Understanding AS1684
Residential Timber Framed Construction

Bracing example

Background
Timber Queensland and the Building Services Authority are experiencing increasing feedback and concerns from the building industry regarding the performance and premature failure of H3 Light Organic Solvent Preservative (LOSP) treated pine products due to decay. In many instances failure of these products has occurred under 5 years in-service. These products may include solid timber, laminated and finger jointed timber and LVL.

Photo 1: Avoid premature failure by applying supplementary preservative and oil-based alkyd primers on all cuts, notches, holes etc.

Satisfactory in-service performance of these products is dependent upon the timber, the quality of the LOSP treatment, together with the painting, installation and maintenance practices applied.

This advisory note provides information and advice aimed at improving and ensuring the in-service performance of these products such as beams, cladding, hand rails, posts, newels, mouldings, decking etc.
- C2
- Split level
- Dutch gable roofs
- Ceiling height 2560
- Eaves 600mm
- Roof pitch 25°
Bracing Design Process (Clause 8.3.1)

1. Determine the wind classification
   Clauses 1.4.2 & 1.5 & AS4055/AS/NZS1170.2

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 and Tables 8.1 to 8.5

5. Design the bracing systems
   - Sub-floors
   - Walls
   Clause 8.3.5, Fig 8.4, Tables 8.7 - 8.16, C1 only
   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, Tables 8.20 – 8.21 and Figs 8.5 – 8.6

7. Connection of bracing to roof/ceilings at walls and floors
   Clause 8.3.6.9 and 8.3.6.10, Table 8.23

AS1684.3 pg108
1. Determine the Wind Classification

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

C2
(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 108] also Tables 8.1 to 8.5 [pgs 112–120]

Need:
• the roof pitch,
• the width of the building, and
• whether there are any flat walls, skillion ends, gable (or Dutch gables) or hip ends.

Complex designs may require separate pressures within the one wind direction as is the case in this example.
Dutch Gables

In this example, the house has Dutch gables which are neither a full gable or a hip end as described by the pressure tables in AS 1684.3.

It is recommended that where the height of the Dutch gable (a) is equal to or less than half the full height to the ridge (h), that the Dutch gable end be treated as a hip end. If ‘a’ is greater than 1/2h, then treat the Dutch gable end as a full gable end.

2.1 Determine the wind pressure

(for Wind direction 1)

See Table 8.1 [pg 112] and Table 8.2 [pg 113]

Split the house into it’s two components
• Two storey section with Dutch gable
• Single storey hip roof (long length of building)
2.1 (cont) Determine the wind pressure
(for Wind direction 1)

For each section, determine the wind pressure for each level:

- Two storey section with Dutch gable
  - Level 3 (upper storey of two storey)
  - Level 1 (lower storey of two storey)
- Single storey hip roof (long length of building)
  - Level 2 (single storey)
  - Subfloor (lower storey of two storey)

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Two storey Dutch gable end

Single storey Hip roof long side

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Two storey Dutch gable end treated as a full gable

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Two storey section with Dutch gable
- Level 3 (upper storey of two storey)
Dutch Gable > ½ height of ceiling to ridge, therefore treat as a full gable end.
### Table 8.1

**Pressure at different area of elevation (m²)—Single Storey**

<table>
<thead>
<tr>
<th>Wind classification</th>
<th>Pressure (kPa)</th>
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</tr>
<tr>
<td>C3</td>
<td>3.2</td>
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</table>

#### 2.1 (Cont) Determine the wind pressure

*(for Wind direction 1 — Dutch gable end treated as a full gable)*

Dutch Gable > ½ height of ceiling to ridge, therefore treat as a full gable end.

See Table 8.1 [pg 112]

Pressure (Assuming gable end) = 2.1 kPa (kN/m²)
2.1 (cont) Determine the wind pressure
(for Wind direction 1)

Two storey section with Dutch gable
- Level 1 (lower storey of two storey)
Dutch Gable > ½ height of ceiling to ridge,
therefore treat as a full gable end.

| TABLE 8.1 |
| Pressures (kPa) on area of elevation (m²) — 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) |

<table>
<thead>
<tr>
<th>Wind classification</th>
<th>Pressure (kPa)</th>
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</thead>
<tbody>
<tr>
<td>C1</td>
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<td>2.1</td>
</tr>
<tr>
<td>C3</td>
<td>3.2</td>
</tr>
</tbody>
</table>
2.1 (cont) Determine the wind pressure
(for Wind direction 1 gable end)

