DESIGN RIGHT

Subfloor bracing

IN *BUILD* 131 (PAGES 29–30), WE EXPLAINED THE INFORMATION NEEDED BEFORE STARTING BRACING CALCULATIONS FOR A BUILDING. THIS TIME, WE WORK THROUGH A SUBFLOOR EXAMPLE.

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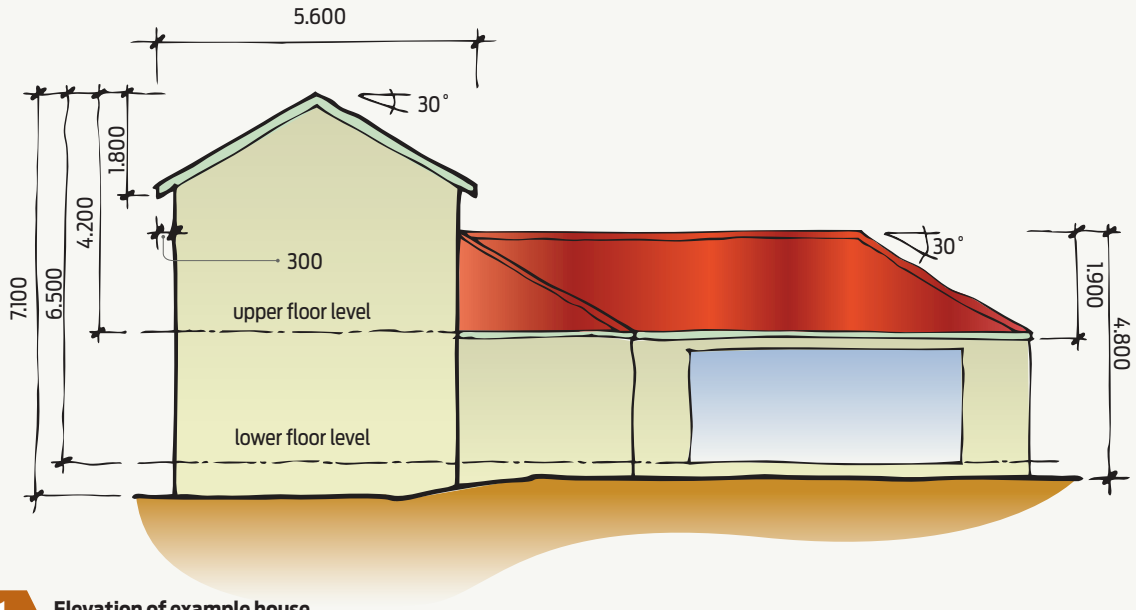


Figure 1 **Elevation of example house.**

THE HOUSE BEING USED in this example has a second storey on part of the house (see Figures 1–2).

Data for this example

Refer to *Build* 131 for how to establish these values.

Wind zone: Medium

Earthquake zone: 2

Floor plan area

This example has a mixture of single and double storeys. Because these have different wind and earthquake demands, two calculations are required – one for the subfloor area of the 2-storey portion and one for the subfloor area of the single-storey (shown in Figure 3). The slab floor in the garage has no subfloor so does not form part of the calculation.

Gross floor plan area for:

2-storey = 10.6 × 5 = 53 m²

1-storey = 8.1 × 9.3 = 75.3 m² (for simplicity, the area has not been reduced for the entry porch).

Once the demand is established, the overlap of the 2-storey will be deducted from the 1-storey.

Soil type: Rock

Weight of claddings: Light subfloor, lower storey, upper storey and roof

Roof pitch: 30 degrees, so choose 25–45 degrees

Building shape: Subfloor has no wings or blocks

Heights for building

2-storey to apex H = 7.1 m, roof height above eaves h = 1.8 m.

Note: Where heights don't exactly match the table, use the next highest bracing unit (BU). For example, in the subfloor structure (using Table 5.5), H = 7.1 m, so round up to 8 m, and h = 1.8 (round down to 1 m, this is a higher BU requirement).

Single-storey to apex H = 4.8 m, h = 1.9 m.

Roof type and building dimension

The 2-storey has a gable roof with 300 mm soffit/verge.

As the roof is over 25°, when considering wind on the 2-storey part of the building, use the overall dimensions of the roof for the width and length.

