

AS/NZS 1170.2:2021
(Incorporating Amendment No. 1)



Australian/New Zealand Standard™

Structural design actions

Part 2: Wind actions



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AS/NZS 1170.2:2021

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- Concrete Masonry Association of Australia
- Engineers Australia
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- Steel Reinforcement Institute of Australia
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Australian/New Zealand Standard™

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Part 2: Wind actions

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Preface

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee, BD-006, General Design Requirements and Loading on Structures, to supersede AS/NZS 1170.2:2011.

[A1] This Standard incorporates Amendment No. 1 (May 2023). The start and end of changes introduced by the Amendment are indicated in the text by tags including the Amendment number 1. **[A1]**

The objective of this Standard is to provide wind actions for use in the design of structures subject to wind action. It provides a detailed procedure for the determination of wind actions on structures, varying from those less sensitive to wind action to those for which dynamic response are to be taken into consideration.

The objectives of this revision are to remove ambiguities, and to incorporate recent research and experiences from recent severe wind events in Australia and New Zealand.

This Standard is Part 2 of the *Structural design actions* series, which comprises the following parts:

AS/NZS 1170.0, *Structural design actions, Part 0: General principles*

AS/NZS 1170.1, *Structural design actions, Part 1: Permanent, imposed and other actions*

AS/NZS 1170.2, *Structural design actions, Part 2: Wind actions*

AS/NZS 1170.3, *Structural design actions, Part 3: Snow and ice actions*

AS 1170.4, *Structural design actions, Part 4: Earthquake actions in Australia*

NZS 1170.5, *Structural design actions, Part 5: Earthquake actions — New Zealand*

The wind speeds provided are based on analysis of existing data. The major changes in this edition are as follows:

- (a) Definitions and notation have been moved to [Clauses 1.4](#) and [1.5](#) respectively and new definitions and notation added. Appendices C to G have been re-labelled as [Appendices A](#) to [E](#).
- (b) Structures covered by and excluded from this Standard have been clarified in [Clause 1.1](#).
- (c) The aerodynamic shape factor is now denoted as C_{shp} (in previous editions it was C_{fig}).
- (d) A climate change multiplier (M_c) has been included ([Equation 2.2](#) and [Clause 3.4](#)), with a current value of 1.05 for cyclonic regions. The uncertainty factors F_C and F_D for cyclonic regions have been removed.
- (e) The ground level datum for buildings on sloping or excavated sites has been clarified. Average roof height for buildings with two or more roofs has been clarified.
- (f) Windborne debris test speeds when the impacted surface is not vertical or horizontal have been provided ([Clause 2.5.8](#)).
- (g) New regional boundaries for Australia and New Zealand have been defined with new Regions A0, B1, B2, NZ1, NZ2, NZ3, and NZ4 [[Figures 3.1\(A\)](#) and [3.1\(B\)](#)].
- (h) Interpolation between boundaries, according to distance from the coastline, is allowed in Regions C and D [[Table 3.1\(A\)](#)]. Regional wind speeds for New Zealand have been revised [[Table 3.1\(B\)](#)].
- (i) Wind direction multipliers (M_d) have been revised for all regions in Australia and New Zealand. The wind direction multiplier (M_d) has been set to 1.0 for circular or polygonal chimneys, tanks and poles.

- (j) Terrain Category 1.5 has been removed. Terrain Category 1 has been re-defined to include all over-water surfaces. The description of Terrain Category 2.5 has been revised ([Clause 4.2](#)).
- (k) Terrain-height multipliers ($M_{z,cat}$), and turbulence intensities, for Terrain Category 1 have been reduced to reflect observed values of gust factors and turbulence intensities for over-water winds.
- (l) Terrain-height multipliers for Region A0 have been revised to reflect measured wind gust profiles measured in convective downdrafts.
- (m) The shielding multiplier (M_s) has been set to 1.0 for buildings greater than 25 m in height, and for buildings on steep slopes.
- (n) The topographic multiplier (M_t) has been reduced in Region A0.
- (o) New lee effect multipliers and zones have been defined for New Zealand.
- (p) A new clause ([Clause 5.3.4](#)) has been added for an open area/volume factor. This allows some reduction in peak internal pressure for buildings with large internal volumes, and small opening areas.
- (q) Values of area reduction factor (K_a) have been included for windward and leeward walls ([Clause 5.4.2](#)).
- (r) The reference area a for local pressure factors has been changed for roofs of large low-rise buildings. A new local pressure case (RC2) has been introduced for the windward end of high-pitched gable roofs ([Clause 5.4.4](#)).
- (s) Further clarification of the applicability of [Section 6](#) has been given in [A1](#) [Clauses 6.1](#) to [6.3](#) [A1](#). Highly dynamically wind-sensitive structures are excluded.
- (t) New methods are provided for the dynamic response factor for the along-wind response of poles or masts with headframes, and for long span horizontal structures.
- (u) The equations for the crosswind force spectrum coefficient (C_{fs}) for tall buildings with rectangular cross-sections have been revised [A1](#) ([Clause 6.5.2.3](#)) [A1](#). A new more accurate method for the crosswind response of chimneys, poles and masts of circular cross-section has been introduced [A1](#) ([Clause 6.5.3](#)) [A1](#).
- (v) A new method for the combination of along-wind and crosswind base moments has been introduced [A1](#) ([Clause 6.6.1](#)) [A1](#).
- (w) Some alternate values of external pressure coefficient ($C_{p,e}$) for saw-tooth roofed buildings have been included ([Clause A.2](#)).
- (x) The external pressure coefficients for curved roofs have been revised ([Table A.3](#)).
- (y) New net pressure coefficients ($C_{p,n}$) have been provided for conical canopies ([Clause B.3.3](#)), and for arrays of inclined ground-mounted solar panels.
- (z) New Notes have been added in [Appendix C](#) for determination of wind loads on complex, porous industrial plants, and warnings regarding crosswind response of rectangular sections.
- (aa) New informative Clauses have been added to [Appendix E](#) for rotational velocities ([Clause E.4](#)), peak torsional accelerations ([Clause E.5](#)) and combined peak accelerations ([Clause E.6](#)).

The design wind actions prescribed in this Standard are the minimum for the general cases described. The Joint Committee has considered exhaustive research and testing information from Australian, New Zealand and overseas sources in the preparation of this Standard.

The terms “normative” and “informative” are used in Standards to define the application of the appendices to which they apply. A “normative” appendix is an integral part of a Standard, whereas an “informative” appendix is only for information and guidance.

Notes to the text contain information and guidance and are not considered to be an integral part of the Standard.

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Australian/New Zealand Standard

Structural design actions

Part 2: Wind actions

Section 1 Scope and general

1.1 Scope

This Standard sets out procedures for determining wind speeds and resulting wind actions to be used in the structural design of structures subjected to wind actions other than those caused by tornadoes.

The Standard covers structures within the following criteria:

- (a) Buildings and towers less than or equal to 200 m high.
- (b) Structures with unsupported roof spans of less than 100 m.
- (c) Offshore structures within 30 km from the nearest coastline.
- (d) Other structures apart from: offshore structures more than 30 km from the nearest coastline, bridges, windfarm structures and power transmission and distribution structures, including supporting towers and poles.

NOTE 1 This Standard is a stand-alone document for structures within the above criteria. It may be used, in general, for all structures but other information may be necessary.

NOTE 2 If a tall building has a natural frequency less than 1 Hz, [Section 6](#) requires dynamic analysis to be carried out. For other structures, such as lighting poles, dynamic analysis may be required even if the first-mode frequency exceeds 1 Hz (see limits in [Clause 6.3](#)).

NOTE 3 For structures excluded by (a) and (b), specialist techniques, including wind-tunnel testing, are required. Further advice, which may include wind-tunnel testing, also should be sought for roofs with unusual geometries or support systems, or the roofs of podiums at the base of tall buildings.

NOTE 4 For structures excluded by (d), wind loads are specified by other Australian or New Zealand Standards (bridges and power transmission and distribution structures), or by international standards (structures more than 30 km offshore, and windfarm structures). These may draw on this Standard for some aspects of wind load determination.

NOTE 5 Structures on any island territory of Australia and New Zealand, and offshore structures within 30 km of the shoreline of any of those territories, are covered by this Standard.

NOTE 6 In this document, the words “this Standard” indicates AS/NZS 1170.2, which is Part 2 of the AS/NZS 1170 series (see Preface).

1.2 Application

This Standard shall be read in conjunction with AS/NZS 1170.0.

This Standard may be used as a means for demonstrating conformance with the requirements of Part B1 of the National Construction Code (Australia).

NOTE Use of methods or information not given in this Standard should be justified by a special study (refer to AS/NZS 1170.0, Appendix A).

1.3 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this Standard.