See Table 8.1 [pg 112]

Pressure (Assuming gable end)

\[ P = 2.1 \text{ kPa (kN/m}^2\text{)} \]

2.1 (cont) Determine the wind pressure
(for Wind direction 1 – hip end long side of building)

Single storey section
- Level 2 (single storey)
Wind direction 1

Level 1 and Level 2

Wind direction 2

Level 3

Wind direction 2

TABLE 8.2
PRESSURE (kPa) ON AREA OF ELEVATION (m²) SINGLE STOREY OR UPPER
STOREY OF TWO STOREYS — LONG LENGTH OF BUILDING —
HIP OR GABLE ENDS

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NOTE: See Figure 1.1 for guidance on determining W.

W (m) Actual

8.910

NOTE: If pitch is provided for interpolation purposes only.
2.1 (cont) Determine the wind pressure
(for Wind direction 1 – hip end long side of building)

See Table 8.2 [pg 113]

Single storey - hip roof - long side

Building Width is 8.91m, but say 9.0m, as interpolation would not gain a lot in this case

Pressure = 1.7 kPa (kN/m²)

<table>
<thead>
<tr>
<th>Wind direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind direction</td>
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</tbody>
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TABLE 8.3
PRESSURE (kPa) ON AREA OF ELEVATION (m²) - LOWER STOREY OR SHORTER OF SINGLE STOREY OR TWO STOREYS - LONG LENGTH OF BUILDING - HIP OR GABLE ENDS

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<th>W (m)</th>
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NOTE: See Figure 1.1 for guidance on determining W.

Actual 8.910

NOTE: Pitch is provided for interpolation purposes only.
2.1 (cont) Determine the wind pressure
(for Wind direction 1 – hip end long side of building)

See Table 8.3 [pg 115]

Lower storey of two storey or sub-floor of single storey

Building Width is 8.91m, but say 9.0m, as interpolation would not gain a lot in this case

Pressure = 1.9 kPa (kN/m²)

2.2 Determine the wind pressure
(for Wind direction 2)

As the wind in direction 2 can come from either side onto the east or west elevation, a decision is required on how to account for the worst case.

The house is also split level, so other decisions are also required on how the wind will be distributed into bracing walls in each level. This matter will be discussed later.
2.2 (cont) Determine the wind pressure

(for Wind direction 2 – Hip end – Long length of building or from Dutch gable end)

Discussion
As can be seen from the elevation, the single storey (Level 2) section of the house falls almost entirely within the area envelope of the two storey section. The rear patio is assumed to remain open. The front porch is assumed to be closed one end by lattice.

Also, as the height of the Dutch gable on the east East elevation elevation is equal or less than half the overall height to the ridge of the roof, this can be treated as a hip end similar to the hip roof from the west elevation. This section of gable will therefore not result in greater forces than that of the hip roof so it can be ignored in this regard.

It is therefore recommended to consider the wind for Direction 2 on the two storey section, and make allowance for any additional small areas of elevation (as shown in orange) outside of the two storey section and account for these forces appropriately where these areas are also considered as a hip.

<table>
<thead>
<tr>
<th>TABLE 8.2</th>
<th>PRESSURE (Pa) ON AREA OF ELEVATION (m²) – SINGLE STOREY OR UPPER STOREY OF TWO STOREY</th>
<th>LONG LENGTH OF BUILDING – HIP OR GABLE ENDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>W (m)</td>
<td>Roof pitch (degrees)</td>
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NOTE: If pitch is provided for interpolation purposes only, (continued)
2.2 (cont) Determine the wind pressure
(for Level 3, Wind direction 2 – Hip end – Long length of building)

See Table 8.2 [pg 113]

Roof pitch 25°

Pressure (hip roof - long side) = 1.6 kPa (kN/m²)

---

TABLE 8.3
PRESSURE (kPa) ON AREA OF ELEVATION (m²) – LOWER STOREY OR SUBSTORY OF SINGLE STOREY OR TWO STOREYS – LONG LENGTH OF BUILDING – HIP OR GABLE ENDS

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</tr>
</tbody>
</table>

NOTE: See Figure 1.1 for guidance on determining W.

