. Where trusses are tied direct to floor/slab, then this alternative tie-down would not be used.

Note: 1. If the tie-down crs from top plate to bottom plate are increased, this will impact upon the required top plate size as it will mean it is spanning further in the wind uplift mode.

2. In cyclonic areas, a min of M12 rods are normally readily available and used

(f)

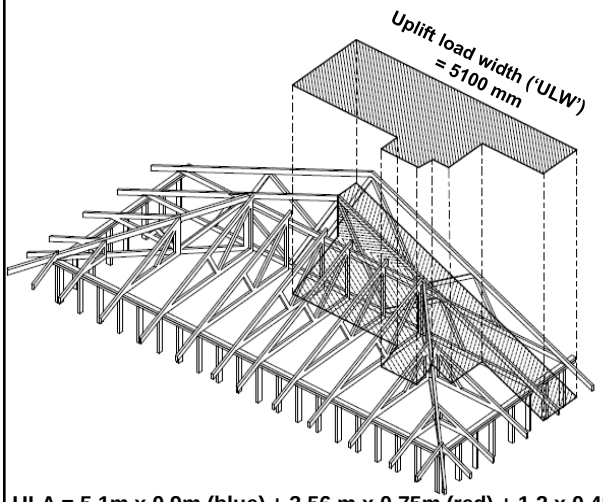


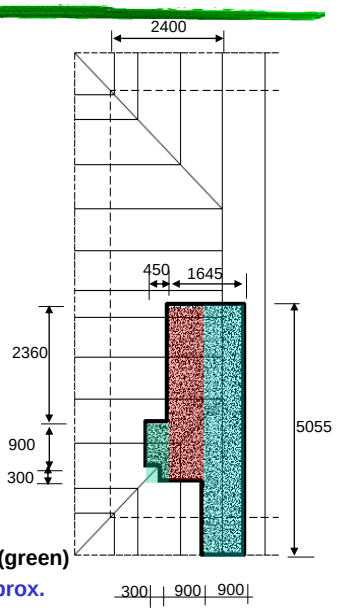
Bolt	JD4					
M10	18	18	18	15	15	9.0
M12	27	27	26	20	16	12
M16	50	50	46	35	28	21

AS1684.3 p 186

6. Select a suitable tie-down connection *Cont.*

(Dutch girder truss to wall frame)





ULA = 5.1m x 0.9m (blue) + 3.56 m x 0.75m (red) + 1.2 x 0.45 (green)
– 0.3 x 0.3 = 4.59 + 2.67 + 0.54 - 0.09 = 7.7 m² approx.

6. Select a suitable tie-down connection *Cont.*

(Dutch Girder to wall frame)

Wind Uplift Force:

= Uplift Load Area x Net Uplift Pressure

Dutch girder wall frame.

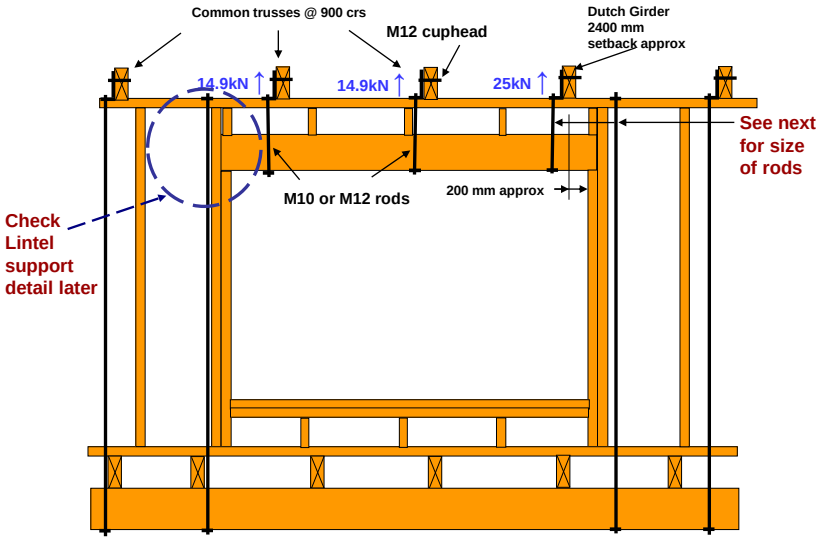
Wind Uplift Force =

$7.7\ m^2 \times 3.25\ kN/m^2\ (kPa) =$ 25 kN

AS1684.3 p 165

6. Select a suitable tie-down connection *Cont.*

(Lintels and studs at sides of openings to Floor Frame or Slab)



