Understanding
AS1684

Residential Timber Framed Construction

http://www.docstoc.com/docs/139519457/AS16842-SS-Bracing-Example

Bracing Example

- Wind classification - N2
- Single storey
- “L” - shaped
- Gable & hip roofs
- Ceiling height 2400mm
- Eaves 600mm
- Roof pitch 22.5^{o}

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- N2
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- Ceiling height 2400mm
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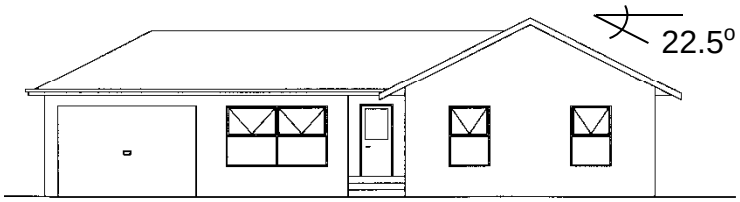
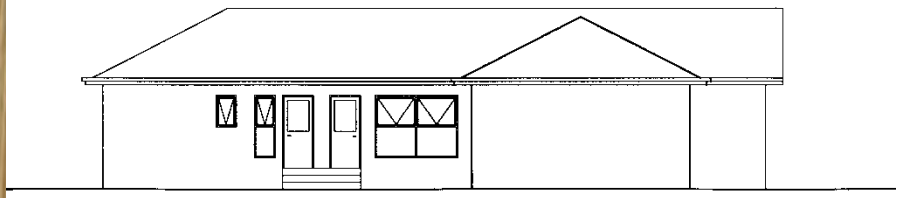


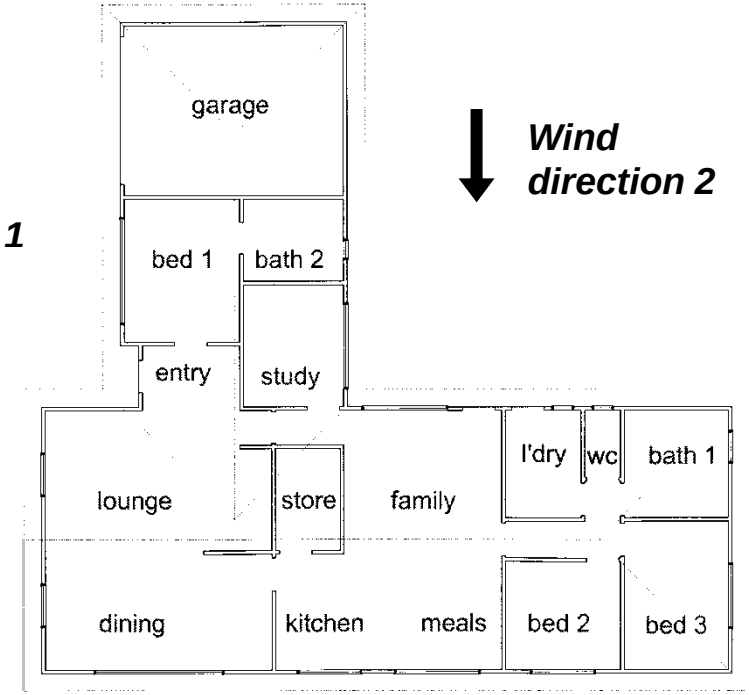
B - west elevation

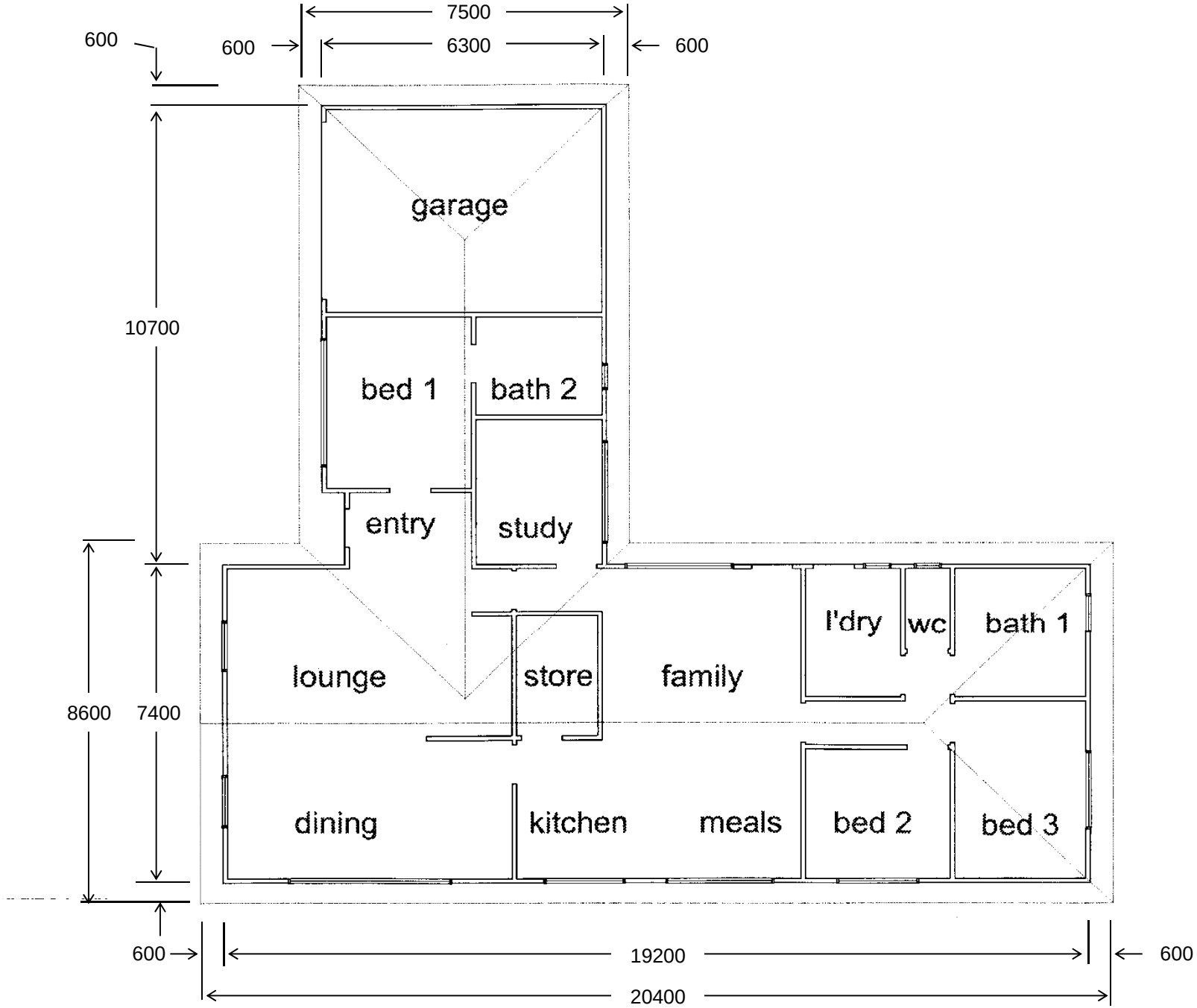


A - south elevation

Wind direction 1

Wind direction 2




7500
600
6300
600
600
garage
10700
bed 1
bath 2
entry
study
l'dry
wc
bath 1
lounge
store
family
8600
7400
dining
kitchen
meals
bed 2
bed 3
600
19200
600
20400

Bracing Design Process (Clause 8.3.1)

1. Determine the wind classification	Clauses 1.4.2 & 1.5 & AS4055/AS1170.2
2. Determine the wind pressure	Clause 8.3.2 & Tables 8.1 to 8.5
3. Determine the area of elevation	Clause 8.3.3 and Figure 8.2(A) or (B)
4. Calculate the racking force	Clause 8.3.4
5. Design the bracing systems	
- Sub-floors	Clause 8.3.5
- Walls	Clause 8.3.6, Tables 8.18 and 8.19
6. Check even distribution and spacing	Clause 8.3.6.6 and 8.3.6.7
7. Connection of bracing to roof/ceilings (at walls) and floors	Clause 8.3.6.9 and 8.3.6.10

AS1684.2 pg112

1. Determine the Wind Classification

Refer Clause 1.4.2 [pg 9] and AS 4055 or AS/NZS 1170.2

N2

(provided by structural engineer, building professional or local building authority)

2. Determine the wind pressure

(for both wind directions)

See Clause 8.3.2 [pg 112] also
Tables 8.1 to 8.5 [pgs 116–124]

Need:

- the roof pitch,
- the width of the building, and
- whether there are any flat walls, skillion ends, gable or hip ends.

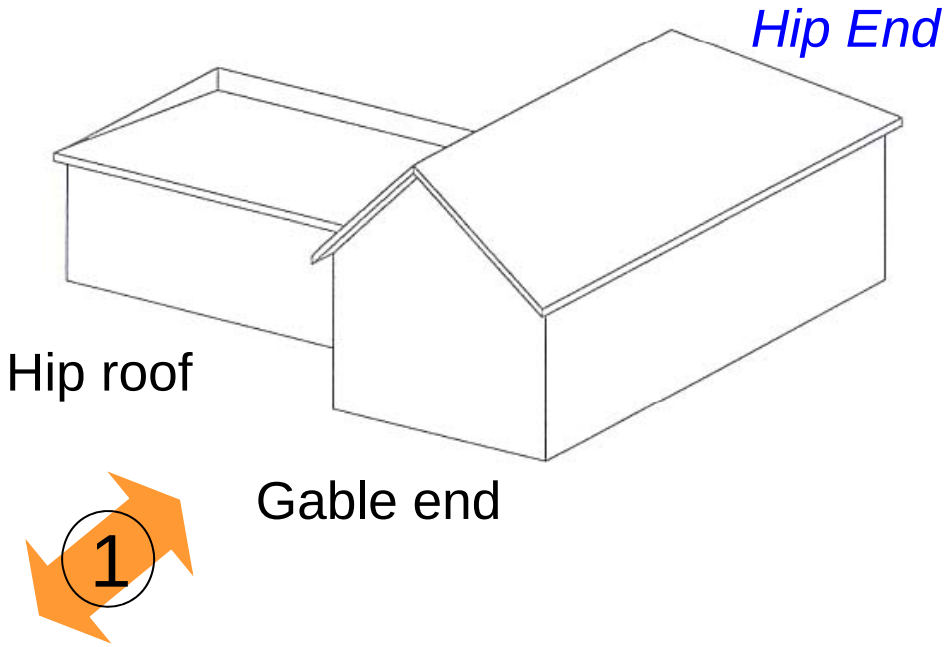
Complex designs may require separate pressures within the one wind direction.