So, 2-storey section building dimensions are:

Length = 10.6 + 0.300 + 0.300 = 11.2 m

Width = 5.0 + 0.300 + 0.300 = 5.6 m.

Single-storey dimensions are:

Length = 9.3 m (no soffit to lower level)

Width = 8.1 m (no soffit to lower level).

Transfer these values to the calculation sheets (Figures 4 and 6).

Note that, because this is a hip roof shape, wind demand in both the along and across directions is the same, so choice of length and width is not critical.

Bracing calculation sheets

The above data is then entered into bracing calculation sheets to obtain the bracing demand (see Figures 4 and 6). Sheets can be downloaded from the Toolbox on the BRANZ website www.branz.co.nz.

2-storey section

Using the calculation sheets (see Figure 4), bracing demand for the 2-storey section is:

- 1176 BUs for wind across the ridge
- 627 BUs for wind along the ridge
- 636 BUs for earthquake.

Use 1176 BUs for wind across and 636 for both wind along and earthquake.

Single-storey section

Bracing demand results for the single-storey area (see Figure 6) are:

- 521 BUs for wind across
- 454 BUs for wind along
- 603 BUs for earthquake.

Use 603 BUs for along and across as it is the higher value in both directions.

Choose bracing element

The subfloor is 600 mm or less high. Anchor piles have been chosen as the subfloor bracing element as they are rated as 160 BUs for wind and 120 BUs for earthquake.

Moving to the bracing lines

For this example, the exterior walls will be used as bracing lines in each direction along with the common wall between the garage and the house. These are within the 5 m rule and provide an even distribution of bracing throughout the building.

We now need to calculate the minimum bracing needed in each line and check the bracing distribution complies with the requirements of NZS 3604:2011 clause 5.5:

- maximum spacing of bracing lines in the subfloor = 5 m

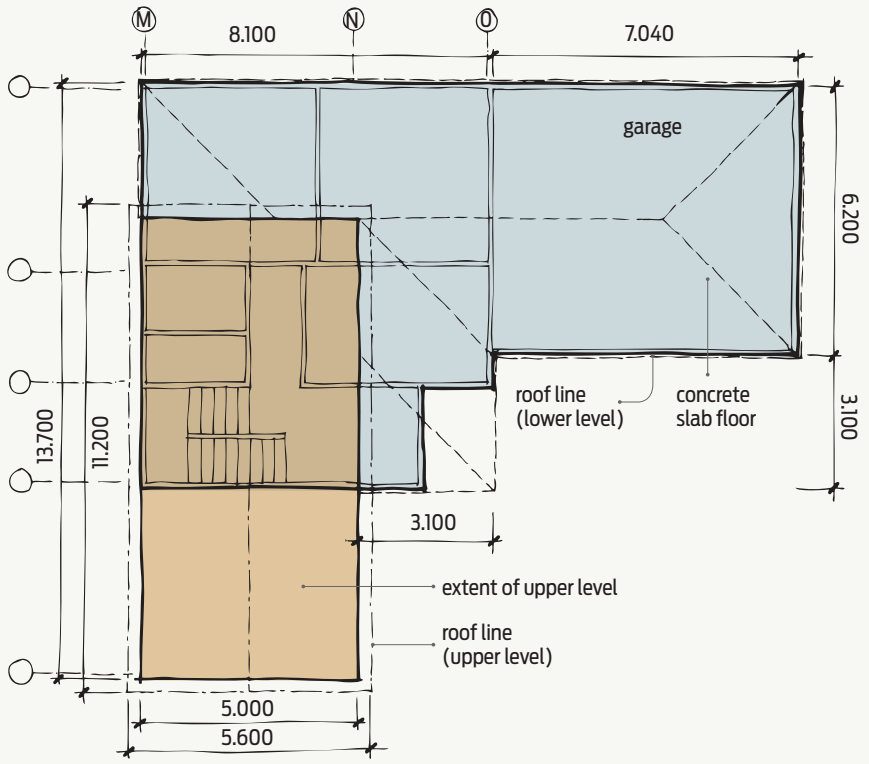


Figure 2 **Floor plan of example house.**

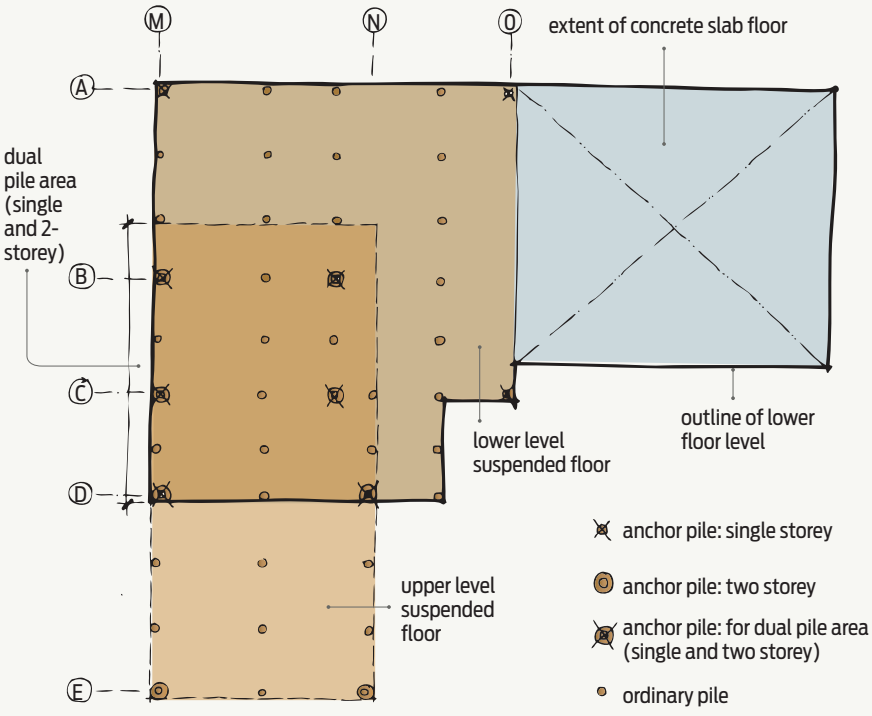
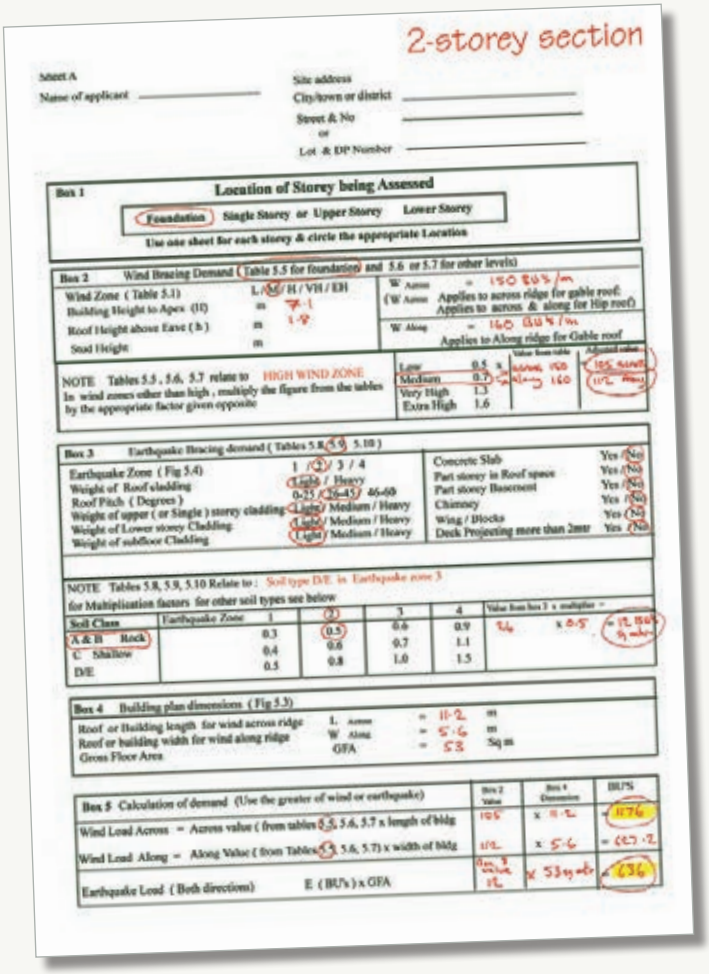


