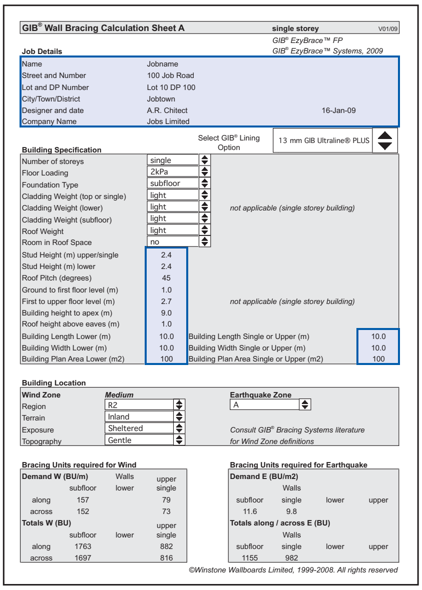
Bracing Calculations

APRIL 2009

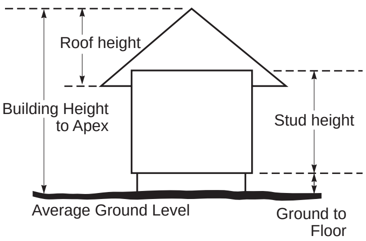
Bracing calculations using GIB® EzyBrace™ FP software

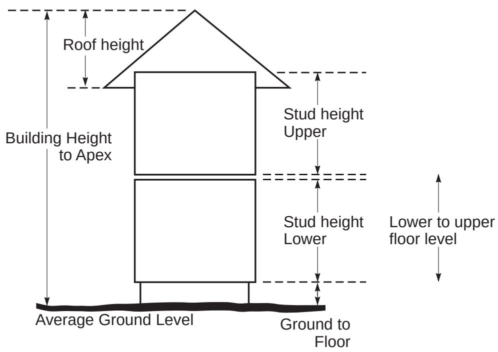
Designers are strongly advised to carry out bracing calculations electronically using our GIB® EzyBrace™ FP software which has been independently appraised (BRANZ Appraisal No. 294, 2009). Bracing Demand calculation using the GIB® EzyBrace™ FP software is based on "first principles" engineering. Output may differ from the generally more conservative tabular approach contained in NZS 3604:1999. The embedded Bracing Unit per metre (BU/m) ratings for various GIB® EzyBrace™ Systems increase as a function of wall length and are higher than those published for manual calculations. The use of specific and more accurate Demand and Resistance values results in the most efficient design. ***Download a free copy of the GIB® EzyBrace™ FP software from www.gib.co.nz/ezybrace.*** For training needs contact the GIB® Helpline on 0800 100 442.



The process for selecting the parameters to determine the Wind and Earthquake Zones is given in pages 10-14. Other input requirements include project details and building dimensions and weights. The Bracing Units required (Demand) are calculated by the GIB® EzyBrace™ FP software and transferred to the Resistance (Along and Across) calculation sheets. Two storey structures can now be designed using a single workbook and dimensions for upper and lower floors are entered individually resulting in optimum design efficiencies. Examples of the main input pages from GIB® EzyBrace™ FP software are shown above.

Dimensions





Wall and Sub-floor Cladding Weights

Heavy — A cladding having a mass exceeding 80 kg/m² but not exceeding 220 kg/m² (typical examples are clay or concrete masonry veneers).

Medium — A cladding having a mass exceeding 30 kg/m² but not exceeding 80 kg/m² (a typical example is stucco cladding)

Light — A cladding having a mass not exceeding 30 kg/m² (typical examples are timber or fibre-cement weatherboards)

Roof Cladding Weights

Heavy — Roofing material (cladding and sarking) having a mass exceeding 20 kg/m² but not exceeding 60 kg/m² (typical examples are concrete tiles and slates)

Light — Roofing material (cladding and sarking) having a mass not exceeding 20 kg/m² (typical examples are metal roofing of normal thickness and 6mm fibre-cement tiles without sarking)

Bracing Calculations

GIB® EzyBrace™ Systems – Specification Numbering System

The GIB® EzyBrace™ Specification Numbering System is designed to make specification of GIB® EzyBrace™ Systems by designers and identification on site by builders and building officials more transparent. Note: The GIB® EzyBrace™ Specification Numbering System (and sub-components thereof) are protected by copyright.