Interpolation permitted but not necessary

Actual 6.880
2.2 (cont) Determine the wind pressure

(for Level 1, Wind direction 2 – Hip end – Long length of building)

See Table 8.3 [pg 115]

Roof pitch 25°

Pressure (hip roof - long side) = 1.9 kPa (kN/m²)

---

PRESSURE (kPa) ON AREA OF ELEVATION (m²) — SINGLE STORY OR UPPER OF TWO STORY — SHORT END OF BUILDING — HIP ENDS

W = 6.88

- Pressure (hip roof - long side) = 1.9 kPa (kN/m²)

---

<table>
<thead>
<tr>
<th>W (m)</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
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</tbody>
</table>

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

---

NOTE: 0° pitch is provided for interpolation purposes only. (continued)
2.2 (cont) Determine the wind pressure
(for Level 1, Wind direction 2 – Short end of building - Hip end )

See Table 8.4 [pg 117]

Note: The additional areas highlighted in orange, outside the envelope of the two-storey section are considered as pressure on a hip end (rather than gable), as the height of the Dutch gable on this elevation is less than \( \frac{1}{2} \) the height from ceiling to the ridge.

Pressure (Hip roof end of building )
\[ = 1.8 \text{ kPa (kN/m}^2) \]

2.2 (cont) Determine the wind pressure
(for Sub-floor of Level 1, Wind direction 2 – Hip end )

Note: Bracing of the sub-floor (indicated in orange) is not required for wind direction 2 as the pressures or forces will be taken by the Level 1 bracing of the two storey section of the house.

However, some consideration of the small additional areas as indicated previously may need to be added to the Level 1 forces.
### 2.2 (cont) Determine the wind pressure

#### Summary of Pressures

<table>
<thead>
<tr>
<th>Level</th>
<th>Direction 1</th>
<th>Direction 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level 3</td>
<td>Level 3</td>
</tr>
<tr>
<td></td>
<td>2.1 kN/m²</td>
<td>1.6 kN/m²</td>
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<tr>
<td></td>
<td>(gable)</td>
<td>(gable)</td>
</tr>
<tr>
<td></td>
<td>Level 1</td>
<td>Level 1 &amp; 2</td>
</tr>
<tr>
<td></td>
<td>2.1 kN/m²</td>
<td>1.9 kN/m²</td>
</tr>
<tr>
<td></td>
<td>(gable)</td>
<td>(hip)</td>
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<tr>
<td></td>
<td>Level 2</td>
<td>Level 1 &amp; 2</td>
</tr>
<tr>
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<td>1.7 kN/m²</td>
<td>1.9 kN/m²</td>
</tr>
<tr>
<td></td>
<td>(hip)</td>
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<tr>
<td></td>
<td>Level 2 subfloor</td>
<td>Level 1 &amp; 2</td>
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<tr>
<td></td>
<td>1.9 kN/m²</td>
<td>1.8 kN/m²</td>
</tr>
<tr>
<td></td>
<td>(hip)</td>
<td>(hip)</td>
</tr>
</tbody>
</table>

### 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 triangular portion of eaves up to 1000mm wide may be ignored. See Note 3 to Figures 8.2 (A, B & C), pg 109 – 111

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

\[
\text{Area} = \frac{W}{2} \times \frac{W}{2} \tan X' + 0.15 \times W
\]

The triangular part of eaves is ignored.
3.1 Determine the Area of Elevation
(for Wind Direction 1 – Gable end – Level 3)
(Eaves 600mm, roof pitch 25°)

Height FCL to ridge:
- \( \frac{6880}{2} \times \tan 25° \)
- \( = 3440 \times 0.47 \)
- \( = 1604 \text{ mm. Say 1.6 m} \)

Area of gable = \( 3.44 \times 1.6 \)
- \( = 5.50 \text{ m}^2 \)

Area due to depth of roof frame (assume 150 mm)
- \( = 0.15 \times 6.88 = 1.03 \text{ m}^2 \)

Area of wall = \( \frac{1}{2} \) Ceiling height x width
- \( = 2.56/2 \times 6.88 \)
- \( = 8.81 \text{ m}^2 \)

Total Gable End Area – Level 3
- \( = 5.5 + 1.03 + 8.81 \)
- \( = 15.34 \text{ m}^2 \) say 15.3 m²

3.1 (Cont) Determine the Area of Elevation
(for Wind Direction 1 – Gable end – Level 1)
(Eaves 600mm, roof pitch 25°)

Area of gable = \( 3.44 \times 1.6 \) (same as before)
- \( = 5.50 \text{ m}^2 \)

Area due to depth of roof frame (assume 150 mm)
- \( = 0.15 \times 6.88 = 1.03 \text{ m}^2 \)