NOTE Documents referenced for informative purposes are listed in the Bibliography.

AS 4040.3, *Methods of testing sheet roof and wall cladding, Method 3: Resistance to wind pressures for cyclone regions*

AS/NZS 1170.0, *Structural design actions, Part 0: General principles*

Australian Building Codes Board. National Construction Code (NCC)

1.4 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

1.4.1

aerodynamic shape factor

factor to account for the effects of the geometry of the structure on surface pressure due to wind

1.4.2

aspect ratio

ratio of the average roof height of a building to the smallest horizontal dimension, or the ratio of the largest dimension of a structural member to its crosswind breadth

1.4.3

average recurrence interval

average interval (R) between exceedances of a given wind speed, usually measured in years

Note 1 to entry: For values of R greater than 5 years, this is equal to the reciprocal of the annual probability of exceedance.

1.4.4

awning

roof-like structure, usually of limited extent, projecting from a wall of a building

1.4.5

canopy

roof adjacent to or attached to a building, generally not enclosed by walls

1.4.6

cladding

material that forms the external surface over the framing of a building or structure

1.4.7

design wind speed

wind speed for use in design, adjusted for average recurrence interval, wind direction, geographic position, surrounding environment and height

1.4.8

discharge coefficient

for a ventilator, a non-dimensional quantity relating the rate of airflow through the ventilator to the pressure drop across it

Note 1 to entry: Values for particular ventilators can be obtained from tests carried out by manufacturers or suppliers.

1.4.9**downdraft**

vertical air motion originating in a thunderstorm, resulting in severe horizontal winds at ground level

Note 1 to entry: Strong winds of this type are the dominant extreme wind event in inland Australia (Region A0) and may also occur in some coastal regions.

1.4.10**drag**

force acting in the direction of the wind stream

Note 1 to entry: See also *lift* ([1.4.31](#)).

1.4.11**dynamic response factor**

factor to account for the effects of fluctuating forces and resonant response on wind-sensitive structures

1.4.12**eccentricity**

distance from the centroid of a surface, to the point of application of the resultant force derived from the net wind pressure

1.4.13**effective surface**

wall, roof or internal surface of a building that contributes significantly to load effects on major structural elements

1.4.14**elevated building**

building with a clear, unwallled space underneath the first floor, level with a height from ground to underside of the first floor of one-third or more of the total height of the building

1.4.15**enclosed building**

building that has a roof and full perimeter walls (nominally sealed) from floor to roof level

1.4.16**escarpment**

two-dimensional, steeply sloping face between nominally level lower and upper plains, where the plains have average slopes of not greater than 5 %

1.4.17**first mode shape**

deflected shape of a structure at its maximum amplitude under first mode natural vibration

1.4.18**first mode natural frequency**

frequency of free oscillation corresponding to the lowest harmonic of vibration of a structure

1.4.19**force coefficient**

coefficient that, when multiplied by the incident wind pressure and a reference area, gives the force in a specific direction

1.4.20**free roof**

roof (of any type) with no enclosing walls underneath

Note 1 to entry: For example, a freestanding carport.

1.4.21**freestanding walls**

walls that are exposed to the wind on both sides, with no roof attached

Note 1 to entry: Includes fences.

1.4.22**frictional drag**

wind force per unit area acting in a direction parallel to the surface in question

1.4.23**gable roof**

ridged roof with two sloping surfaces and vertical triangular end walls

1.4.24**hill**

isolated three-dimensional topographic feature standing above the surrounding plains having slopes < 5 %

1.4.25**hip roof**

roof with four sloping (pitched) surfaces, pyramidal in shape, and with level eaves all round

Note 1 to entry: A hip roof on a rectangular plan has two triangular sloping roofs at the short sides (hip ends) and two trapezoidal sloping roofs at the long sides.

1.4.26**hoardings**

freestanding (rectangular) signboards, and the like, supported clear of the ground

1.4.27**immediate supports**

supporting members to which cladding is directly fixed

Note 1 to entry: Examples include battens, purlins, girts and studs.

1.4.28**lag distance**

horizontal distance downwind, required for the effects of a change in terrain roughness on wind speed to reach the height being investigated

1.4.29**large opening**

opening greater than 0.5 % of the area in the external surface of an enclosed building, which directly influences the average internal pressure

1.4.30**lattice towers**

three-dimensional frameworks comprising three or more linear boundary members interconnected by linear bracing members joined at common points (nodes), enclosing an open area through which the wind may pass

1.4.31**lift**

force acting at 90° to the wind stream

Note 1 to entry: See also *drag* ([1.4.10](#)).

1.4.32**mansard roof**

roof with two slopes on all four sides, the lower slope steeper than the upper slope

Note 1 to entry: A mansard roof with the upper slopes less than 10° may be assumed to be flat topped.

1.4.33**monoslope roof**

planar roof with a constant slope and without a ridge

Note 1 to entry: See also *skillion roof* ([1.4.46](#)).

1.4.34**obstructions**

natural or man-made objects that generate turbulent wind flow, ranging from single trees to forests and from isolated small structures to closely spaced multi-storey buildings

1.4.35**offshore structures**

fixed or floating platforms, jetties, towers or poles

Note 1 to entry: This Standard only applies to offshore structures within 30 km from the nearest coastline of Australian or New Zealand territory.

1.4.36**permeable**

surface with an aggregation of small openings, cracks, and the like, which allows air to pass through under the action of a pressure differential

1.4.37**pitched roof**

bi-fold, bi-planar roof (two sloping surfaces) meeting at a ridge

1.4.38**pressure**

air pressure referenced to ambient air pressure

Note 1 to entry: In this Standard, negative values are less than ambient (suction), positive values exceed ambient. Net pressures act normal to a surface in the direction specified.

1.4.39**pressure coefficient**

ratio of the pressure acting at the point on a surface, to the free-stream dynamic pressure of the incident wind

1.4.40**rectangular building**

building generally made up of rectangular shapes in plan

Note 1 to entry: See [Section 5](#) for calculation of the aerodynamic shape factor for rectangular buildings.

1.4.41**Reynolds number**

Re

ratio of the inertial forces to the viscous forces in the airflow

1.4.42**ridge (topographic feature)**

two-dimensional crest or chain of hills with sloping faces on either side of the crest

1.4.43**roughness length**

theoretical quantification of the turbulence-inducing nature of a particular type of terrain on airflow (wind)

1.4.44**Scruton number****Sc**

mass-damping parameter

1.4.45**shelter room**

space designated to provide shelter to one or more persons

1.4.46**skillion roof**

roof on a building with a single roof slope that has a high edge at one side of the building and a low edge at the opposite side

Note 1 to entry: See also *monoslope roof* ([1.4.33](#)).

1.4.47**solidity (of cladding)**

ratio of the solid area to the total area of the surface

1.4.48**structural elements, major**

structural elements with tributary areas that are greater than 10 m²

1.4.49**structural elements, minor**

structural elements with tributary areas that are less than or equal to 10 m²

1.4.50**terrain**

surface roughness condition when considering the size and arrangement of obstructions to the wind

1.4.51**topography**

major land surface features, comprising hills, valleys and plains, that strongly influence wind flow patterns

1.4.52**tornado**

violently rotating column of air, that is suspended, observable as a funnel cloud attached to the cloud base of a convective cloud

1.4.53**tributary area**

area of building surface contributing to the force being considered

1.4.54**tropical cyclone**

non-frontal warm-cored low-pressure weather system of synoptic scale that develops over warm waters and has deep organised convection and gale force mean winds or greater extending more than half-way around near the centre and persisting for at least 6 hours

[SOURCE: Bureau of Meteorology]

Note 1 to entry: Wind, rain, wave and storm surge impacts can extend hundreds of kilometres from the centre depending on the storm intensity and scale.

Note 2 to entry: Refer to the Commonwealth of Australia Bureau of Meteorology for further information.

Note 3 to entry: Winds circulate in a clockwise direction in the southern hemisphere

1.4.55

troughed roof

bi-fold, bi-planar roof with a valley at its lowest point

1.4.56

turbulence intensity

ratio of the standard deviation of the fluctuating component of wind speed to the mean (time averaged) wind speed

1.5 Notation

Unless stated otherwise, the notation used in this Standard has the following meaning with respect to the structure, member or condition to which the Clause applies.

NOTE See [Clause 1.7](#) for units.