Figure 3 **Foundation plan.**



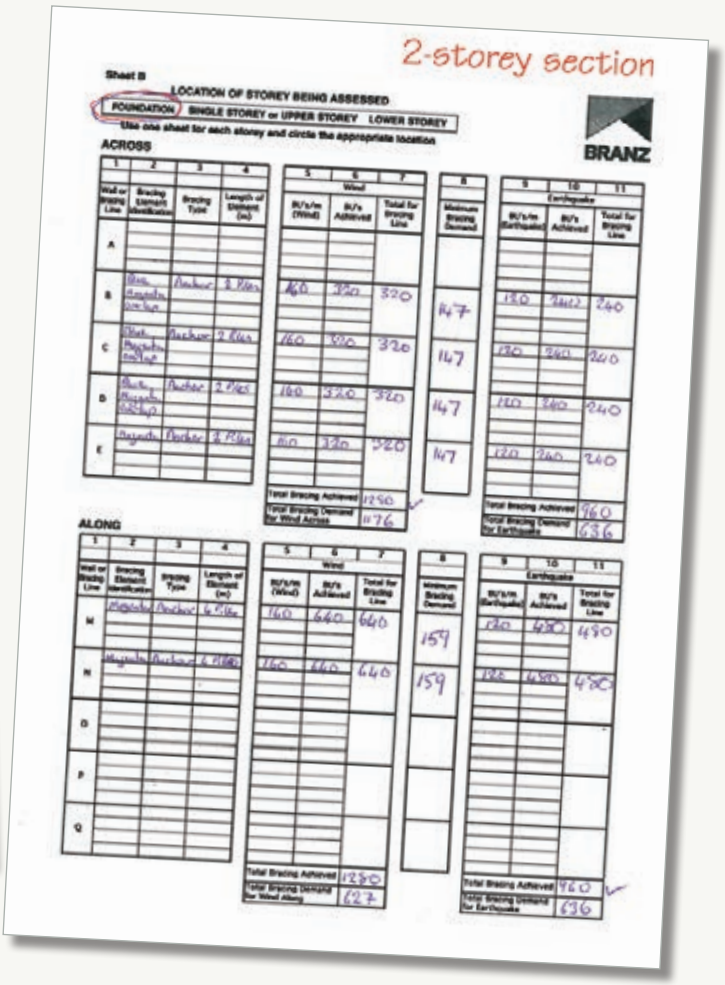


Figure 4 Calculation sheet for demand – 2-storey section of subfloor.

Figure 5 Calculation sheet for bracing achieved – 2-storey section of subfloor.

- minimum capacity of subfloor bracing lines is the greater of:
  - 100 BUs
  - 15 BU/m of bracing line
  - 50% of the total bracing demand, divided by the number of bracing lines in the direction being considered.

See Table 1 where this has been worked through.

Minimum bracing for 2-storey section

Using the calculation sheet (see Figure 5) gives:

- 1280 BUs for wind across
- 960 BUs for earthquake and along.

This meets the minimum demand requirements from the calculation sheet (see Figure 4) and NZS 3604:2011 clause 5.5.2.

Minimum bracing for single-storey section

Using the calculation sheet (see Figure 7) gives:

- 1080 BUs for earthquake bracing across
- 1080 BUs for earthquake bracing along.

This meets the minimum demand requirements from the calculation sheet (see Figure 6) and NZS 3604 clause 5.5.2.

The piles in brace line N are staggered to comply with the requirement that braced or load-bearing walls are within 200 mm of the pile line.

More to check

Buildings where the height exceeds 1.7 times the width must be on a continuous foundation wall (NZS 3604:2011 clause 5.4.3.2). Height is measured from the underside of the bottom plate on the lowest floor to the top of the roof). In this example, width 5 m × 1.7 = 8.5 m, so this design is OK as the height is 6.5 m from underside of bottom plate to top of roof.

There is also a minimum number of subfloor braces (NZS 3604:2011 clause 5.5.6) – a minimum of four braced or anchor piles placed in each direction symmetrically around the perimeter. Wherever practical, they should be placed near a corner. This design has five piles in the across direction and nine in the along direction so is OK.