2.1 Determine the wind pressure

(for Wind direction 1)

See Table 8.1 [pg 116] and Table 8.2 [pg 117]

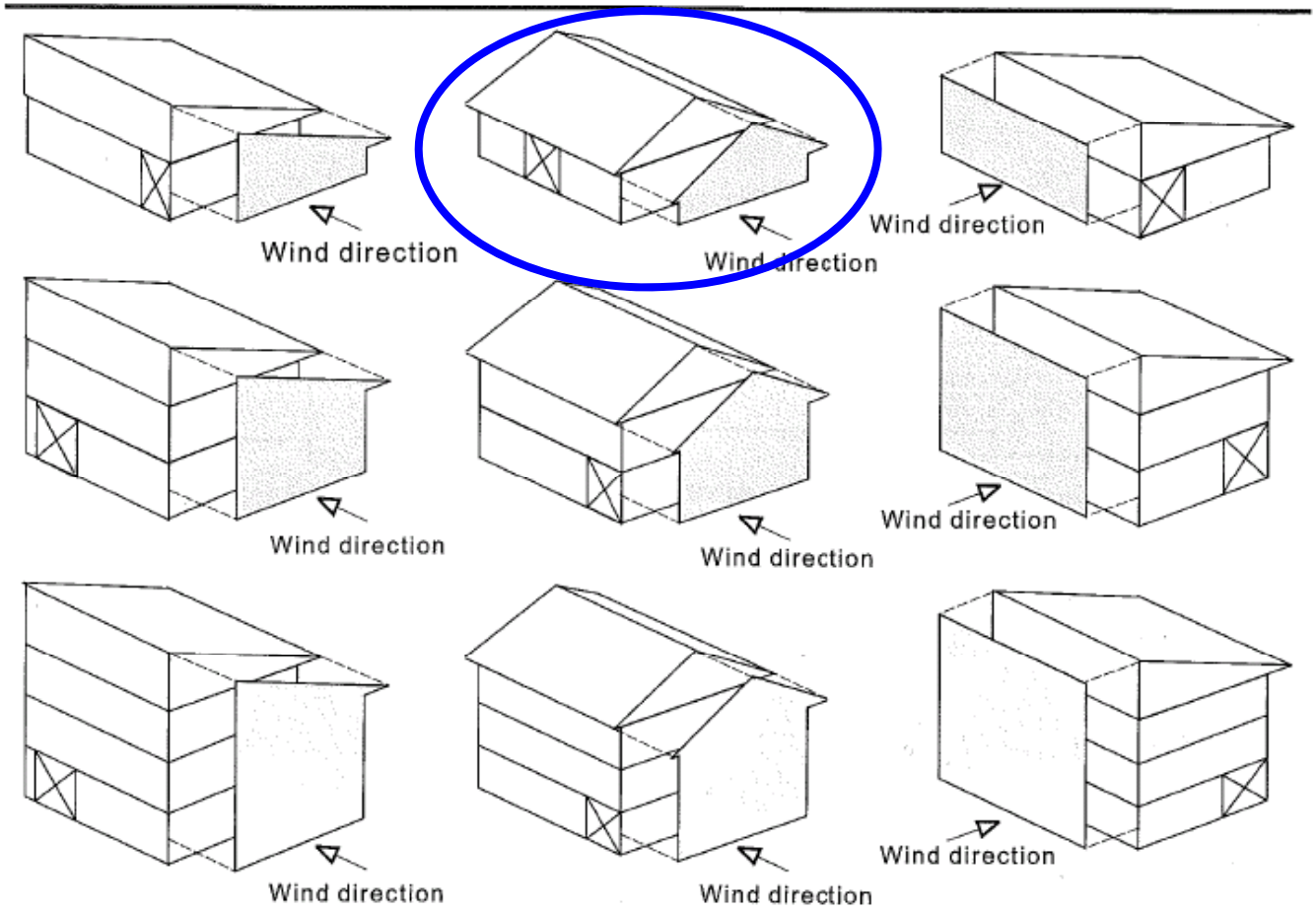
NOTE: For wind direction 1, adopt this elevation as the wind blowing onto the 'flat' surface of the gable end will produce a higher force compared to wind blowing on the opposite hip end elevation.



Split the house into it's two components
Gable end (with Hip other end)
Hip roof (long length of building)

TABLE 8.1

PRESSURE (kPa) ON AREA OF ELEVATION (m^2)—SINGLE STOREY, UPPER OF TWO STOREYS, LOWER STOREY OR SUBFLOOR OF SINGLE STOREY OR TWO STOREYS—ALL VERTICAL SURFACE ELEVATIONS (GABLE ENDS, SKILLION ENDS AND FLAT WALL SURFACES)

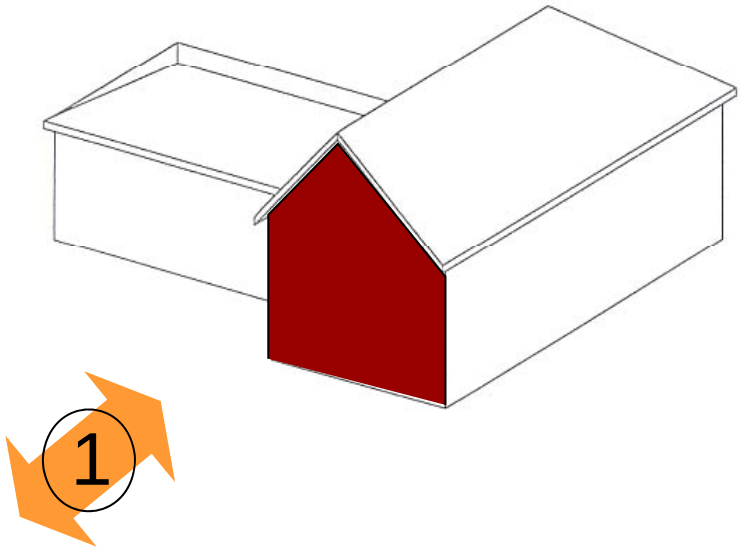


Wind classification	Pressure (kPa)
N1	0.67
N2	0.92
N3	1.4
N4	2.1

2.1 Determine the wind pressure

(for Wind direction 1 – Gable end)

See Table 8.1 [pg 116]



Pressure *(Gable end)*
= 0.92kPa *(kN/m^2)*

2.1 Determine the wind pressure

(for Wind direction 1 – Hip end – Long length of building)

Roof pitch = 22.5˚

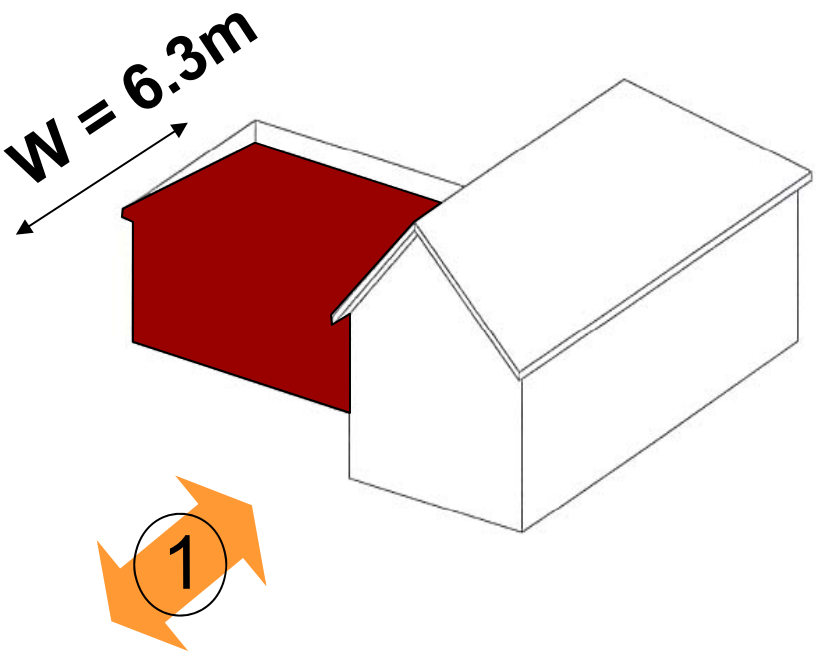


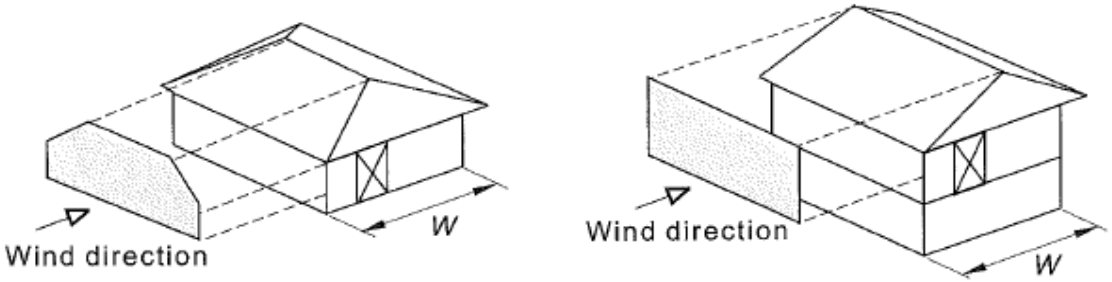
Table 8.2 is used for determining the pressure on single or upper storey elevations where the wind direction is at 90^{o} to a ridge and for wind speeds N1, N2, N3 & N4.

Interpolation permitted

Answer rounded up to the nearest 0.05

TABLE 8.2

PRESSURE (kPa) ON AREA OF ELEVATION (m^2)—SINGLE STOREY OR UPPER STOREY OF TWO STOREYS—LONG LENGTH OF BUILDING—HIP OR GABLE ENDS



NOTE: See Figure 1.1 for guidance on determining *W*.

22.5°

W (m)	Roof pitch (degrees)							
	0	5	10	15	20	25	30	35
N2								
4.0	0.84	0.74	0.67	0.61	0.61	0.72	0.77	0.76
5.0	0.84	0.71	0.64	0.57	0.58	0.69	0.75	0.74
6.0	0.84	0.69	0.61	0.55	0.59	0.70	0.74	0.74
7.0	0.84	0.67	0.58	0.53	0.59	0.70	0.73	0.74
8.0	0.84	0.65	0.56	0.51	0.60	0.71	0.72	0.75
9.0	0.84	0.64	0.54	0.49	0.61	0.71	0.71	0.75
10.0	0.84	0.62	0.52	0.48	0.61	0.72	0.70	0.75
11.0	0.84	0.60	0.50	0.48	0.62	0.72	0.71	0.75
12.0	0.84	0.59	0.47	0.49	0.63	0.72	0.71	0.76
13.0	0.84	0.57	0.45	0.49	0.63	0.73	0.71	0.77
14.0	0.84	0.56	0.43	0.50	0.64	0.73	0.72	0.77
15.0	0.84	0.55	0.42	0.50	0.65	0.73	0.72	0.77
16.0	0.84	0.53	0.40	0.51	0.65	0.73	0.72	0.78

6.3m

0.65

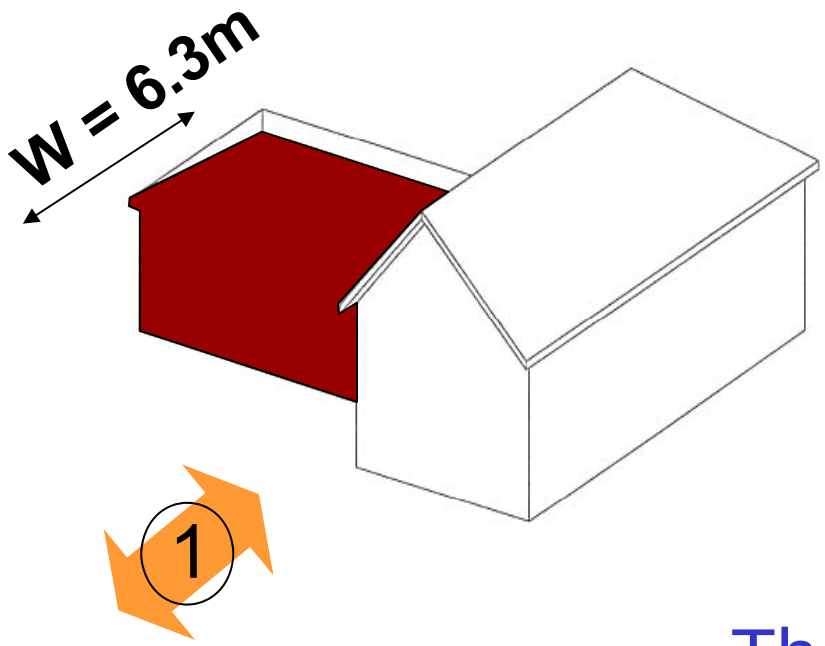
NOTE: 0° pitch is provided for interpolation purposes only.