GS = GIB® Standard Plasterboard
BL = GIB Braceline®
BLP = GIB Braceline® / Plywood
BLG = GIB Braceline® / GIB® Standard Plasterboard

1 = lined one side
2 = lined both sides

(10) = 10mm GIB® Plasterboard
(13) = 13mm GIB® Plasterboard

Manual Bracing calculations

The BU/m ratings for various GIB® EzyBrace™ Systems embedded in the GIB® EzyBrace™ FP software increase as a function of wall length and are higher than those presented below. The tabulated BU/m ratings are intended for manual calculations or for entry into other proprietary software and for use with Demand calculations based on the Wind and Earthquake design Tables 5.5 to 5.10 contained in NZS 3604:1999. These BU/m ratings for manual calculations are conservative and have been rounded for ease of use and to minimise calculation error.

Bracing Units are determined using the BRANZ P21 Test and Evaluation Procedure. Three identical specimens are tested under laboratory conditions. The mean of these three results becomes the published BU rating. This means that one or two out of three panels perform below the published BU rating. The P21 Procedure does not apply any safety factors to allow for distribution of results, site variations or workmanship, but assumes redundancies in NZS 3604 construction. With modern house designs these redundancies are gradually eroding.

Complex detailing and higher BU ratings imply more risk and should not necessarily be seen as "better". A responsibly conservative approach to bracing design is recommended. To aid the design, construction and inspection processes GIB® EzyBrace™ Systems and construction detailing have been kept simple and transparent.

Designing with "mean ultimate" values is not accepted engineering practice where "characteristic" values are commonly used. The application of P21 BU ratings in specific engineering design must be treated with utmost caution.

Table 1: 10 mm GIB® Plasterboard BU ratings

GIB® Bracing Systems 2009					
Type	L (m) minimum	Lining	Other Requirements	BU/m	
				W	EQ
GIB® Standard					
GS1(10)	0.4	10 mm GIB® Standard Plasterboard one face	n/a	60	55
	1.2			70	55
GS2(10)	0.6	10 mm GIB® Standard Plasterboard both faces		75	70
	1.8			90	80
GIB Braceline®					
BL1(10)	0.4	10mm GIB Braceline® one face	Hold-Downs	120	100
	1.2			135*	100
BLP	0.4	10mm GIB Braceline® one face plywood other		135*	135*
	0.9			150*	150*
BLG	0.6	10mm GIB Braceline® one face 10mm GIB® Standard other		145*	135*
	1.2			150*	135*

Note: The BU/m ratings are conservative. Using the GIB® EzyBrace™ FP software will deliver higher ratings.

** **Timber Floors** - Based on BRANZ research we recommend a limit of 120 BU/m for NZS 3604:1999 timber floors unless specific engineering ensures that uplift forces generated by elements rated higher than 120 BU/m can be resisted by floor framing.*

Table 2: 13 mm GIB® Plasterboard BU ratings

GIB® Bracing Systems 2009					
Type	L (m) minimum	Lining	Other Requirements	BU/m	
				W	EQ
GIB® Standard					
GS1(13)	0.4	13 mm GIB® Standard Plasterboard one face	n/a	60	60
	1.2			70	60
GS2(13)	0.6	13 mm GIB® Standard Plasterboard both faces		75	70
	1.8			90	80
GIB Braceline®					
BL1(13)	0.4	13 mm GIB Braceline® one face	Hold-Downs	140*	130*
	0.6			150*	130*

BL1(13) systems are to be fastened using GIB Braceline® screws only
Note: The BU/m ratings are conservative. Using the GIB® EzyBrace™ FP software will deliver higher ratings.

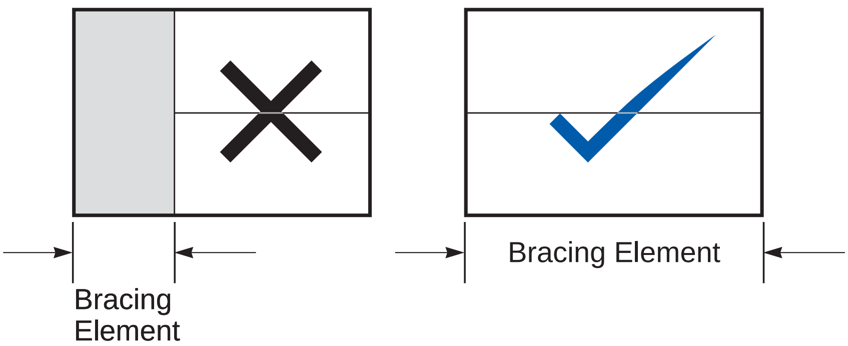
* ***Timber Floors** – Based on BRANZ research we recommend a limit of 120 BU/m for NZS 3604:1999 timber floors unless specific engineering ensures that uplift forces generated by elements rated higher than 120 BU/m can be resisted by floor framing.*

Wall Heights other than 2.4m

The published Bracing Unit ratings are based on a 2.4 metre height. For greater heights, the ratings must be multiplied by a factor *f* = 2.4 divided by the actual wall height. The Bracing Unit ratings for walls higher than 2.4 metres will reduce.
For example:
The Bracing Unit rating of a 2.7 metre high wall is obtained by multiplying the values in Tables 1 and 2 by f = 2.4/2.7 = 0.89
The Bracing Unit rating of a 3.6 metre high wall is obtained by multiplying the values in Tables 1 and 2 by f = 2.4/3.6 = 0.67
The height of walls with a sloping top plate can be taken as the average height.
Walls lower than 2.4 metres shall be rated as if they were 2.4 metres high.

