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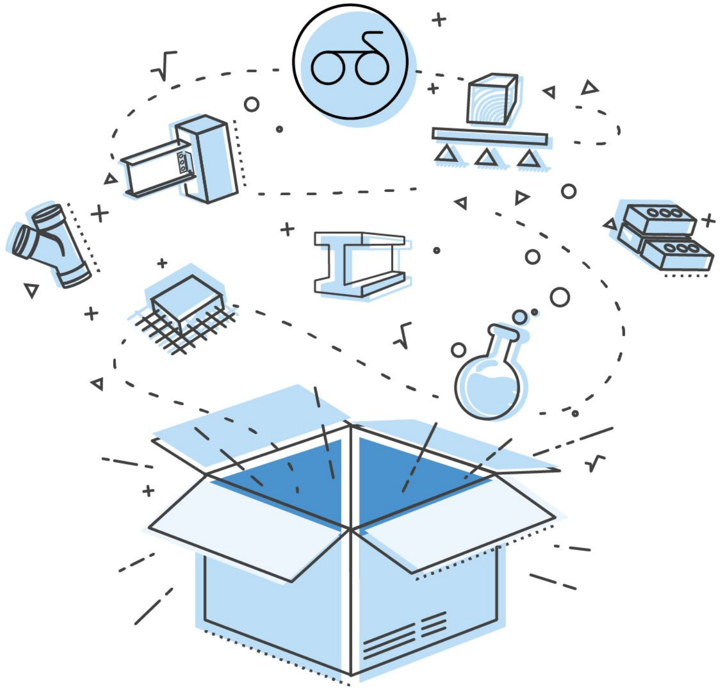
AS/NZS 1170.2:2021

Wind Assessment for Residential Projects



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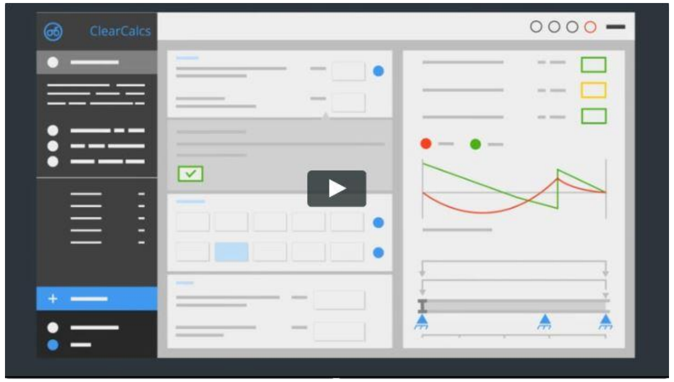
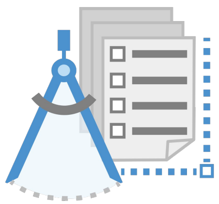


Intro Video Hyperlink



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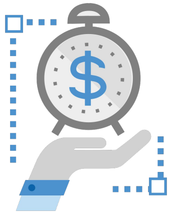
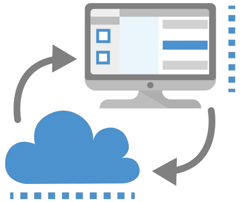
Design more accurately with unrestricted and accessible FEA analysis



Eliminates Wasted Time
Eliminate time wasted using clunky methods or waiting for software licenses to free up



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Meet the Presenter

- **Brooks H. Smith | Head of Engineering R&D**
  - Chartered Professional Engineer (AU) & P.E. (USA)
    - MCivE from University of Massachusetts
    - BEng from Dartmouth College
  - 8 years of previous experience in:
    - Structural engineering R&D consulting, specialising in cold-formed steel
    - Research fellowship in system behaviour of thin-walled steel
    - Forensic structural engineering, specialising in reinforced and PT concrete
  - Almost 5 years now with ClearCalcs
    - Focusing on R&D and QA

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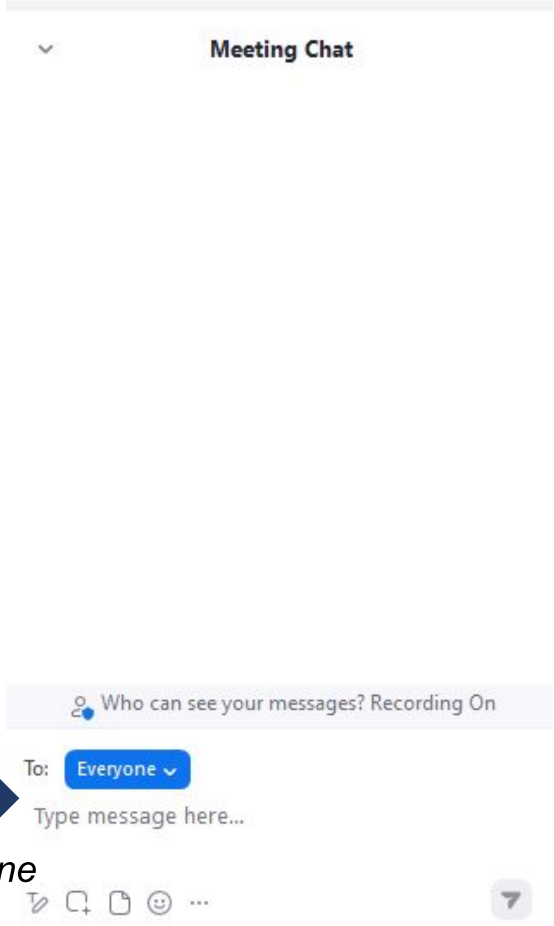
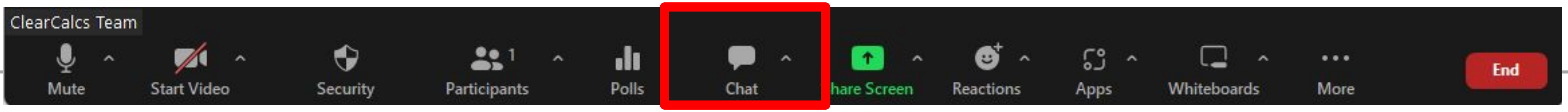
How to Ask Questions

- **Type your questions in the Chat tab on your Zoom control panel and click Send**
  - Please send your questions to “everyone”
  - We will address all questions in the second half of the webinar during the 15-minute Q&A session
  - We might invite you to unmute yourself to ask your question live!



Ask your questions here

Send to everyone



Agenda – Today's Goals

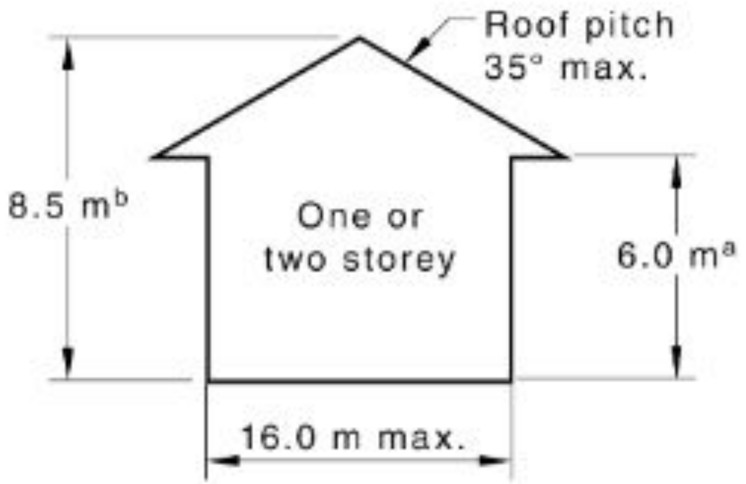
- **Overview of AS/NZS 1170.2:2021**
  - AS 4055 vs AS/NZS 1170.2
  - Changes in new revision
- **Determining Wind Loads**
  - Calculation Strategy
  - Wind Speed
  - Internal Pressures
  - External Pressures
  - Final Wind Load
- **Worked Examples**
  - Using ClearCalcs

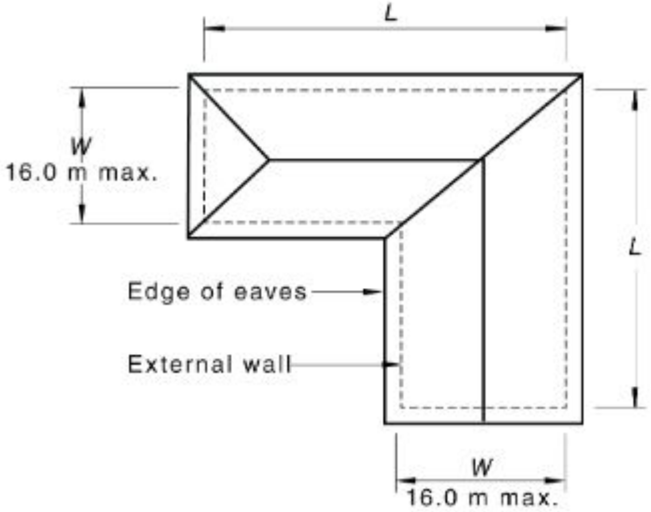
Overview of AS/NZS 1170.2:2021

Comparing with AS 4055, and changes in new revision

AS 4055 – Geometry Restrictions

- Both will give you valid wind loads for a house
- AS 4055 is intended only for residential houses:
  - Class 1 & 10 structures, with geometry restrictions
- AS 1170.2 is intended for most onshore structures:
  - ≤ 200m high, ≤ 100m free spans





AS4055, Fig1.1(a)

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AS 4055 - Simplifying Assumptions

