AUSTRALIAN STEEL INSTITUTE
STEEL SHED GROUP

Wind Actions on Steel Sheds & Garages

Design Guide

This Guide will assist the reader in understanding how wind actions (AS/NZS 1170:2:2002) on sheds and garages are determined.

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WHAT THIS GUIDE IS ABOUT

This Guide outlines the principles for determining design wind actions on *steel sheds, garages and similar buildings* for construction in Australia. It explains how structural designers should apply existing wind design criteria and concepts to the ultimate limit state design of steel sheds falling within a defined scope. It does not replace the Building Code of Australia, its referenced standards and other engineering texts but should be read in conjunction with them. This guide was compiled for distribution to building certifiers and shed suppliers.

WHY IT'S IMPORTANT

The classification and importance level of a specific building are regulatory matters for the relevant Building Authority. Depending on the building classification and importance level, the designer will make design decisions taking into account the performance requirements or building solutions of Volume 1 of the BCA. Steel Shed Group encourages and expects that these requirements will be adhered to in the design of all shed products.

Steel Shed Group policy is that:

- Regardless of their importance level or classification, buildings should not fail when subjected to the ultimate loading events for which they are certified to be designed.
- Each building and its location are unique, and the designer must ascertain the appropriate classification and importance level to determine the appropriate design actions on the structure.
- "Generic" designs should take into account, and clearly disclose in documentation and literature, the most adverse use for which a building may be sold or recommended, or is reasonably likely to be used.

APPLICATION

This Guide applies to buildings with structural frames made predominantly from cold-formed steel and clad predominantly with steel wall and roof sheeting.

The following buildings are not covered by Steel Shed Group recommendations:

- Habitable buildings of any kind and any structures attached to them
- Silos and similar produce stores where stored contents applies vertical or lateral wall loads
- Buildings taller than 10 metres, longer than 100 metres or with span greater than 40 metres
- Small garden type sheds, gazebos and summerhouses of less than 10 square metres, or less than 2 metres span or with eave height less than 2 metres

DISCLAIMER

ABOUT STEEL SHED GROUP

The Steel Shed Group is a self-funded industry based association under the umbrella of the Australian Steel Institute. Its main purpose is to promote compliance for engineering and documentation standards for the steel shed industry via technical publications, education and creating awareness.

Membership of Steel Shed Group is open to all companies and individuals involved in the design, certification, manufacture and supply of Australian steel sheds and the materials from which they are made. Members are required to meet the compliance criteria of the Steel Shed Group.

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DEFINITIONS & DESIGN

What is a Shed or Garage?

For the purposes of this Guide, a *shed* is "any freestanding non-habitable general purpose building used for domestic, commercial, industrial or agricultural purposes". A *residential shed* is one constructed on a residential allotment and used predominantly for private, domestic purposes.

Garages are "special-purpose buildings designed to shelter vehicles". Garages are fully enclosed freestanding structures with at least one vehicle-sized door. All other vehicle shelters, including those attached to buildings, are carports and are not covered by this Guide.

Design Basis

Steel sheds and garages should be designed to current Australian codes and standards using accepted engineering principles. They should always be fit for the stated purpose(s) for which they are designed or offered for sale. Design details should be documented to a level that can reasonably ensure satisfactory construction to meet structural design objectives.

PROCEDURE

1 : Importance Level

BCA 2007

Building authorities, on behalf of the community, regulate how strongly buildings are constructed to resist the loads they are expected to experience, and what risk of structural failure is acceptable for various types and uses of building. The national regulator, the Australian Building Codes Board, expresses this community interest via the Importance Level in the BCA.

BCA 2007 explains that importance levels:

- Apply to *structural safety only*, not to serviceability or functionality;
- Are a function of both *hazard to human life* and *public impact* of building failure, and
- Must be assigned on a case by case basis.

The ***Importance Level*** can be determined from the following table:

BUILDING IMPORTANCE LEVEL					
CONSEQUENCES OF BUILDING FAILURE		**IMPACT ON THE PUBLIC**			
		Low	Moderate	Substantial	Extreme
HAZARD TO HUMAN LIFE	Low	**1**	**2**	**2**	**3**
	Moderate	**2**	**2**	**3**	**3**
	Substantial	**2**	**3**	**3**	**4**
	Extreme	**3**	**3**	**4**	**4**

Source: Guide to the BCA 2007, Section B1.2.