A	=	surface area of the element or the tributary area that transmits wind forces to the element, being—
	=	area upon which the pressure acts, which may not always be normal to the wind stream when used in conjunction with the pressure coefficient (C_p);
	=	projected area normal to the wind stream when used in conjunction with a drag force coefficient (C_d); or
	=	areas as defined in applicable clauses (see Appendix C) when used in conjunction with a force coefficient ($C_{F,x}$) or ($C_{F,y}$)
A_a	=	reference area of ancillaries on a tower
a_L	=	constant for determination of the response to vortex shedding of structures with circular cross section (Clause 6.5.3.1)
A_{ref}	=	reference area of flag
$A_{z,s}$	=	total projected area of the tower section at height z
A_z	=	reference area, at height (z), upon which the pressure (p_z) at that height acts
a	=	dimension used in defining the extent of application of local pressure factors
	=	exponential decay factor
B'	=	background factor for horizontal slender structures
B_s	=	background factor, which is a measure of the slowly varying background component of the fluctuating response, caused by low-frequency wind speed variations
b	=	breadth of a structure or element, usually normal to the wind stream; or
	=	average diameter of a circular section
b_D	=	diagonal breadth of UHF antennas
b_{eff}	=	effective breadth of a headframe

b_i	=	average diameter or breadth of a section of a tower member
b_N	=	normal breadth of UHF antennas
b_{0h}	=	average breadth of the structure between heights 0 and h
b_s	=	average breadth of shielding buildings, normal to the wind stream
b_{sh}	=	average breadth of the structure between heights s and h
b_t	=	average breadth of the top third of the structure
b_z	=	average breadth of the structure at the section at height (z)
b/w	=	ratio of the average diameter of an ancillary to the average width of a structure
C_c	=	aerodynamic excitation parameter $\boxed{A_1}$ (Clause 6.5.3.1) $\langle A_1 \rangle$
C_d	=	drag force coefficient for a structure or member in the direction of the wind stream
C_{da}	=	value of drag force coefficient (C_d) on an isolated ancillary on a tower
C_{de}	=	effective drag force coefficient for a tower section with ancillaries
C_{dyn}	=	dynamic response factor
$C_{F,x}$	=	force coefficient for a structure or member, in the direction of the x-axis
$C_{F,y}$	=	force coefficient for a structure or member, in the direction of the y-axis
C_f	=	frictional drag force coefficient
C_{fs}	=	crosswind force spectrum coefficient generalized for a linear mode shape
$C_{p,b}$	=	external pressure coefficient for sides of bins, silos and tanks
$C_{p,e}$	=	external pressure coefficient
$C_{p,i}$	=	internal pressure coefficient
$C_{p,l}$	=	net pressure coefficient for the leeward half of a free roof
$C_{p,n}$	=	net pressure coefficient acting normal to the surface for canopies, freestanding roofs, walls and the like
$C_{p,w}$	=	net pressure coefficient for the windward half of a free roof
$C_{p1}(\theta_b)$	=	external pressure coefficient on walls of bins, silos or tanks of unit aspect ratio ($c/b = 1$) as a function of θ_b
C_{shp}	=	aerodynamic shape factor
$C_{shp,1}$	=	aerodynamic shape factor for the first frame in the upwind direction
c	=	exponential decay parameter (Clause C.4.2.3)
	=	net height of a hoarding, flag, bin, silo or tank (not including roof or lid height); or
	=	height between the highest and lowest points on a hyperbolic paraboloid roof
c_1, c_2	=	parameters for crosswind response calculation $\boxed{A_1}$ (Clause 6.5.3.1) $\langle A_1 \rangle$

D	=	downwind roof slope
d	=	depth or distance parallel to the wind stream to which the plan or cross-section of a structure or shape extends (e.g. the outside diameter); or
	=	length of span of curved roof
d_a	=	along-wind depth of a porous wall or roof surface
d_s	=	length of span of the first pitched roof in a multi-span building
E	=	site elevation above mean sea level
E_t	=	spectrum of turbulence in the approaching wind stream
e	=	the base of Napierian logarithms (approximately 2.71828)
e	=	horizontal eccentricity of net pressure (Clause B.2.1)
F	=	force on a building element, in newtons
F_{res}	=	resonant component of the along-wind force (Appendix E)
f	=	frictional force per unit area parallel to a surface, in newtons per square metre
f_z	=	the design frictional-distributed force parallel to the surface, calculated in Clause 2.4.2 at height z , in newtons per square metre
g_R	=	peak factor for resonant response (10 min period)
g_c	=	peak factor cross-wind response of chimneys, masts and poles
g_v	=	peak factor for upwind velocity fluctuations
H	=	height of the hill, ridge or escarpment
H_s	=	height factor for the resonant response
h	=	average roof height of structure above ground
h_1, h_2	=	component heights of a conical canopy
h_c	=	height from ground to the attached canopy, freestanding roof, wall or the like
h_{eff}	=	effective height of a headframe
h_p	=	height of parapet above average roof level
h_r	=	average height of surface roughness
h_s	=	average roof height of shielding buildings
I_h	=	turbulence intensity, obtained from Table 6.1 by setting z equal to h
I_z	=	turbulence intensity at height z given for various terrain categories in Table 6.1
K	=	factor for maximum tip deflection
K_a	=	area reduction factor (Clause 5.4.2); or
	=	aerodynamic damping parameter $\overline{A_1}$ (Clause 6.5.3.1) $\overline{A_1}$

K_{ar}	=	aspect ratio correction factor for individual member forces
K_b	=	factor for breadth/span of curved roofs (Clause A.3)
K_c	=	combination factor
$K_{c,e}$	=	combination factor for external pressures
$K_{c,i}$	=	combination factor for internal pressures
K_i	=	factor to account for the angle of inclination of the axis of members to the wind direction
K_{in}	=	correction factor for interference
K_ℓ	=	local pressure factor
K_m	=	mode shape correction factor for crosswind acceleration
K_p	=	net porosity factor, used for free walls; or
	=	porous cladding reductive factor, used for cladding on buildings
K_r	=	parapet reduction factor
K_{sh}	=	shielding factor for shielded frames in multiple open-framed structures
K_v	=	open area and volume factor for internal pressures
$\boxed{A_1} K_\theta$	=	torsional stiffness (Clause E.4) $\boxed{A_1}$
k	=	mode shape power exponent
k_b	=	factor for a circular bin
L_h	=	measure of integral turbulence length scale at height h
L_u	=	horizontal distance upwind from the crest of the hill, ridge or escarpment to a level half the height below the crest
L_1	=	length scale, in metres, to determine the vertical variation of M_h , to be taken as the greater of $0.36 L_u$ or $0.4 H$
L_2	=	length scale, in metres, to determine the horizontal variation of M_h , to be taken as $4 L_1$ upwind for all types, and downwind for hills and ridges, or $10 L_1$ downwind for escarpments
L	=	leeward wall; or
	=	life of structure
l	=	length of member
l_f	=	flag length
l_s	=	average spacing of shielding buildings
ℓ	=	upwind segment of the roofs of circular, bins, silos and tanks
M_c	=	climate change multiplier (see Clause 3.4); or

	=	crosswind base overturning moment
M_d	=	wind direction multiplier (see Clause 3.3)
M_h	=	hill shape multiplier
M_{lee}	=	lee (effect) multiplier (taken as 1.0, except in New Zealand lee zones, see Clause 4.4.3)
M_{res}	=	resonant component of the along-wind base moment (Appendix E)
M_s	=	shielding multiplier
M_t	=	topographic multiplier
$M_{z,cat}$	=	terrain/height multiplier
m_0	=	average mass per unit height
m_f	=	mass per unit area of flag
m_t	=	average mass per unit height over the top third of the structure
$m(z)$	=	mass per unit height as a function of height z
N	=	reduced frequency (non-dimensional)
N_g	=	number of stress exceedances
n	=	number of spans of a multi-span roof
n_1	=	first mode natural frequency of vibration of a structure, in hertz
n_a	=	first mode natural frequency of vibration of a structure in the along-wind direction, in hertz
n_c	=	first mode natural frequency of vibration of a structure in the crosswind direction, in hertz
n_s	=	number of upwind shielding buildings within a 45° sector of radius $20h$ and with $h_s \geq h$
n_θ	=	natural frequency of twisting (torsional) mode of a tall building (Appendix E)
p	=	design wind pressure acting normal to a surface, in pascals
	=	p_e , p_i or p_n where the sign is given by the C_p values used to evaluate C_{shp}
		NOTE: Pressures are taken as positive, indicating pressures above ambient and negative, indicating pressures below ambient.
p_e	=	external wind pressure
p_i	=	internal wind pressure
p_n	=	net wind pressure
p_z	=	design wind pressure, in pascals (normal to the surface), at height z , calculated in Clause 2.4.1

NOTE: The sign convention for pressures leads to forces towards the surface for positive pressures and forces away from the surface for negative pressures.