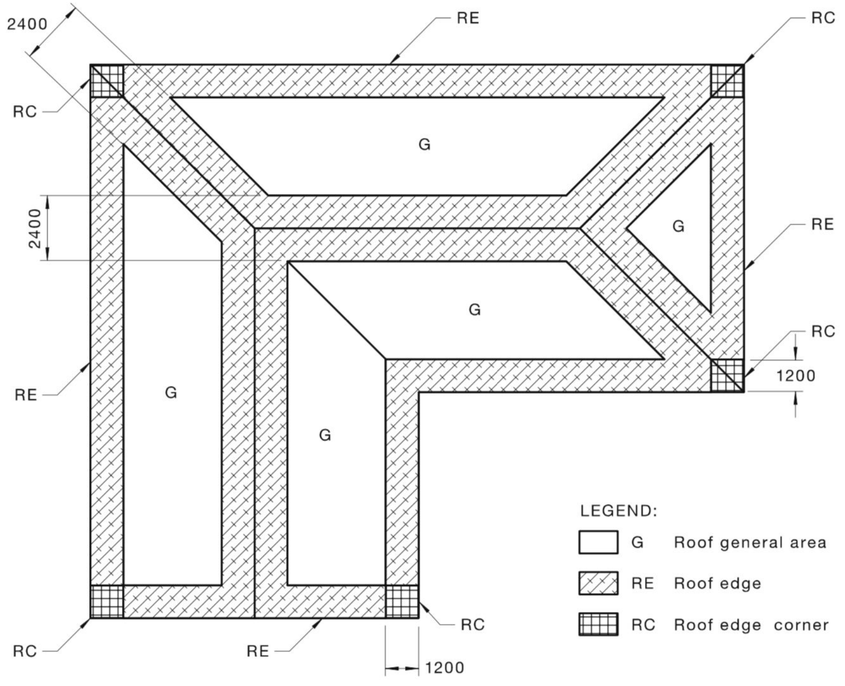
- Many simplifying assumptions (generally conservative) are taken in AS 4055:
  - Discrete classes (N1-N6, C1-C4) combine multiple factors
  - Applying worst-case wind in all directions
  - Fewer pressure zones on buildings
  - Assumes average roof height of 6.5m
  - 5% added conservativism
- Results in a simple table lookup:

Table 2.2
Site wind classification from wind region and site conditions

Wind region	TC	Topographic classification									
		T0	T0	T0	T1	T1	T1	T2	T2	T2	T3
		FS	PS	NS	FS	PS	NS	FS	PS	NS	PS
A	3	N1	N1	N1	N1	N2	N2	N2	N2	N2	N3
	2.5	N1	N1	N2	N1	N2	N2	N2	N3	N3	N3
	2	N1	N2	N2	N2	N2	N3	N2	N3	N3	N3
	1	N2	N2	N3	N2	N3	N3	N3	N3	N3	N4
B	3	N2	N2	N3	N2	N3	N3	N3	N3	N4	N4
	2.5	N2	N3	N3	N3	N3	N3	N3	N4	N4	N4
	2	N2	N3	N3	N3	N3	N4	N3	N4	N4	N4

AS 4055 - Coefficients & Factors

- In AS 4055:
  - Many fewer pressure zones (only 3)
  - $K_c C_{p,n}$ (net pressure coefficient) looked up in one of a few tables
- AS/NZS 1170.2:
  - Numerous pressure zones
  - Several factors independently determined and combined:
    - Separate interior and exterior $C_{p,i}$ and $C_{p,e}$
    - Several *K* factors relevant for different types of elements within a building



NOTE: Indicated plan width varies to suit roof pitch.

DIMENSIONS IN MILLIMETRES

FIGURE 3.1 PRESSURE ZONES ON HOUSING—ROOFS (PLAN VIEW)

AS 4055 - Total Uplift / Racking

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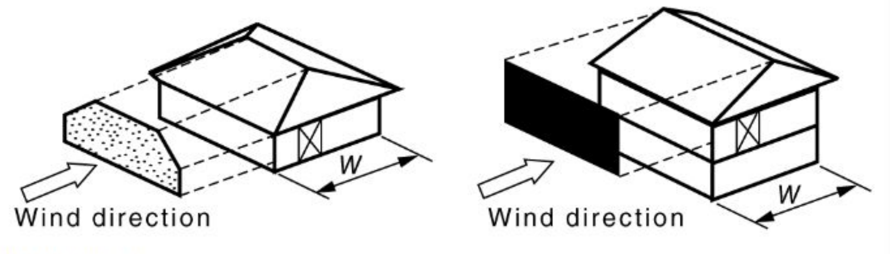
- AS 4055: Completely independent section, with its own independent table lookups
  - Numerous conservative simplifications
    - e.g. 2.7m stories, worst-case geometry ratios
- AS/NZS 1170.2: Sum of all external pressures calculated
  - Though there are a lot of them…

Table 5.2(B)

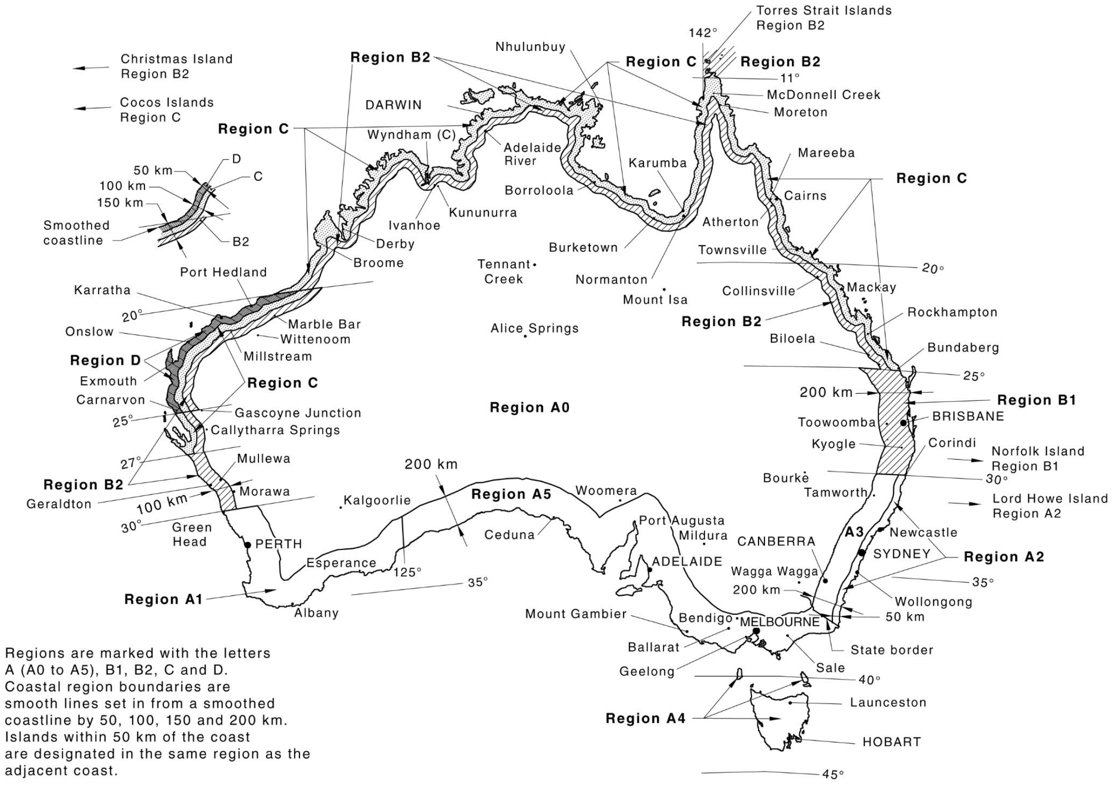
Hip roofs and side wind on gable roofs — Pressure (kPa) on area of elevation — Single storey or upper floor of two storeys



Single storey or upper floor of two storeys — 2.4 m storey, 0.3 m floor								
Width (m)	Roof pitch (degrees)							
	0	5	10	15	20	25	30	35
N1: Wind on side								
4	0.58	0.51	0.46	0.43	0.47	0.53	0.53	0.54
5	0.58	0.49	0.44	0.42	0.47	0.53	0.52	0.54
6	0.58	0.48	0.41	0.42	0.48	0.53	0.52	0.55
7	0.58	0.46	0.39	0.42	0.48	0.53	0.52	0.55
8	0.58	0.45	0.37	0.42	0.48	0.53	0.52	0.55

Changes 2011 → 2021: Wind Regions

- Wind region map updated; new regions A0, B1, B2, & NZ1-4
- Special F_C and F_D factors for Regions C & D removed



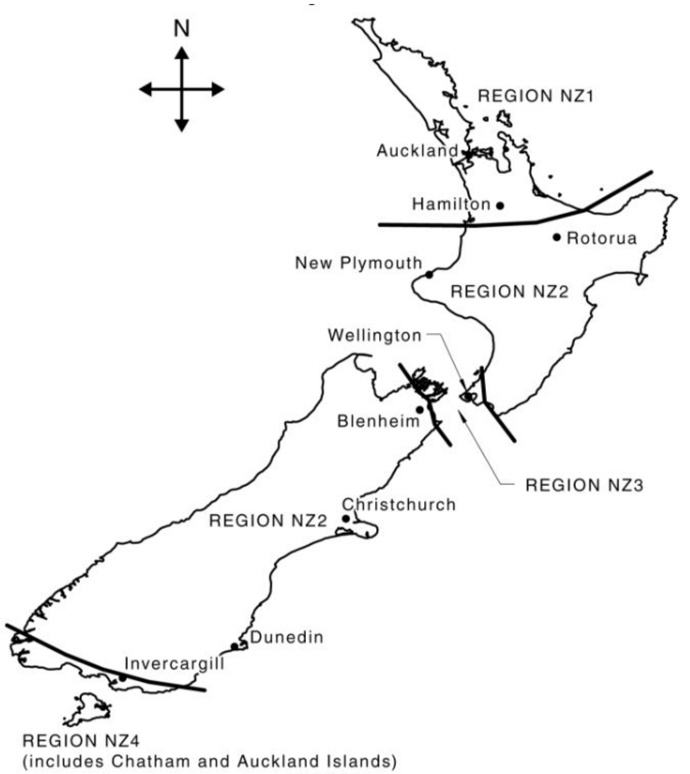


Figure 3.1(B)
Wind regions — New Zealand

Changes 2011 → 2021: Multipliers

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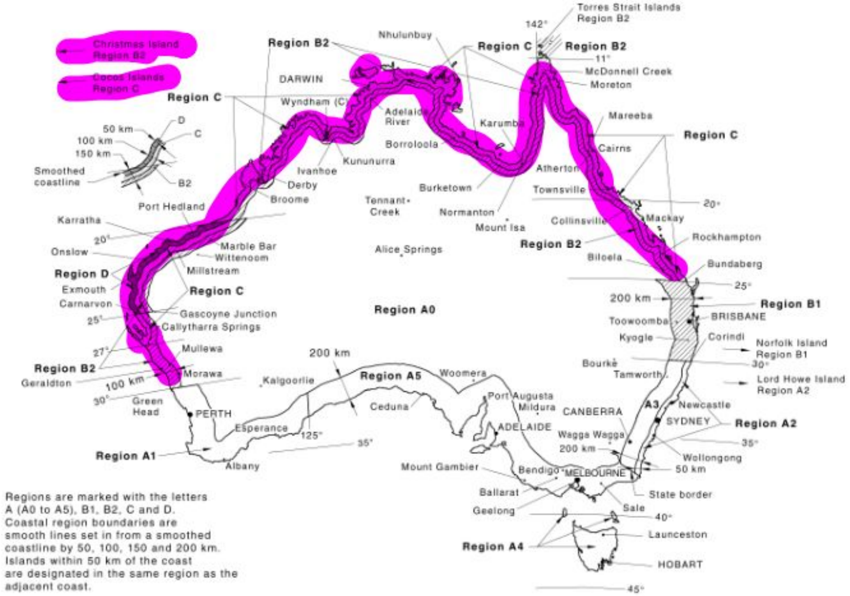
- New Climate Change Multiplier $M_c = 1.0 \text{ or } 1.05$
  - 5% wind speed increase for coastal north
- Shielding Multiplier $M_s = 1.0$ always if building $h > 25\ m$
- Hill Multiplier $M_h = 1.0$ always if hill $H < 10\ m$