Verandah 18 24 sw

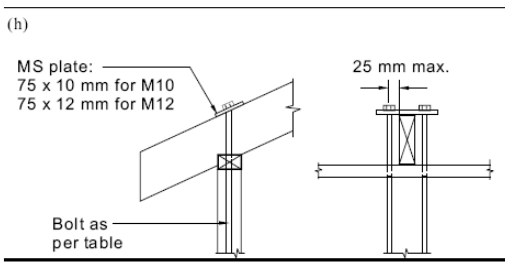
6. Select a suitable tie-down connection *Cont.*

(Dutch Girder to wall frame)

Dutch girder to lintel. Assume lintel and Dutch girder are MGP12/JD4 minimum.

Required uplift capacity = 25 kN

Use 2/M12 rods/bolts through MS plate, capacity 40kN



No. of bolts	JD4					
2/M10	36	36	36	30	24	18
2/M12	54	54	52	40	32	24

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6. Select a suitable tie-down connection *Cont.*

(Dutch Girder to wall frame)

As the Dutch girder lands over an opening, the loads from it plus the common trusses that also land over the opening have to be distributed to the tie-down either side of the opening. The loads should be distributed to each side in approximate proportion to the amount that is going to be resisted by tie-down at each side.

In this example, assume all the load from the Dutch girder goes to the RH side tie-down, 50% of the middle common truss goes to both sides and all the load from the LH common truss goes to the LH side of the opening.

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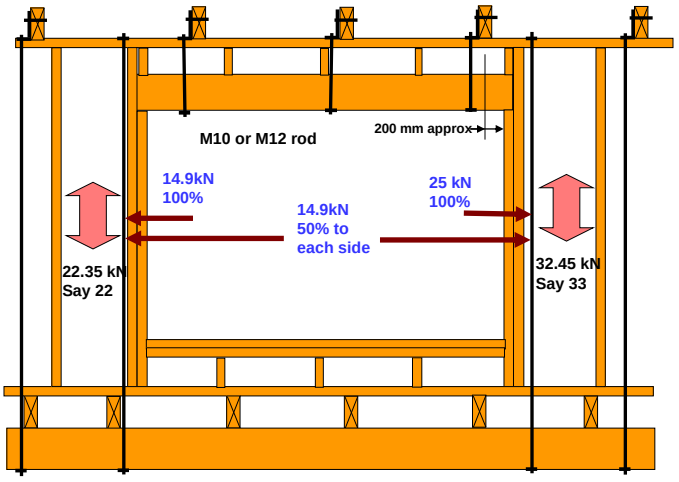
6. Select a suitable tie-down connection *Cont.*

(Lintels and studs at sides of openings to Floor Frame or Slab)

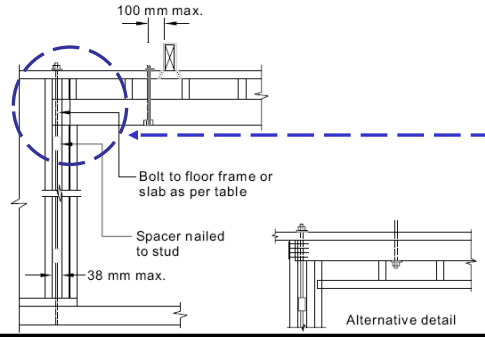


Verandah 18 24 sw

6. Select a suitable tie-down connection *Cont.*

(Tie-down at sides of opening)

Position of tie-down connection	Uplift capacity (kN)					
	Unseasoned timber			Seasoned timber		
Beams/lintels to studs/posts	J2	J3	J4	JD4	JD5	JD6
(d) NOTE: The top plate shall be fixed to the lintel within 100 mm of each rafter/truss, or the rafter/truss fixed directly to the lintel with a fixing of equivalent tie-down strength to that required for the rafter/truss.	Bolt size					
	M12	27	27	26	20	16	12
	M16	50	50	46	35	28	21



Sides of openings, assume JD4

Required uplift capacity = 25 kN to LHS and 33 kN to RHS

Use M16 rods either side

Allowable capacity

35 kN.