R	=	average recurrence interval of the wind speed in years (Clause 3.2); or
	=	furthest point from the centre of rigidity (Appendix E)
R	=	crosswind roof slope
	=	distance from the initiating crest to the leeward edge of the shadow zone (Clause 4.4.3)
Re	=	Reynolds number
r	=	rise of a curved roof;
	=	corner radius of a structural shape; or
	=	aspect ratio of a building (Clause 5.4.4)
	=	radius of a conical canopy
S	=	size reduction factor for tall buildings and free-standing towers
S'	=	effective size reduction factor for towers, poles and masts with headframes
S''	=	size reduction factor for horizontal slender structures
S	=	side wall
Sc	=	Scruton number
St	=	Strouhal number — non-dimensional vortex shedding frequency
s	=	shielding parameter;
	=	height of the level at which action effects are calculated for a structure; or
	=	distance between the underside of a solar panel and the roof surface
	=	equivalent frame spacing
T	=	top roof section
U	=	upwind roof slope
$V_{des,\theta}$	=	building orthogonal design wind speeds (usually, $\theta = 0^\circ, 90^\circ, 180^\circ$ and 270°), as given in Clause 2.3
		NOTE: $V_{des,\theta}$ may be expressed as a function of height z , for some applications, e.g. windward walls of tall buildings (>25 m).
$V_{des,\theta}(z)$	=	building orthogonal design wind speeds as a function of height z
V_n	=	reduced velocity (non-dimensional)
V_R	=	regional gust wind speed, in metres per second, for annual probability of exceedance of $1/R$
$V_{sit,\beta}$	=	wind speeds for a site, varying according to compass direction
W	=	wind actions (refer to AS/NZS 1170.0)
W	=	windward wall

W_s	=	wind actions for serviceability limit states (determined using a regional wind speed appropriate to the annual probability of exceedance for serviceability limit states)
W_u	=	wind actions for ultimate limit states (determined using a regional wind speed appropriate to the annual probability of exceedance specified for ultimate limit states)
w	=	width of a tower; or
	=	shortest horizontal dimension of the building
w_c	=	width of canopy, awning carport, or similar, from the face of the building
$w_{eq}(z)$	=	equivalent static wind force per unit height as a function of height z
x	=	distance from the windward edge of a canopy or cantilevered roof;
	=	distance from initiating crest (NZ lee zones — Clause 4.4.3); or
	=	horizontal distance upwind or downwind of the structure to the crest of the hill, ridge or escarpment
x_i	=	distance downwind from the start of a new terrain roughness to the position where the developed height of the inner layer equals z (lag distance)
$\ddot{x}_{max}$	=	peak acceleration, at the top of a structure in the along-wind direction
$\ddot{y}_{max}$	=	peak acceleration, at the top of a structure in the crosswind direction
y_{max}	=	maximum amplitude of tip deflection in crosswind vibration at the critical wind speed
z	=	reference height on the structure above the average local ground level, or rotational displacement (Appendix E)
z_0	=	aerodynamic roughness length
α	=	angle of slope of a roof
β	=	angle of compass wind direction, measured clockwise from North (0°), for determining site wind velocities
ΔC_d	=	additional drag coefficient due to an ancillary attached to one face or located inside the tower section
Δz	=	height of the section of the structure upon which the wind pressure acts
δ	=	solidity ratio of the structure (surface or open frame) which is the ratio of solid area to total area of the structure
δ_e	=	effective solidity ratio for an open frame
$\varepsilon_{a,m}$	=	action effect derived from the mean along-wind response
$\varepsilon_{a,p}$	=	action effect derived from the peak along-wind response
$\varepsilon_{c,p}$	=	action effect derived from the peak crosswind response
ε_t	=	combined peak scalar dynamic action effect

ζ	=	ratio of structural damping to critical damping of a structure
σ	=	stress level
$\hat{\sigma}_{a(x,y,z)}$	=	combined peak acceleration (see Appendix E)
σ_a	=	standard deviation of acceleration (Appendix E)
$\sigma_{\max}$	=	maximum stress
θ	=	angle of upwind direction to the orthogonal axes of a structure, in degrees; or
	=	rotational displacement (Appendix E)
$\dot{\theta}$	=	rotational velocity (Appendix E)
θ_a	=	angle of deviation of the wind stream from the line joining the centre of the tower cross-section to the centre of the ancillary, in degrees
θ_b	=	angle from the wind direction to a point on the wall of a circular bin, silo or tank, in degrees
θ_m	=	angle between the wind direction and the longitudinal axis of the member, in degrees
λ	=	spacing ratio for parallel open frames, equal to the frame spacing (centre-to-centre) divided by the projected frame width normal to the wind direction
π	=	the ratio of the circumference of any circle to its diameter (approx. 3.14159)
ρ	=	ratio of the highest component of peak acceleration to the second highest
ρ_{air}	=	density of air, which shall be taken as 1.2 kg/m ³
NOTE: This value is based on 20 °C and typical ground level atmospheric pressure and variation may be necessary for very high altitudes or cold environments.		
$\phi_1(z)$	=	first mode shape as a function of height z , normalized to unity at $z = h$

1.6 Determination of wind actions

Values of wind actions (W) for use in design shall be established. The values shall be appropriate for the type of structure or structural element, its intended use, design working life and exposure to wind action.

The following wind actions, determined in accordance with this Standard (using the procedures detailed in [Section 2](#) and the values given in the remaining Sections) are deemed to conform to the requirements of this Clause:

- (a) W_u determined using a regional wind speed appropriate to the annual probability of exceedance (P) specified for ultimate limit states as given in AS/NZS 1170.0, or the National Construction Code (Australia).
- (b) W_s determined using a regional wind speed appropriate to the annual probability of exceedance for the serviceability limit states (see Note 3).

NOTE 1 Information on serviceability conditions and criteria can be found in AS/NZS 1170.0 (see Preface).

NOTE 2 Some design processes require the determination of wind pressure (ultimate or serviceability wind pressure). Such pressures should be calculated for the wind speed associated with the annual probability of exceedance (P) appropriate to the limit state being considered.

NOTE 3 For guidance on Item (b), refer to AS/NZS 1170.0.

1.7 Units

Except where specifically noted, this Standard uses the SI units of kilogram, metre, second, pascal, newton, degree and hertz (kg, m, s, Pa, N, Hz).

Section 2 Calculation of wind actions

2.1 General

The procedure for determining wind actions (W) on structures and elements of structures or buildings shall be as follows:

- (a) Determine site wind speeds (see [Clause 2.2](#)).
- (b) Determine design wind speed from the site wind speeds (see [Clause 2.3](#)).
- (c) Determine design wind pressures and distributed forces (see [Clause 2.4](#)).
- (d) Calculate wind actions (see [Clause 2.5](#)).

2.2 Site wind speed

The site wind speeds ($V_{\text{sit},\beta}$) defined for the 8 cardinal directions (β) at the reference height (z) above ground (see [Figure 2.1](#)) shall be calculated from [Equation 2.2](#):

$$V_{\text{sit},\beta} = V_R M_c M_d (M_{z,\text{cat}} M_s M_t) \quad 2.2$$

where

V_R	=	regional gust wind speed, in metres per second, for average recurrence interval of R years, as given in Section 3
M_c	=	climate change multiplier, as given in Section 3
M_d	=	wind directional multipliers for the 8 cardinal directions (β) as given in Section 3
$M_{z,\text{cat}}$	=	terrain/height multiplier, as given in Section 4
M_s	=	shielding multiplier, as given in Section 4
M_t	=	topographic multiplier, as given in Section 4

Generally, the wind speed is determined at the average roof height (h). In some cases, this varies according to the structure.

2.3 Design wind speed

The building orthogonal design wind speeds ($V_{\text{des},\theta}$) shall be taken as the maximum cardinal direction site wind speed ($V_{\text{sit},\beta}$) linearly interpolated between cardinal points within a sector $\pm 45^\circ$ to the orthogonal direction being considered (see [Figures 2.2](#) and [2.3](#)).

NOTE That is, $V_{\text{des},\theta}$ equals the maximum value of site wind speed ($V_{\text{sit},\beta}$) in the range $[\beta = \theta \pm 45^\circ]$ where β is the cardinal direction clockwise from true North and θ is the angle to the building orthogonal axes.

In cases such as walls and hoardings and lattice towers, where an incident angle of 45° is considered, $V_{\text{des},\theta}$ shall be the maximum value of $V_{\text{sit},\beta}$ in a sector $\pm 22.5^\circ$ from the 45° direction being considered.

For ultimate limit states design, $V_{\text{des},\theta}$ shall not be less than 30 m/s.

A conservative approach is to design the structure using the wind speed and multipliers for the worst direction. For example, for a building on an escarpment it may be easily checked whether the $V_R M_c M_d (M_{z,\text{cat}} M_s M_t)$ on the exposed face (towards the escarpment) is the worst case. To simplify design, this value could then be used as the design wind speed for all directions on the building.