Changes 2011 → 2021 - TCs & Factors

- All intermediate terrain categories except TC 2.5 removed
  - TC 2.5 is essentially for outer suburbs
- Internal wind factors with large openings:
  - New open area / volume factor K_v for open structures
  - Internal wind pressure coefficients now include K_a and K_l factors

Table 4.1
Terrain/height multipliers for gust wind speeds in fully developed terrains — All regions except A0

Height (z) (m)	Terrain/height multiplier ($M_{z,cat}$)				
	Terrain Category 1	Terrain Category 2	Terrain Category 2.5	Terrain Category 3	Terrain Category 4
≤ 3	0.97	0.91	0.87	0.83	0.75
5	1.01	0.91	0.87	0.83	0.75
10	1.08	1.00	0.92	0.83	0.75
15	1.12	1.05	0.97	0.89	0.75
20	1.14	1.08	1.01	0.94	0.75
30	1.18	1.12	1.06	1.00	0.80

Table 5.1(B)
Internal pressure coefficients ($C_{p,i}$) for buildings with openings greater than 0.5 % of the area of the corresponding wall or roof

Ratio of area of openings on one surface to the sum of the total open area (including permeability) of other wall and roof surfaces	Largest opening on windward wall	Largest opening on leeward wall	Largest opening on side wall	Largest opening on roof
0.5 or less	−0.3, 0.0	−0.3, 0.0	−0.3, 0.0	−0.3, 0.0
1	−0.1, 0.2	−0.3, 0.0	−0.3, 0.0	−0.3, 0.0
2	$0.7\ K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$
3	$0.85\ K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$
6 or more	$K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$
	t5-1(b)-1			

Determining Wind Loads

The steps for performing an 1170.2 calculation

Calc Strategy – Calculation Heights

- Most calculations based upon *h* = average roof height
  - Especially for residential buildings (1-2 storey)
- In large structures, might calc loads at every floor *z* individually

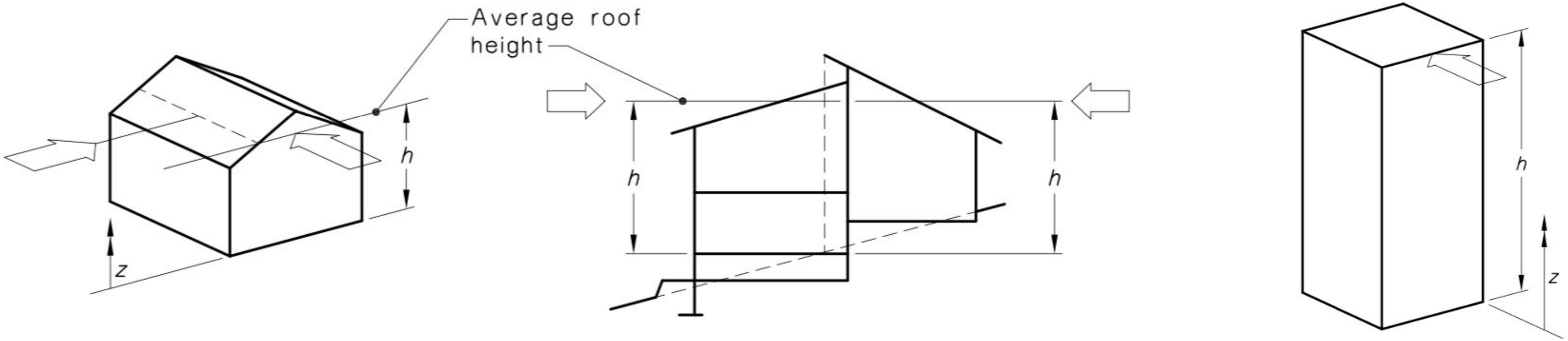


FIGURE 2.1 REFERENCE HEIGHT OF STRUCTURES

Calc Strategy - Directions

- Site wind speed at **8 cardinal directions**
  - N = 0°, NE = 45°, …
- Design wind speed at **4 building directions**
  - Front = 0°, Right = 90°, …
- Some calcs are easier if “front” is taken as:
  - **Hip roofs:** perpendicular to a long side of building
  - **Gable/monoslope roofs:** perpendicular to ridge

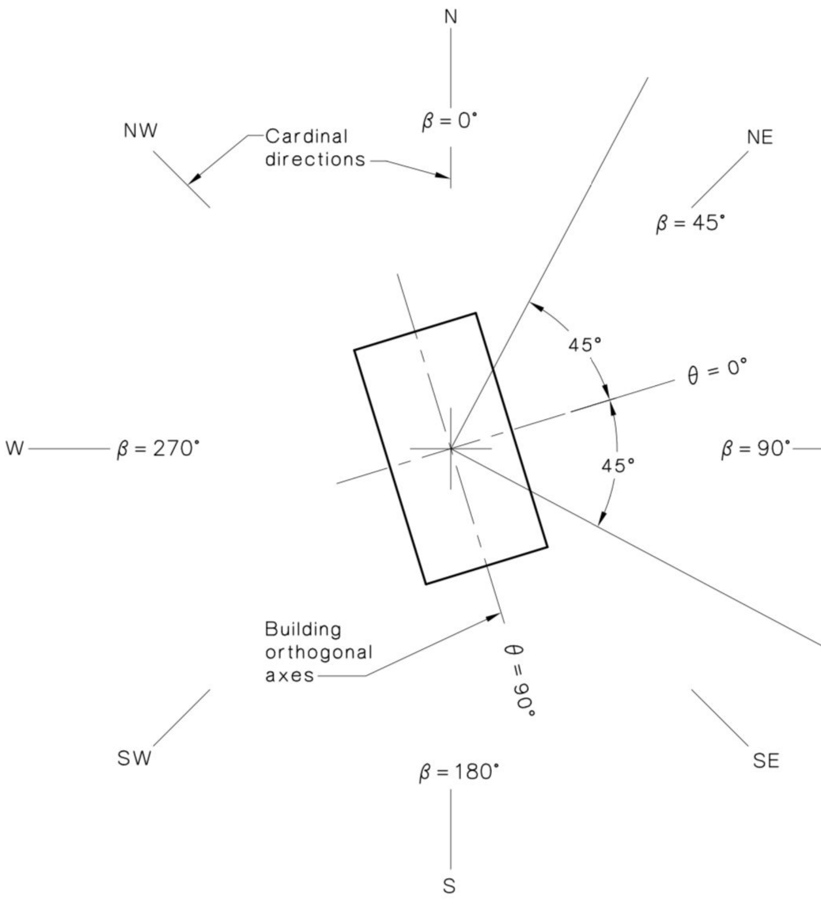


FIGURE 2.2 RELATIONSHIP OF WIND DIRECTIONS AND BUILDING ORTH AXES

Calc Strategy – Overall

- There are two equations that really govern this process:
  - **(1) Site Wind Speed**
    - The directional wind speed, including topographic and geographic

$$V_{sit,\beta} = V_R\, M_d\, (M_{z,cat}\, M_s\, M_t) \qquad \ldots 2.2$$

    - Converted into a "design wind speed" $V_{des,\theta}$, based on orientation
  - **(2) Design Wind Pressure**
    - The actual pressure to be applied to the structure

$$p = (0.5\rho_{air})\, [V_{des,\theta}]^2\, C_{shp} C_{dyn} \qquad 2.4(1)$$

$$C_{shp} = C_{p,i}\, K_{c,i} K_v \text{ , for internal pressures} \quad 5.2(1)$$

$$C_{shp} = C_{p,e}\, K_a K_{c,e} K_\ell K_p \text{ , for external pressures} \quad 5.2(2)$$

$$C_{shp} = C_f K_a K_{c,e} \text{ , for frictional drag forces} \quad 5.2(3)$$

- Top of each slide will highlight the factor being considered

$$V_{sit,\beta} = V_R M_d (M_{z,cat} M_s M_t) \rightarrow V_{des,\theta}$$

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Wind Speed - Regions

- Select your wind region based upon location:
  - Note that regions “A”, “B”, “NZ” are subdivided