Note the bolt and jamb stud arrangement required for this detail.

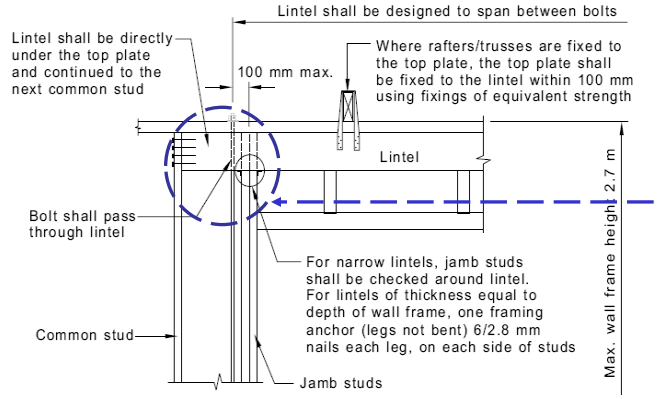
AS 1684.3 pg 188

6. Select a suitable tie-down connection *Cont.*

(Tie-down at sides of opening – alternative detail)

(d) NOTE: The top plate shall be fixed to the lintel within 100 mm of each rafter/truss, or the rafter/truss fixed directly to the lintel with a fixing of equivalent tie-down strength to that required for the rafter/truss.

Bolt size	JD4					
M12	27	27	26	20	16	12
M16	50	50	46	35	28	21



Sides of openings, assume JD4

Required uplift capacity = 25 kN to LHS and 33 kN to RHS

Use M16 rods either side

Allowable capacity

35 kN.

Note the bolt and jamb stud arrangement required for this detail.

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6. Select a suitable tie-down connection *Cont.*

(Bottom Plates to Floor Frame or Slab)

TABLE 9.5

NET UPLIFT PRESSURE, kPa

Connection/tie-down position	Wind classification					
	C1		C2		C3	
	Tile	Sheet	Tile	Sheet	Tile	Sheet
Roof battens to rafters/trusses — within 1200 mm of edges — general area	3.27 1.92	3.67 2.32	5.10 3.09	5.50 3.49	7.73 4.78	8.13 5.18
Single- or upper storey- rafters/trusses to wall frames and wall plates to studs, floor frame or slab	1.68	2.08	2.85	3.25	4.54	4.94
Single- or upper- storey bottom plates to floor frame or slab	1.36	1.76	2.53	2.93	4.22	4.62
Single- or upper- storey floor frame to supports	*1.0*	*1.2*	*2.0*	*2.1*	*3.8*	*3.8*
Lower storey wall frame to floor frame or slab	*1.0*	*1.2*	*2.0*	*2.1*	*3.8*	*3.8*
Lower storey floor frame to supports	*0.5*	*0.6*	*1.7*	*1.8*	*3.8*	*3.8*

NOTE: The values in italics make allowance for overturning forces, which dictate rather than direct uplift.

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6. Select a suitable tie-down connection *Cont.*

(Bottom Plates to Floor Frame or Slab)

From the example already worked, the trusses will be tied direct to floor frame or slab with full length tie-down rods (M12 or M16). If for some reason there is a tie-down required just from the bottom plate to the floor frame or slab, then a reduced net uplift pressure, 2.93 kN/m^2, could be used. This reduced pressure at this level takes into account the extra dead load of the walls that assist to resist uplift.

Single or upper storey bottom plates to floor frame or slab. Assume bottom plates are tied down at 900 mm crs along the plate.