With reference to [Figure 2.1](#), when determining the reference height on a structure, the ground level shall be taken as that of the natural ground (i.e. excluding any excavations, etc.) at the centroid of the footprint of the roof(s). Where there are upper and lower roof(s) on a building, the average roof height shall be taken as that of the upper roof.

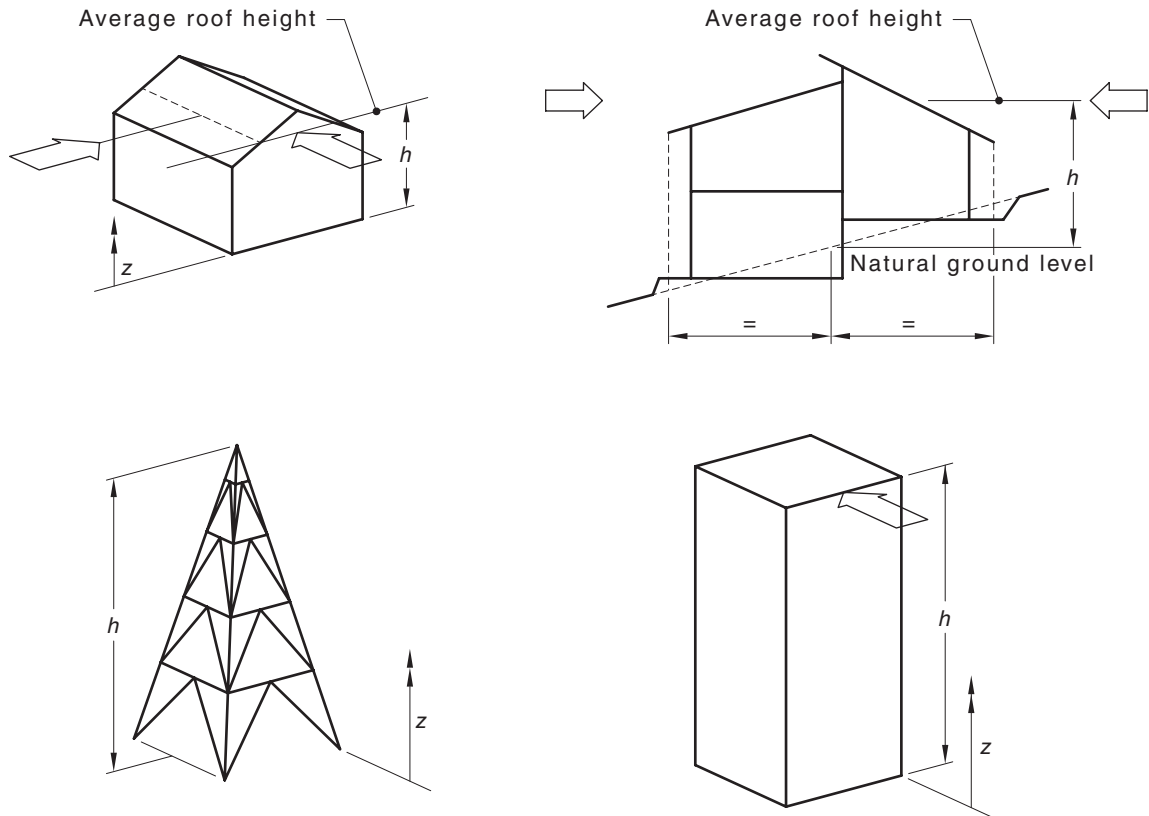


Figure 2.1 — Reference height of structures

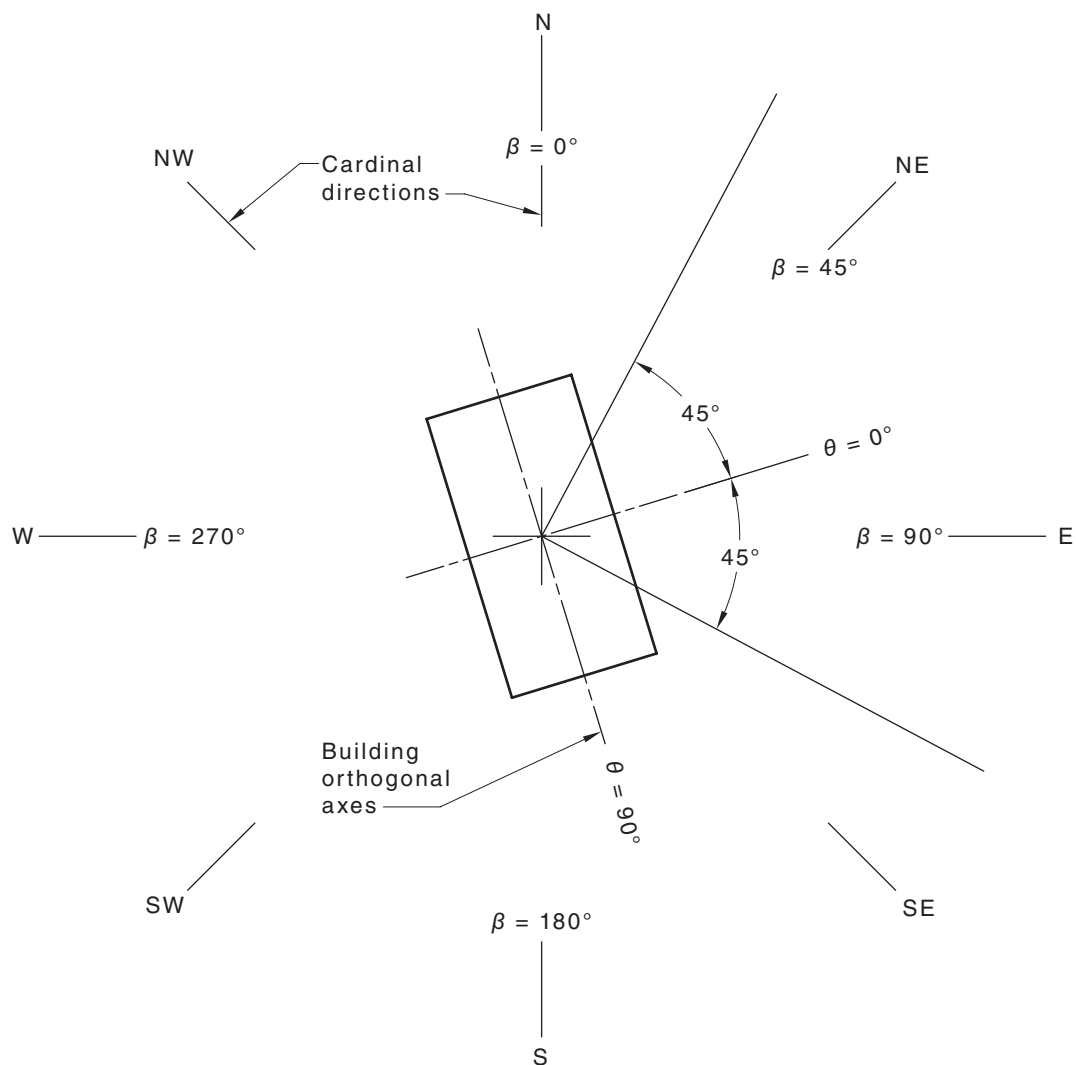
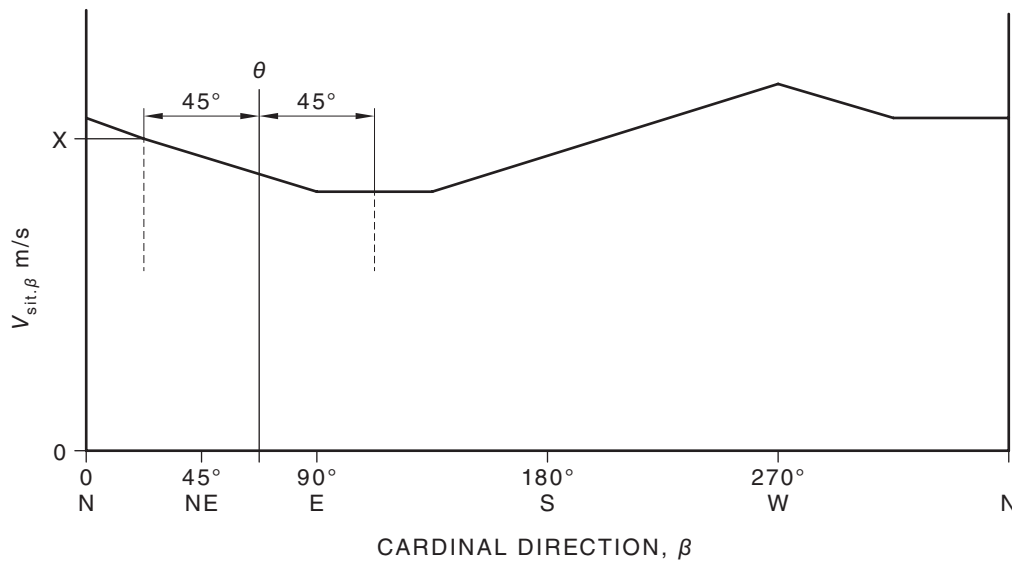


Figure 2.2 — Relationship of wind directions and building orthogonal axes



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

Figure 2.3 — Example of $V_{sit,\beta}$ conversion to $V_{des,\theta}$

2.4 Design wind pressure and distributed forces

2.4.1 Design wind pressures

The design wind pressures (p), in pascals, shall be determined for structures and parts of structures from [Equation 2.4\(1\)](#):

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

where

p = design wind pressure in pascals

= p_e, p_i or p_n where the sign is given by the C_p values used to evaluate C_{shp}

NOTE: Pressures are taken as positive, indicating pressures above ambient and negative, indicating pressures below ambient.