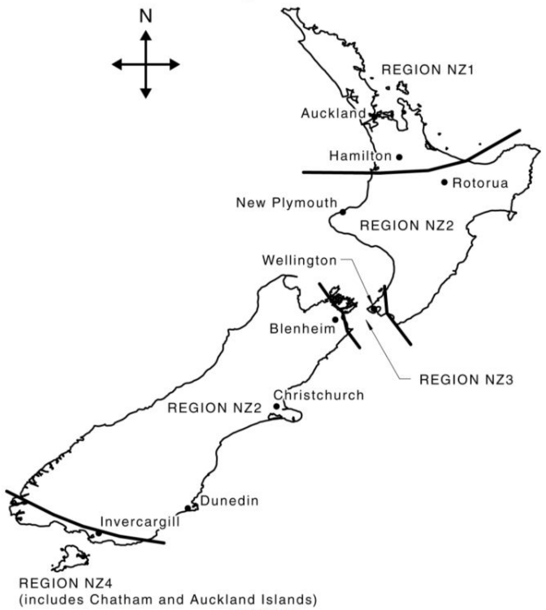
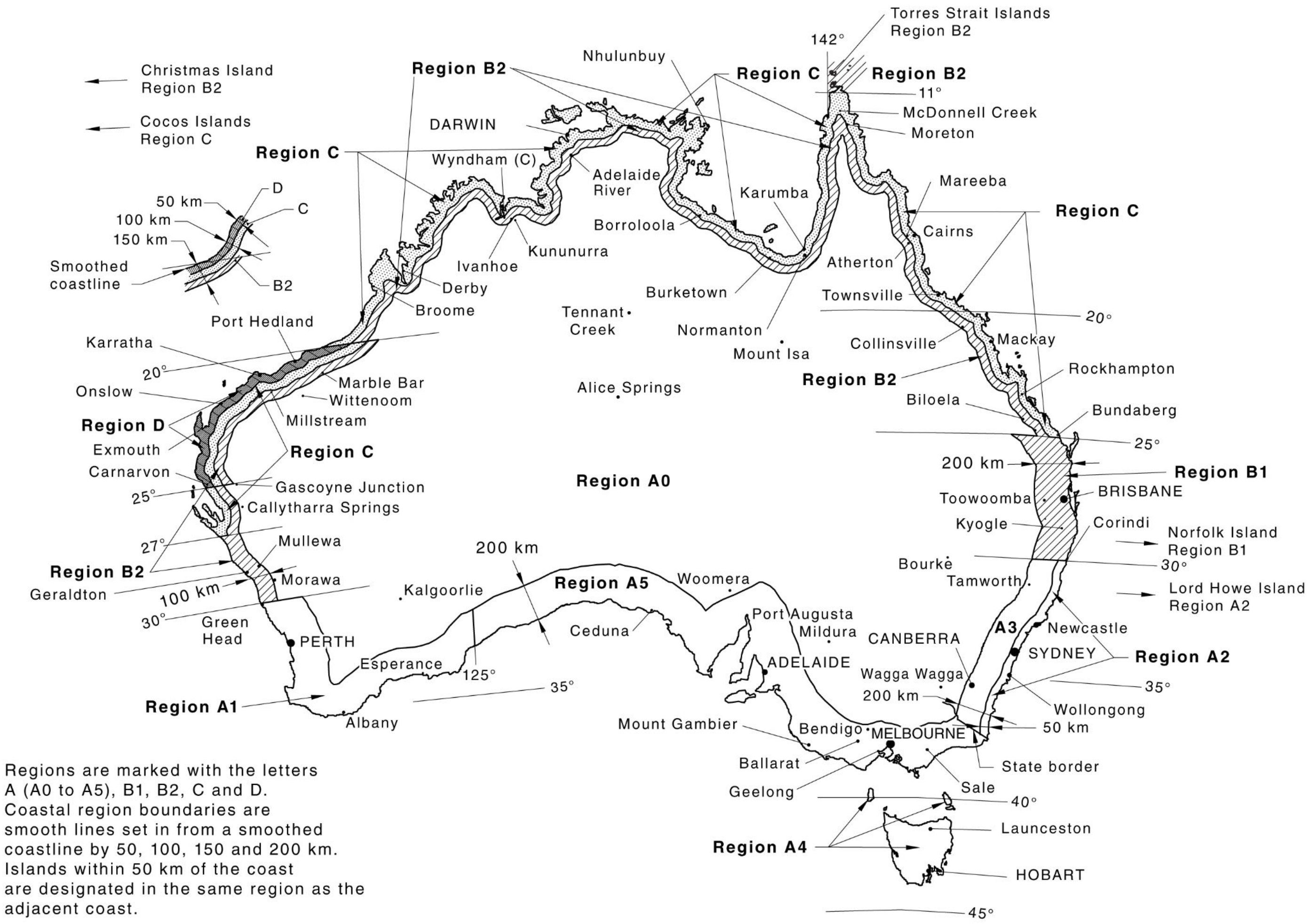


Figure 3.1(B)
Wind regions — New Zealand



$$V_{sit,\beta} = V_R M_d (M_{z,cat} M_s M_t) \rightarrow V_{des,\theta}$$

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Wind Speed – Regional Wind Speed

- Look up equation for non-directional base wind speed V_R
  - Which is based upon probability of exceedance = *1/R*
  - See NCC 2022, Cl B1D3(c); Houses: R_{ult} = 500 year, R_{serv} = 25 years
- And then direction multipliers for 8 cardinal directions

Table 3.1(A)
Regional wind speeds — Australia

Regional wind speed (m/s)	Region			
	Non-cyclonic		Cyclonic	
	A (0 to 5)	B1, B2	C (maximum)	D (maximum)
V_1	30	26	23	23
V_R ($R \geq 5$ years)	$67-41R^{-0.1}$	$106-92R^{-0.1}$	$122-104R^{-0.1}$	$156-142R^{-0.1}$

Table 3.2(A)
Wind direction multiplier (M_d) — Australia

·dinal ctions	Region A0	Region A1	Region A2	Region A3	Region A4	Region A5	Region B1	Regions B2, C, D
N	0.90	0.90	0.85	0.90	0.85	0.95	0.75	0.90
NE	0.85	0.85	0.75	0.75	0.75	0.80	0.75	0.90
E	0.85	0.85	0.85	0.75	0.75	0.80	0.85	0.90
SE	0.90	0.80	0.95	0.90	0.80	0.80	0.90	0.90
S	0.90	0.80	0.95	0.90	0.80	0.80	0.95	0.90
SW	0.95	0.95	0.95	0.95	0.90	0.95	0.95	0.90
W	1.00	1.00	1.00	1.00	1.00	1.00	0.95	0.90
NW	0.95	0.95	0.95	0.95	1.00	0.95	0.90	0.90

$$V_{sit,\beta} = V_R M_d \left(M_{z,cat} M_s M_t \right) \rightarrow V_{des,\theta}$$

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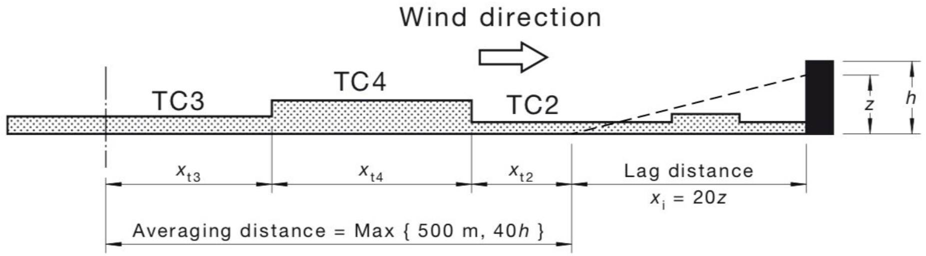
Wind Speed - Terrain / Height Multiplier

- Terrain category in each direction - buildings & vegetation
    - TC1 = Very exposed open terrain (e.g. deserts and lakes)
    - TC2 = Open terrain with scattered obstructions (e.g. farmland)
    - TC2.5 = Isolated trees or obstructions (e.g. outer suburbs)
    - TC3 = Numerous closely-spaced obstructions (e.g. inner suburbs)
    - TC4 = Numerous large obstructions (e.g. CBDs)
  - May be averaged if it varies outward



$$M_{z,cat} = \frac{M_{z,cat2}\,x_{t2} + M_{z,cat4}\,x_{t4} + M_{z,cat3}\,x_{t3}}{x_{t2} + x_{t4} + x_{t3}} \quad \text{for the case illustrated}$$

NOTE: The terrain within the lag distance, x_i, is ignored when averaging terrain-height multipliers.

FIGURE 4.1 EXAMPLE OF AVERAGING OF TERRAIN-HEIGHT MULTIPLIERS

Table 4.1
Terrain/height multipliers for gust wind speeds in fully developed terrains — All regions except A0

Height (z) (m)	Terrain/height multiplier ($M_{z,cat}$)				
	Terrain Category 1	Terrain Category 2	Terrain Category 2.5	Terrain Category 3	Terrain Category 4
≤ 3	0.97	0.91	0.87	0.83	0.75
5	1.01	0.91	0.87	0.83	0.75
10	1.08	1.00	0.92	0.83	0.75
15	1.12	1.05	0.97	0.89	0.75
20	1.14	1.08	1.01	0.94	0.75
30	1.18	1.12	1.06	1.00	0.80

$$V_{sit,\beta} = V_R M_d (M_{z,cat} M_s M_t) \rightarrow V_{des,\theta}$$

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Wind Speed – Shielding Multiplier

- Definition of shielding structure very important:
  - Only buildings, within a distance of *20*h*, with height $h_s \geq z$
  - Determined independently for each 45° arc from structure
- Shielding "parameter":

$$s = \frac{l_s}{\sqrt{h_s b_s}} \qquad \ldots 4.3(1)$$

Table 4.2
Shielding multiplier (M_s) (for $h \leq 25$ m)

Shielding parameter (s)	Shielding multiplier (M_s)
≤ 1.5	0.7
3.0	0.8
6.0	0.9
≥ 12.0	1.0

NOTE For intermediate values of *s*, use linear interpolation.

  - Warning: "average spacing" l_s doesn't exactly mean the … average spacing:

$$l_s = h\left(\frac{10}{n_s} + 5\right) \qquad \ldots 4.3(2)$$

$$V_{sit,\beta} = V_R M_d \left(M_{z,cat} M_s M_t \right) \rightarrow V_{des,\theta}$$

Wind Speed – Topographic Multiplier

- Hills M_h: Consider features within *min(500m, 20*h)* distance, > 10 metres in height

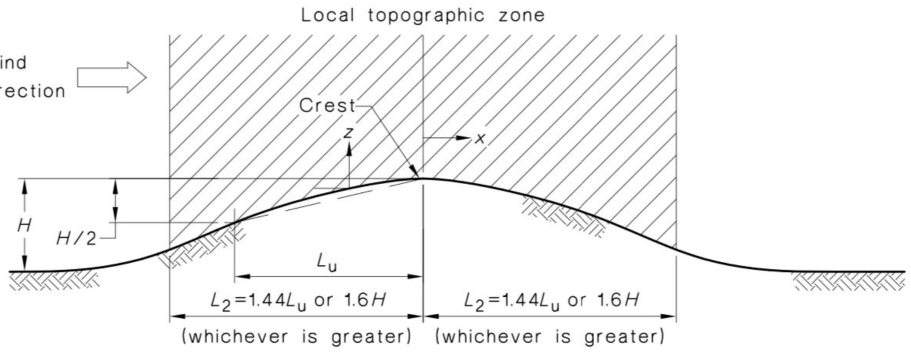
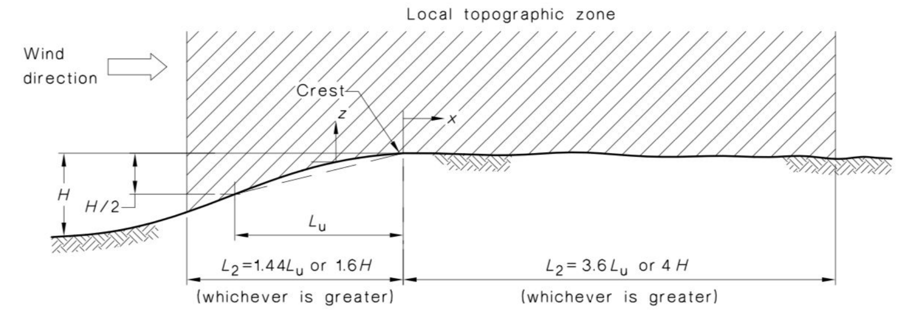


FIGURE 4.2 HILLS AND RIDGES



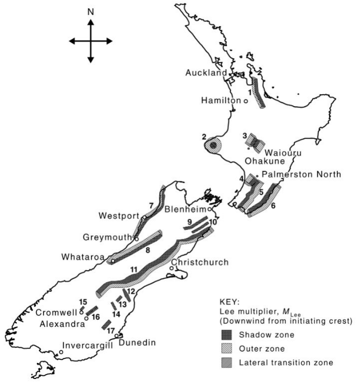
NOTE: For escarpments, the average downwind slope, measured from the crest to a distance of the greater of 3.6 L_u or 4 H shall not exceed 0.05.