General Guidelines

Always use the maximum *available wall length* for bracing purposes by moving the bracing element fasteners out to the perimeter of the wall. This maximises the Bracing Units achieved from a wall section and enhances the quality of finish by having the majority of fasteners at wall ends or in corners. For example, it is inefficient to designate only 1.2 metres of a 3.6 metre wall for bracing purposes.



Specifying GIB® Bracing Elements	
Inside lining on External Walls	**Brace type**
400 mm or greater	GS1, BL1, BLP
Internal Walls (if only one side available for bracing)	**Brace type**
400 mm or greater	GS1, BL1
Internal Walls (if both sides available for bracing)	**Brace type**
600 mm or greater	GS2, BLG
400 mm or greater	BLP

Wall Bracing Calculation Sheet A

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Job Details (tick appropriate boxes) — Box 1

Name			
Street Address			
Lot No		DPS No	
City/Town			

Location of Storey:

Single/upper storey	
Upper storey of two	
Lower storey of two	

Floor type:

Sub-floor	
Slab	

Floor load:

2kPa	
3kPa	

Key dimensions

Building height to apex			Metres
Roof height above eaves			Metres
Stud height			Metres
Average roof pitch			Degrees
Building Length	BL		Metres
Building Width	BW		Metres
Gross Plan Area	GPA		Sq Metres

Note: When the average roof pitch is over 25 degrees, use the eaves length and width to determine BL and BW

Cladding weight	Light	Medium	Heavy
Sub-floor			
Lower storey			
Upper or Single Storey			

	Light	Medium
Roof weight		

	Yes	No
Room in roof space		

Wind Zone — Box 2

Factors	*Select relevant option*	Points	*Enter points from the relevant options*
Region	R1	0	
	R2	1	
Terrain	Inland	0	
	Coastal	1	
Exposure	Sheltered	0	
	Exposed	1	
Topography	Gentle	0	
	Moderate	1	
	Extreme	3	
		Total Points	

Total Points	Applicable Wind Zone	Tick
0	Low	
1	Medium	
2	High	
3	Very High	
4	Requires specific design	

Earthquake Zone — Box 3

From Earthquake Region EQ1 select Earthquake Zone

A	B	C

BUs required Wind — Box 4

Refer to NZS 3604; 1999 Tables 5.6 or 5.7 to determine the BUs required for Wind (W Across and W Along)

W Across			BUs per m
W Along			BUs per m

Total Wind Load

	Enter BL from box 1	Multiply by	BUs per m Across	Equals Across W required
W Across		X		

	Enter BW from box 1	Multiply by	BUs per m Along	Equals Along W required
W Along		X		

BUs required Earthquake — Box 5

Refer to NZS 3604; 1999 Tables 5.8, 5.9 or 5.10 to determine the BUs required for Earthquake (EQ)

E =		BUs per m²

Note: For a room in the roof space use E + 3 BU/m²

Total Earthquake Load

	Enter GPA from box 1	Multiply by	E	Equals E required
EQ Requirement Along and Across		X		

Transfer to calculation sheet B

For manual calculations only — *Please photocopy this page*

Wall Bracing Calculation Sheet B

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Design

Along

WALL OR BRACING LINE		BRACING ELEMENTS PROVIDED			WIND		EARTHQUAKE	
1	2	3	4	5	6 W	7 W	6 E	7 E
Line Label	Minimum BUs Required	Bracing Element No.	Bracing Type	Length Element (m) L	Rating BU/m W	BUs Achieved (BU/m x L) W	Rating BU/m E	BUs Achieved (BU/m x L) E
A								
B								
C								
D								
E								

Totals Achieved		**W** achieved	**E** achieved
From Sheet A	**Totals Required**	**W** required*	**E** required*
		W achieved must exceed W required*	E achieved must exceed E required*

*** from Calculation Sheet A**

Across

WALL OR BRACING LINE		BRACING ELEMENTS PROVIDED			WIND		EARTHQUAKE	
1	2	3	4	5	6 W	7 W	6 E	7 E
Line Label	Minimum BUs Required	Bracing Element No.	Bracing Type	Length Element (m) L	Rating BU/m W	BUs Achieved (BU/m x L) W	Rating BU/m E	BUs Achieved (BU/m x L) E
M								
N								
O								
P								
Q								