ρ_{air} = density of air, which shall be taken as 1.2 kg/m^3

$V_{des,\theta}$ = building orthogonal design wind speeds (usually, $\theta = 0^\circ, 90^\circ, 180^\circ$ and 270°), as given in [Clause 2.3](#)

NOTE: For some applications, $V_{des,\theta}$ may be a single value or may be expressed as a function of height (z), e.g. windward walls of tall buildings ($>25 \text{ m}$).

C_{shp} = aerodynamic shape factor, as given in [Section 5](#)

C_{dyn} = dynamic response factor, as given in [Section 6](#) (the value is 1.0 except where the structure is dynamically wind sensitive [see [Section 6](#)])

2.4.2 Design frictional drag force per unit area

The design wind frictional drag force per unit area (f), in pascals, shall be taken for structures and parts of structures from [Equation 2.4\(2\)](#):

$$f = (0.5\rho_{\text{air}}) \left[V_{\text{des},\theta} \right]^2 C_{\text{shp}} \quad 2.4(2)$$

2.5 Wind actions

2.5.1 General

Wind actions (W_u and W_s) for use in AS/NZS 1170.0 shall be determined as given in [Clauses 2.5.2 to 2.5.4](#) and deflections and accelerations of dynamically wind-sensitive structures as given in [Clause 2.5.7](#).

2.5.2 Directions

Wind actions shall be derived by considering wind from no fewer than four orthogonal directions aligned to the structure.

2.5.3 Forces on surfaces or structural elements

2.5.3.1 Forces derived from wind pressure

To determine wind actions, the forces (F) in newtons, on surfaces or structural elements, such as a wall or a roof, shall be the vector sum of the forces calculated from the pressures applicable to the assumed areas (A), using [Equation 2.5\(1\)](#):

$$F = \sum (p_z A_z) \quad 2.5(1)$$

where

p_z = design wind pressure in pascals (normal to the surface) at height z , calculated in [Clause 2.4.1](#)

NOTE: The sign convention for pressures leads to forces towards the surface for positive pressures and forces away from the surface for negative pressures.

A_z = reference area, in square metres, at height z , upon which the pressure at that height (p_z) acts

For enclosed buildings, internal pressures shall be taken to act simultaneously with external pressures, including the effects of local pressure factors (K_ℓ).

Generally, the most severe combinations of internal and external pressures shall be selected for design, but some reduction in the combined load may be applicable according to [Clause 5.4.3](#).

Where it is required to divide the height of a tall structure into sectors to calculate wind actions (e.g. windward walls of tall buildings [[Table 5.2\(A\)](#)] or for lattice towers [[Clause C.4.1](#)]), the sectors shall be of a size to represent reasonably the variation of wind speed with height, as given in [Clause 4.2.2](#).

2.5.3.2 Forces derived from frictional drag

To determine wind actions, the forces (F), in newtons, on a building element, such as a wall or a roof, shall be the vector sum of the forces calculated from distributed frictional drag stresses applicable to the assumed areas, using [Equation 2.5\(2\)](#):

$$F = \sum (f_z A_z) \quad 2.5(2)$$

where

f_z = design frictional drag per unit area parallel to the surface (calculated in [Clause 2.4.2](#)) at height z , in pascals

A_z = reference area, in square metres, on which the distributed frictional drag stresses (f_z) act

2.5.3.3 Forces derived from force coefficients

[Appendices C](#) and [D](#) cover structures for which shape factors are given in the form of force coefficients rather than pressure coefficients. In these cases, to determine wind actions, the forces (F) in newtons shall be calculated from [Equation 2.5\(3\)](#):

$$F = (0.5 \rho_{\text{air}}) \left[V_{\text{des}, \theta} \right]^2 C_{\text{shp}} C_{\text{dyn}} A_z \quad 2.5(3)$$

where

A_z = as defined in [Clause C.4](#) for lattice towers

= $l \times b$ for members and simple sections in [Clause C.2](#)

= A_{ref} as defined in [Appendix D](#) for flags and circular shapes

2.5.4 Forces and moments on complete structures

To determine wind actions, the total resultant forces and overturning moments on complete structures shall be taken to be the summation of the effects of the external pressures on all surfaces of the building.

For rectangular enclosed buildings with $h > 70$ m, torsion shall be applied, based on an eccentricity of $0.2b$ with respect to the centre of geometry of the building on the along-wind loading.

NOTE For $d/b > 1.5$, the torsional moments are primarily generated by crosswind forces and specialist advice should be sought.

For dynamic effects, the combination of along-wind and crosswind responses shall be calculated in accordance with [Section 6](#).

2.5.5 Number of stress exceedances produced by wind loading

For structures that may be fatigue sensitive, [Figure 2.4](#) and [Equation 2.5\(4\)](#) show the number of times, N_g , that a stress level, σ , is exceeded under wind loading in a lifetime, L , where L is 20 to 100 years and is expressed as a percentage of the expected maximum stress, σ_{max} , in the lifetime, L .

NOTE 1 To assess potential high-cycle fatigue damage in elements of a structure subjected to repeated and fluctuating stresses under wind loading, the stress count given in [Figure 2.4](#) and in [Equation 2.5\(4\)](#) may be used, together with stress/cycles to failure relationships, (S-N curves), such as those given for various detail categories in AS 4100. The stress counts in [Figure 2.4](#) include quasi-static stress cycles produced by wind gusting, as well as those produced by resonant vibrations.

NOTE 2 A simplified design approach to steel design, that links the design for fatigue under wind loading to the maximum stress associated with the ultimate load is given by Holmes and Genner (2012). This approach makes use of the cycle count of [Figure 2.4](#).

NOTE 3 The methods in this Clause are not appropriate for assessing the low-cycle fatigue performance of cladding elements in Regions C and D, which is covered separately in [Clause 2.5.6](#).

NOTE 4 The methods of this Clause are appropriate to wind-induced fluctuating loading from buffeting by turbulence (usually acting in the along-wind direction). They are not suitable to assess fatigue damage produced by crosswind vibrations of slender structures produced by vortex shedding (see [Clause 6.5.3](#)). In those cases, potential fatigue damage should be avoided by mitigating the vibrations by various means, such as auxiliary dampers, or aerodynamic devices such as helical strakes.

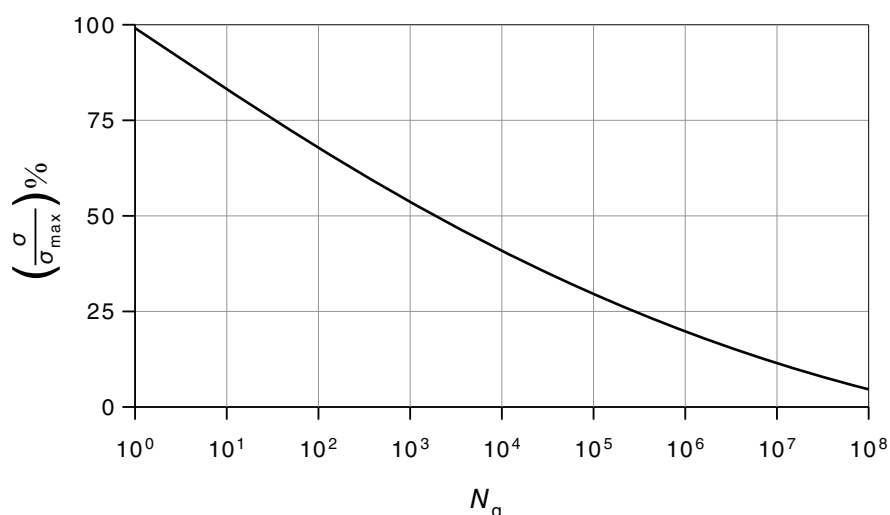


Figure 2.4 — Number of wind load cycles, N_g , for an effect, $\sigma/\sigma_{\max}$, during a 20 to 100 year period

The relationship between $\sigma/\sigma_{\max}$ and N_g is given by [Equation 2.5\(4\)](#), as follows:

$$\frac{\sigma}{\sigma_{\max}} = 0.7 \left(\log(N_g) \right)^2 - 17.4 \log(N_g) + 100 \quad 2.5(4)$$

2.5.6 Performance of cladding elements sensitive to low-cycle fatigue

In Regions C and D, cladding, its connections and immediate supporting members and their fixings shall demonstrate performance under the pressure sequences defined in AS 4040.3 and the National Construction Code (Australia), based on the ultimate limit state wind pressure on external and internal surfaces, as determined in accordance with this Standard.