Area of wall = \( \frac{1}{2} \) Ceiling height level 3 + floor depth + \( \frac{1}{2} \) wall height level 1) x width
- \( = (2.56 + 0.2 + 1.2) \times 6.88 \)
- \( = 27.24 \text{ m}^2 \)

Total Gable End Area – Level 3
- \( = 5.5 + 1.03 + 27.24 \)
- \( = 33.77, \text{ say 33.8 m}^2 \)
3.1 (Cont) Determine the Area of Elevation
(for Wind Direction 1 – Hip end – Level 2)

(Eaves 600mm, roof pitch 25°, for purpose of this example assume Dutch gable is ½ height from FCL to ridge, width of Dutch gable end is 8910 mm)

Hip Roof

Height FCL to ridge = 8910/2 x Tan 25°
= 4455 x 0.47
= 2077 mm, say 2.08 m

Depth of roof frame = 0.15 m (assumed)

Total height to ridge = 2.08 + 0.15 = 2.23 m

Height Dutch gable = 2.23/2 = 1.12 m

Offset of Dutch gable = 1.12/tan 25°
= 2.40 m

Area of roof = length x height to ridge – ¾ blue area
= (6.67 x 2.23) – (0.75 x 2.4 x 2.23)
= 14.87 – 4.01
= 10.86 m²

Total Area – Level 2
= 10.86 + 8.54
= 19.4 m²

3.1 (Cont) Determine the Area of Elevation
(for Wind Direction 1 – Hip end – sub-floor of Level 2)

(Eaves 600mm, roof pitch 25°, assume Dutch gable is ½ height to ridge, width of Dutch gable end is 8910 mm)

Hip Roof

Area of roof and wall for Level 2 as previously calculated = 19.4 m²

Additional area of lower half of Level 2 wall + area of ½ the height of the sub-floor (shaded blue) is to be added to the above area, to get the total area of elevation required for the sub-floor bracing.

= length x (1/2 wall height + ½ the sub-floor height)
= 6.67 x (2.56/2 + 1.05/2)
= 12.04 m²

Total Area – Level 2, sub-floor
= 19.4 + 12.04
= 31.44, say 31.4 m²
3.1 (Cont) Determine the Area of Elevation
(for Wind Direction 2 – Hip roof – Level 3)
(Eaves 600mm, roof pitch 25°)

Total Area – Level 3
= 14.55 + 11.4
= 25.95, say 26.0 m²

3.1 (Cont) Determine the Area of Elevation
(for Wind Direction 2 – Hip roof – Level 1)
(Eaves 600mm, roof pitch 25°)

Total Area – Level 1
= 26 + 23.9
= 49.9 m²
3.1 (Cont) Determine the Area of Elevation

(for Wind Direction 2 – Hip roof - Level 1
– additional small areas, shaded blue Eaves 600mm, roof pitch 25°)

Note: For the additional areas, the full height of the wall sections for Level 2 have been used as the loads are assumed to be shared by both Levels 1 and 2

Hip Roof

Front porch assuming one end closed in approximately
\[ = \frac{3.6}{2} \times 1.15 = 2.07 \text{ m}^2 \]

Rear patio gable, assuming not filled in, and additional wall area under gable approximately
\[ = 2.55 \times \tan 25 \times 2.55/2 + 0.6 \times 1.55 \]
\[ = 1.51 + 0.93 \]
\[ = 2.44 \text{ m}^2 \]

Total additional areas – Level 1
\[ = 2.07 + 2.44 \]
\[ = 4.51 \text{ m}^2 \text{ say } 4.5 \text{ m}^2 \]

Wind direction 2

3.1 (cont) Determine the Area of Elevation

Summary of Areas

<table>
<thead>
<tr>
<th>Direction 1</th>
<th>Direction 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 3</td>
<td>Level 3</td>
</tr>
<tr>
<td>15.3 m²</td>
<td>26.0 m²</td>
</tr>
<tr>
<td>(gable)</td>
<td>(hip)</td>
</tr>
<tr>
<td>Level 1</td>
<td>Level 1 &amp; 2</td>
</tr>
<tr>
<td>33.8 m²</td>
<td>49.9 m²</td>
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<tr>
<td>(gable)</td>
<td>(hip)</td>
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<tr>
<td>Level 2</td>
<td>Level 1 &amp; 2</td>
</tr>
<tr>
<td>19.4 m²</td>
<td>Additional</td>
</tr>
<tr>
<td>(hip)</td>
<td>areas</td>
</tr>
<tr>
<td>Level 2</td>
<td>4.5 m²</td>
</tr>
<tr>
<td>subfloor</td>
<td>(hip)</td>
</tr>
</tbody>
</table>
4. **Calculate the racking force**  
*(for both Wind Directions)*