FIGURE 4.3 ESCARPMENTS

$$M_h = 1 + \left(\frac{H}{3.5(z + L_1)} \right) \left(1 - \frac{|x|}{L_2} \right) \quad \ldots 4.4(2)$$

- Lee effect M_{lee}: Only for New Zealand

$$M_t = M_h \, M_{lee} \, (1 + 0.00015 \, E) \quad \ldots 4.4(1)$$



$V_{sit,\beta} = V_R M_d (M_{z,cat} M_s M_t) \rightarrow V_{des,\theta}$

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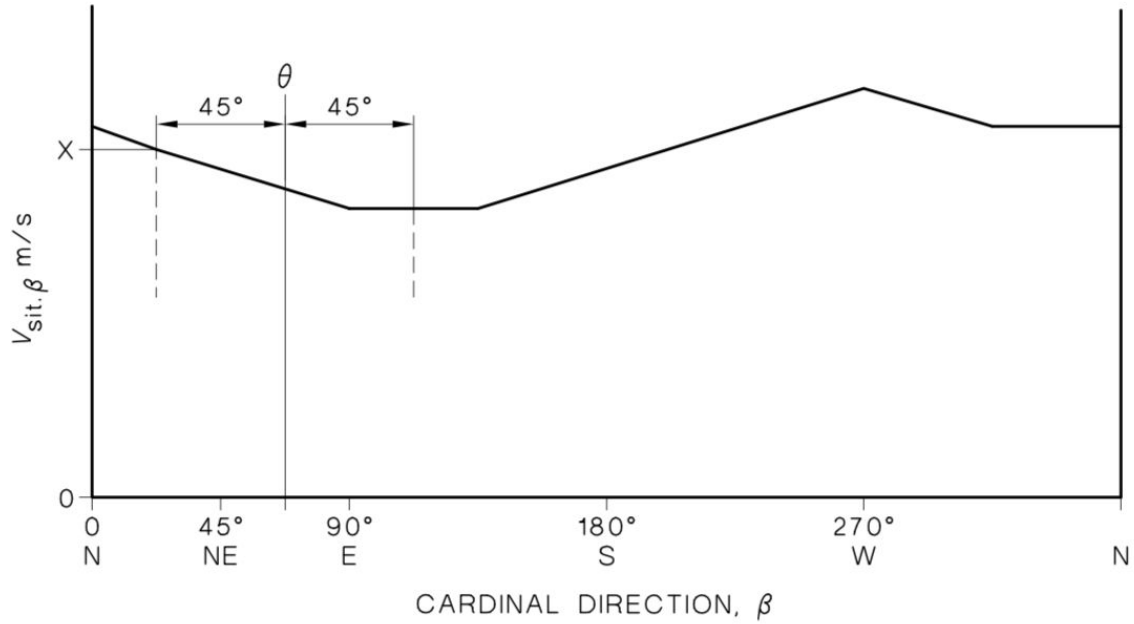
Wind Speed - Design Wind Speed

- 8 site wind speeds
  → 4 design wind speeds
- $V_{des,\theta} = V_{sit,\beta = \theta \pm 45°}$
  - In words: design wind speed is the maximum site wind speed within ±45° of the direction of a face of the building



The value of $V_{des,\theta}$ is the maximum of $V_{sit,\beta}$ in the range $\theta \pm 45°$, which, in the case shown here, is the wind speed X.

FIGURE 2.3 EXAMPLE OF $V_{sit,\beta}$ CONVERSION TO $V_{des,\theta}$

$$V_{sit,\beta} = V_R M_d (M_{z,cat} M_s M_t) \rightarrow V_{des,\theta}$$

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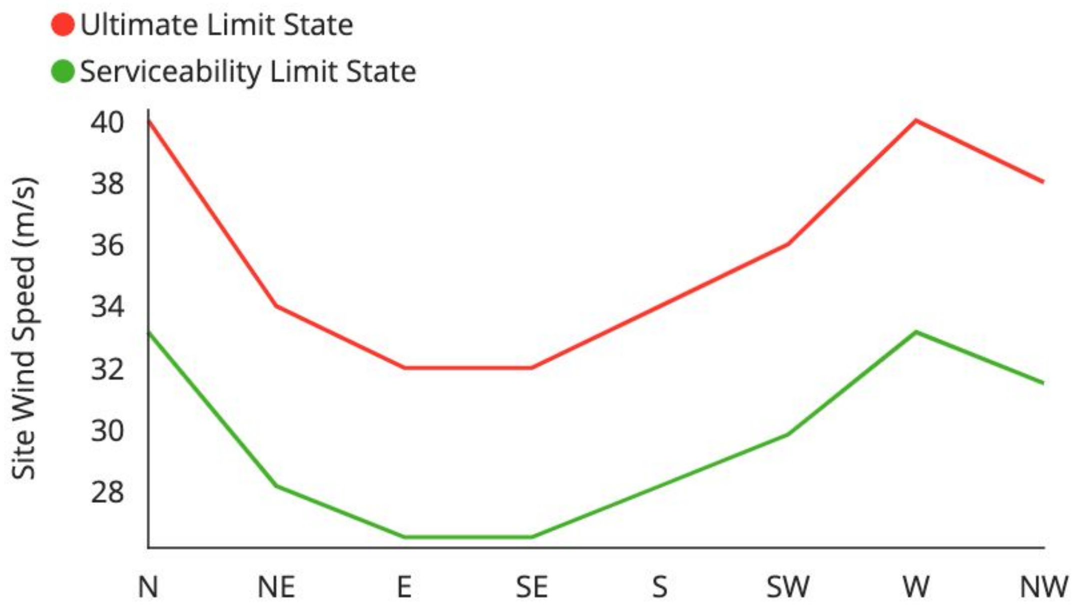
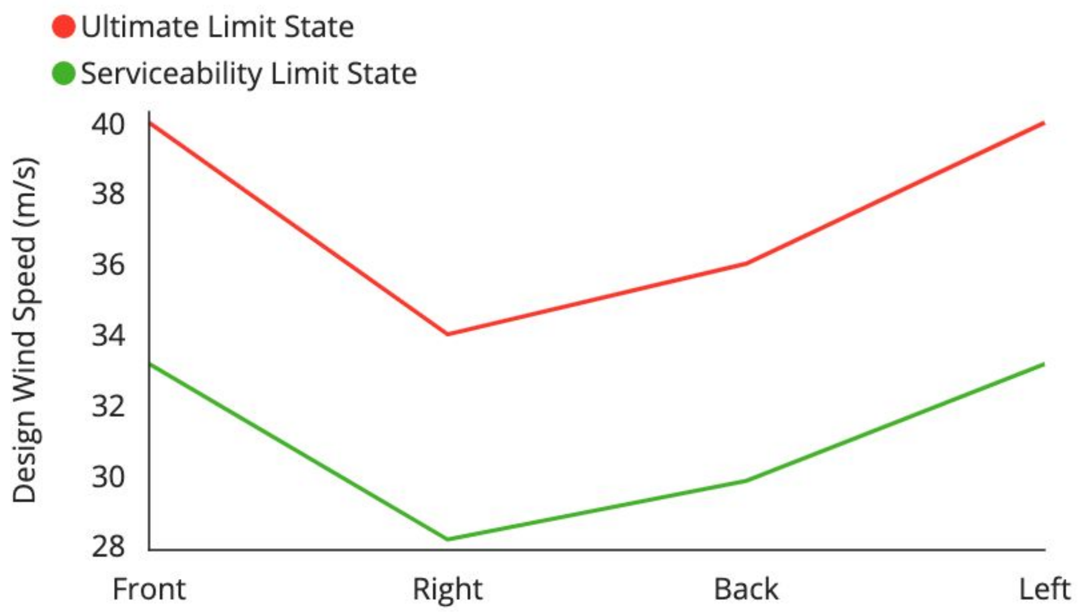
Wind Speed – Design Wind Speed

- Remember, repeat in 8 cardinal directions → 4 building directions!
  - And for both ultimate & service limit states!





$$p_i = (0.5\rho_{air})[V_{des,\theta}]^2 \cdot \{C_{fig,i} = C_{p,i}K_{c,i}\} \cdot C_{dyn}$$

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Internal Pressures – Permeable Structure

- "Opening" defined in great detail in Cl 5.3.2
  - But generally includes anything that can be opened, such as doors, windows, ventilators, etc – unless specially-designed for resistance
- Vital parameter = first column
  - Includes your roof! (skylights)
  - Essentially, measuring how balanced your openings are between surfaces
  - For example, if you have 1m^2 of openings on three walls, but 3m^2 of openings on one wall, then this maximum ratio would be equal to 1.0
    - because $3m^2 / (1m^2 + 1m^2 + 1m^2) = 1.0$

Table 5.1(B)
Internal pressure coefficients ($C_{p,i}$) for buildings with openings greater than 0.5 % of the area of the corresponding wall or roof