Note **Having trouble reading Figures 4–7? You can download these with this article from www.branz.co.nz/welcome_to_build then Design Right.**

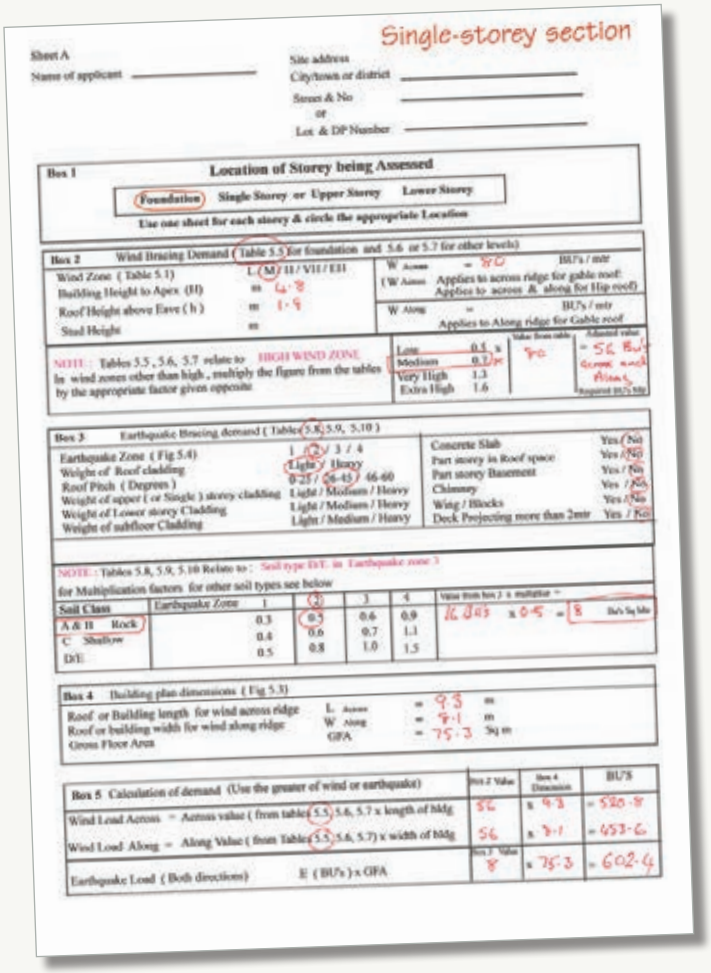


Figure 6 Calculation sheet for demand – single-storey section of subfloor.