(continued)

2.1 Determine the wind pressure

(for Wind direction 1 – Hip end – Long length of building)

Roof pitch = 22.5°

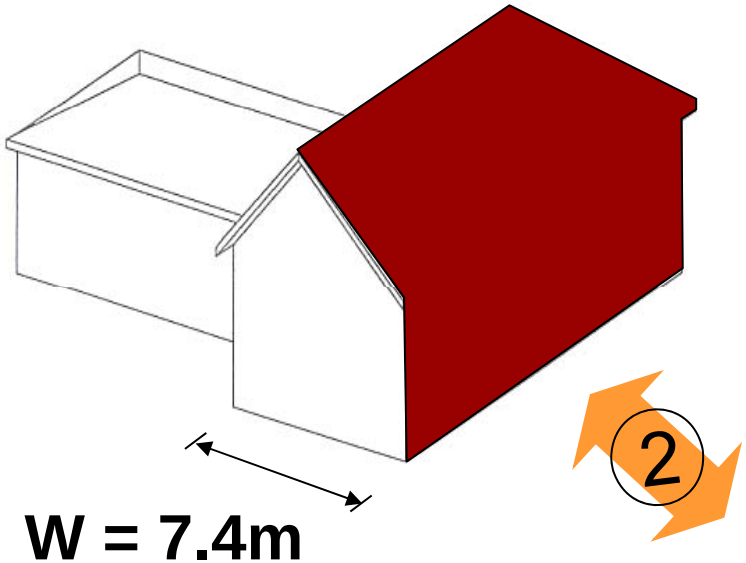


Therefore, pressure *(Hip end)*
= 0.65kPa *(kN/m^2)*

2.2 Determine the wind pressure

(for Wind direction 2 – Hip end – Long length of building)

Roof pitch = 22.5°



W = 7.4m

Table 8.2 is used for determining the pressure on single or upper storey elevations where the wind direction is at 90^{o} to a ridge and for wind speeds N1, N2, N3 & N4.

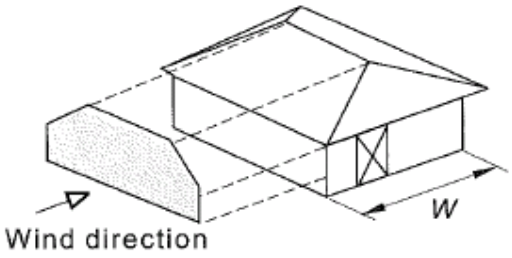
NOTE: Table 8.2 is applicable as the roof runs the long length of building and contains a hip or gable end.

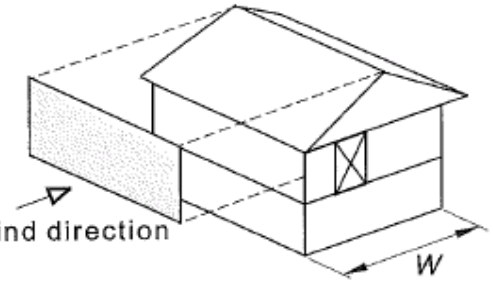
TABLE 8.2

PRESSURE (kPa) ON AREA OF ELEVATION (m^2)—SINGLE STOREY OR UPPER STOREY OF TWO STOREYS—LONG LENGTH OF BUILDING—HIP OR GABLE ENDS

Interpolation permitted

Answer rounded up to the nearest 0.05





NOTE: See Figure 1.1 for guidance on determining *W*.

22.5°

W (m)	Roof pitch (degrees)							
	0	5	10	15	20	25	30	35
N2								
4.0	0.84	0.74	0.67	0.61	0.61	0.72	0.77	0.76
5.0	0.84	0.71	0.64	0.57	0.58	0.69	0.75	0.74
6.0	0.84	0.69	0.61	0.55	0.59	0.70	0.74	0.74
7.0	0.84	0.67	0.58	0.53	0.5[illegible]	[illegible]70	0.73	0.74
8.0	0.84	0.65	0.56	0.51	0.6[illegible]	[illegible]71	0.72	0.75
9.0	0.84	0.64	0.54	0.49	0.61	0.71	0.71	0.75
10.0	0.84	0.62	0.52	0.48	0.61	0.72	0.70	0.75
11.0	0.84	0.60	0.50	0.48	0.62	0.72	0.71	0.75
12.0	0.84	0.59	0.47	0.49	0.63	0.72	0.71	0.76
13.0	0.84	0.57	0.45	0.49	0.63	0.73	0.71	0.77
14.0	0.84	0.56	0.43	0.50	0.64	0.73	0.72	0.77
15.0	0.84	0.55	0.42	0.50	0.65	0.73	0.72	0.77
16.0	0.84	0.53	0.40	0.51	0.65	0.73	0.72	0.78

7.4m

0.65

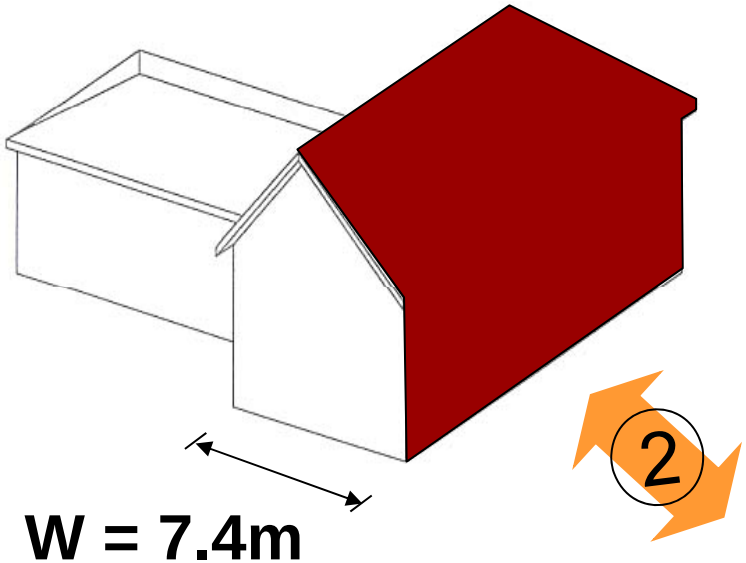
NOTE: 0° pitch is provided for interpolation purposes only.

(continued)

2.2 Determine the wind pressure

(for Wind direction 2 – Hip end – Long length of building)

Roof pitch = 22.5°



Therefore, pressure *(Hip end)*
= 0.65kPa *(kN/m²)*

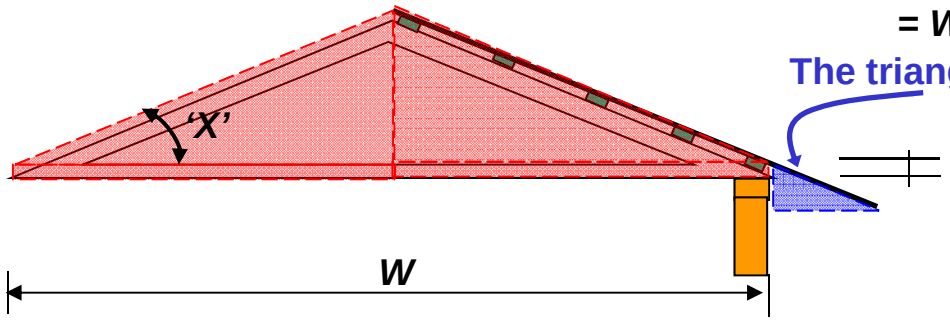
3.1 Determine the Area of Elevation

- Discussion

Whilst the area/s of elevation should be determined relatively accurately, high levels of precision are not really warranted and therefore use of calculation methods (as used in this example), planimeters or by scaling from drawings would all be acceptable.

NOTE: The area of elevation of the triangular portion of eaves overhang up to 1000mm wide may be ignored – Figure 8.2(B), Note 3 [pg 114].

The following method has been used in this example to calculate the area of elevation of the triangular roof section:



Area of Roof
= *W/2* x *W/2* Tan'*X'* + 0.15 x *W*

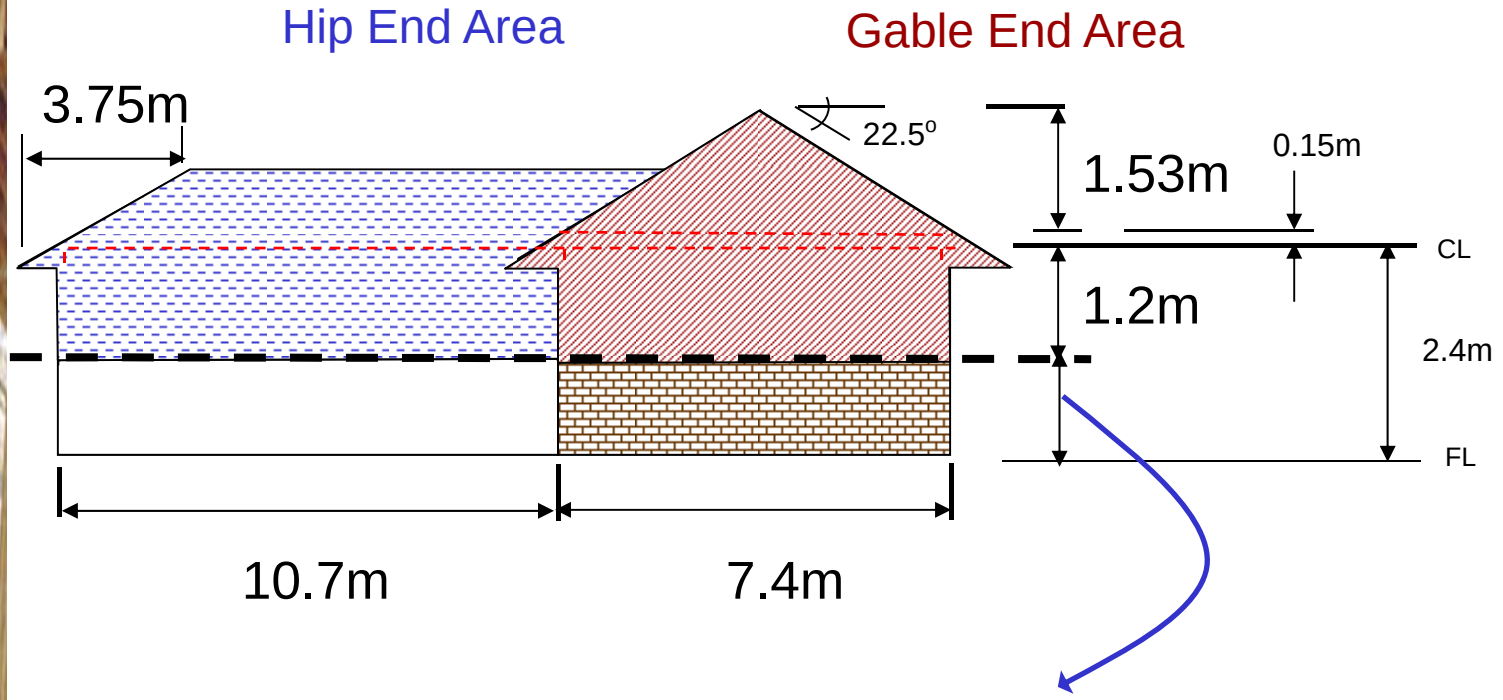
The triangular part of eaves is ignored.

150 mm nominal allowance for depth roof frame, battens and roofing. Increase this if necessary i.e. for exposed rafter roofs.