Importance Level Examples

BCA 2007

BUILDING DESCRIPTION	BCA CLASS	FAILURE CONSEQUENCES		IMPORTANCE LEVEL
		HUMAN HAZARD	PUBLIC IMPACT	
Isolated farm building	10a	Low	Low	1
Residential shed/garage/carport	10a	Mod	Low	2
Small school shade structure	9b	Mod	Mod	2
Produce sales building	6	Mod	Mod	2
Shearing shed	8	Sub	Mod	2
Large commercial storage warehouse	7	Mod	Sub	3
Large (250+) school assembly shelter	9b	Sub	Sub	3
Shed housing hospital emergency generator	10a	Sub	Ext	4
Emergency vehicle garage	10a	Sub	Ext	4

Source: BCA 2007 Table B1.2a and Guide to the BCA 2007 Section B1.2.

2 : Wind Probability

BCA 2007

The BCA requires that regional wind speeds of specific probability be used for building design. The more important the building, the less the allowable risk that the design speed will be exceeded in any one year and the higher the speed required in design. ***Regardless of their importance level or classification, buildings should not fail when subjected to the wind event for which they are certified to be designed.***

The ***Annual Probability of Exceedance for Wind Speed*** is selected from the following table:

IMPORTANCE LEVEL	ANNUAL PROBABILITY OF EXCEEDANCE FOR WIND SPEED	
	NON-CYCLONIC	CYCLONIC
1	1:100	1:200
2	1:500	1:500
3	1:1000	1:1000
4	1:2000	1:2000

Source: BCA 2007 Table B1.2b

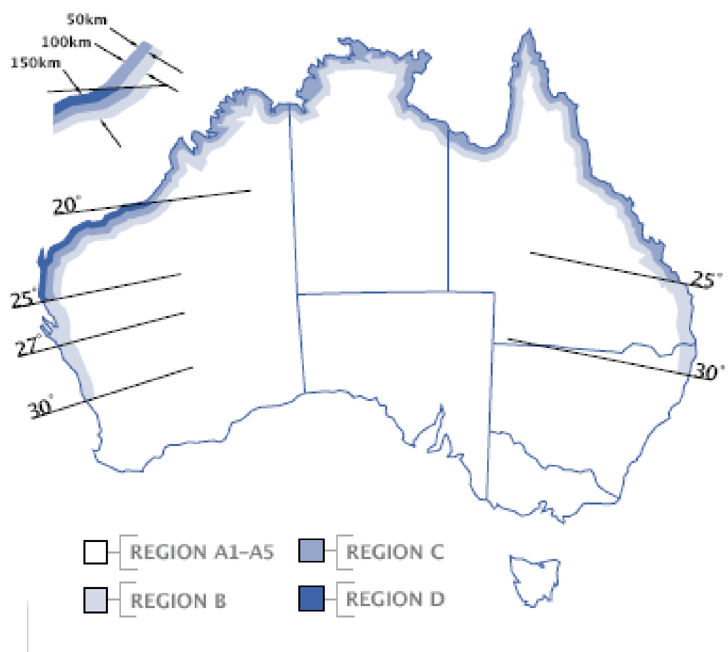
3 : Wind Region

AS/NZS 1170.2 Figure 3.1

Australia is divided into several regions based on the maximum wind speed expected during peak storm activity. The region associated with a particular building locality can be found from:

- The local Council for that area, or
- A structural engineer, building surveyor or certifier.

The following map shows the approximate location of the region boundaries. It should be taken only as a guide, and the region verified by one of the above methods.



4 : Regional Wind Speed

AS/NZS 1170.2 Clause 3.2

The ***Regional Wind Speed*** – ultimate limit state - for the Region and Annual Probability of Exceedance is determined from the following table:

REGIONAL WIND SPEED m/s				
Speed Probability	**Region A**	**Region B**	**Region C**	**Region D**
V_{100}	41	48	59	73
V_{200}	43	52	64	79
V_{500}	45	57	69	88
V_{1000}	46	60	74	94
V_{2000}	48	63	77	99

Source: AS/NZS 1170.2 Table 3.1 and Clause 3.4.