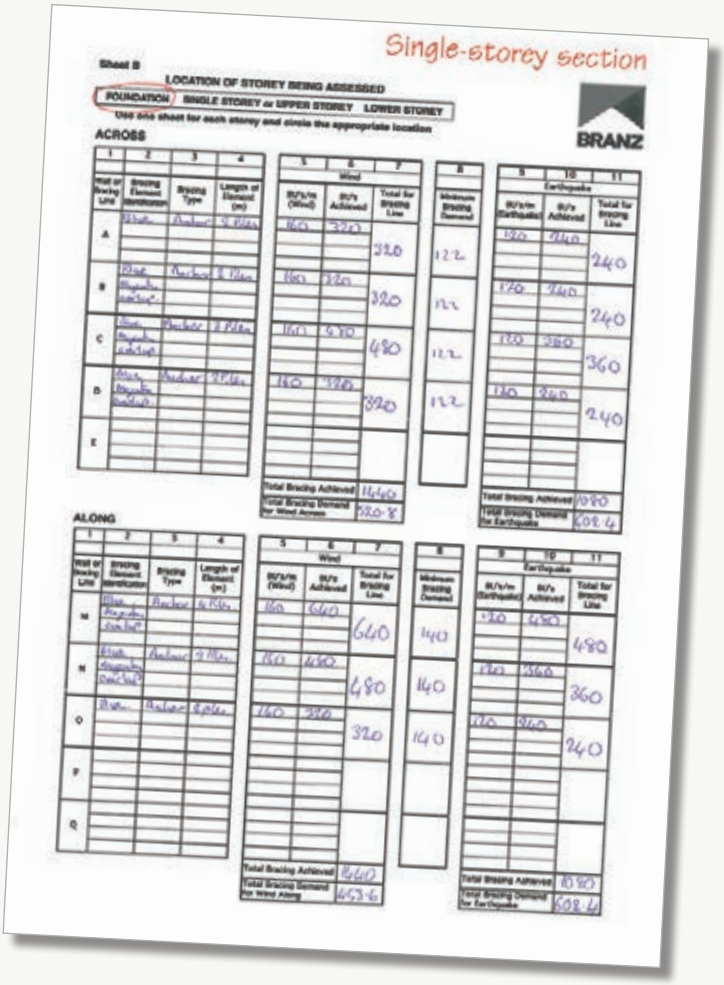


Figure 7 Calculation sheet for bracing achieved – single-storey section of subfloor.

Table 1

MINIMUM BRACING NEEDED IN EACH LINE

	2-STOREY SECTION	SINGLE-STOREY SECTION
WIND ACROSS RIDGE		
Bracing lines	B, C, D and E = 5 m long	A, B, C, D = 8.1 m long
Bracing demand per line (greatest value)	100 BUs or 75 BUs (5.0 x 15 BUs) or **147** BUs (1176 BUs divided by 2 = 588 divided by 4 lines)	100 BUs or **122** BUs (8.1 x 15) or 76 BUs (603 BUs divided by 2 = 301.5 divided by 4 lines)
Minimum BUs per line	147 BUs	122 BUs
Minimum anchor piles per line	1 anchor pile = 160 BUs (wind)	2 anchor piles = 240 BUs (120 each for earthquake)
WIND ALONG RIDGE		
Bracing lines	M and N = 10.6 m long	M, N, O = 9.3 m long
Bracing demand per line (greater value)	100 BUs or **159** BUs (10.6 x 15) or **159** BUs (636 BUs (for earthquake) divided by 2 = 318 divided by 2 lines)	100 BUs or **140** BUs (9.3 x 15) or 100 BUs (603 BUs divided by 2 = 301.5 divided by 3 lines)
Minimum BUs per line	159 BUs	140 BUs
Minimum piles per line	2 anchor piles = 240 BUs (120 each for earthquake)	2 anchor piles = 240 BUs (120 each for earthquake)

2-storey section

Sheet A

Name of applicant _____

Site address
City/town or district _____
Street & No _____
or
Lot & DP Number _____

Box 1 **Location of Storey being Assessed**

(Foundation) Single Storey or Upper Storey Lower Storey

Use one sheet for each storey & circle the appropriate Location

Box 2 Wind Bracing Demand (Table 5.5 for foundation and 5.6 or 5.7 for other levels)

Wind Zone (Table 5.1)	L / (M) / H / VH / EH	
Building Height to Apex (H)	m	7.1
Roof Height above Eave (h)	m	1.8
Stud Height	m	

W Across = 150 BU's/m
(W Across Applies to across ridge for gable roof:
Applies to across & along for Hip roof)

W Along = 160 BU's/m
Applies to Along ridge for Gable roof

NOTE Tables 5.5 , 5.6, 5.7 relate to HIGH WIND ZONE
In wind zones other than high , multiply the figure from the tables by the appropriate factor given opposite

		Value from table	Adjusted value
Low	0.5 x	across 150	= 105 across
(Medium)	0.7	along 160	112 Along
Very High	1.3		
Extra High	1.6		

Box 3 Earthquake Bracing demand (Tables 5.8, 5.9, 5.10)

Earthquake Zone (Fig 5.4)	1 / (2) / 3 / 4	Concrete Slab	Yes / (No)
Weight of Roof cladding	(Light) / Heavy	Part storey in Roof space	Yes / (No)
Roof Pitch (Degrees)	0-25 / (26-45) / 46-60	Part storey Basement	Yes / (No)
Weight of upper (or Single) storey cladding	(Light) / Medium / Heavy	Chimney	Yes / (No)
Weight of Lower storey Cladding	(Light) / Medium / Heavy	Wing / Blocks	Yes / (No)
Weight of subfloor Cladding	(Light) / Medium / Heavy	Deck Projecting more than 2mtr	Yes / (No)