3.1 Determine the Area of Elevation

(for Wind Direction 1)

Work out each area individually

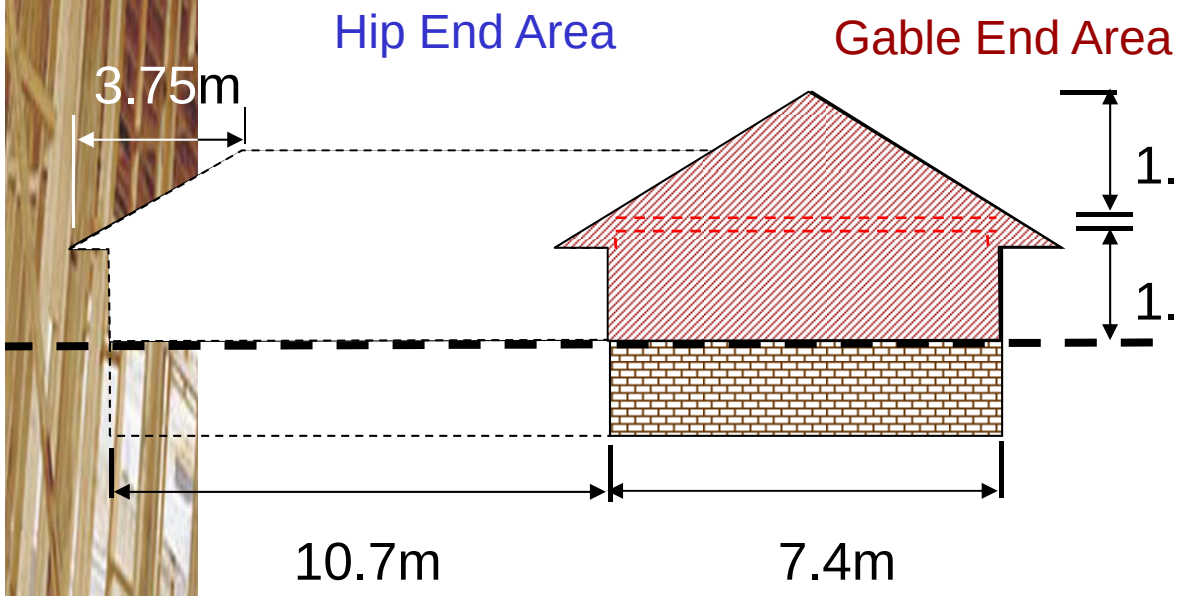


NOTE: Wind force on the area below half wall height goes straight into floor and does not add to the wall racking (bracing) force.

3.1 Determine the Area of Elevation

(for Wind Direction 1 – Gable end)

Hip End + Gable End



Area Roof
= 0.5x7.4x1.53 +
0.15x7.4 (depth of roof frame)
= 6.77m^2 *(say)*

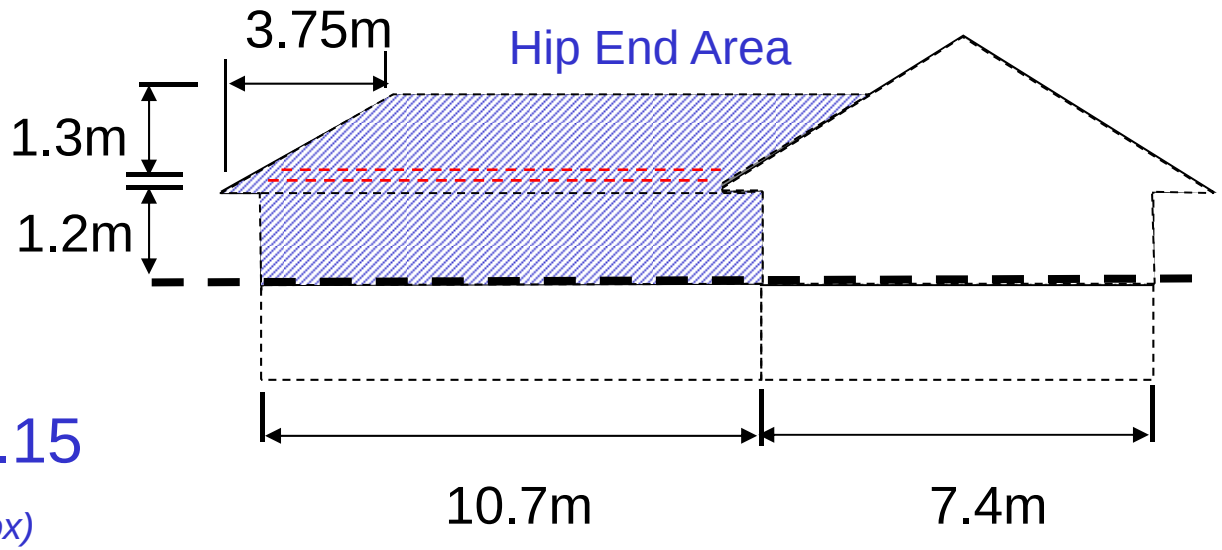
Area Wall
= 7.4x1.2 *(half wall height)*
= 8.88m^2

Total Gable End Area
= 6.77+8.88
= 15.7m^2 *(say)*

3.1 Determine the Area of Elevation

(for Wind Direction 1 – Hip end – Long length of Building)

Hip End + Gable End *(Eaves 600mm)*



Area Roof
= 10.7x1.3 +
(10.7-0.6)x0.15
= 15.43m^2 *(Approx)*

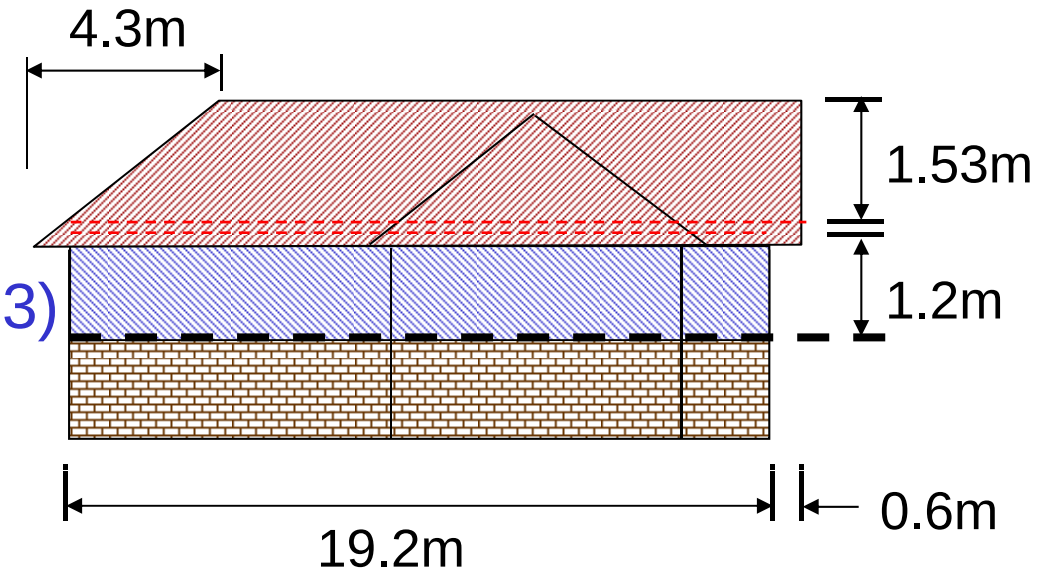
Area Wall
= 10.7x1.2 *(half wall height)*
= 12.84m^2

Total Hip End Area
= 15.43+12.84 = 28.3m^2 *(say)*

3.2 Determine the Area of Elevation

(for Wind Direction 2)

(Eaves 600mm)



Area Roof

= (19.2+0.6)x1.53

- (0.5x(4.3-0.6)x1.53)

+ (19.2+0.6)x0.15

= 30.43m^2 *(say)*

Area Wall

=19.2x1.2 *(half wall height)*

= 23.04m^2

Total Area Wind Direction 2

= 30.43 + 23.04 = 53.5m^2 *(say)*

4. Calculate the racking force

(for both Wind Directions)

Use the formula:

Racking Force = Area of Elevation x Wind Pressure
(kN) (m^2) (kPa) - (kN/m^2)

For complex elevations, combine the results of separate calculations to end up with a total racking force in each of the two wind directions.

4. Calculate the racking force

(for both Wind Directions)

Use the formula:

Racking Force = Area of Elevation x Wind Pressure
(kN) (m^2) (kN/m^2)

Total racking force for **Wind Direction 1**

Gable = $15.7m^2$ x 0.92 = 14.44kN

Hip = $28.3m^2$ x 0.65 = 18.40kN

= 32.8kN *(say)*

Total racking force for **Wind Direction 2**

= $53.5m^2$ x 0.65kPa = 34.8kN *(say)*

5. Design the wall bracing systems

In this example we will use diagonal bracing where possible – usually one diagonal brace per wall and two (opposing) wherever space permits in long walls.

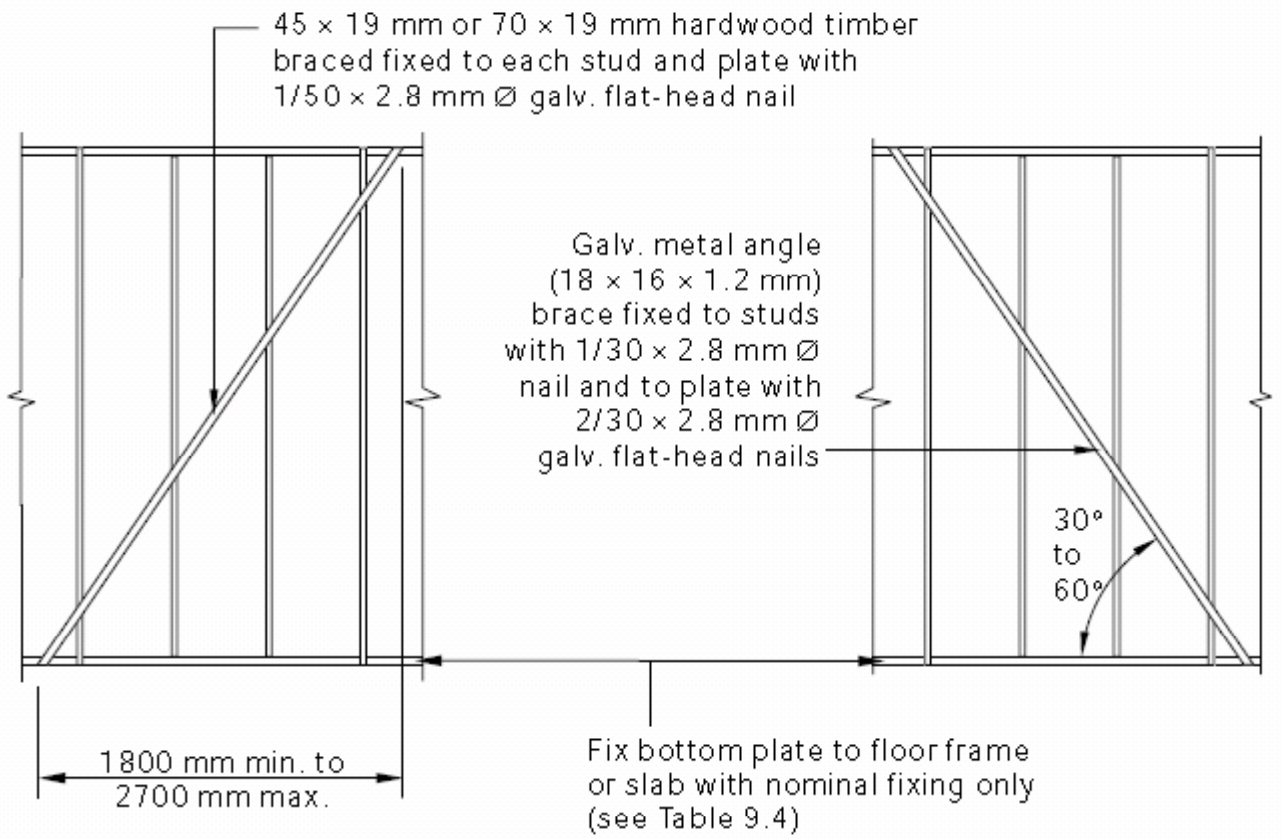
Diagram (a) in Table 8.18 AS 1684.2 [pg 141] illustrates the allowable limits for angle braces.