2.5.7 Deflections of dynamically wind-sensitive structures

Wind actions for dynamically wind-sensitive structures (as defined in [Clause 6.1](#)), which may include chimneys, masts and poles of circular cross-section, shall be calculated in accordance with [Section 6](#).

NOTE Information on peak acceleration of other wind-sensitive structures is given in [Appendix E](#).

2.5.8 Impact loading from windborne debris

Where windborne debris loading is required for impact resistance testing, the debris impact loading shall be—

- (a) a timber test member of 4 kg mass, of a density of at least 600 kg/m³, with a nominal cross-section of 100 mm × 50 mm impacting end on at:
 - (i) 0.4 V_R , normal to wall surfaces;
 - (ii) 0.4 V_R × sine of the roof slope, normal to roof surfaces greater than 15° pitch; and
 - (iii) 0.1 V_R , normal to roof surfaces less than, or equal to, 15° pitch; and
- (b) a spherical steel ball, 8 mm in diameter (approximately 2 g mass) impacting at 0.4 V_R normal to wall surfaces, and roof surfaces greater than 35° pitch; and 0.3 V_R normal to roof surfaces less than, or equal to, 35° pitch,

where V_R is the regional wind speed given in [Clause 3.2](#).

NOTE 1 Examples of the use of this Clause would be for the evaluation of internal pressure (see [Clause 5.3.2](#)), or the demonstration of resistance to penetration of the building envelope enclosing a shelter room.

NOTE 2 The two test debris items are representative of a large range of windborne debris of varying masses and sizes that can be generated in severe wind storms.

NOTE 3 The spherical ball missile is representative of small missiles, which could penetrate protective screens with large mesh sizes.

NOTE 4 These impact loadings should be applied independently in time and location.

NOTE 5 This Standard does not specify a test method or acceptance criteria. Acceptance criteria may vary according to the purpose of the test. An appropriate test method and acceptance criteria for debris tests are given in Technical Note No. 4 (see Bibliography).

Section 3 Regional wind speeds

3.1 General

This Section shall be used to calculate gust wind speeds appropriate to the region in which a structure is to be constructed, including wind direction effects.

3.2 Regional wind speeds (V_R)

Regional wind speeds (V_R) for all directions based on peak gust wind data shall be as given in [Table 3.1\(A\)](#) or [Table 3.1\(B\)](#) for the regions shown in [Figure 3.1\(A\)](#) and [Figure 3.1\(B\)](#) where R (average recurrence interval) is the average time interval between exceedances of the wind speed listed. For $R \geq 5$ years, it is equal to the reciprocal of the annual probability of exceedance of the wind speed.

The calculated values of V_R have been rounded to the nearest 1 m/s.

In Region C, values of V_R shall be obtained by linear interpolation between the value given for Region C (maximum) and the value given for Region B2 for the same R , according to the distance from the smoothed coastline. In Region D, values of V_R shall be obtained by linear interpolation between the value given for Region D (maximum) and the value given for Region C (maximum) for the same R , according to the distance from the smoothed coastline.

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_5	32	28	33	35
V_{10}	34	33	39	43
V_{20}	37	38	45	51
V_{25}	37	39	47	53
V_{50}	39	44	52	60
V_{100}	41	48	56	66
V_{200}	43	52	61	72
V_{250}	43	53	62	74
V_{500}	45	57	66	80
V_{1000}	46	60	70	85
V_{2000}	48	63	73	90
V_{2500}	48	64	74	91
V_{5000}	50	67	78	95
V_{10000}	51	69	81	99
$V_R (R \geq 5 \text{ years})$	$67-41R^{-0.1}$	$106-92R^{-0.1}$	$122-104R^{-0.1}$	$156-142R^{-0.1}$

NOTE 1 The peak gust has an equivalent moving average time of approximately 0.2 s (Holmes and Ginger, 2012).

NOTE 2 Values for V_1 have not been calculated by the formula for V_R in the Australian regions.

NOTE 3 For ultimate or serviceability limit states, refer to the National Construction Code (Australia) or AS/NZS 1170.0 for information on values of importance level and annual probability of exceedance appropriate for the design of structures. For buildings in townships in cyclonic regions, users should consider overall risk to a community when selecting importance levels.

NOTE 4 For Regions C and D, only the maximum values for the region are tabulated. Lower values of V_R may apply in those regions, depending on the distance of the site from the smooth coastline.

Table 3.1(B) — Regional wind speeds — New Zealand

Regional wind speed (m/s)	Region		
	NZ (1 to 2)	NZ3	NZ4
V_1	31	37	38
V_5	35	42	42
V_{10}	37	44	43
V_{20}	39	46	44
V_{25}	39	46	45
V_{50}	41	48	46
V_{100}	42	50	47
V_{200}	43	51	48
V_{250}	44	51	49
V_{500}	45	53	50
$V_{1\ 000}$	46	54	50
$V_{2\ 000}$	47	55	51
$V_{2\ 500}$	47	55	52
$V_{5\ 000}$	48	56	52
$V_{10\ 000}$	49	57	53
V_R	$61-30R^{-0.1}$	$71-34R^{-0.1}$	$63-25R^{-0.1}$

NOTE 1 The peak gust has an equivalent moving average time of approximately 0.2 s (Holmes and Ginger, 2012).

NOTE 2 For ultimate or serviceability limit states, refer to AS/NZS 1170.0 for information on values of importance level and annual probability of exceedance appropriate for the design of structures in New Zealand.

3.3 Wind direction multiplier (M_d)

Except for the following cases, the wind direction multiplier (M_d) for all regions shall be as given in [Table 3.2\(A\)](#) or [Table 3.2\(B\)](#). For the following cases, M_d shall be taken as 1.0:

- (a) structures such as chimneys, tanks and poles with circular or polygonal cross-sections; and
- (b) cladding and immediate supporting structure (as defined in [Clause 5.4.4](#)) on buildings in Regions B2, C and D.

NOTE In regions where the prevailing wind directions vary with wind speed, wind direction multipliers have been calculated for the higher wind gusts (i.e. those associated with ultimate limit states design).

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

Cardinal directions	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

NOTE In Region A0 non-synoptic winds are dominant. In Regions A1 and A4, extra-tropical synoptic winds are dominant. Extreme winds in Regions A2, A3, A5 and B1 are caused by a mixture of synoptic (extra-tropical large-scale pressure systems, or tropical cyclones in the case of B1) and non-synoptic (thunderstorm) events. In Regions B2, C, and D, extreme winds from tropical cyclones are dominant.

Table 3.2(B) — Wind direction multiplier (M_d) — New Zealand

Cardinal directions	Region NZ1	Region NZ2	Region NZ3	Region NZ4
N	0.90	0.95	1.00	0.95
NE	0.95	0.90	0.75	0.75
E	0.95	0.80	0.75	0.75
SE	0.95	0.90	0.85	0.75
S	0.90	0.95	0.95	0.85
SW	1.00	1.00	0.95	0.95
W	1.00	1.00	0.90	1.00
NW	0.95	1.00	1.00	1.00

NOTE In all New Zealand regions, extra-tropical synoptic winds are dominant.

3.4 Climate change multiplier (M_c)

The climate change multiplier (M_c) shall be as given in [Table 3.3](#).

Table 3.3 — Climate change multiplier (M_c)

Region	M_c
A (0 to 5)	1.0
B1	1.0
B2	1.05
C	1.05
D	1.05
NZ (1 to 4)	1.0

NOTE The climate change multiplier allows for possible changes in climate affecting extreme winds during the life of structures designed by this Standard. Values of M_c may be adjusted in future amendments, depending on observed or predicted trends.