5 : Wind Direction Multiplier

AS/NZS 1170.2 Clause 3.3

In Region A only, where the final orientation of the building is *unknown*, M_d = 1.00. Where the final orientation of the building is *specified in design documentation*, M_d should be determined from AS/NZS 1170.2 Table 3.2.

In Regions B, C and D, M_d = 0.95 for forces on complete buildings and major structural members and 1.00 for all other design cases.

6 : Terrain/Height Multiplier

AS/NZS 1170.2 Clause 4.2

The ***Terrain/Height multiplier*** is determined from the following table:

Building Height (m)	Region A & B (Ultimate limit state) All Regions (Serviceability limit state)				Region C & D (Ultimate limit state)		
	TC1	TC2	TC2.5	TC3	TC 1 & 2	TC2.5	TC 3
<= 3	0.99	0.91	0.87	0.83	0.90	0.85	0.80
5	1.05				0.95	0.88	
10	1.12	1.00	0.92		1.00	0.95	0.89

Source: AS/NZS 1170.2 Table 4.1(A). Linear interpolation may be used for intermediate values of height and terrain category. Building Height is defined in AS/NZS 1170.2 Fig 2.1.

TC	Description
1	Exposed open terrain with few or no obstructions
2	Water surfaces, open terrain, grassland with few, well-scattered obstructions having heights generally from 1.5 m to 10 m.
2.5	Terrain with few trees, isolated obstructions such as agricultural land, cane fields or long grass, up to 600 mm high.
3	Terrain with numerous closely spaced obstructions 3 m to 5 m high such as areas of suburban housing.
4	Terrain with numerous large 10 m to 30 m high closely spaced obstructions such as large city centres and well-developed industrial complexes.

Note*: Generic shed documentation should include the above descriptions to clarify the conditions for which the design is suitable. Definition and interpolated values for TC 2.5 are included for convenience. Designers should evaluate the actual terrain conditions and select the appropriate multiplier in accordance with AS/NZS 1170.2.*

7 : Shielding Multiplier

AS/NZS 1170.2 Clause 4.3

The ***Shielding Multiplier*** is a *local development effect*. It reduces the design wind speed by taking into account the protection afforded by upwind local buildings. A Shielding Multiplier of 1.0 should be applied outside suburban areas unless a lower value is justifiable and supported by a competent site survey.

On suburban sites where all adjoining allotments are fully developed and the average upwind gradient is less than 0.2, a Shielding Multiplier of 0.85 may be applied as suggested in AS/NZS 1170.2 Supplement 1.

8 : Topography Multiplier

AS/NZS 1170.2 Clause 4.4

The ***Topography Multiplier*** is a *local geographic effect*. It increases the design wind speed based on the gradient upwind of the site. Any site on a hill or escarpment of any size must be properly evaluated to determine the Topography Multiplier. A multiplier of 1.0 is not a conservative assumption. Whatever value is calculated or selected by the designer, the value and its corresponding site description should be clearly stated on all documentation.

OBSOLETE CODES

In some localities, the use of the "W" wind classification system has persisted. This system relates to the "permissible stress" design methodology, as described in AS 1170 – 1989.

With the implementation of the AS/NZS 1170 series of new standards in 2002, the previous wind load code AS 1170.2 - 1989 was superseded. Amendment No. 12 to the Building Code of Australia allowed the use of the old loading code series, clarifying that the old codes could be used but only in isolation. Similarly the new codes could be used, but only in isolation, thus preventing the use of old & new codes at the same time. The *farm structures code* AS 2867 was withdrawn from the BCA in 2007.

Steel Shed Group recommends that designs prepared and certified to AS 1170.2 - 1989 and/or AS 2867 should not be quoted or constructed unless they have been re-certified to current limit state standards. New designs should be based only on current standards.

AS 4055 SUITABILITY

Steel Shed Group does not recommend the use of AS 4055 *Wind loads for housing* to determine wind actions on sheds, garages and similar non-habitable buildings. Although generally based on an Importance Level of 2, which is conservative for many rural sheds, AS 4055 permits the use of net pressure coefficients which are valid only for the configuration of openings and overall permeability typical of houses.