NOTE: Bracing should initially be placed in external walls and, where possible, at the corners of the building – Clause 8.3.6.6 [pg 148].

AS1684.2 p141

TABLE 8.18

STRUCTURAL WALL BRACING (MAXIMUM WALL HEIGHT 2.7 m)

Type of bracing	Bracing capacity (kN/m)
(a) *Two diagonally opposed timber or metal angle braces*	
	0.8

NOTE: All flat-head nails shall be galvanized or equivalent.

5. Design the wall bracing systems *(cont.)*

Determine the **length of wall** that the brace is acting in and **multiply** this by the **bracing capacity**.

For basic timber and metal angle braces, the bracing capacity is **0.8kN per metre**.

Note : The braces should be set up in opposing pairs. Do not allow single braces to be less than 1.8m or exceed 2.7m in wall length.

In this example, the angle of the braces is set to give the maximum 2.7m length for a single brace.

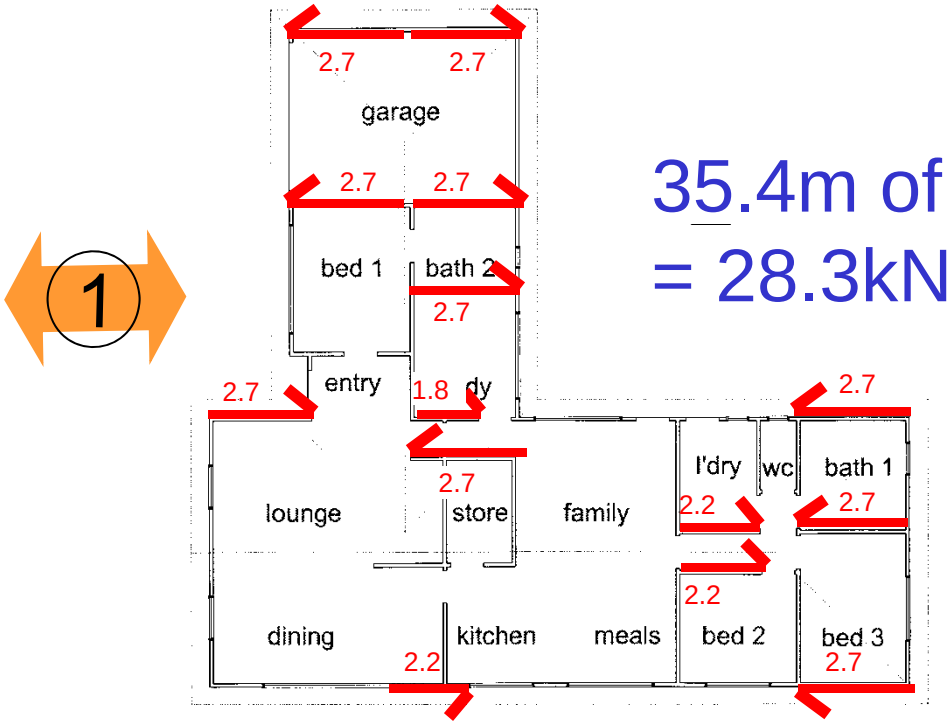
5.1 Design the wall bracing systems

(for Wind Direction 1)

[Length of each brace indicated on plan below]

(2x2.7) + (2x2.7) + 2.7 + 2.7 + 1.8 + 2.7 + 2.7 + 2.2
+ 2.7 + 2.2 + 2.7 + 2.2 = 35.4 m

NOTE: 1.8m minimum bracing length for diagonal bracing.



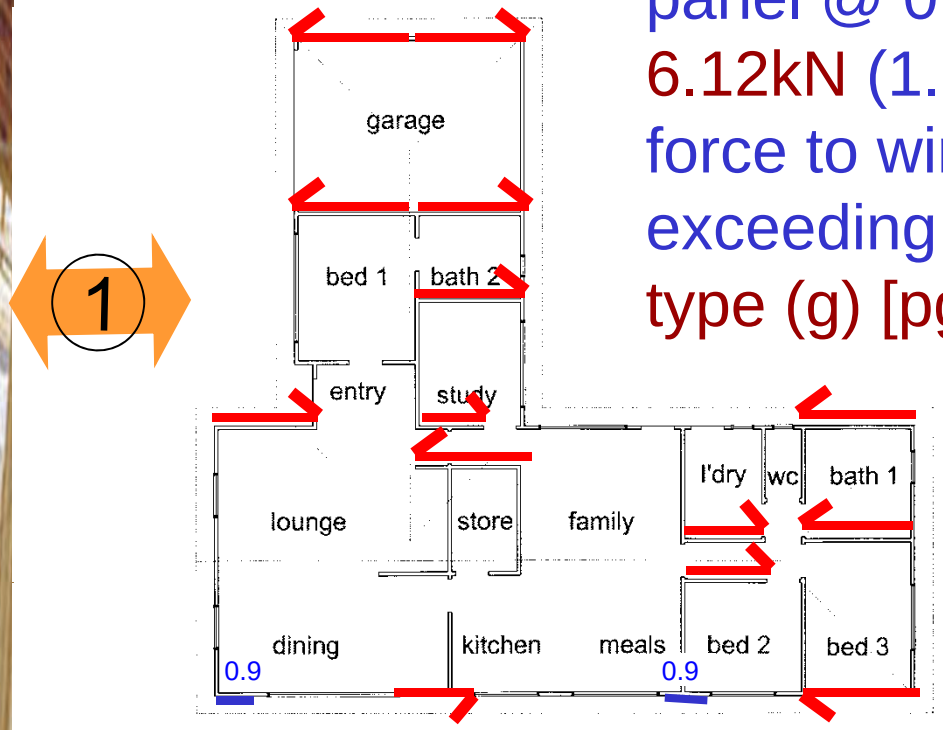
35.4m of bracing x 0.8kN/m
= 28.3kN *(say)*

Additional bracing (racking force) required
= 32.8 – 28.3
= 4.5kN

5.1 Design the wall bracing systems

(for Wind Direction 1)

Wind Direction 1 *(needs an additional 4.5kN)*



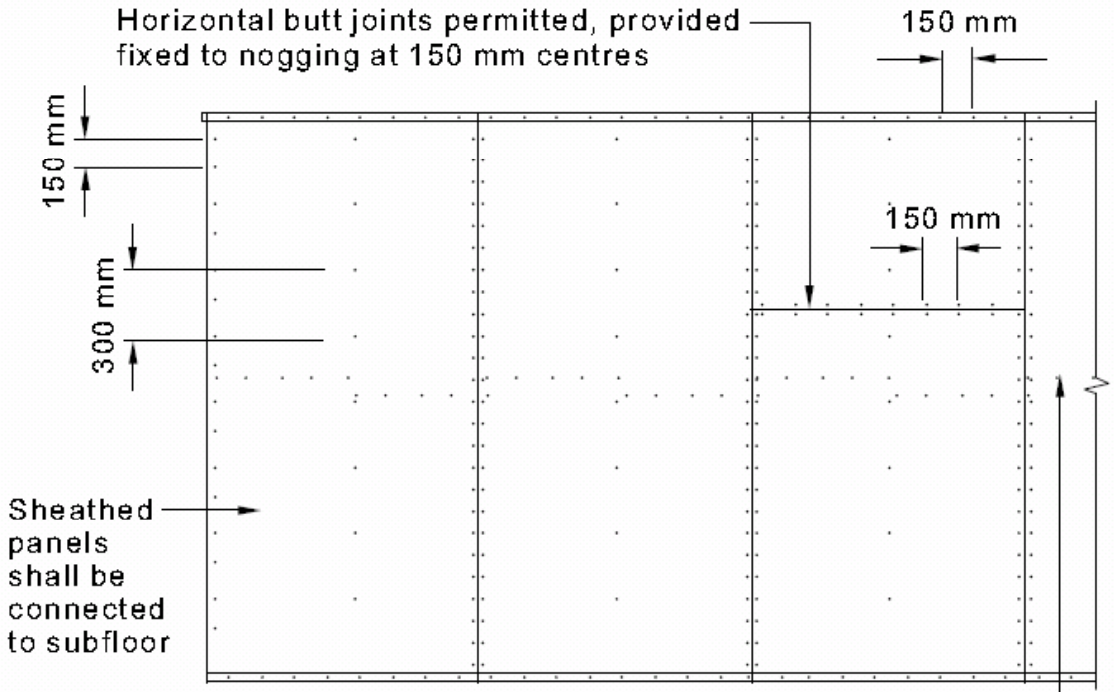
Sheathing in plywood, 1 panel @ 0.9m on the dining room corner and 1 panel @ 0.9m at Bed 2 will add 6.12kN (1.8m x 3.4kN/m) of racking force to wind direction 1, thereby exceeding the 4.0kN required. Adopt type (g) [pg 143].

NOTE: Nominal bracing (plasterboard) can also be used in certain instances – *refer Section 4.3 following*.

AS1684.2 p143

Type of bracing	Bracing capacity (kN/m)

(g) *Plywood* Plywood shall be nailed to frame using 30 mm × 2.8 mm ∅ galvanized flat-head nails or equivalent.



Minimum plywood thickness (mm)			Bracing capacity (kN/m)
Stress grade	Stud spacing mm		
	450	600	
No nogging (except horizontal butt joints)			
F8	7	9	
F11	4.5	7	
F14	4	6	
F27	3	4.5	
One row of nogging			
F8	7	7	3.4
F11	4.5	4.5	
F14	4	4	
F27	3	3	

NOTES:

1 For plywood fixed to both sides of the wall, see Clauses 8.3.6.5 and 8.3.6.10.

2 No other rods or straps are required between top or bottom plate.

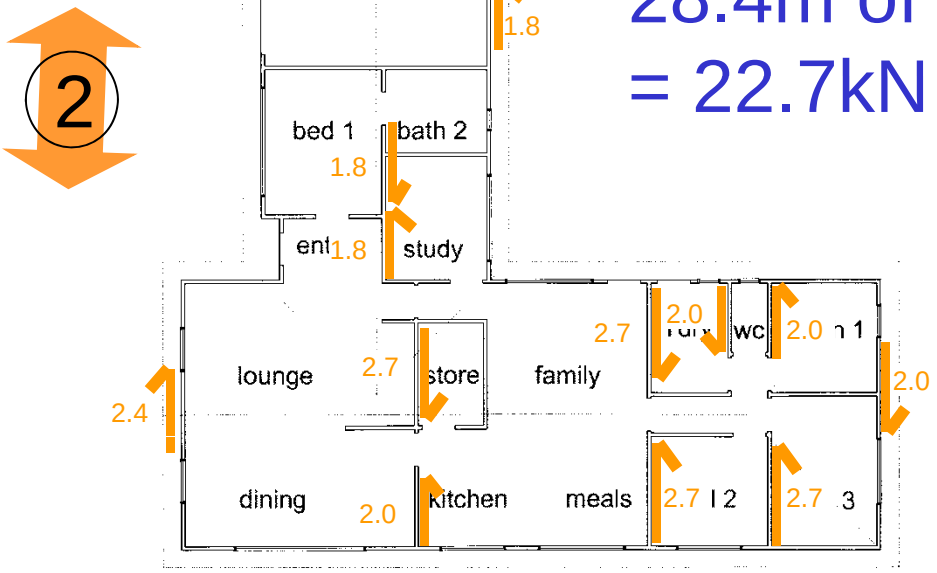
3 Fix bottom plate to floor frame or slab with nominal fixing only (see Table 9.4).