NOTE Tables 5.8, 5.9, 5.10 Relate to : Soil type D/E in Earthquake zone 3
for Multiplication factors for other soil types see below

Soil Class	Earthquake Zone 1	(2)	3	4	Value from box 3 x multiplier =
(A & B Rock)	0.3	(0.5)	0.6	0.9	24 x 0.5 = 12 BU's sq mtr
C Shallow	0.4	0.6	0.7	1.1	
D/E	0.5	0.8	1.0	1.5	

Box 4 Building plan dimensions (Fig 5.3)

Roof or Building length for wind across ridge	L Across	= 11.2	m
Roof or building width for wind along ridge	W Along	= 5.6	m
Gross Floor Area	GFA	= 53	Sq m

Box 5 Calculation of demand (Use the greater of wind or earthquake)	Box 2 Value	Box 4 Dimension	BU'S
Wind Load Across = Across value (from tables 5.5, 5.6, 5.7 x length of bldg	105	x 11.2	= 1176
Wind Load Along = Along Value (from Tables 5.5, 5.6, 5.7) x width of bldg	112	x 5.6	= 627.2
Earthquake Load (Both directions) E (BU's) x GFA	Box 3 value 12	x 53 sq mtr	= 636

2-storey section

Sheet B

LOCATION OF STOREY BEING ASSESSED

FOUNDATION | **SINGLE STOREY or UPPER STOREY** | **LOWER STOREY**

Use one sheet for each storey and circle the appropriate location

BRANZ

ACROSS

1	2	3	4	5	6	7	8	9	10	11
				Wind				Earthquake		
Wall or Bracing Line	Bracing Element Identification	Bracing Type	Length of Element (m)	BU's/m (Wind)	BU's Achieved	Total for Bracing Line	Minimum Bracing Demand	BU's/m (Earthquake)	BU's Achieved	Total for Bracing Line
A										
B	Blue Magenta Overlap	Anchor	2 Piles	~~160~~ 120	320	320	147	120	240	240
C	Blue Magenta Overlap	Anchor	2 Piles	160	320	320	147	120	240	240
D	Blue Magenta Overlap	Anchor	2 Piles	160	320	320	147	120	240	240
E	Magenta	Anchor	2 Piles	160	320	320	147	120	240	240
				Total Bracing Achieved		1280 ✓		Total Bracing Achieved		960
				Total Bracing Demand for Wind Across		1176		Total Bracing Demand for Earthquake		636

ALONG

1	2	3	4	5	6	7	8	9	10	11
				Wind				Earthquake		
Wall or Bracing Line	Bracing Element Identification	Bracing Type	Length of Element (m)	BU's/m (Wind)	BU's Achieved	Total for Bracing Line	Minimum Bracing Demand	BU's/m (Earthquake)	BU's Achieved	Total for Bracing Line
M	Magenta	Anchor	4 Piles	160	640	640	159	120	480	480
N	Magenta	Anchor	4 Piles	160	640	640	159	120	480	480
O										
P										
Q										
				Total Bracing Achieved		1280		Total Bracing Achieved		960 ✓
				Total Bracing Demand for Wind Along		627		Total Bracing Demand for Earthquake		636

Sheet A

Single-storey section

Name of applicant _____

Site address

City/town or district _____

Street & No _____

or

Lot & DP Number _____

Box 1 **Location of Storey being Assessed**

(Foundation) **Single Storey or Upper Storey** **Lower Storey**

Use one sheet for each storey & circle the appropriate Location

Box 2 Wind Bracing Demand (Table 5.5 for foundation and 5.6 or 5.7 for other levels)

Wind Zone (Table 5.1)	L (M) / H / VH / EH	W Across = 80	BU's / mtr
Building Height to Apex (H)	m 4.8	(W Across Applies to across ridge for gable roof: Applies to across & along for Hip roof)	
Roof Height above Eave (h)	m 1.9	W Along =	BU's / mtr
Stud Height	m	Applies to Along ridge for Gable roof	

NOTE : Tables 5.5 , 5.6, 5.7 relate to HIGH WIND ZONE
In wind zones other than high , multiply the figure from the tables by the appropriate factor given opposite