Ratio of area of openings on one surface to the sum of the total open area (including permeability) of other wall and roof surfaces	Largest opening on windward wall	Largest opening on leeward wall	Largest opening on side wall	Largest opening on roof
0.5 or less	−0.3, 0.0	−0.3, 0.0	−0.3, 0.0	−0.3, 0.0
1	−0.1, 0.2	−0.3, 0.0	−0.3, 0.0	−0.3, 0.0
2	0.7 $K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$
3	0.85 $K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$
6 or more	$K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$	$K_a K_\ell C_{p,e}$
	t5-1(b)-1			

NOTE 1 $C_{p,e}$ is the relevant external pressure coefficient at the location of the largest opening. For example, in Column 2, $C_{p,e}$ means the windward wall pressure coefficient obtained from *Table 5.2(A)*; in Column 3, $C_{p,e}$ means the leeward wall pressure coefficient obtained from *Table 5.2(B)*, in Column 5, $C_{p,e}$ means the roof pressure coefficient for that part of the roof containing the opening.

$$p_e = (0.5\rho_{air})\left[V_{des,\theta}\right]^2 \cdot \{C_{fig,e} = C_{p,e}K_aK_{c,e}K_lK_p\} \cdot C_{dyn}$$

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External Pressures

	Facing Wind	Away from Wind	Sides
Walls:	Windward	Leeward	Side
Roofs:	Upwind	Downwind	CRosswind

- Note: “wall” pressure is also applied to underside of adjacent eaves
  - “roof” loads only mean *top* of roof

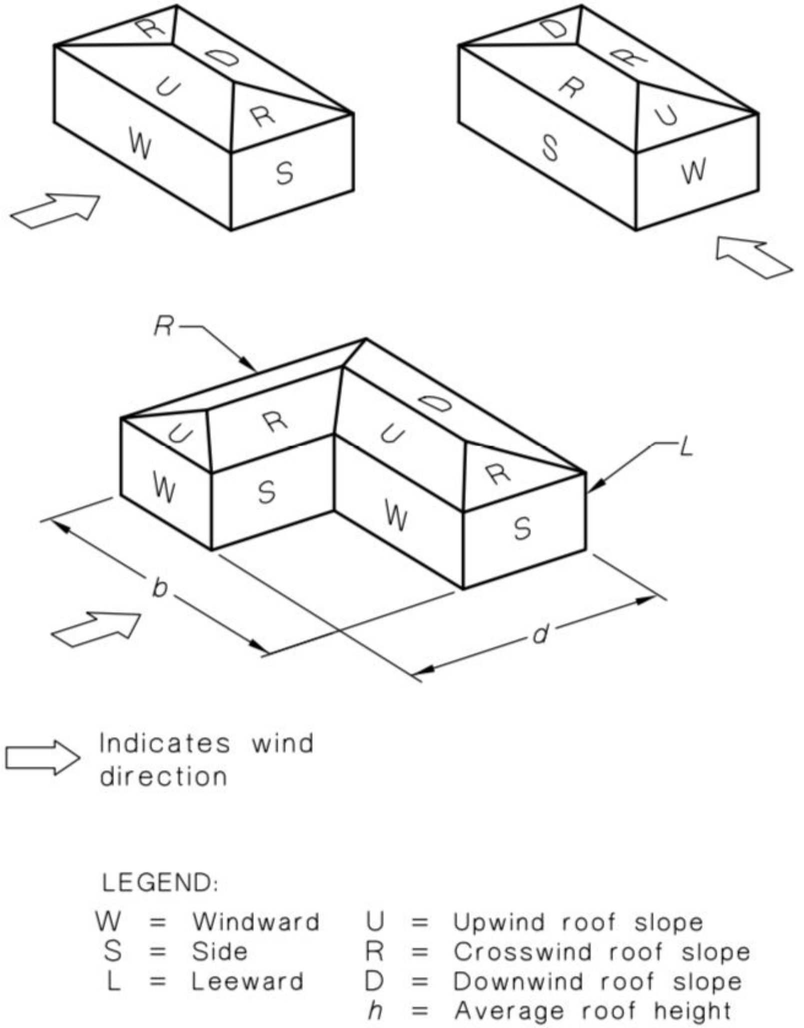


FIGURE 5.2 PARAMETERS FOR RECTANGULAR ENCLOSED BUILDINGS

$$p_e = (0.5\rho_{air})[V_{des,\theta}]^2 \cdot \{C_{fig,e} = C_{p,e} K_a K_{c,e} K_l K_p\} \cdot C_{dyn}$$

ClearCalcs

External Pressures - Table Lookups

- Separate lookup tables for each direction
  - Often with two values given (min and max)
- Warnings:
  - Several lookups depend upon a *d/b* or *d/h* ratio - but which dimension is *d* or *b* changed based on the wind direction you're looking at!
    - *d* is parallel to wind direction, *b* is perpendicular
  - Wall "side" and roof "crosswind" directions have multiple pressure zones
    - Depending on distance to the windward edge

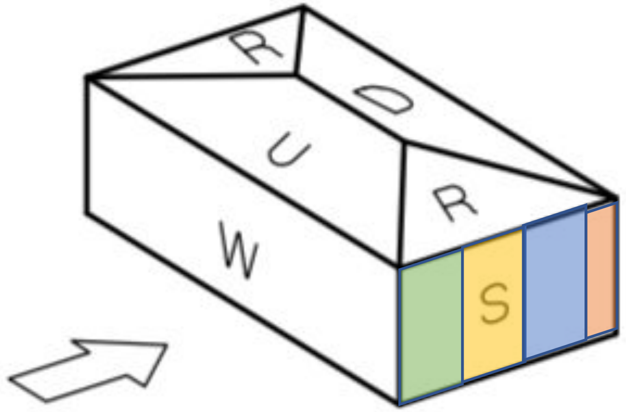


FIGURE 5.2 PARAMETERS FOR RECTANGULAR ENCLOSED BUILDINGS

Final Wind Loads – Constants

- Up to now, calculations only had to be done *once per building*
  - But most *K* factors depend on the *specific element* for which load is calculated

$$V_{sit,\beta} = V_R M_d \left(M_{z,cat} M_s M_t\right) \rightarrow V_{des,\theta}$$

$$p_i = (0.5\,\rho_{air})\,[V_{des,\theta}]^2\,\{C_{shp} = C_{p,i}\,K_{c,i}\,K_v\}\,C_{dyn}$$

$$p_e = (0.5\,\rho_{air})\,[V_{des,\theta}]^2\,\{C_{shp} = C_{p,e}\,K_a\,K_{c,e}\,K_l\,K_p\}\,C_{dyn}$$

$$p_f = (0.5\,\rho_{air})\,[V_{des,\theta}]^2\,\{C_{shp} = C_f\,K_a\,K_{c,e}\}\,C_{dyn}$$

  - K_v = open area / **v**olume factor (which is new)
  - K_a = tributary **a**rea factor
  - K_l = **l**ocal cladding factor
  - K_p = **p**ermeable cladding factor

$$p_e = (0.5\rho_{air})\left[V_{des,\theta}\right]^2 \cdot \{C_{fig,e} = C_{p,e} K_a K_{c,e} K_l K_p\} \cdot C_{dyn}$$

$$p_i = (0.5\rho_{air})\left[V_{des,\theta}\right]^2 \cdot \{C_{fig,i} = C_{p,i} K_{c,i}\} \cdot C_{dyn}$$

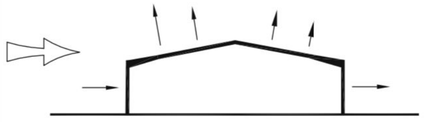
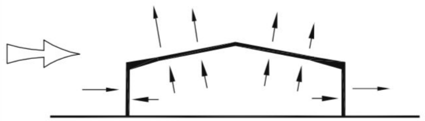
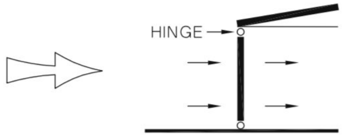
Final Wind Loads – Combination Factors

- Wind loads calculated are worst-case, and it’s not always reasonably possible for worst to occur on every surface at once
  - So, for designing a system, such as a portal frame, affected by multiple surfaces, combination factors can be used to reduce loads
  - Table 5.5 has many examples, but this is the governing clause:

Where pressures on two contributing surfaces act together in combination to produce a structural action effect, $K_{c,e}$ and $K_{c,i}$ may be taken as 0.9. Where three (or more) contributing surfaces act in combination, $K_{c,e}$ and $K_{c,i}$ may be taken as 0.8.

TABLE 5.5

EXAMPLES OF ACTION COMBINATION FACTORS $K_{c,e}$ AND $K_{c,i}$ FOR ACTION EFFECTS ON STRUCTURAL ELEMENTS FROM WIND PRESSURE ON EFFECTIVE SURFACES

Design case	Example diagram	External $K_{c,e}$	Internal $K_{c,i}$
(a) *3 effective surfaces* Pressures from windward and leeward walls in combination with roof pressures		0.8	1.0 (not an effective surface)
(b) *4 effective surfaces* Pressures from windward and leeward walls in combination with roof pressures and internal pressures		0.8	0.8
(h) *2 effective surfaces* Lateral pressure on external and internal surfaces		0.9	0.9

Final Wind Loads – Wind Directions

- Rearranging formulas:

$$p_i = [\ (0.5\ \rho_{air})\ [V_{des,\theta}]^2\ C_{p,i}\ C_{dyn}\ ] * K_{c,i}\ K_v$$

$$p_e = [\ (0.5\ \rho_{air})\ [V_{des,\theta}]^2\ C_{p,e} C_{dyn}\ ] * K_a\ K_{c,e}\ K_l\ K_p$$

$$p_f = [\ (0.5\ \rho_{air})\ [V_{des,\theta}]^2\ C_f\ C_{dyn}\ ] * K_a\ K_{c,e}$$

- 4 wind directions / 4 sides, 2 pressure coefficients per side
  - Take worst-case of all four wind directions
  - So 8 values of p_i and 16 values of p_e (8 for walls + 8 for roof)

Design External Pressures on Roof $p_{e,roof,table} =$

Windward Wall	Front Pressure #1 $p_{e,rF,1}$ (kPa)	Front Pressure #2 $p_{e,rF,2}$ (kPa)	Right Pressure #1 $p_{e,rR,1}$ (kPa)	Right Pressure #2 $p_{e,rR,2}$ (kPa)	Back Pressure #1 $p_{e,rB,1}$ (kPa)	Back Pressure #2 $p_{e,rB,2}$ (kPa)	Left Pressure #1 $p_{e,rL,1}$ (kPa)	Left Pressure #2 $p_{e,rL,2}$ (kPa)
Front	-0.577	-0.144	-1.25	-0.577	-0.577	-0.577	-1.25	-0.577
Right	-0.681	-0.306	-0.278	0.0347	-0.681	-0.306	-0.417	-0.417
Back	-0.467	-0.467	-1.01	-0.467	-0.467	-0.117	-1.01	-0.467
Left	-0.942	-0.423	-0.577	-0.577	-0.942	-0.423	-0.385	0.0481