5.2 Design the wall bracing systems

(for Wind Direction 2)

2.4 + (2x1.8) + 2.7 + 2 + (2x1.8) + 2.7 + 2.7 + 2 + 2 + 2.7 + 2 = 28.4m

NOTE: 1.8m minimum bracing length for diagonal bracing.



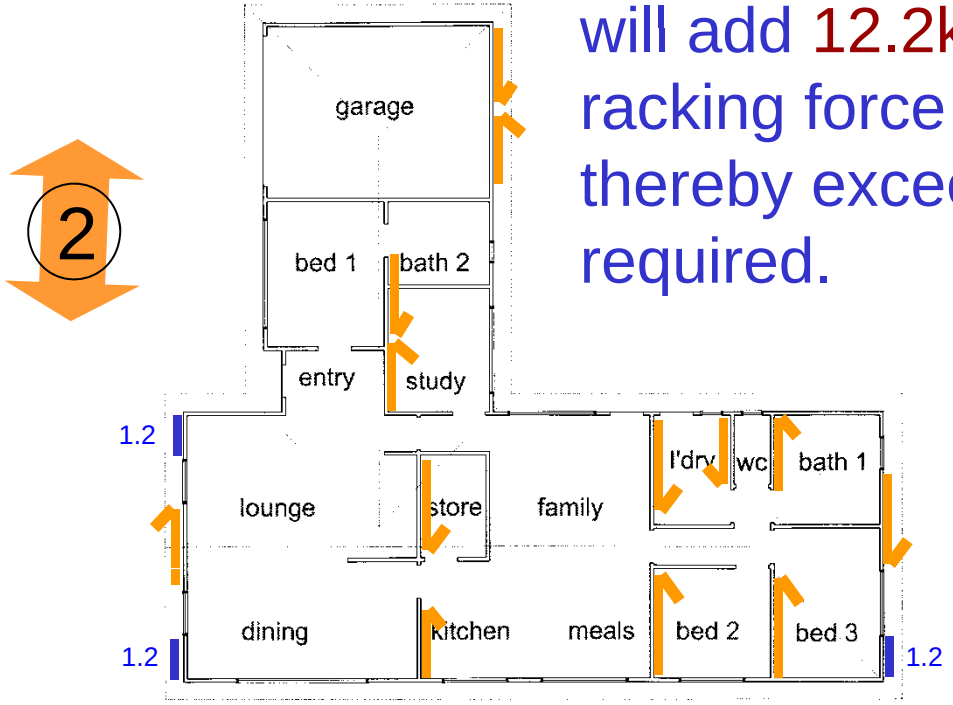
28.4m of bracing x 0.8kN/m = 22.7kN *(say)*

Additional bracing (racking force) required = 34.8 – 22.7 = 12.1kN

5.2 Design the wall bracing systems

(for Wind Direction 2)

Wind Direction 2 *(needs an additional 12.1kN)*



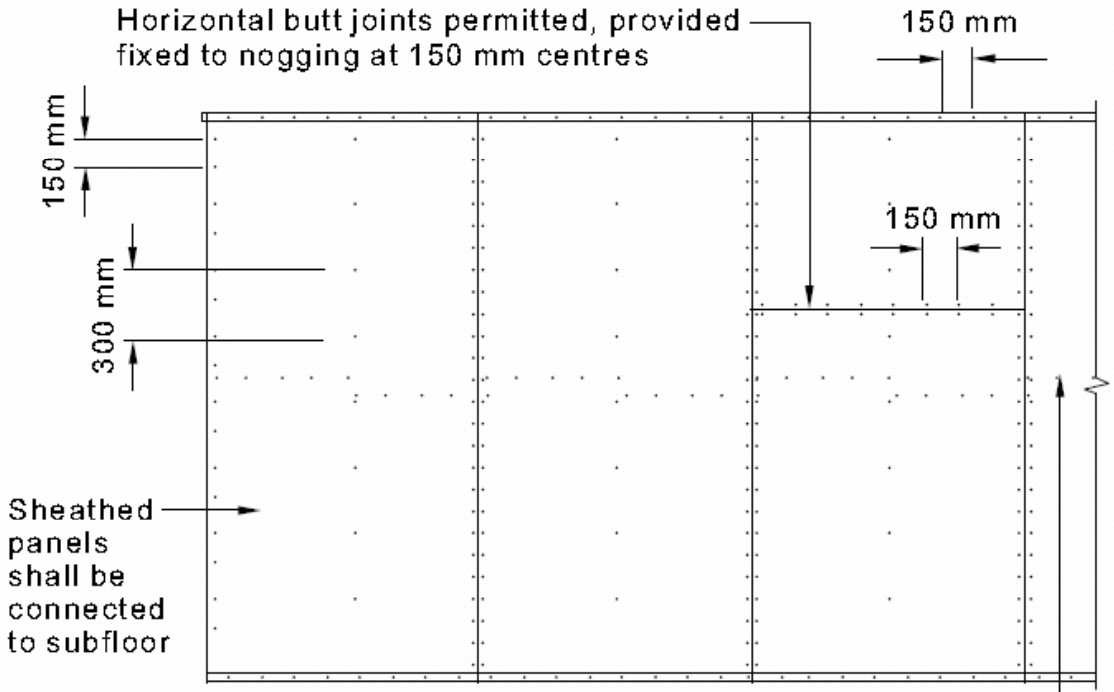
Sheathing in plywood, panels on the lounge/dining room side (2 panels @ 1.2m) and 1 panel @ 1.2m at bed 3, will add 12.2kN (3.6m x 3.4kN/m) of racking force to wind direction 2, thereby exceeding the 12.1kN required.

Adopt type (g) [pg 143].

AS1684.2 p143

Type of bracing	Bracing capacity (kN/m)

(g) *Plywood* Plywood shall be nailed to frame using 30 mm × 2.8 mm ∅ galvanized flat-head nails or equivalent.



Minimum plywood thickness (mm)			Bracing capacity (kN/m)
Stress grade	Stud spacing mm		
	450	600	
No nogging (except horizontal butt joints)			
F8	7	9	
F11	4.5	7	
F14	4	6	
F27	3	4.5	
One row of nogging			
F8	7	7	3.4
F11	4.5	4.5	
F14	4	4	
F27	3	3	

NOTES:

1 For plywood fixed to both sides of the wall, see Clauses 8.3.6.5 and 8.3.6.10.

2 No other rods or straps are required between top or bottom plate.

3 Fix bottom plate to floor frame or slab with nominal fixing only (see Table 9.4).

5.3 Nominal bracing

If the total racking forces have not been achieved, assess whether nominal bracing can be used.

Nominal wall bracing is scarce in this example because most walls require a structural brace. Nominal wall bracing is also not evenly distributed throughout the building and therefore can be ignored – see Clauses 8.3.6.2 and 8.3.6.3 page 140.

6. Maximum spacing of bracing walls

For N2 wind classifications and single storey construction, the maximum distance between braced walls (at right angles to the building length or width) is 9.0m – Clause 8.3.6.7 [pg 149].

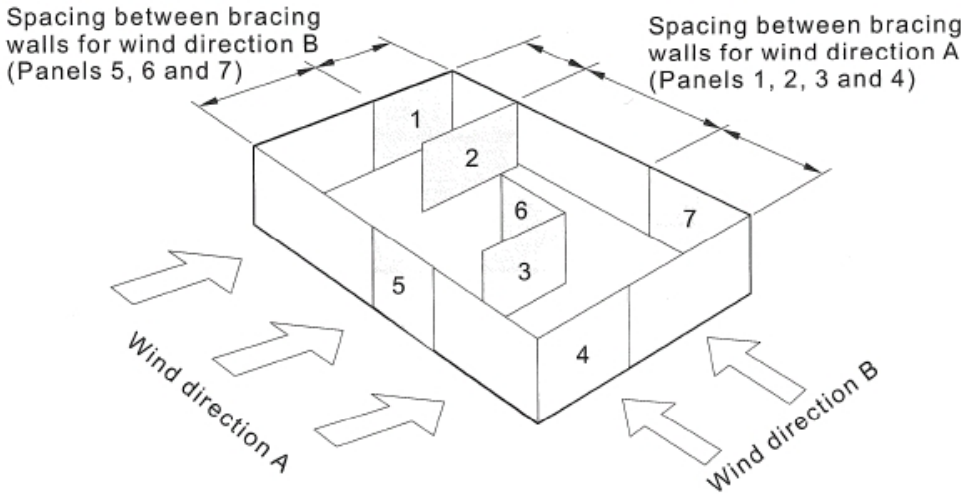


FIGURE 8.6 SPACING OF BRACING

6. Maximum spacing of bracing walls *Cont.*

NOTE: N3 or N4 wind classifications for single storey construction, the maximum distance between braced walls (at right angles to the building length or width) is determined from Tales 8.20 & 8.21 respectively.

For the lower storey of two storey construction, refer Clause 8.3.6.7 [pg 149].

Fixing of Bottom of Bracing Walls

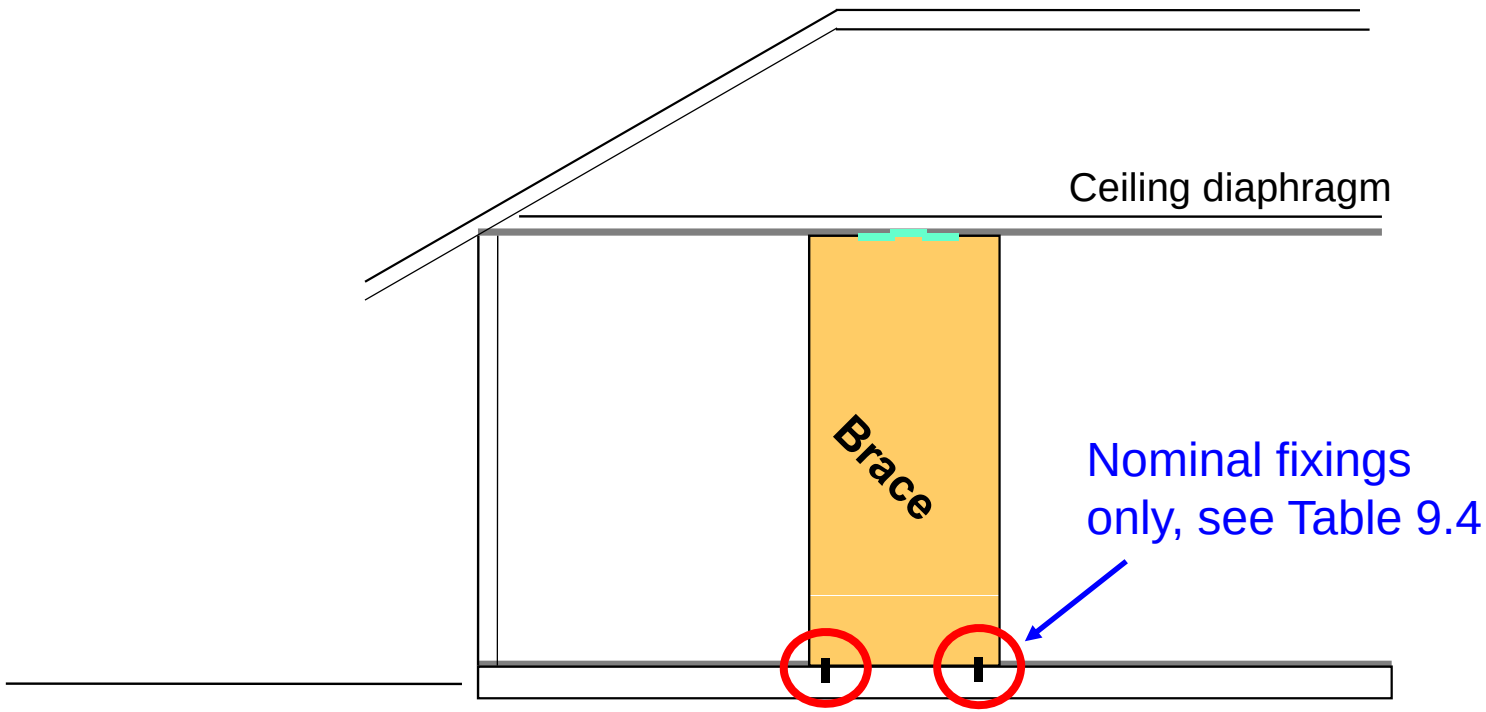
7. Connection of bracing - floors

"The bottom plate of timber-framed bracing walls shall be fixed at the ends of the bracing panel and, if required,intermediately to the floor frame or concrete slab with connections determined from Table 8.18."