		Value from table	Adjusted value
Low	0.5 x	80	= 56 Bu's across and Alongs
Medium	0.7 x		
Very High	1.3		
Extra High	1.6		Required BU's Mtr

Box 3 Earthquake Bracing demand (Tables 5.8, 5.9, 5.10)

Earthquake Zone (Fig 5.4)	1 / (2) / 3 / 4	Concrete Slab	Yes / (No)
Weight of Roof cladding	(Light) / Heavy	Part storey in Roof space	Yes / (No)
Roof Pitch (Degrees)	0-25 / (26-45) / 46-60	Part storey Basement	Yes / (No)
Weight of upper (or Single) storey cladding	Light / Medium / Heavy	Chimney	Yes / (No)
Weight of Lower storey Cladding	Light / Medium / Heavy	Wing / Blocks	Yes / (No)
Weight of subfloor Cladding	Light / Medium / Heavy	Deck Projecting more than 2mtr	Yes / (No)

NOTE : Tables 5.8, 5.9, 5.10 Relate to : Soil type D/E in Earthquake zone 3

for Multiplication factors for other soil types see below

Soil Class	Earthquake Zone 1	(2)	3	4	Value from box 3 x multiplier =
(A & B Rock)	0.3	(0.5)	0.6	0.9	16 BU's x 0.5 = (8) Bu's Sq Mtr
C Shallow	0.4	0.6	0.7	1.1	
D/E	0.5	0.8	1.0	1.5	

Box 4 Building plan dimensions (Fig 5.3)

Roof or Building length for wind across ridge	L Across	= 9.3	m
Roof or building width for wind along ridge	W Along	= 8.1	m
Gross Floor Area	GFA	= 75.3	Sq m

Box 5 Calculation of demand (Use the greater of wind or earthquake)	Box 2 Value	Box 4 Dimension	BU'S
Wind Load Across = Across value (from tables 5.5, 5.6, 5.7 x length of bldg	56	x 9.3	= 520.8
Wind Load Along = Along Value (from Tables 5.5, 5.6, 5.7) x width of bldg	56	x 8.1	= 453.6
Earthquake Load (Both directions) E (BU's) x GFA	Box 3 Value 8	x 75.3	= 602.4

Single-storey section

Sheet B

LOCATION OF STOREY BEING ASSESSED

FOUNDATION | SINGLE STOREY or UPPER STOREY | LOWER STOREY

Use one sheet for each storey and circle the appropriate location

BRANZ

ACROSS

1	2	3	4	5	6	7	8	9	10	11
				Wind				Earthquake		
Wall or Bracing Line	Bracing Element Identification	Bracing Type	Length of Element (m)	BU's/m (Wind)	BU's Achieved	Total for Bracing Line	Minimum Bracing Demand	BU's/m (Earthquake)	BU's Achieved	Total for Bracing Line
A	Blue	Anchor	2 Piles	160	320	320	122	120	240	240
B	Blue Magenta overlap.	Anchor	2 Piles	160	320	320	122	120	240	240
C	Blue Magenta overlap.	Anchor	3 Piles	160	480	480	122	120	360	360
D	Blue Magenta Overlap.	Anchor	2 Piles	160	320	320	122	120	240	240
E										
				Total Bracing Achieved		1440		Total Bracing Achieved		1080
				Total Bracing Demand for Wind Across		520.8		Total Bracing Demand for Earthquake		602.4

ALONG

1	2	3	4	5	6	7	8	9	10	11
				Wind				Earthquake		
Wall or Bracing Line	Bracing Element Identification	Bracing Type	Length of Element (m)	BU's/m (Wind)	BU's Achieved	Total for Bracing Line	Minimum Bracing Demand	BU's/m (Earthquake)	BU's Achieved	Total for Bracing Line
M	Blue Magenta overlap.	Anchor	4 Piles.	160	640	640	140	120	480	480
N	Blue Magenta overlap	Anchor	3 Piles.	160	480	480	140	120	360	360
O	Blue.	Anchor	2 piles.	160	320	320	140	120	240	240
P										
Q										
				Total Bracing Achieved		1440		Total Bracing Achieved		1080
				Total Bracing Demand for Wind Along		453.6		Total Bracing Demand for Earthquake		602.4