Wind Uplift Force:

= Uplift Load Area x Net Uplift Pressure

= ULW x tie-down spacing (joist spacing) x *Net Uplift Pressure*

= 5.1 m x 0.9 m x 2.93 kN/m^2 (kPa) = 13.5 kN

6. Select a suitable tie-down connection *Cont.*

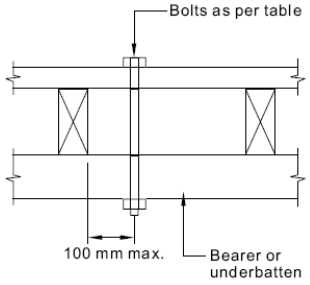
(Bottom Plates to Floor Frame)

Required uplift capacity = 13.5 kN

Joint Group = JD4 (softwood bottom plates)

Adopt – M10 bolt at 900 mm crs (but more likely that the existing M12 or M16 rods will be taken through to bearer)

(b)



Bolts				JD4		
M10 cup-head	16	14	10	10	7.0	5.0
M10	18	18	18	15	12	9.0
M12	27	27	26	20	16	12

Axial load in bolt (kN)	Underbatten size (depth × breadth), mm			
	F5	F8	F14	F17
6	70 × 70	45 × 70	45 × 70	35 × 70
10	90 × 70	70 × 70	70 × 70	45 × 70
15	90 × 70	90 × 70	70 × 70	70 × 70
20	120 × 70	90 × 70	70 × 70	70 × 70
30	140 × 70	120 × 70	90 × 70	90 × 70
50	190 × 70	170 × 70	140 × 70	120 × 70

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6. Select a suitable tie-down connection *Cont.*

(Bottom Plates to Slab)

OR

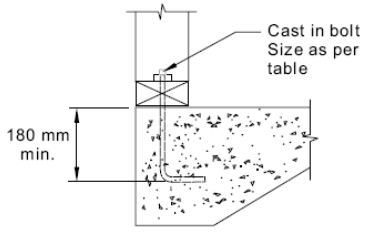
Required uplift capacity = 13.5 kN

Joint Group = JD4 (softwood bottom plates)

Adopt – M10 bolt at 900 mm crs (but more likely that M12 or M16 cast in bolts with a coupling nut will be used to pick up existing M12 or M16 tie-down rods)

Bottom plates to floor joists or slab	J2	J3	J4	JD4	JD5	JD6
Bolts						
M10	18	18	18	15	12	9.0
M12	27	27	26	20	16	12

(d)



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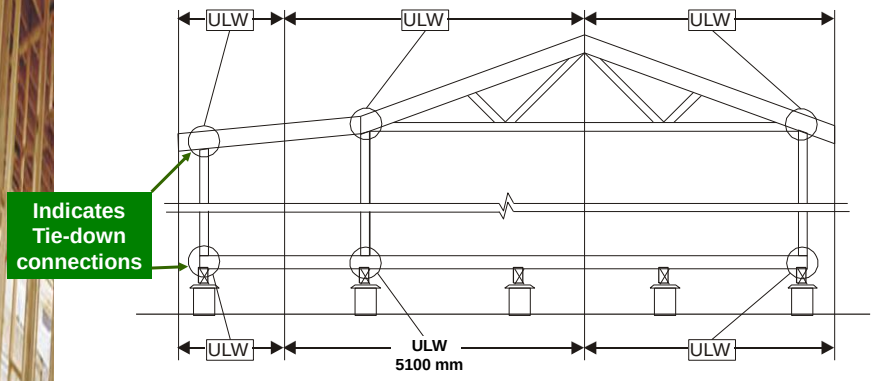
6. Select a suitable tie-down connection

(Bearers to piers/stumps)



***ULW* for floor frames**

(c) Roof truss construction

FIGURE 9.5 FLOOR UPLIFT LOAD WIDTH *ULW*

AS1684.3 p164

6. Select a suitable tie-down connection *Cont.*

(Bottom Plates to Floor Frame or Slab)

TABLE 9.5

NET UPLIFT PRESSURE, kPa

Connection/tie-down position	Wind classification					
	C1		C2		C3	
	Tile	Sheet	Tile	Sheet	Tile	Sheet
Roof battens to rafters/trusses — within 1200 mm of edges — general area	3.27 1.92	3.67 2.32	5.10 3.09	5.50 3.49	7.73 4.78	8.13 5.18
Single- or upper storey- rafters/trusses to wall frames and wall plates to studs, floor frame or slab	1.68	2.08	2.85	3.25	4.54	4.94
Single- or upper- storey bottom plates to floor frame or slab	1.36	1.76	2.53	2.93	4.22	4.62
Single- or upper- storey floor frame to supports	*1.0*	*1.2*	*2.0*	*2.1*	*3.8*	*3.8*
Lower storey wall frame to floor frame or slab	*1.0*	*1.2*	*2.0*	*2.1*	*3.8*	*3.8*
Lower storey floor frame to supports	*0.5*	*0.6*	*1.7*	*1.8*	*3.8*	*3.8*