Use the formula:

\[ \text{Racking Force} = \text{Area of Elevation} \times \text{Wind Pressure} \]

\[ (kN) \quad (m^2) \quad (kPa) \cdot (kN/m^2) \]

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

**Example: Total racking force for Wind Direction 2, Levels 1 & 2**

- **Hip** = 49.9 m\(^2\) x 1.9 kN/m\(^2\) = 94.8 kN
- Additional areas = 4.5 m\(^2\) x 1.8 kN/m\(^2\) = 8.1 kN
- **Total** = 102.9 kN
4. Calculate the racking forces

(Summary of racking forces for both Wind Directions)

Direction 1

Level 3: 32.1 kN
Level 1: 71.0 kN
Level 2: 33 kN
Level 2 subfloor: 59.7 kN

Direction 2

Level 3: 41.6 kN
Level 1 & 2: 94.8 kN
Level 1 & 2 Additional areas: 8.1 kN

Distribution of racking forces

Discussion: Wind direction 1

Distribution of racking forces is relatively simple in this direction.
Consider the house broken into two parts – the two storey section (Levels 1 and 3) and the single storey section (Level 2). The racking forces that occur on each section should be distributed into that section.

The racking forces should also be distributed in proportion to the forces that occur on each level in each section.

Bracing of the sub-floor for Level 2 will be discussed later.
Distribution of racking forces

Discussion: Wind direction 2

Distribution of racking forces in this direction is more complicated.

It is assumed that Level 2 is integrally tied and connected to Levels 1 and 3, and forces can therefore be distributed across these levels.

Level 3 should be designed as 'stand alone', and therefore does not contribute to forces in Level 2.

It is suggested that up to 1/2 of the forces that occur on Level 1 can be distributed into Level 2 in addition to the force due to the small additional areas.

The forces to be distributed in Level 2 will therefore be equal to the difference between 94.8 kN (Level 1) and what is actually taken by Level 1 (57.6 kN see later), \( (94.8 - 57.6 = 37.2 \text{ kN}) \) + \( 8.1 \text{ kN} = 45.3 \text{ kN} \)

Bracing of the sub-floor for Level 2 will be discussed later.
5. Design the wall bracing systems

Wind direction 1 - Level 1

As the racking force is of a significant magnitude, relatively strong bracing walls will be required.

As an initial start, assume bracing walls will be plywood rated at 6.4kN/m, min panel length 600 mm (Method A) – Table 8.18 (h) [pg 140]

Therefore length of bracing wall required

\[ \frac{71.0}{6.4} = 11.09 \text{, say 11.0 m} \]

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].
Minimum panel length for Plywood is 600 mm for Type A bracing.  
Clause 8.3.6.5(a) [pg 144]

Wall 1.
For LH garage wall, available wall length is 900 + 600 (corners) + 3600 = 5100 mm
5.1 x 6.4 kN/m = 32.6 kN
Wall 2
2 x 1.2 m panels = 2.4 m x 6.4
= 15.4 kN
Wall 3
1 x 0.9 m = 0.9 x 6.4 = 5.7 kN
Wall 4
Available length is 4.4 m but use 4.2 x 6.4 = 26.9 kN
TOTAL = 32.6 + 15.4 + 5.7 + 26.9 = 80.6 kN therefore satisfactory
Note: Wall 3 could be deleted and still OK.

Wind direction 1 - Level 1

Wind direction 1 - Level 2

Minimum panel length for Plywood is 600 mm for Type A bracing.  
Clause 8.3.6.5(a) [pg 144]

Wall 5.
Length is 2400 mm
2.4 x 6.4 kN/m = 15.4 kN
Wall 6
0.8 m x 6.4 kN/m
= 5.1 kN
Wall 7
1.2 m x 6.4 kN/m
= 7.7 kN
Wall 8
1.2 m x 6.4 kN/m
= 7.7 kN
TOTAL = 15.4 + 5.1 + 7.7 + 7.7 = 35.9 kN therefore satisfactory
Wind direction 1 - Level 3