(Clause 8.3.6.10)

AS1684.2 p155

7.1 Fixing of Bottom of Bracing Walls



7.1 Fixing of Bottom of Bracing Walls *Cont.*

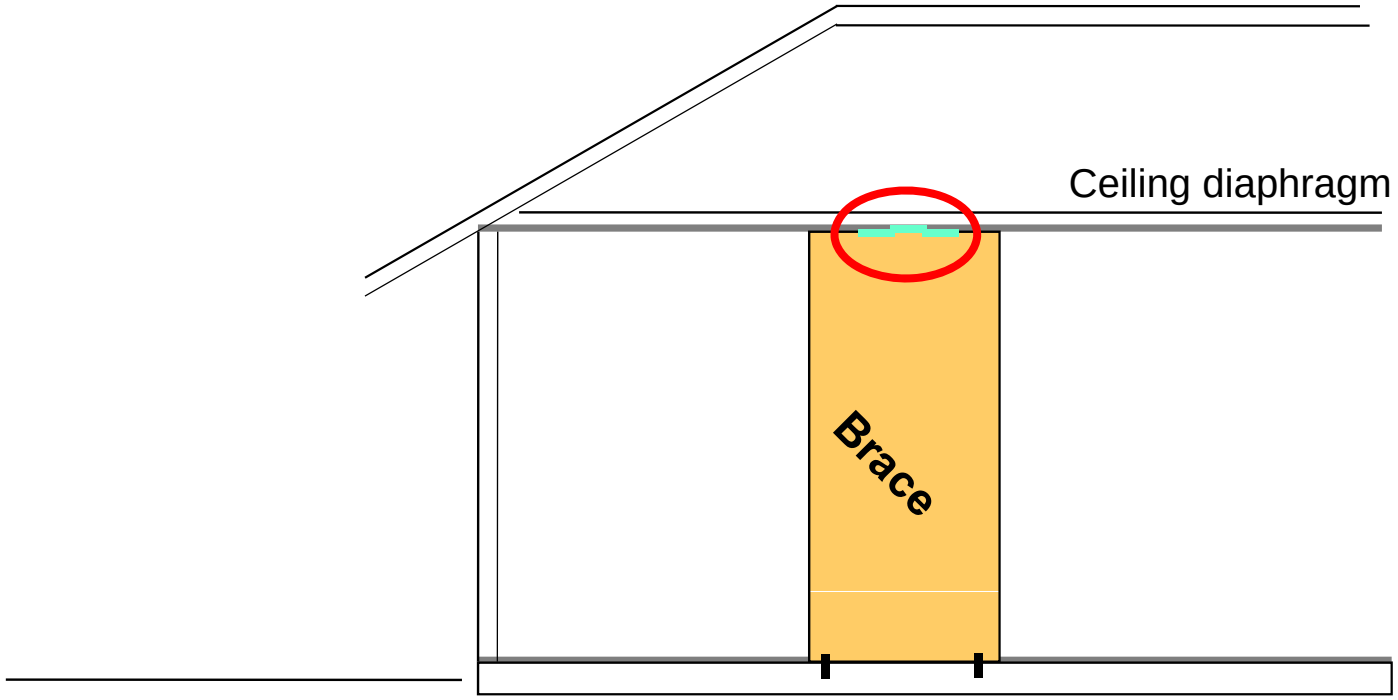
Nominal bracing walls and sheathed walls (i.e. ply bracing panels) with a capacity up to and including 3.4 kN/m require nominal fixing only.

Note: This applies to bottom plate fixing only and does not relate to Tie Down requirements.

For the preceding example, only nominal bottom plate fixing is required, such as a masonry nail, screw or bolt at 1200mm maximum centers – see Table 9.4 [pg 167].

Fixing of Top of Bracing Walls

7.2 Fixing of Top of Bracing Walls



7.2 Fixing of Top of Bracing Walls *Cont.*

All internal brace walls must be fixed at the top "with structural connections of equivalent shear capacity to the bracing capacity of that particular bracing wall"

(Clause 8.3.6.9)

These fixings are determined using Table 8.22, p152-155.

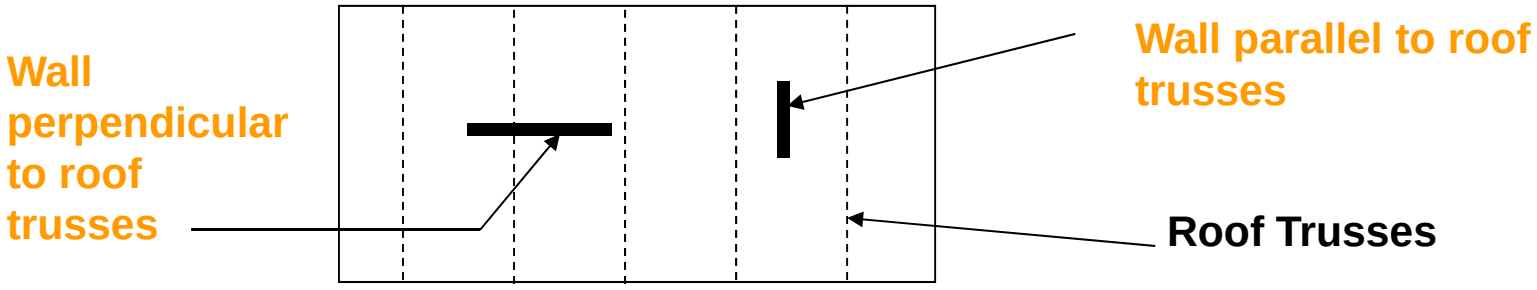
AS1684.2 p151

7.2 Fixing of Top of Bracing Walls *Cont.*

To determine the correct fixing at the top plate, look at the (in this case) truss plan.

And….

1. Determine what direction the walls are running in relation to the trusses.



Plan view

7.2 Fixing of Top of Bracing Walls *Cont.*

2. Select an appropriate fixing requirement from Table 8.22

7.2 Fixing of Top of Bracing Walls *Cont.*

NOTE: Be sure that the total bracing capacity of that individual wall can be resisted by the connection.

For our diagonal braces (maximum 2.7 m horizontal length), the force to be resisted by the connection at the top of the brace wall is:

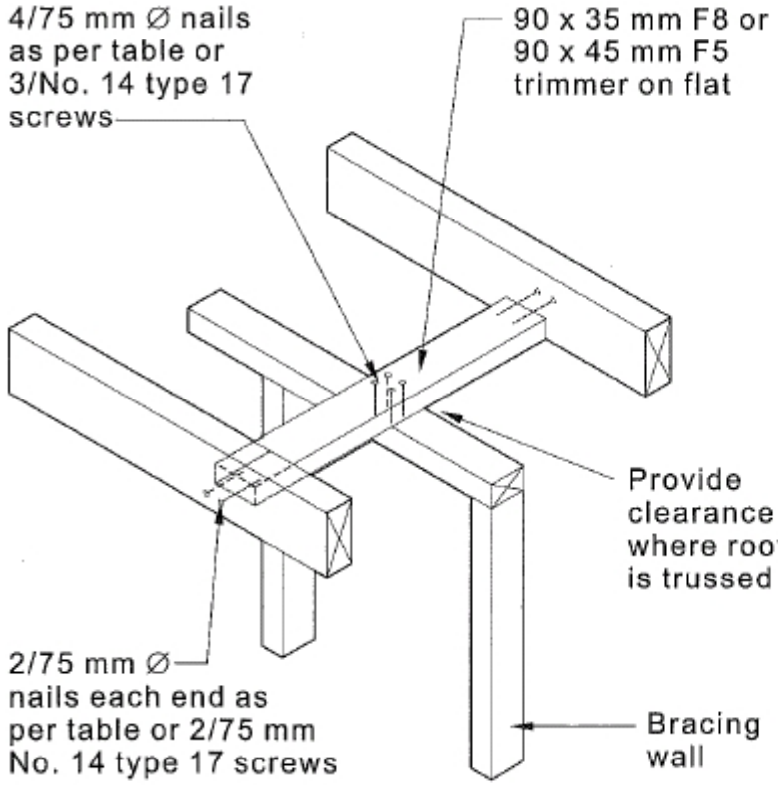
2.7m x 0.8 (kN/m) = 2.16 kN

TABLE 8.22

FIXING OF TOP OF BRACING WALLS

Rafters, joists or trusses to bracing wall	Shear capacity (kN)					
	Unseasoned timber			Seasoned timber		
	J2	J3	J4	JD4	JD5	JD6
Nails						
3.05	3.0	2.1	1.5	2.1	1.8	1.3
3.33	3.3	2.4	1.7	2.4	2.0	1.5
Screws						
No.14 Type 17	12	8.3	5.9	8.3	5.9	4.3

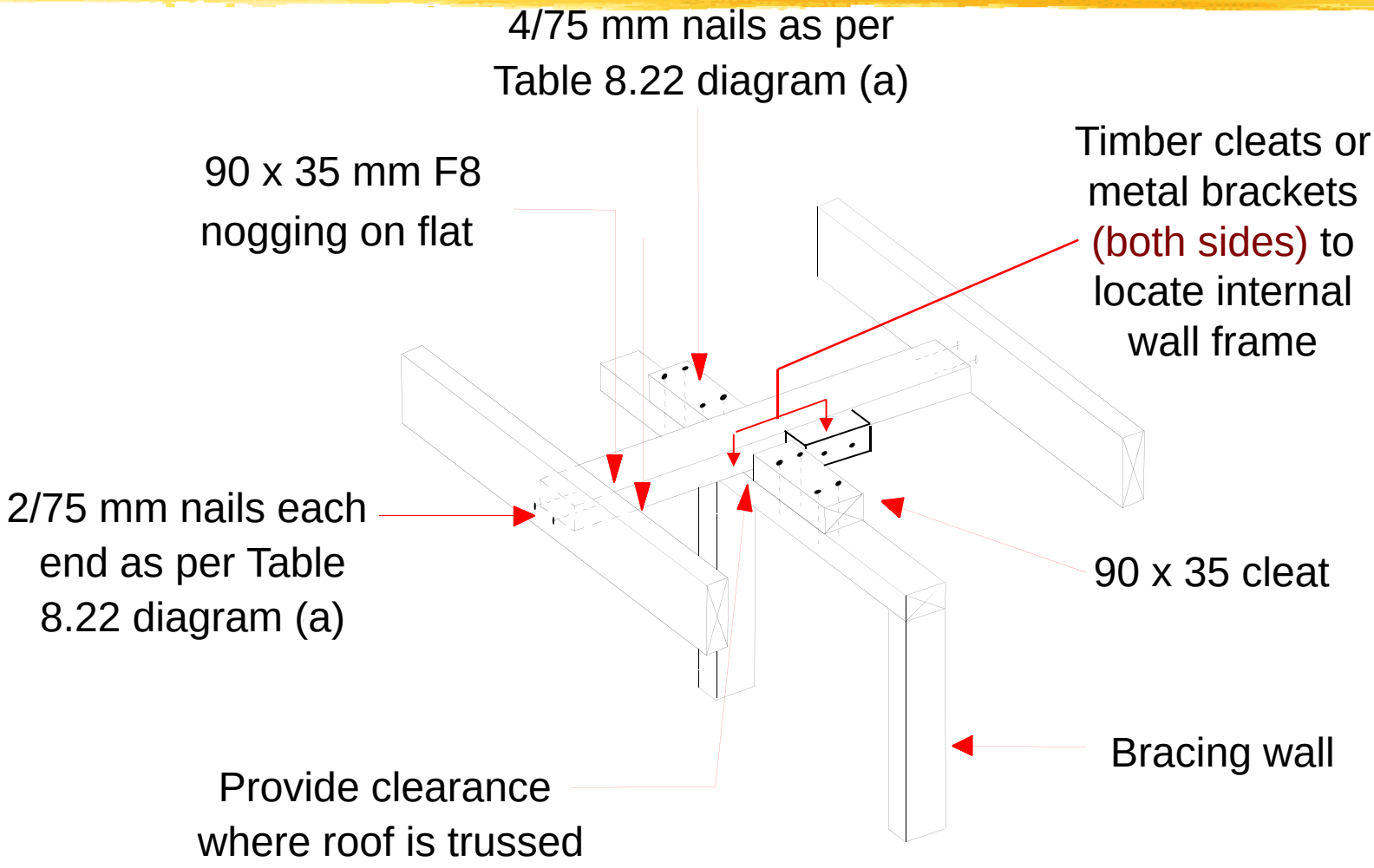
(a)



NOTE: For trussed roofs, nails or screws through the top plate shall be placed in holes that permit free vertical movement of the trusses. Alternatively, provide timber blocks either side of the trimmer, fixed as prescribed for each block.