Totals Achieved		**W** achieved	**E** achieved
From Sheet A	**Totals Required**	**W** required*	**E** required*
		W achieved must exceed W required*	E achieved must exceed E required*

*** from Calculation Sheet A**

For manual calculations only

Please photocopy this page

Design Step 1 – Wind

The Wind Zone

Determining the wind zone for a particular building site can be a complicated step in preparing a bracing schedule. **Some building consent authorities already have wind zoning maps prepared to assist designers. Ring your local building consent authority to find out.** If the information is not available, the wind zone can be worked out by following the simple procedure below. The GIB® EzyBrace™ FP software determines the Wind Zone automatically based on the input parameters selected. The "points system" here applies to manual calculations only.

The wind forces that act on a building depend on the wind region, the terrain roughness, the site exposure, and the topography.

By considering these four variables individually and assigning points, based on severity of wind loading, the total number of points scored will determine the site wind zone;

Wind Region
+
Terrain Roughness
+
Site Exposure
+
Topographic Classification
=
Wind Zone

POINTS	WIND ZONE	
0	Low	(L)
1	Medium	(M)
2	High	(H)
3	Very High	(VH)
4 or more	Specific Design	(SD)

Wind Zone Variable 1:
Wind Region (R1/R2)

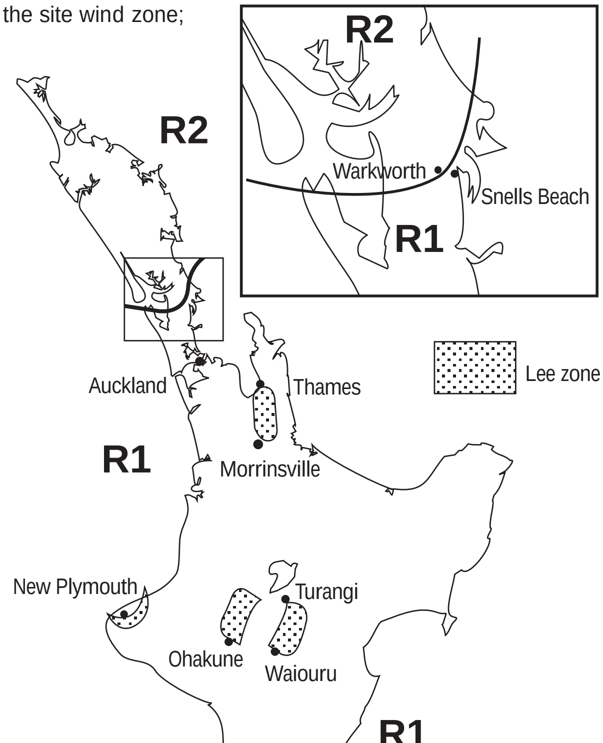
New Zealand is divided into wind regions as illustrated in Figure W1.

i The majority of the country is classified R1.

ii Strong winds commonly occur in the extreme regions of both islands and these regions are classified R2.

Determine the wind region from Figure W1 and assign points as follows:
R1 = 0, R2 = 1

Note: *Shaded areas in Figure W1 must have a topographic classification of at least 'moderate'.*