Wall 9.
0.9 m x 6.4 kN/m = 5.7 kN
Wall 10
1.2 m x 6.4 kN/m = 7.7 kN
Wall 11
0.6 m x 6.4 kN/m = 3.8 kN
Wall 12
1.2 m x 6.4 kN/m = 7.7 kN
Wall 13
1.2 m x 6.4 kN/m = 7.7 kN
(Note: A 2.4 m panel of double diagonal strap bracing rated at 3.0 kN/m may be better placed here as this would not interfere with line of internal or external lining etc)
Wall 14
1.2 m x 6.4 kN/m = 7.7 kN
TOTAL = 5.7 + 7.7 + 3.8 + 7.7 + 7.7 + 7.7 = 40.4 kN therefore satisfactory
Note: Wall 10 could be deleted and would still OK

Wind direction 2 - Level 1

Wall a.
2.7 m x 6.4 kN/m = 17.3 kN
Wall b
1.8 m x 6.4 kN/m = 11.5 kN
Wall c
2.1 m x 6.4 kN/m = 13.4 kN
Wall d
Note: To enable as much bracing as possible to be distributed into the front of the garage wall, both sides of the walls either side of garage door will be sheeted to enable doubling the rating to 12 kN/m. See Clause 8.3.6.5 [pg 144] Note this also requires doubling the connections at the top and bottom of wall.
0.6 m x 12.8 kN/m = 7.7 kN
Wall e
0.6 m x 12.8 kN/m = 7.7 kN
Total = 17.3 + 11.5 + 13.4 + 7.7 + 7.7 = 57.6 kN
Required racking resistance equals assumed actual racking force, therefore satisfactory.
### Wind direction 2 - Level 2

- **Wall f.**
  - $1.2 \, \text{m} \times 6.4 \, \text{kN/m} = 7.7 \, \text{kN}$

- **Wall g.**
  - $1.2 \, \text{m} \times 6.4 \, \text{kN/m} = 7.7 \, \text{kN}$

- **Wall h.**
  - $2.4 \, \text{m} \times 6.4 \, \text{kN/m} = 15.4 \, \text{kN}$

- **Wall i.**
  - $1.2 \, \text{m} \times 6.4 \, \text{kN/m} = 7.7 \, \text{kN}$

- **Wall j.**
  - $1.2 \, \text{m} \times 6.4 \, \text{kN/m} = 7.7 \, \text{kN}$

**Total** = $6 \times 7.7 = 46.2 \, \text{kN}$ therefore OK

### Wind direction 2 - Level 3

- **Wall k.**
  - $0.6 \, \text{m} \times 6.4 \, \text{kN/m} = 3.8 \, \text{kN}$

- **Wall l.**
  - $1.2 \, \text{m} \times 6.4 \, \text{kN/m} = 7.7 \, \text{kN}$

- **Wall m.**
  - $2.4 \, \text{m} \times 6.4 \, \text{kN/m} = 15.4 \, \text{kN}$

- **Wall n.**
  - $0.6 \, \text{m} \times 6.4 \, \text{kN/m} = 3.8 \, \text{kN}$

- **Wall o.**
  - $1.2 \, \text{m} \times 6.4 \, \text{kN/m} = 7.7 \, \text{kN}$

- **Wall p.**
  - $0.6 \, \text{m} \times 6.4 \, \text{kN/m} = 3.8 \, \text{kN}$

**Total** = $3 \times 3.8 + 2 \times 7.7 + 15.4 = 42.2 \, \text{kN}$ therefore OK
5.3 Nominal wall bracing

Clause 8.3.6.2 [pg 136] permits up to 50% of required permanent bracing to be provided by nominal bracing (normal lined walls).

Nominal bracing has not been considered in this C2 example because for high wind classifications, it is usually difficult to find any significant lengths of un-braced wall available to utilize the nominal bracing capacity that may have otherwise been available.

This example demonstrates this.

Bracing the sub-floor of Direction 1 - Level 2

For Level 2, the racking force of 33.0 kN has already been accounted for. For the sub-floor of Level 2 the racking force required to be resisted in Direction 1 is 59.7 kN.
For Level 3, the racking force of 46.7 kN has already been accounted for. For Level 1, 57.6 kN out of a total of 94.8 kN has been accounted for by bracing in Level 1. The remainder 37.2 kN plus the additional small area component, 8.1 kN = Total = 45.3 kN is distributed into Level 2 via the Level 2 ceiling and floor diaphragms and then into the sub-floor.