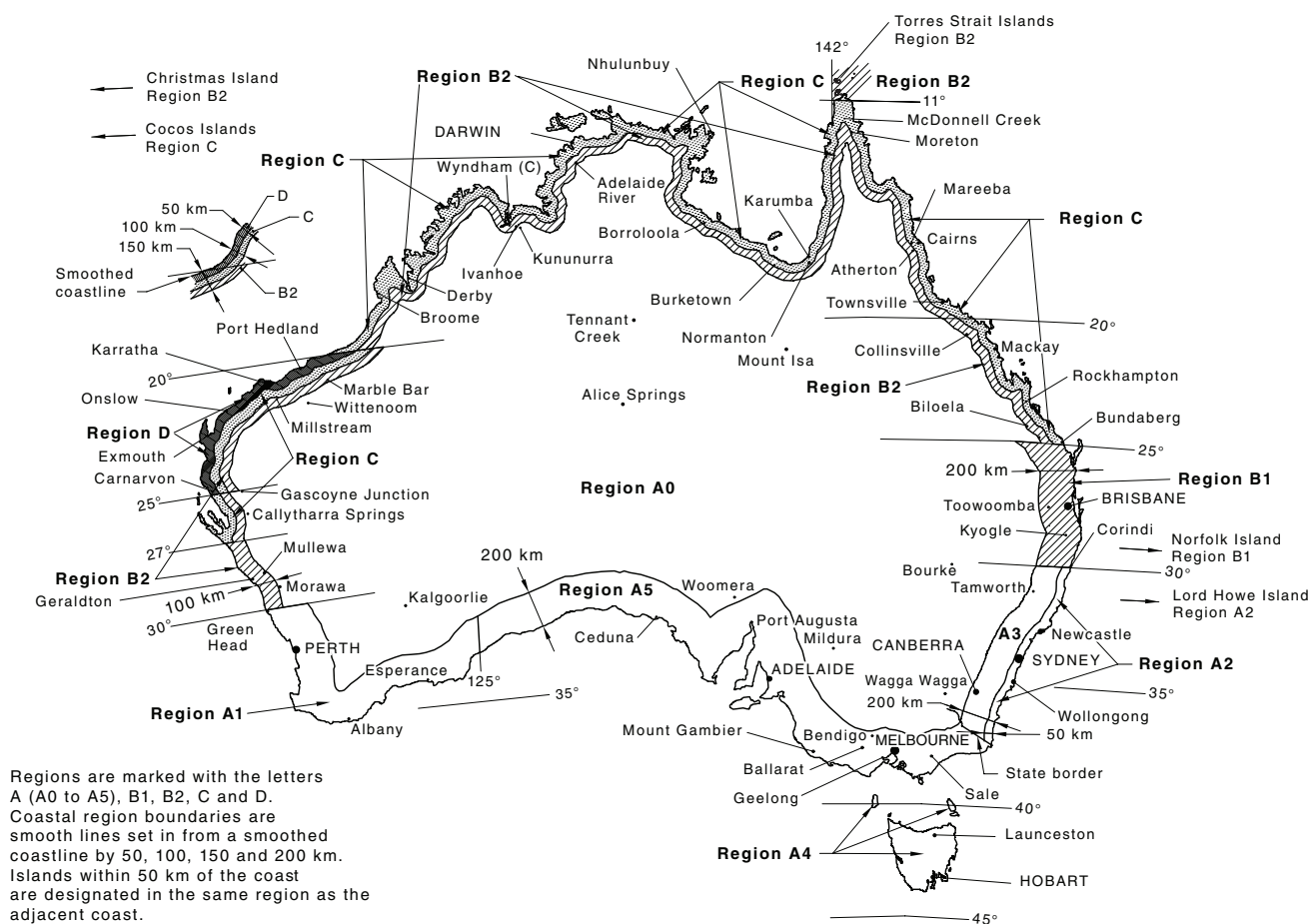


Figure 3.1(A) — Wind regions — Australia

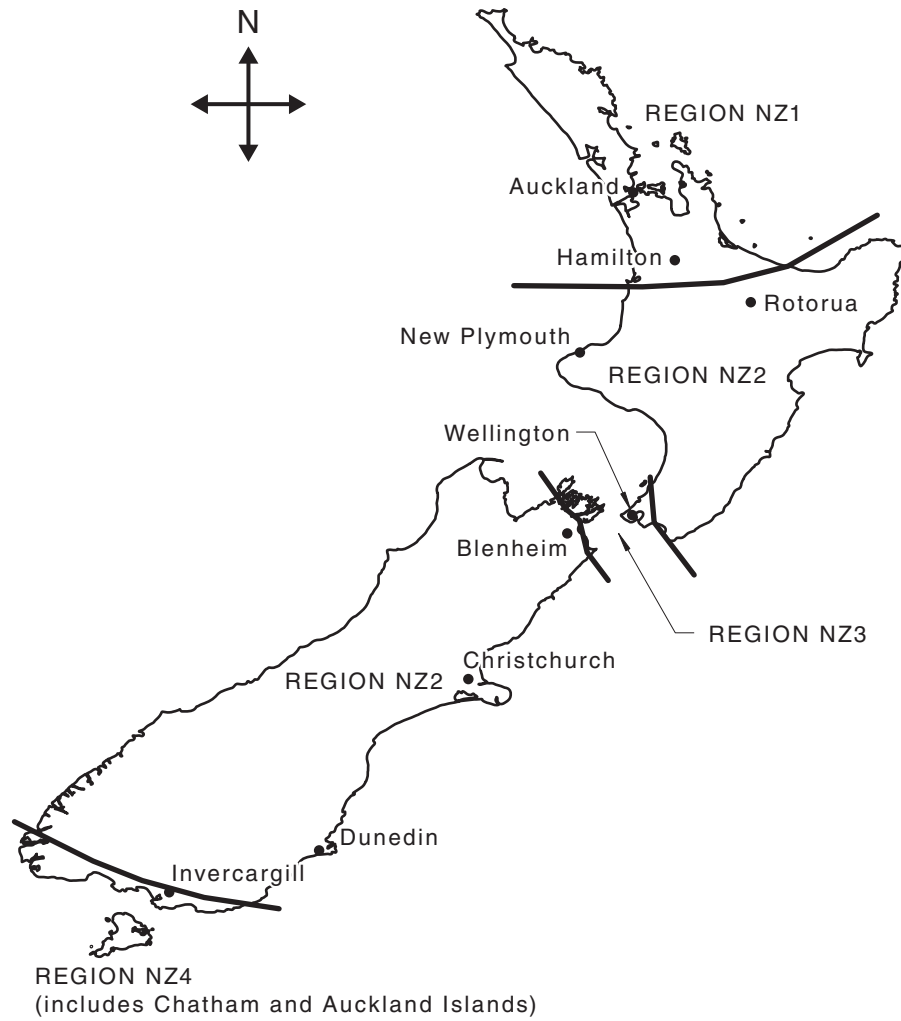


Figure 3.1(B) — Wind regions — New Zealand

Section 4 Site exposure multipliers

4.1 General

This Section shall be used to calculate the exposure multipliers for site conditions related to terrain/height ($M_{z,cat}$), shielding (M_s) and topography (M_t).

The design shall take account of known future changes to terrain roughness when assessing terrain category and to buildings providing shielding when assessing shielding.

4.2 Terrain/height multiplier ($M_{z,cat}$)

4.2.1 Terrain category definitions

Terrain, over which the approach wind flows towards a structure, shall be assessed on the basis of the following category descriptions:

- (a) *Terrain Category 1 (TC1)* — Very exposed open terrain with very few or no obstructions, and all water surfaces (e.g. flat, treeless, poorly grassed plains; open ocean, rivers, canals, bays and lakes).
- (b) *Terrain Category 2 (TC2)* — Open terrain, including grassland, with well-scattered obstructions having heights generally from 1.5 m to 5 m, with no more than two obstructions per hectare (e.g. farmland and cleared subdivisions with isolated trees and uncut grass).
- (c) *Terrain Category 2.5 (TC2.5)* — Terrain with some trees or isolated obstructions, terrain in developing outer urban areas with scattered houses, or large acreage developments with more than two and less than 10 buildings per hectare.
- (d) *Terrain Category 3 (TC3)* — Terrain with numerous closely spaced obstructions having heights generally from 3 m to 10 m. The minimum density of obstructions shall be at least the equivalent of 10 house-size obstructions per hectare (e.g. suburban housing, light industrial estates or dense forests).
- (e) *Terrain Category 4 (TC4)* — Terrain with numerous large, high (10 m to 30 m tall) and closely-spaced constructions, such as large city centres and well-developed industrial complexes.

Selection of the terrain category shall be made with due regard to the permanence of the obstructions that constitute the surface roughness.

NOTE The aerodynamic roughness length, z_0 , in metres, is related to the terrain category number by the following relation: $z_0 = 2 \times 10^{(TC \text{ number} - 4)}$

4.2.2 Determination of terrain/height multiplier ($M_{z,cat}$)

The variation with height (z) of the effect of terrain roughness on wind speed (terrain and structure height multiplier, $M_{z,cat}$) shall be taken from the values for fully developed profiles given in [Table 4.1](#). For intermediate values of height and terrain category, use linear interpolation.