Connection of braced walls parallel to trusses

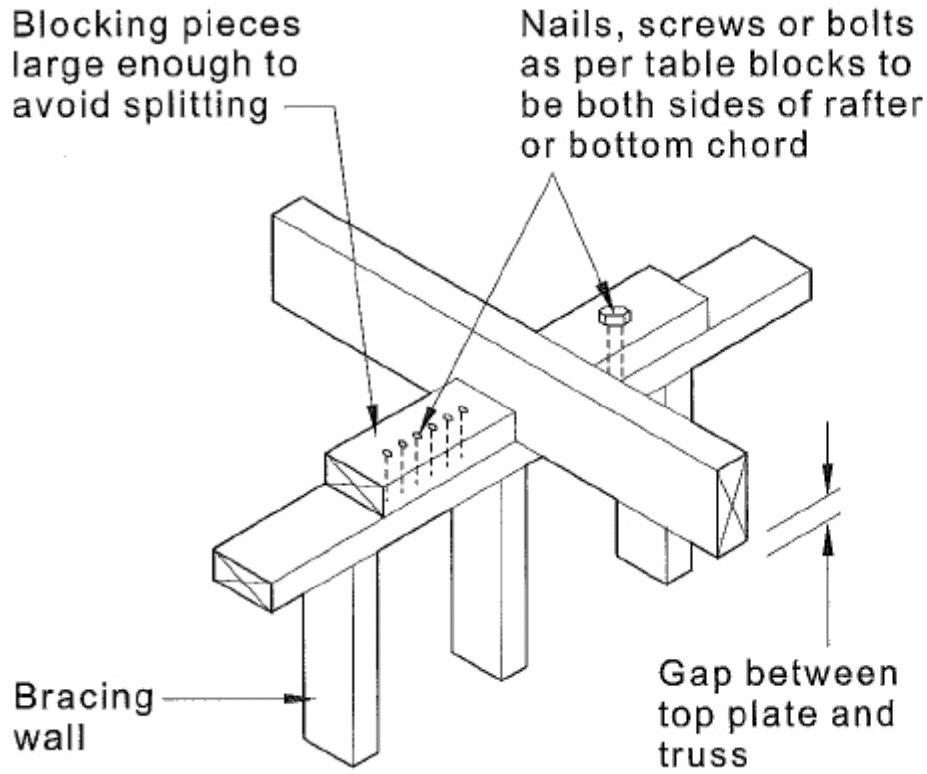
7.2 Fixing of Top of Bracing Walls *Cont.*



Alternative fixing detail *(also 2.4kN in JD4)*

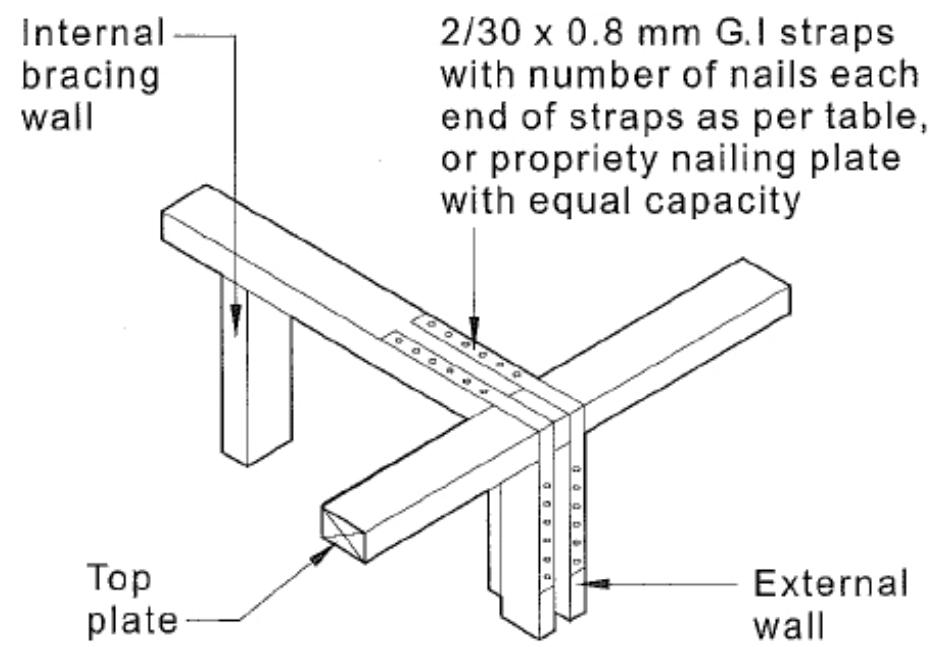
TABLE 8.22 (*continued*)

Rafters, joists or trusses to bracing wall	Shear capacity (kN)					
	Unseasoned timber			Seasoned timber		
	J2	J3	J4	JD4	JD5	JD6
(j)						
Nails						
4/3.05	5.0	3.6	2.5	3.6	3.0	2.2
6/3.05	6.6	4.7	3.4	5.0	4.2	3.1
4/3.33	5.6	4.0	2.8	4.0	3.3	2.5
6/3.33	7.4	5.3	3.7	5.5	4.6	3.5
Bolts						
M10	6.4	4.1	2.6	4.3	3.0	2.0
M12	7.6	4.9	3.1	5.1	3.6	2.5
2/M10	13	8.0	5.1	8.4	5.9	4.0
Screws						
2/No.14 Type17	9.7	6.9	4.9	6.9	4.9	3.6
3/No.14 Type17	15	10	7.4	10	7.4	5.4



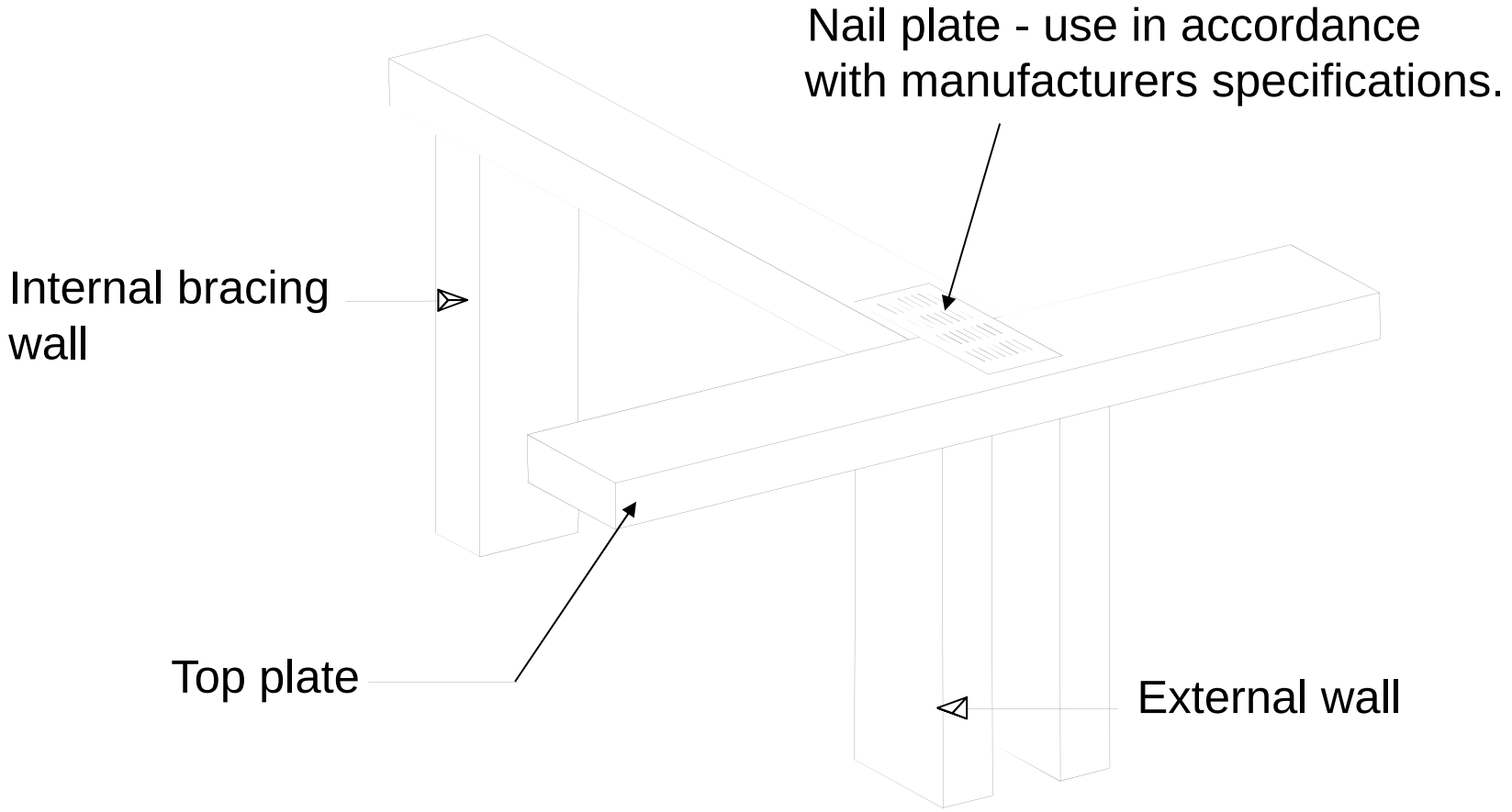
Connection of braced walls perpendicular to trusses

TABLE 8.22 (*continued*)

Rafters, joists or trusses to bracing wall		Shear capacity (kN)					
		Unseasoned timber			Seasoned timber		
		J2	J3	J4	JD4	JD5	JD6
(k) 	Straps	Nails					
	1	4/2.8	4.3	3.1	2.2	3.3	3.0	2.1
		6/2.8	6.5	4.6	3.3	4.9	4.0	3.1
	2	4/2.8	8.7	6.2	4.4	6.6	5.4	4.1
		6/2.8	13	9.3	6.6	9.8	8.1	6.1

Connection of braced internal walls abutting external walls

Connection of braced internal walls abutting external walls - alternative detail



Capacities available from nail-plate manufacturers

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