TOTAL in Direction 2 for Levels 1 and 2 = 102.9 kN

Sub-floor bracing

Clause 8.3.5.8 and Table 8.16 [pg 135] provide bracing capacities for un-reinforced masonry. Min. panel length ($l_1$ or $l_2$) = 900 mm and minimum total length of panels ($l_1$ or $l_2$) in any one wall 3000 mm

<table>
<thead>
<tr>
<th>Description</th>
<th>Bracing capacity (kN/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subfloor of single storey with brick veneer over</td>
<td>3</td>
</tr>
<tr>
<td>Subfloor of two storeys with brick veneer over</td>
<td>2.5</td>
</tr>
<tr>
<td>Subfloor of single storey with chin frame over</td>
<td>1.5</td>
</tr>
<tr>
<td>Subfloor of two storeys with chin frame over</td>
<td>3</td>
</tr>
</tbody>
</table>

Subfloor of single storey with brick veneer over 3 kN/m
Direction 1

East wall, min panel lengths > 900 ok.
Sum of panel lengths = 7710 - 2400 mm
= 5310 mm
Bracing resistance = 5.3 x 3 kN/m = 15.9 kN

Direction 2

North and South walls
Sum of panel lengths = (2 x 6670) – (900 +2400 + 1800 + 1800) mm
= 6440 mm
Bracing resistance = 6.4 x 3 kN/m = 9.9 kN
Total Direction 2 = 19.2 kN

Contribution of un-reinforced masonry sub-floor bracing

Direction 1

From the preceding, 59.7 – 15.9 = 43.8 kN is still required to be provided by bracing stumps or diagonal bracing sets between stumps.

Direction 2

From the preceding, 45.3 – 19.2 = 26.1 kN is still required to be provided by bracing stump or diagonal bracing sets between stumps.

Six stumps are available to provide bracing in each direction.

Additional bracing resistance using steel or timber bracing stumps will be required to resist the remaining racking forces.
Clause 8.3.5.6 [pg 123 gives] gives Bracing Capacities for timber stumps in a concrete footing, but the values are only applicable to Wind Classifications up to C1. As this example is C2, these values cannot be applied.

It is worth noting, as can be seen for Wind Classifications up to C1 from Table 8.10, pg 124 and from Table 8.14 [pg 133], for timber stumps 800 mm high, with a footing diameter and depth of 450 mm and 1000 mm respectively, reasonable bracing capacities can be obtained. By engineering design, reasonable capacities may also be able to be obtained for C2.

As noted in Clause 8.3.5.6, capacities of these stumps (timber or steel) in Wind Classification C2 are required to be determined by engineering design in accordance with AS 2870. Therefore refer to an engineer for design and certification.

### 8.3.5.3 Soil classification reduction factor

The bracing capacities given in Tables 8.7 to 8.13 are based on soil classifications A, S and M. When other soil classification are found, the capacity shall be reduced by multiplying the values in these tables by the load capacity reduction factor given in Table 8.6.

Tables 8.7 to 8.13 are based on nil or minimal net uplift on supports and are suitable for wind classifications up to C1. For wind classifications C2 and C3, the values in the tables shall be modified in accordance with AS 2870.

---

### 6. Maximum spacing of bracing walls

For C2 wind classification, the maximum distance between braced walls (at right angles to the building length or width) is determined in accordance with – Clause 8.3.6.7 [pg 145] and Table 8.21 [pg 146].

![FIGURE 8.6 SPACING OF BRACING](image)
6. Maximum spacing of bracing walls

Ceiling diaphragm depth – Direction 1 – Level 3 = 7870 mm

Ceiling diaphragm depth – Direction 2 – Level 3 = 6440 mm

Ceiling diaphragm depth – Direction 1 – Level 2 = 8590 mm

For Direction 1 – Level 2 – Diaphragm depth = 8590,
Therefore maximum spacing of bracing walls is 5.1 m

Interpolation permitted

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<thead>
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<th>Ceiling depth (m)</th>
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<th>15</th>
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</tbody>
</table>
For Wind direction 1 - Level 2, the maximum spacing is 3.6 m which is less than 5.1 m therefore satisfactory.

Note: For wind direction 2 for Level 2, maximum spacing of bracing walls is not a concern, as this direction is restrained by the two-storey section.

### Maximum spacing of Bracing walls

For Direction 1 – Level 3 – Diaphragm depth = 6440, Therefore maximum spacing of bracing walls is 4.5 m approx.