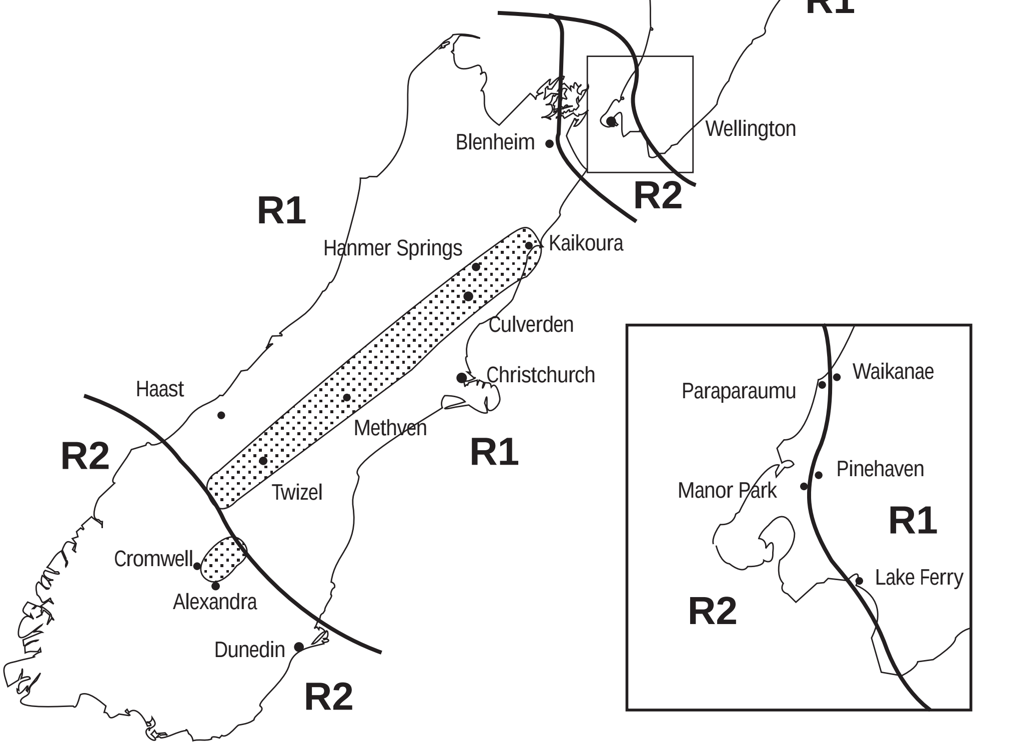


Figure W1:
Wind Regions

Wind Zone Variable 2: Terrain (Inland/Coastal)

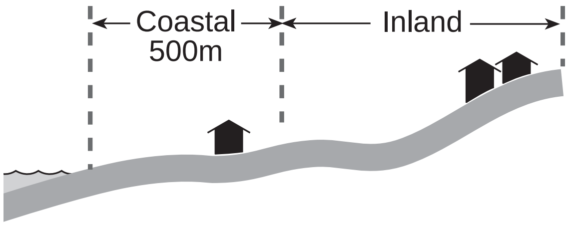
The roughness of the terrain over which the wind must pass before it reaches the building site slows down the wind speed.

i The site is classified as coastal terrain if within 500m of the sea coast, open water, or the edge of coastal mudflats, flat beaches, airfields, etc.

__Note:__ Open water includes lakes, rivers and inland waterways wider than 300m.

ii Sites not within the coastal terrain are classified as inland.

Determine the terrain category and assign points as follows: Inland = 0, Coastal = 1



Wind Zone Variable 3: Site Exposure (Sheltered/Exposed)

Nearby obstructions will provide shelter to a proposed building from wind coming over open parks, motorways, rivers, or other open spaces greater than 100m wide.

i At least two rows of similarly sized, permanent obstructions in each upwind direction are required for the site to be considered sheltered.

ii If the proposed building does not receive such shelter from nearby obstructions then it should be classified as exposed (e.g., a clear unobstructed view from the ground floor level over neighbouring buildings).

__Note:__ In situations such as growing sub-divisions, the site exposure may be based on the expected conditions five years hence.

Determine the site exposure and assign points as follows: Sheltered = 0, Exposed = 1

Sheltered

Exposed

Wind Zone Variable 4: Refer Figure TC1 Topographic Classification (Gentle/Moderate/Extreme)

The topography of the land will affect the wind flow, e.g., hill top sites will receive higher wind loadings than sites on the flat.

i Sites with a gentle classification are;
- Sites on flat land or undulating hills less than 20 metres high,
- Sites on the lower slopes of hills which have a slope flatter than 1:5.

The gentle classification covers the majority of building sites in New Zealand.

ii Sites with a moderate classification are;
- Sites more than 20 metres above a valley floor,
- Sites within 150 metres of the crest of a hill, ridge or spur which has a slope flatter than 1:5,
- Sites on the crest of an escarpment.

iii Sites with an extreme classification are;
- Sites within 250 metres of the crest of a hill, ridge or spur which has a slope steeper than 1:5,
- Sites at the head of a valley.

__Note:__ Some small pockets where there is known evidence of strong winds as a result of specific local land formations are identified on Figure W1. These must be classified at least moderate.

Determine the site topography and assign points as follows: Gentle = 0, Moderate =1, Extreme = 3

Notes to assist with the determination of the topographic classification:

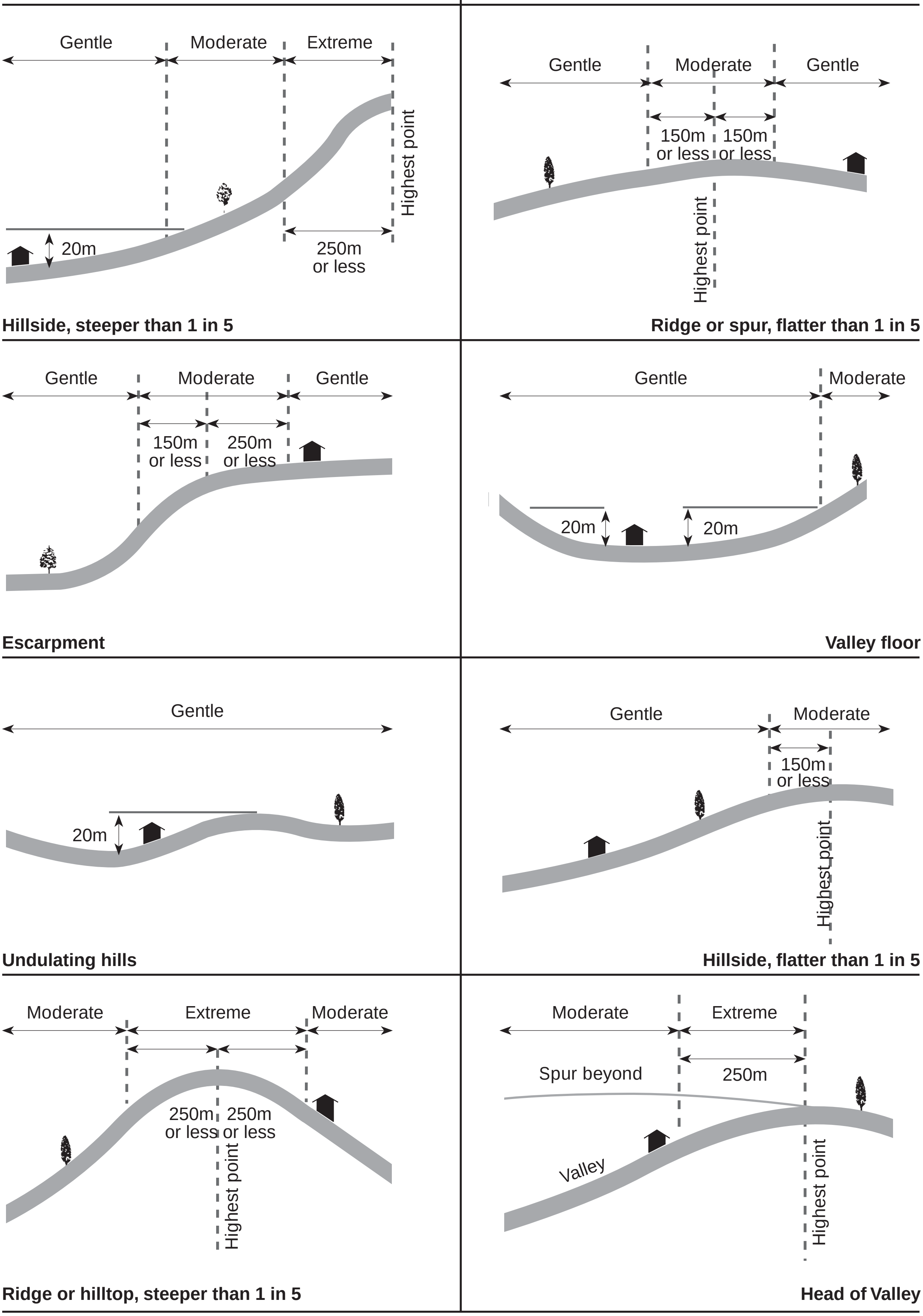
Establishing heights is easiest from contour maps of your local area. Your building consent authority may be able to assist.

To determine the topography, select the landform that best fits your building site. Cross sections should be taken so that they represent the worst case (i.e., steepest slope). Remember that it is impossible to capture NZ's topography in a few simple sketches. Your judgement is sometimes required. If in doubt, talk to your local building consent authority.

On hill slopes steeper than 1:5, roads and driveways will tend to follow the contour. On flatter slopes they tend to take the shortest route up the hill.

20 metres is approximately 3 times the height of a two storey house.

Figure TC1:
Topographic classification



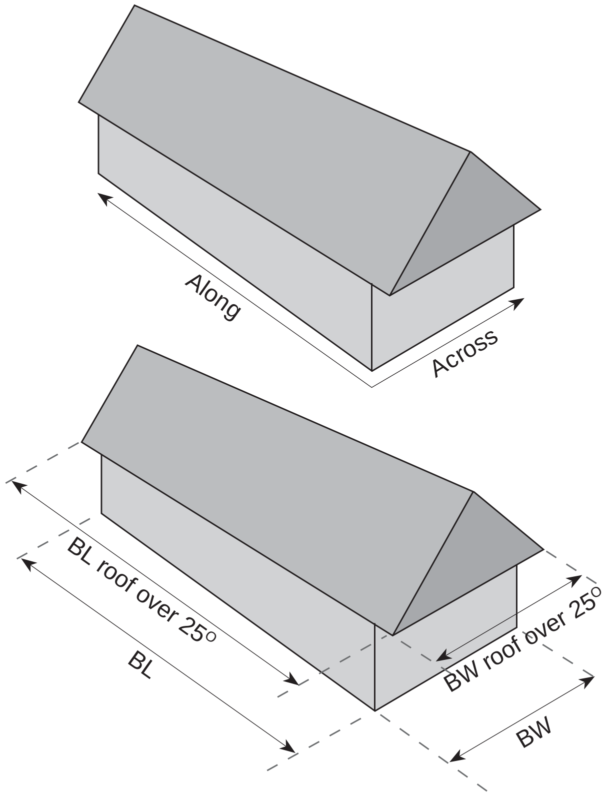
Working Out the Bracing Units (BUs) Required for Wind