AS 4055 was developed for "houses as a group or large numbers of buildings". Steel sheds are highly wind sensitive structures, vulnerable to inappropriate design based on simplified or invalid assumptions about critical design factors. Their structural design – and the suitability recommendations of their suppliers - should be based on actual expected service conditions for individual buildings rather than on generalised assumptions.

Steel Shed Group recommends that structural designers of sheds, garages and similar buildings should use AS/NZS 1170.2 for all wind action computations, taking into account all relevant factors and applying, in an informed and fully transparent way, any simplifications or concessions appropriate to an individual building design.

PRESSURE COEFFICIENTS

Internal

AS/NZS 1170.2 Clause 5.3

The internal pressure coefficients selected by the designer depend mainly on the size, shape and orientation of the building and on the size and configuration of its openings. They also depend, in part, on the wind region in which the building is located.

In all regions, designers may use their discretion as to which openings are assumed closed during peak wind events, as explained in AS/NZS 1170.2 Supplement 1. However, *any such closed openings must be capable of withstanding peak wind forces under the critical loading conditions.* This means that, for example, a roller door rated at 1.0 kPa may only be assumed "closed" during peak wind events if the highest calculated pressure on the door is no more than 1.0 kPa.

In cyclonic regions C and D, a further requirement applies. Designers must consider the resistance of the entire building envelope – windows, doors, roof and wall cladding – to impact by flying debris. Unless the designer is satisfied that the building envelope will be "*capable of resisting impact loading equivalent to a 4 kg piece of timber of 100x50 mm cross-section, projected at 15 m/s at any angle*", as required by AS/NZS 1170.2 Clause 5.3.2, then he/she must select the most adverse internal pressure coefficients arising from building envelope failure. These coefficients are specified in AS/NZS 1170.2 Table 5.1(B).

External

AS/NZS 1170.2 Clause 5.4

Coefficients for walls vary with height (for windward and side walls), depth-to-breadth ratio (for leeward walls), roof pitch (for leeward walls) and distance from the windward edge (for side walls, as a function of average building height).

Coefficients for roofs vary with the type, direction and pitch of each roof plane, distance from the windward edge and height-to-depth ratio.

A statistical combination factor may apply where wind pressures act simultaneously on two or more surfaces to produce action effects on a major structural member.

External pressure coefficients for all buildings in all situations should be selected from the appropriate tables in AS/NZS 1170.2 Clause 5.4.

Common Misconceptions

Sheds and garages are not automatically Importance Level 1. The importance of a building should be correctly assessed in all cases according to the BCA and its guidelines.

Three-sided sheds are not enclosed buildings, and should always be designed for the appropriate dominant opening internal pressure.

A Topography Multiplier of 1.0 is not conservative and should not be the default value. It could be a very unsafe assumption. Topography should be properly assessed in all cases and design assumptions clearly stated in documentation.

Trees and other vegetation do not provide shielding. Only buildings provide shielding, and only when located in the upwind zone specified in AS/NZS 1170.2 on ground of less than 0.2 gradient. Shielding Multiplier should be 1.0 unless proven otherwise.

IMPORTANCE LEVELS - Examples

Domestic Garage

Importance Level 2

Exceedance risk 1:500 in all regions

Farm Shed

Importance Level 1

Exceedance risk 1:100 in regions A & B

Exceedance risk 1:200 in regions C & D

PRESSURE COEFFICIENTS - Examples

Enclosed Shed or Garage

Fully enclosed with roller and access doors

Full internal pressure (dominant opening) in Regions C & D unless doors and cladding impact resistant

Open Rural Machinery Shed

Clad 3 sides

Full internal pressure (dominant opening) in all regions (typically +0.5 to 0.7 depending on opening dimensions and permeability)

WIND SPEED - WORKED EXAMPLE: REGION A (NON-CYCLONIC)