### Table 8.21

<table>
<thead>
<tr>
<th>Ceiling depth (m)</th>
<th>Maximum bracing wall spacing (m)</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>4</td>
<td>3.9</td>
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<td>15</td>
<td>9</td>
</tr>
<tr>
<td>16</td>
<td>9</td>
</tr>
</tbody>
</table>
6. Maximum spacing of bracing walls

For Wind direction 2 - Level 3, the maximum spacing of bracing walls is 3.6 m which is less than 4.5 m therefore satisfactory.

Note: Wind direction 1 for Level 3 also needs to be checked.

Direction 1

6. Maximum spacing of sub-floor bracing

The spacing of bracing in the sub-floor is also required to be checked Clause 8.3.5.9 [pg 135] provides details.

As the maximum spacing in C2 is 11 500 mm, for this example, sub-floor spacing of bracing is not a concern as actual spacing is considerably less in both directions.

8.3.5.9 Spacing of bracing in the lower storey of two-storey construction or the subfloor of single- or two-storey construction

Bracing in the subfloor or lower storey of two storey construction shall be evenly distributed. The maximum distance between bracing sets, stumps, piers, wall or posts, and the like, under a platform strip or sheet timber floor system shall be as follows:

(a) For wind classification C1, 14 000 mm if the minimum width of floor is 6000 mm.

(b) For wind classification C2, 11 500 mm if the minimum width of floor is 6000 mm.

(c) For wind classification C3, 10 000 mm if the minimum width of floor is 6000 mm.

If the width of the floor is less than as given above, the spacing of bracing shall be as per Clause 8.3.6.7 where the width of the floor is considered as the ceiling depth.

NOTE: The minimum width of the floor is measured parallel to the direction of wind under consideration.
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 (pgs 137 to 143 and Table 8.25 (pgs 152 to 153).

(Clause 8.3.6.10, pg 151)
7.1 Fixing of Bottom of Bracing Walls

Plywood, Method A – 6.4 kN/m

Ceiling diaphragm

An M12 rod each end and a 13 kN capacity connection intermittently at 1200 mm maximum

Note: For double sided walls @ 12.8 kN/m fixing requirements are to be in accordance with Clause 8.3.6.10, pg 151. Therefore the tie-down rods each end are required to have a capacity of 2.56 x 12.8 = 32.8 kN

Note: In C2 additional fixings for shear at 900 mm Max crs is required – see Table 9.3, pg 161.
7.1 Fixing of Bottom of Bracing Walls

From Table 8.25, [pg 152 – 153], some acceptable options to achieve 13kN assuming JD4 joint group framing are:

Note:
1. For chemical or other proprietary fasteners or anchors, refer to manufacturers specifications.
2. MGP15 – JD4
   MGP12 – JD4
   MGP10 – JD5

Fixing of Top of Bracing Walls
Fixing of Top of Bracing Walls

All internal bracing 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, pg 147)

These fixings are determined using Table 8.23, p148-151.
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.

2. Select an appropriate fixing requirement from Table 8.23 [pg 148 151]
NOTE: Be sure that the total bracing capacity of that individual wall can be resisted by the connection.

For a 1.2 m Plywood panel rated at 6.4 kN/m, the force to be resisted by the connection at the top of the brace wall is:

\[ 1.2 \text{ m} \times 6.4 \text{ kN/m} = 7.7 \text{ kN} \]

Note: Where MGP10 (JD4) is used for internal frames, alternative fixings or more frequent fixings would be required ie 2 trimmers/1.2 m panel.
Connection of braced walls perpendicular to trusses

Table 8.23 (continued)

<table>
<thead>
<tr>
<th>Shear capacity (kN)</th>
<th>Unseasoned timber</th>
<th>Seasoned timber</th>
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<tr>
<td></td>
<td>J2</td>
<td>J3</td>
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<tr>
<td>Nails</td>
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<td>4/3.05</td>
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<td>3.6</td>
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<tr>
<td>Bolts</td>
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<td>4.9</td>
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<tr>
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<tr>
<td>Screws</td>
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<tr>
<td>3/No.14 Type17</td>
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<td>10.0</td>
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</tbody>
</table>

Connection of braced internal walls to external walls

Note: The braced section of internal wall does not have to abut the external wall, but the top plate must provide a continuous tie to the external wall.
Connection of braced internal walls abutting external walls - alternative detail

Nail plate - use in accordance with manufacturers specifications.

Internal bracing wall

Top plate

External wall

Capacities available from nail-plate manufacturers

Acknowledgement

Prepared and reviewed by:

- Timber Queensland Ltd
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