→

Design External Wind Pressures on Each Side of the Roof $p_{e,roof} =$

Side of Roof	Minimum External Pressure $p_{e,min}$ (kPa)	Maximum External Pressure $p_{e,max}$ (kPa)
Front	-0.942	-0.144
Right	-1.25	0.0347
Back	-0.942	-0.117
Left	-1.25	0.0481

Final Wind Loads - W_u and W_s

- Can now finally calculate your final W_u and W_s wind loads

$$F = \sum(p_z A_z) \qquad \ldots 2.5(1)$$

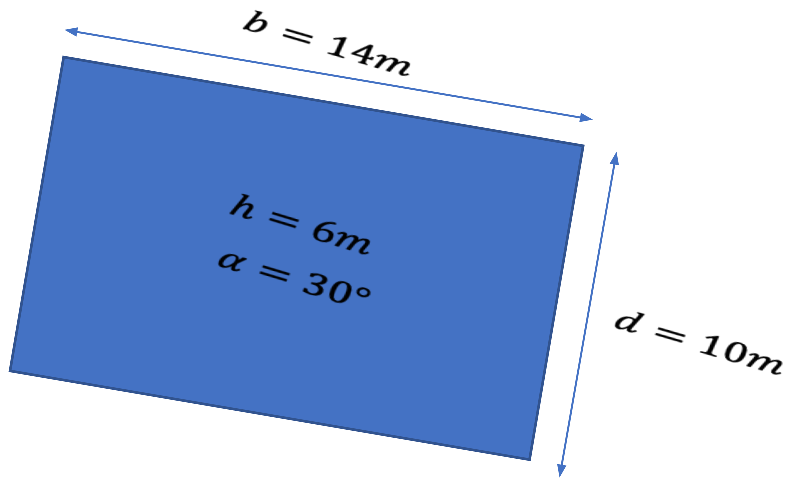
  - Multiply pressures by load widths in appropriate load combinations
  - Still usually 2 values for W_u and 2 values for W_s for a given member on a given side of the building

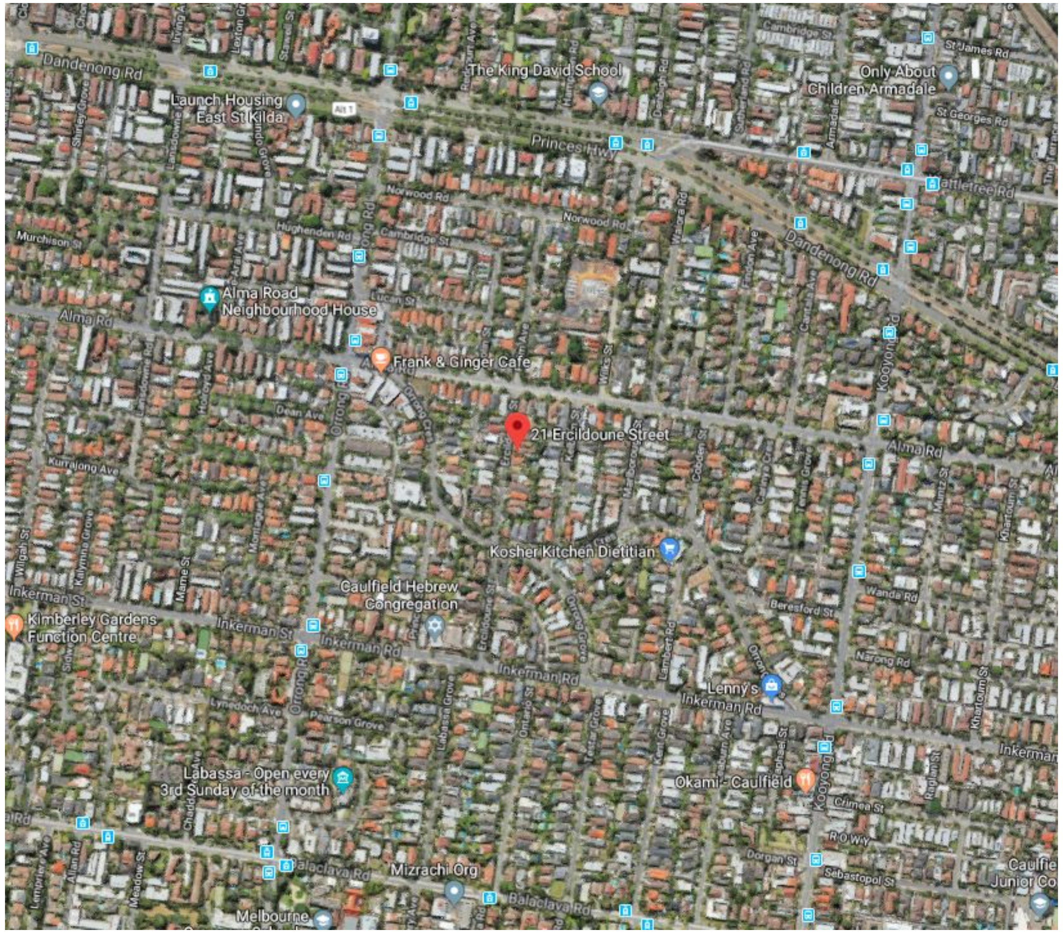
$$W_{u1} = p_{i,min} K_{c,i} A_i + p_{e,max} K_a K_{c,e} K_l K_p A_e$$
$$W_{u2} = p_{i,max} K_{c,i} A_i + p_{e,min} K_a K_{c,e} K_l K_p A_e$$
$$W_{s1} = p_{i,s,min} K_{c,i} A_i + p_{e,s,max} K_a K_{c,e} K_l K_p A_e$$
$$W_{s2} = p_{i,s,max} K_{c,i} A_i + p_{e,s,min} K_a K_{c,e} K_l K_p A_e$$

Worked Examples

How does the workflow look like in ClearCalcs

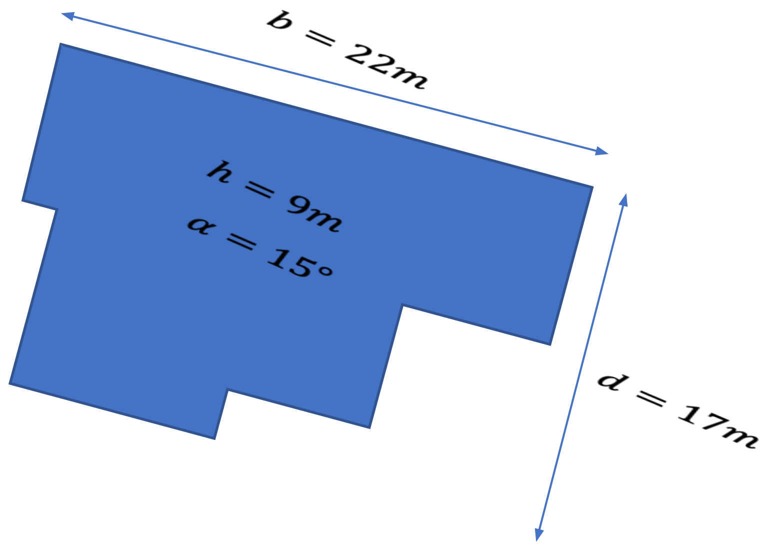
Example #1 – Omni-Directional Simple





- 1-story rectangular house
- “Front” oriented 10° (= NNE)
- Openings ratio = 0.5, largest on front
- 21 Ercildoune Street, Caulfield North, VIC 3161
    - Melbourne SE
    - Flat terrain, surrounded by numerous houses

Example #2 – Directional Complex Site



- 2-story polygonal-shaped house
- “Front” oriented 15° (= NNE)
- Openings ratio = 2.0, largest on front
- 63 Ellsworth Drive, Mount Louisa, QLD 4814
    - Townsville
    - Immediately south of Mount Louisa (185m)
    - 2-story houses North, East, South
    - Open terrain to West

Questions?

ClearCalcs

THANK YOU!

- We will send you a recording of the webinar by email.

- There will be a survey at the end of this webinar, we would appreciate your feedback on how we can improve.

- If you have further questions, send an email to help@clearcalcs.com or use the Help button in ClearCalcs

- Stay tuned for Revolutionising Access To Construction Standards webinar tomorrow!

Appendix

About ClearCalcs

ClearCalcs

Happy Engineers Using ClearCalcs

ClearCalcs has been used in 2,000,000+ designs by a growing number of engineers across the globe, with the US becoming our largest customer base in 2021.

FES Foundation Engineering Specialists LLC

"You are light years ahead of the competition on features and ongoing growth."

Don C.
Foundation Engineering Specialists, LLC

CRITERIUM ENGINEERS

"Why didn't you just use ClearCalcs for that?"

Helen W. via Landon R.
Criterium Engineers

J MICHAEL ENGINEERING, LLC
Engineering & Construction Services

"The program basically does the work for you...Wow, I can finally throw away the last of my spreadsheets!"

Jason M.
J. Michael Engineering, PLLC

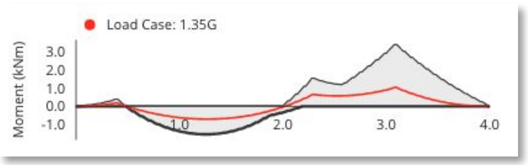
GREEN WORKS · Geo Structures a TERRATEST Company · INDEPENDENT AGENCY INSPECTION MONITORING · SPANN & ASSOCIATES Consulting Engineers · Intrax · BINSKY · hrcd · evolve DESIGN WORKS

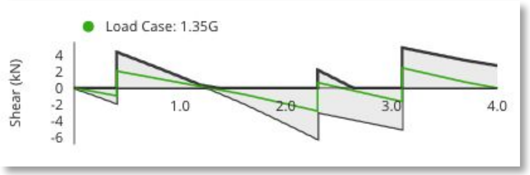
The ClearCalcs Team

A growing team of passionate engineers, programmers, customer success specialists, product managers, marketers, and more!