BUILDING DESCRIPTION

- The project is a 6 m x 6 m x 3.0 m high double garage with twin roller doors, in the vicinity of a house on a 1000 m^2 allotment in outer suburban Melbourne, less than 70 km from Melbourne GPO. The precinct is fully developed with housing and associated buildings and structures. The building will be used for the garaging of private vehicles and other domestic activities such as workshop and storage. As a domestic building, it is a reasonable assumption that the main roller doors of the building will be closed during high winds provided this assumption is communicated to and accepted by the owner.
    - *The building is not a dwelling, but its use is associated with domestic purposes.*
    - *The BCA Classification of the building is 10a, which is appropriate for a non-habitable shed, garage or carport. There are no structural implications of this classification.*
    - *The building doors will be assumed closed during peak wind events. Internal pressure consistent with enclosed buildings may be used for structural design.*

SITE FACTORS

- Check region with Council.
    - *The Council has confirmed in writing that the allotment on which the proposed garage will be built is located in Region A5, as defined in AS/NZS 1170.2.*
- The consequences of structural failure are considered to be *moderate* in terms of human hazard (because the building is associated with domestic use) and *moderate* in terms of impact on the public (because the allotment is in a residential zone).
    - *Importance Level 2 is assigned – this is consistent with residential outbuildings generally. Importance Level 1 can only be justified if both hazard and impact of failure are low.*
    - *Importance Level 2 requires an annual probability of exceedance for wind events of 1:500.*
- The exact orientation of the building and roller door orientation may be design factors for an enclosed building in Region A5. However, in this case the design is to be based on "doors closed".
    - *For Region A5, a wind direction multiplier of 1.00 is applied for all design cases. There is no dominant opening, so no structural design benefit can be gained by wind speed reduction in specific directions.*
- The general terrain of the property precinct is *suburban housing* in all directions. There is no reason to believe it would be redeveloped in any direction for non-housing purposes.
    - *The terrain is Category 3 with no change anticipated. A terrain/height multiplier of 0.83 is appropriate.*
- The proposed garage is well shielded by the house and other dwellings on adjoining blocks, with typically about 10 buildings in each direction. Effects of shielding should be considered.
    - *Evaluate shielding parameter (s) from AS/NZS 1170.2 Clause 4.3.3:*
        - *Average height of shielding buildings (h_s) is about 4 m.*
        - *Average breadth of shielding buildings (b_s) is about 9 m.*
        - *Roof height of garage being shielded (h) is 3 m.*
        - *Number of upwind shielding buildings (n_s) is about 10.*
        - *Shielding parameter s = (3 x (10/10 + 5))/(4 x 9)^$^{0.5}$ = 3.0*
        - *Look up shielding multiplier in Table 4.3, M_s = 0.8*
- The site and surrounding geography are essentially flat and level.
    - *There is no reason to apply a topographic factor higher than 1.0.*
- The steps in calculation of site wind speed are:
    - *Look up regional wind speed for region A5 and 1:500, $V_R = 45$*
    - *Wind directional multiplier for region A5, $M_d = 1.00$*
    - *Look up terrain/height multiplier $M_{z, cat} = 0.83$*
    - *Look up shielding multiplier $M_s = 0.8$*
    - *Look up topography multiplier $M_t = 1.0$*
    - *Calculate $V_{sit} = V_R \times M_d \times M_{z, cat} \times M_s \times M_t$*
    - ***Value for this example, V_{sit} = 45 x 1.00 x 0.83 x 0.8 x 1.0 = 30 m/s***
    - *In this case, as the building orientation is irrelevant this is also the design wind speed V_{des}*
- The calculated design wind speed is then used to calculate the design wind pressures acting on various parts of the structure in accordance with AS/NZS 1170.2 Clause 2.4.

WIND SPEED - WORKED EXAMPLE: REGION C (CYCLONIC)

BUILDING DESCRIPTION

- The project is a 9 m long x 6 m span x 3.8 m high open-sided machinery shed in a specific location on an undulating produce farm near Rockhampton, approximately 25 km from the coast. The shed will be located in a paddock near the dwelling, but remote from any other dwellings or sheds. The building will be used for the garaging and servicing of farm machinery.
  - *The building is not a dwelling, or associated with any domestic purpose.*
  - *The BCA Classification of the building is 10a, which is appropriate for a non-habitable shed, garage or carport. There are no structural implications of this classification.*