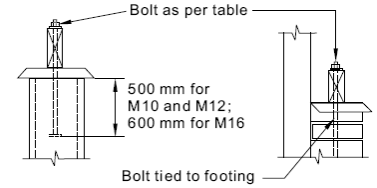
NOTE: The values in italics make allowance for overturning forces, which dictate rather than direct uplift.

6. Select a suitable tie-down connection *Cont.*

(Bearers to piers)

Net uplift pressure 2.1 kN/m^2
ULW = 5100 mm and bearer span is 2400 mm
Uplift = 5.1 x 2.4 x 2.1 = 25.7 kN, therefore use for M12 bolts for HWD bearers (J2) or M16 bolts for softwood bearers (JD4).

TABLE 9.16 (*continued*)

Position of tie-down connection	Uplift capacity (kN)					
	Unseasoned timber			Seasoned timber		
Bearers to stumps, posts, piers	J2	J3	J4	JD4	JD5	JD6
(g) 	Bolts					
	M10	18	18	18	15	12	9
	M12	27	27	26	20	16	12
	M16	50	50	46	35	28	21

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6. Select a suitable tie-down connection *Cont.*

(Bearers to internal stumps – also check shear, see next)

For this example house with a trussed roof, the uplift forces are transferred to the floor frame at the external walls only. Internal stumps may therefore be nominally fixed but the shear strength will also need to be checked - See next.

TABLE 9.4

NOMINAL FIXINGS FOR TIMBER MEMBERS

Joint	Minimum fixing for each joint
Floor framing	
Bearer to timber stump/post	4/75 × 3.33 mm or 5/75 × 3.05 mm machine-driven nails plus 1/30 × 0.8 mm G.I. strap over bearer and fixed both ends to stump with 4/2.8 mm dia. each end; *OR* 1/M10 bolt through bearer halved to stump; *OR* 1/M12 cranked bolt fixed vertically through bearer and bolted to stump plus 4/75 × 3.33 mm or 5/75 × 3.05 mm machine-driven nails
Bearer to masonry column/wall/pier (excluding masonry veneer construction)	1/M10 bolt or 1/50 × 4 mm mild steel bar fixed to bearer with M10 bolt and cast into masonry (to footing)
Bearer to supports (masonry veneer construction)	No requirement
Bearer to concrete stump/post	1/6 mm dia. rod cast into stump, vertically through bearer and bent over
Bearers to steel post	1/M10 coach screw or bolt
Floor joist to bearer	2/75 × 3.05 mm dia. nails

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7. Determine shear force

Determine specific shear force fixing requirements, where appropriate.

Refer to clauses 9.7.1 - 9.7.6 (pages 204 - 211) and see also worked example Appendix E3, pg 223/224. Based on examination of Table 9.3, pg.161, specific shear connections are required for joists to bearers and bearers to stumps.

TABLE 9.3

SHEAR

Connection	Wind classification	
	C1	C2
Bottom plate to slab	N	N at 900 mm max. centres
Joists to bearers	N	S
Bearers to stumps	S	S

N = nominal (minimum) connection only (see Clause 9.5)

S = specific connection may be required for shear forces (see Clauses 9.7.5 and

Specific connections required

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7. Determine shear force for joists and bearers

The projected height is the distance from the ridge to the relevant floor level. For shear connection at floor frame, for Level 2, the projected height is:

= (8910/2 x Tan 25 + 150)[height of roof] + 2560 [wall height] + say 200 [allowance for floor frame] = 4.99 m

Therefore the shear force on joists and bearers for 450 mm and 2400 mm respectively is:

Joists = 4.99 x 0.95 = 4.74 kN and

Bearers = 4.99 x 5.0 = 25 kN

TABLE 9.26

SHEAR FORCE PER METRE OF PROJECTED HEIGHT AT THE FLOOR LINE

Wind classification	Lateral load* (kN/m) of projected height at the floor line									
	Joist spacings or bearer spans (mm)									
	300	450	600	1200	1800	2400	3000	3600	4500	6000
C1	0.42	0.63	0.84	1.7	2.5	3.4	4.2	5.0	6.3	8.4
C2	0.63	0.95	1.3	2.5	3.8	5.0	6.3	7.6	9.5	13
C3	0.96	1.4	1.9	3.8	5.8	7.7	9.6	12	14	19

* Interpolation is permitted

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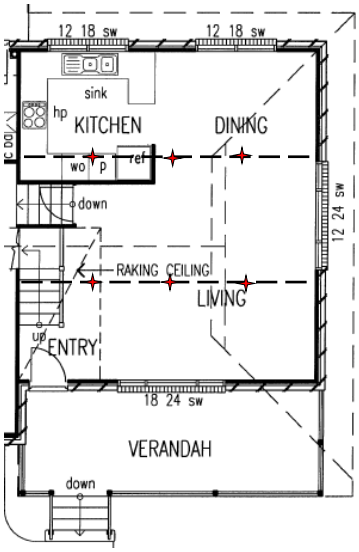
7. Determine shear force for joists and bearers



As there are 4 rows of bearers, these shear force can be distributed evenly over the 4 rows joists to bearers and the bearers to piers resulting in:
Joists to bearers = 4.74/4 = 1.19kN
And
Bearers to piers = 25/4 = 6.3kN

7. Determine shear force for joists

Capacity required - Joists 1.19kN

Assume joists are JD4 therefore use 1/Framing anchor with 4/2.8 dia nails to each leg. Note this restrains top of the bearer, see note.

TABLE 9.27

SHEAR CONNECTIONS FOR FLOOR JOISTS

Position of shear connection		Shear capacity (kN)					
		Unseasoned timber			Seasoned timber		
Floor joists to bearers or top plates		J2	J3	J4	JD4	JD5	JD6
(b) Framing anchors as per table, 4/2.8 dia nails in each leg	No. of framing anchors						
	1	2.4	2.4	2.4	2.4	2.2	2.0
	2	4.8	4.8	4.8	4.8	4.3	3.9
	3	7.2	7.2	7.2	7.2	6.5	5.9
	4	9.6	9.6	9.6	9.6	8.6	7.8

NOTE: This connection does provide rotational restraint to the top of bearers.

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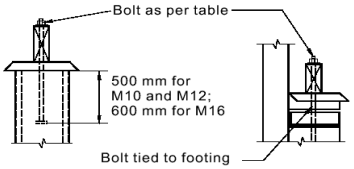
7. Determine shear force for bearers

Capacity required - Bearers 6.3 kN

See Clause 9.7 pg 204 and Table 9.28 pg 207 to 210

From Table 9.28 (g), an M16 Rod through the bearer, where the top of the bearer is laterally restrained achieves a shear capacity of 11kN in J2 hardwood or 7.9kN in JD4 softwood and is therefore satisfactory. Note, the nominal tie-down (M10 already discussed) for the internal bearers would need to be upgraded to this requirement.

Position of shear connection		Shear capacity (kN)					
		Unseasoned timber			Seasoned timber		
Bearers to stumps, posts, piers		J2	J3	J4	JD4	JD5	JD6
		(continued)					
(g) 	Bolts (bearer not restrained by joist)						
	M10	4.8	3.9	2.6	4.5	3.2	2.2
	M12	5.8	4.4	2.8	4.9	3.5	2.4
	M16	7.9	5.1	3.3	5.9	4.2	2.9
	M20	9	5.7	3.6	6.4	4.5	3.1
	Bolts (bearer restrained by joist)						
	M10	6.4	5.2	3.4	6.0	4.3	2.9
	M12	7.7	5.9	3.7	6.5	4.7	3.2
	M16	11	6.9	4.4	7.9	5.5	3.8
	M20	12	7.6	4.8	8.		

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Additional Considerations

This worked example has only covered some of the tie-down connections required to be considered for this house.

Some others that need to be considered include:

- **Tie – down requirements for Level 3 to Level 1 and for Level 1 to the slab**
- **Shear force connections for Level 3 to Level 1**

Acknowledgement

Prepared and reviewed by:

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- Place Designs *(Qld)*

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