When the wind zone has been established you can work out the total number of BUs required to brace the structure against wind loads. You need to consider bracing in two directions, along and across the building. Based on the input parameters selected GIB® EzyBrace™ FP software calculates the Wind Demand in the along and across directions automatically. For manual calculations refer to NZS 3604:1999 Tables 5.6 and 5.7.

NZS 3604:1999 Table 5.6 lists the BUs needed for wind and applies to a single storey building, or the top storey of a two storey building.

NZS 3604:1999 Table 5.7 lists the BUs required for a lower storey of a two storey building.

Both tables list the number of BUs required per metre of building length or width. Normally the building's length and width can be taken off the building plans at floor level. However, when the roof pitch is greater than 25 degrees the building's length and width are taken at eaves level, i.e., the floor plan dimensions plus any eaves overhang. This is because such steep roofs become the dominant target for wind.



From the tables referred to above,

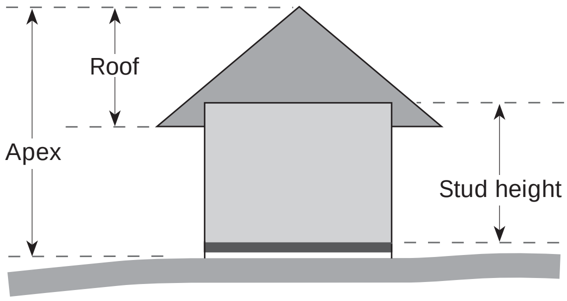
i Select the overall height of the building (height to apex)

ii determine the roof height above the eaves

iii determine the stud height (2.4 or 3.0m)

iv select the appropriate wind zone column

i, **ii** and **iii** will give you a horizontal row on the table. **iv** will narrow the answer down to two readings:



 ***for calculating BUs across***

 ***for calculating BUs along***

Design

Design Step 2 – Earthquake

The Earthquake Zone

The potential earthquake loading on structures is more severe in some areas of New Zealand than it is in others. Figure EQ1 divides the country in three earthquake zones, A, B and C. Look at the map to determine your earthquake zone.
Select earthquake zone A/B/C.

Working Out the Bracing Units (BUs) Required for Earthquake

Based on the input parameters selected GIB® EzyBrace™ FP calculates the Earthquake Demand automatically.
For manual calculations refer to NZS 3604:1999 Tables 5.8, 5.9, 5.10 (2kPa floor load) and 14.1, 14.2, 14.3 (3kPa floor load).
The weight of building materials is important. This is reflected in the tables referred to above. Heavy claddings and roofs mean more BUs required.

- **i** The first three columns have combinations of subfloor, wall and roof cladding weights. Select the category that best fits the building.
- **ii** Select the roof slope from the 4th column.
- **iii** Select the earthquake zone.

You will now be able to read the number of BUs required. This number represents the BU requirement per square metre. Work out the number of BUs needed by multiplying this number per square metre by the building plan area measured at floor level.
The lateral force on a building in an earthquake is a function of the buildings weight. In an earthquake the ground motion can be in any direction, therefore the maximum earthquake force could be the same in any direction. For this reason the BU requirements are the same in both the along and across directions.

Roof Space Areas

- Up to 50% of the roof space area may be developed into attic rooms. If this is the case, then the BU requirements per m^2 of floor area measured at ground level (as derived from NZS 3604:1999 tables) must be increased by 3 BUs per m^2.
- If more than 50% is developed, then the roof space must be considered as an additional storey and the storey below becomes a lower of two.