SITE FACTORS

- Check region with Council.
  - *The Council has confirmed in writing that the allotment on which the proposed shed will be built is located in Region C, as defined in AS/NZS 1170.2. It is not exempt development under the Standard Building Regulations.*
- The consequences of structural failure are considered to be *low* in terms of human hazard (because the shed is not near or associated with a dwelling) and *low* in terms of impact on the public (because the shed is on a large allotment remote from unrelated dwellings and other buildings).
  - *Importance Level 1 can only be justified if both human hazard and impact of failure are low. Importance Level 1 is justifiable in this case, consistent with remote rural buildings generally.*
  - *Importance Level 1 allows an annual probability of exceedance for wind events of 1:200 in a cyclonic area.*
- The exact orientation of the building is not shown on the site layout drawing, but this is not relevant to the wind direction multiplier in region C:
  - *For Region C, a wind direction multiplier of 0.95 is applied for the design of complete buildings and major structural elements. A multiplier of 1.00 is used for all other design cases.*
- The general terrain of the property is observed to be cleared open farming land with relatively few trees or buildings. There is no indication of future rezoning and redevelopment plans in available Council documentation.
  - *The terrain is currently Category 2, and is considered to be "fully developed" in the absence of confirmed future rezoning proposals.*
  - *The building height of 3.8 m allows linear interpolation of terrain/height multiplier between 0.90 and 0.95 giving $M_{z,cat} = 0.92$.*
- The shed is in the open, unshielded by other buildings. There are no plans to construct other buildings in its immediate vicinity.
  - *The proposed building must be regarded as unshielded. No shielding concession on wind speed is justified.*
- The site and surrounding geography are undulating, with the shed located on an extensive flat area about 50 metres from a gentle downslope, beyond which is a flat plain. The topography should be checked to see if it falls within the limits for a topographic factor of 1.0:
  - *Only the hill shape multiplier applies for Australian sites $M_t = M_h$.*
  - *The slope is found to have an overall height (H) of about 12 metres. The height drops to 6 metres about 75 metres down from the crest (L_u). Therefore the value $H/(2L_u) = 0.08$.*
  - *This value is more than 0.05 but less than 0.45. Therefore apply formula 4.4(2) of AS/NZS 1170.2 which gives $M_h = 1.07$.*
- The steps in calculation of site wind speed are:
  - *Look up regional wind speed for region C and 1:200, $V_R = 64$ m/s*
  - *Select wind directional multiplier $M_d = 0.95$ for region C*
  - *Interpolate terrain/height multiplier $M_{z,cat} = 0.92$*
  - *Look up shielding multiplier $M_s = 1.0$*
  - *Calculate topography multiplier $M_t = 1.07$*
  - *Calculate $V_{sit} = V_R \times M_d \times M_{z,cat} \times M_s \times M_t$*
  - ***Value for this example $V_{sit} = 64 \times 0.95 \times 0.92 \times 1.0 \times 1.07 = 60$ m/s***
  - *In this case, as the building orientation is irrelevant, this is also the design wind speed V_{des}*
- The calculated design wind speed V_{des} is then used to calculate the design wind pressures acting on various parts of the structure in accordance with AS/NZS 1170.2 Clause 2.4.

DESIGN INFORMATION – Sheds & Garages			
Pro-forma request for design information by building certifier if design information supplied by shed supplier is inadequate			
	ITEM	**DESIGN VALUE & DETAILS**	**NOTES**
Compliance Details			
1	Shed supplier		
2	Structural designer		
3	Certifying authority		
Building Details			
4	Building description		
5	Specification reference & date		
6	Owner's stated intended use		
7	BCA classification		
8	Length (m)		
9	Width (m)		
10	Height – maximum (m)		
11	Height to eave (m)		
12	Roof pitch (degrees)		
13	Internal pressure coefficient		
14	Average Cpe roof		
15	Average Cpe walls		
16	Local pressure effects applied?		
Site Details			
17	Site address		
18	Site plan reference & date		
19	Wind region		
20	Importance level		
21	Annual probability of exceedance for wind		
22	Cyclonic factor (F_C, F_D) (if applicable)		
23	Regional wind speed (V_R)		
24	Wind direction multiplier		
25	Terrain category		
26	Terrain-height multiplier		
27	Shielding multiplier		
28	Topographic multiplier		
29	Site wind speed (V_{sit})		
30	Design wind speed (V_{des})		