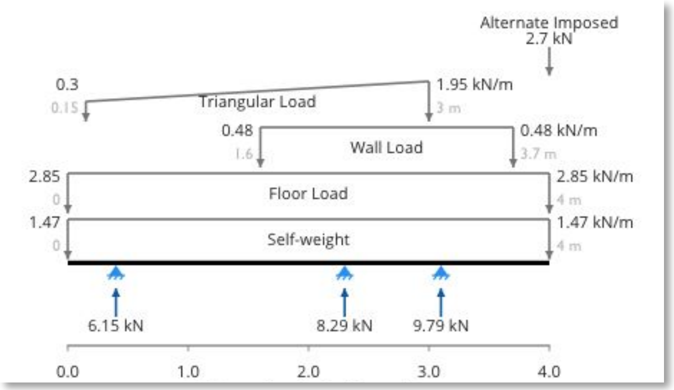
What Sets Our Calculations Apart

- **Live solutions**
  - *Instantly see how every change you make affects the design, in all load cases*

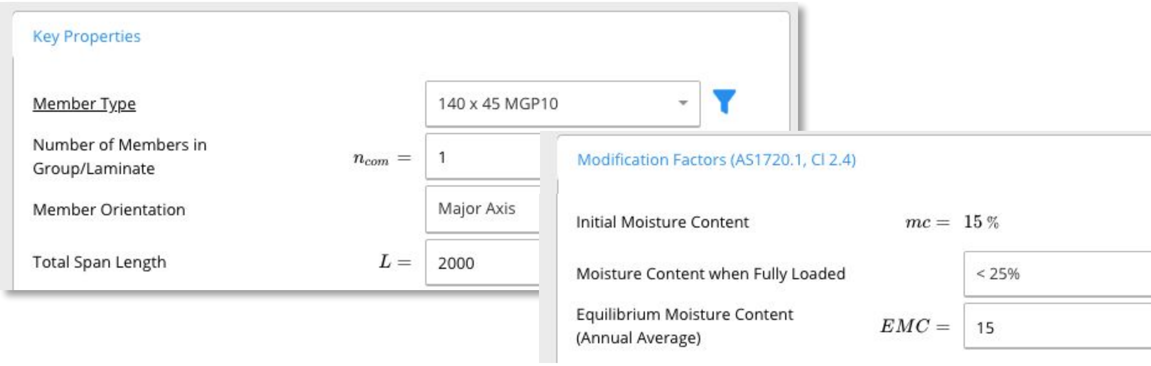




- **Finite Element Analysis**
  - *Get the most accurate results no matter what your configuration*



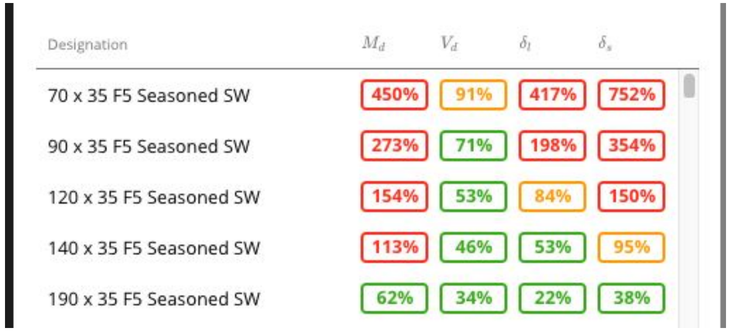
- **As simple or complex as you want**
  - *Safely enter in only a few properties, or tune every parameter – it's up to you*



What Sets Our Design Process Apart

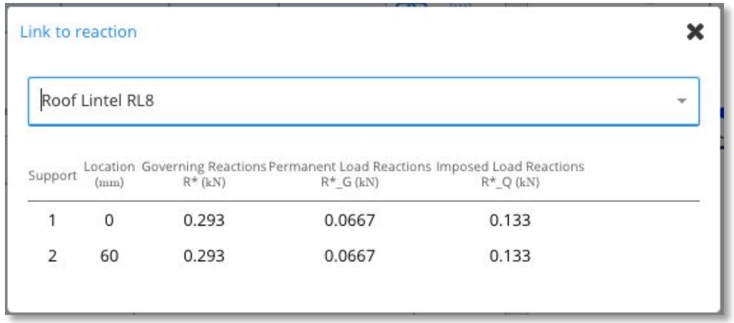
ClearCalcs

- **Member selector**
  - *Check every possible member in seconds*



Designation	M_d	V_d	δ_l	δ_s
70 x 35 F5 Seasoned SW	450%	91%	417%	752%
90 x 35 F5 Seasoned SW	273%	71%	198%	354%
120 x 35 F5 Seasoned SW	154%	53%	84%	150%
140 x 35 F5 Seasoned SW	113%	46%	53%	95%
190 x 35 F5 Seasoned SW	62%	34%	22%	38%

- **Link your loads**
  - *No need to manually copy reactions into the next sheet – just create a link*

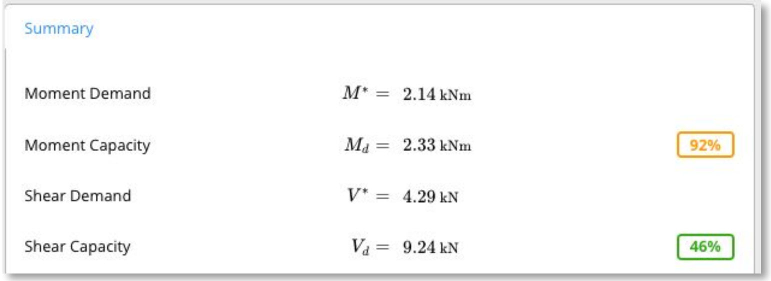


Link to reaction

Roof Lintel RL8

Support	Location (mm)	Governing Reactions R* (kN)	Permanent Load Reactions R*_G (kN)	Imposed Load Reactions R*_Q (kN)
1	0	0.293	0.0667	0.133
2	60	0.293	0.0667	0.133

- **Simple traffic light indicators**
  - *See at a glance how close your design is to perfection*

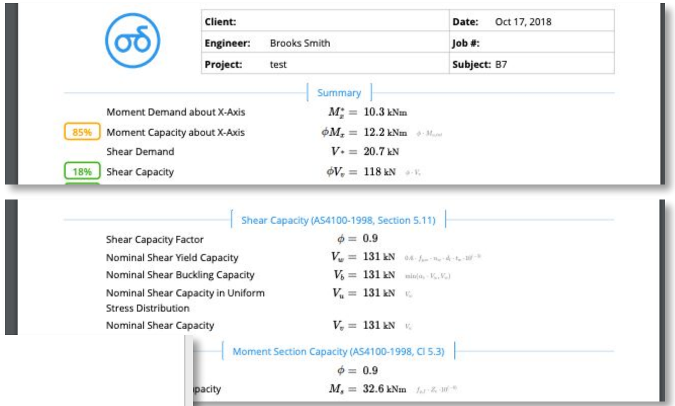


Summary

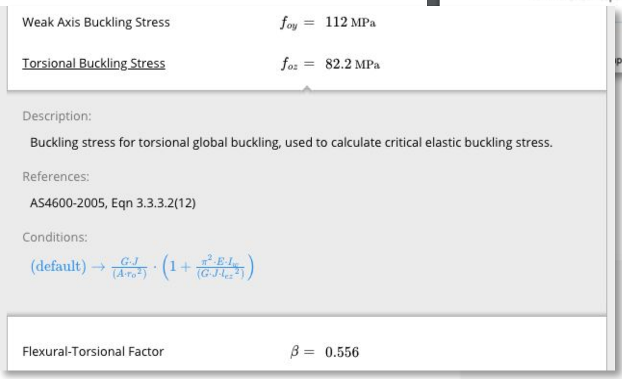
Moment Demand	$M^* = 2.14$ kNm	
Moment Capacity	$M_d = 2.33$ kNm	92%
Shear Demand	$V^* = 4.29$ kN	
Shear Capacity	$V_d = 9.24$ kN	46%

What Sets Our Platform Apart

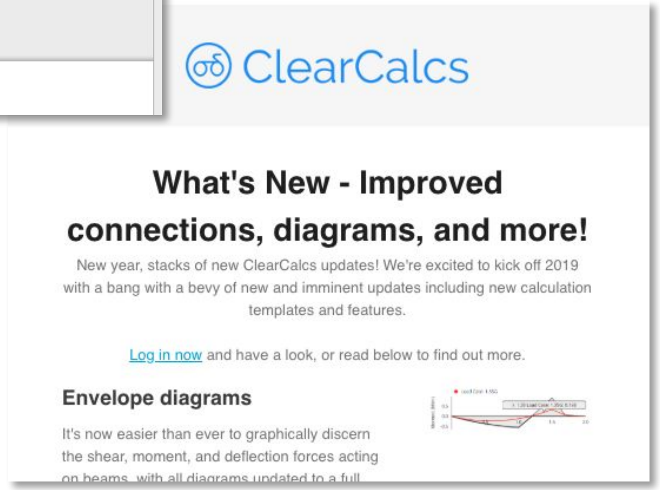
- **Clean, clear printouts**
  - *Beautiful results your clients can understand*



- **See full detail for every field**
  - *References, equations, and more*



- **Rapid product updates**
  - *Receive new features and calculations within days, not years*



ClearCalcs

Key Advantages

ClearCalcs is designed for the modern efficiency focused engineering practice

More accurate results.

Get far better quality and efficiency than spreadsheets with highly accurate FEM calculations and dynamic load path tracking between members.

Easy to understand.

Work faster and impress clients and checkers with professional, easy to understand calculations and quick export to PDF.

Never lose work again.

ClearCalcs was built in the cloud. That means we automatically save your work as you type and keep it securely backed up on our servers.

Help when you need it.

Need help? Our customer support is built right in to the platform. With a single click you can talk to one of our talented engineers.

Save time.

Our wide range of templates and easy linking, duplication, and export are all designed to help automate creation of repetitive calculations.

Always have access.

Shared licenses and lock-outs are a thing of the past! Our simple pricing model makes it easy to give everyone access to ClearCalcs when they need it.

Easy collaboration.

No more USBs or sending files over email! Everything is shared inside ClearCalcs so you can easily collaborate on projects.

Upgrades are always free.

We added over 250 updates to ClearCalcs last year. All of our users had them as soon as they were released, and we didn't charge them a cent extra.

Mobile. Tablet. Desktop.

ClearCalcs was designed to work on any modern device. Nothing to download or install, all you need is a web browser.