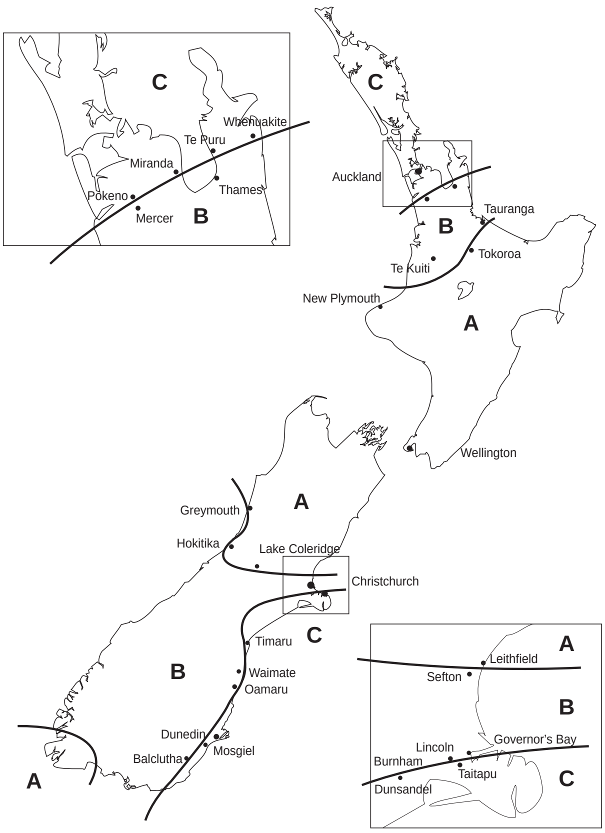
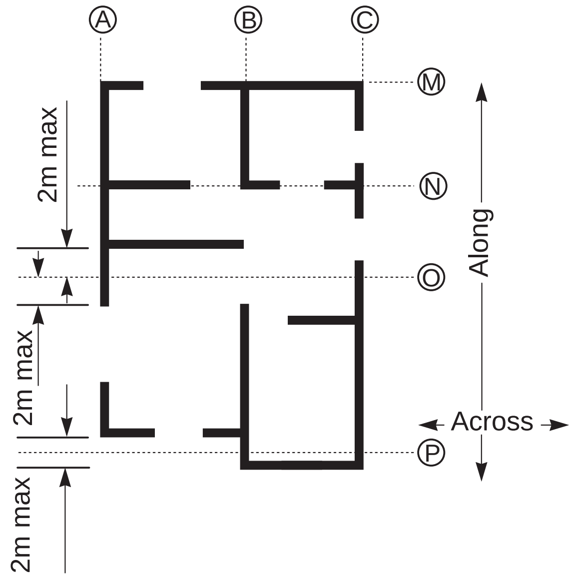


Figure EQ1: Earthquake Regions

Design Step 3 – Distribution of Wall Bracing Elements



When the number of BUs required for wind and earthquake in both the along and across directions have been worked out, the next task is to allocate wall bracing elements on the building plan by using external and internal walls lined with GIB® Plasterboard. Distribution of bracing is done by drawing an imaginary grid pattern of bracing lines along and across the building. These should be numbered A,B,C, etc. in the along direction and M,N,O etc. in the direction across the building. These bracing lines must coincide as much as possible with the wall bracing elements.

- External walls are supported horizontally by bracing lines at right angles. If those supports are spaced too far apart, then the external wall could suffer unacceptable deformation. For this reason the following maximum spacing of bracing lines must be adhered to
  - **i** 6 metres for standard construction with any GIB® Plasterboard ceiling
  - **ii** 7.5 metres with a GIB® Standard Plasterboard ceiling diaphragm, or 7.5 metres when dragon ties in accordance with NZS 3604:1999 are used
  - **iii** 10 metres with a GIB Ultraline® ceiling diaphragm 10 or 13mm
  - **iv** 15 metres with a GIB Braceline® ceiling diaphragm 10 or 13mm

  (For ceiling diaphragms see pages 16 and 17)
- Each bracing line must contain a minimum number of bracing units as follows,
  - **i** external walls 10 BUs per metre and at least 100 BUs total when dragon ties or a ceiling diaphragm are attached
  - **ii** internal walls 70 BUs total, or 100 BUs when supporting a ceiling diaphragm
- Pairs of wall bracing elements can be a maximum of 2 metres either side of a bracing line, and count for the total number of BUs on that line.
- Parallel external walls no more than 2m apart may be treated as one external wall and the bracing line may be situated between them.
- Try and achieve an even distribution of bracing throughout. A building which is heavily loaded with bracing at one end and lightly braced at the other, is likely to suffer damage through rotation under severe wind or earthquake loads.
- Locate bracing in or near external building corners. If it is not practical to locate bracing in corners due to windows, etc., then it is desirable to make the first lined wall section adjacent to the window a wall bracing element.

Recommended distribution check

Designers must ensure that adequate bracing distribution is achieved. The approach described above is based on the NZS 3604:1999 rules which often fall short of this requirement. Therefore, the following check is suggested. Note that this "good practice" recommendation is not a NZS 3604 or New Zealand Building Code requirement.

Divide the BU Demand by the number of bracing lines in the direction being considered (along or across) and make sure each line contains at least 75% of that number of BUs. For example a building with 6 bracing lines and a bracing demand of 1200 BU in the across direction should have no less than 75% of 1200/6 = 150 BUs on each line in that direction.