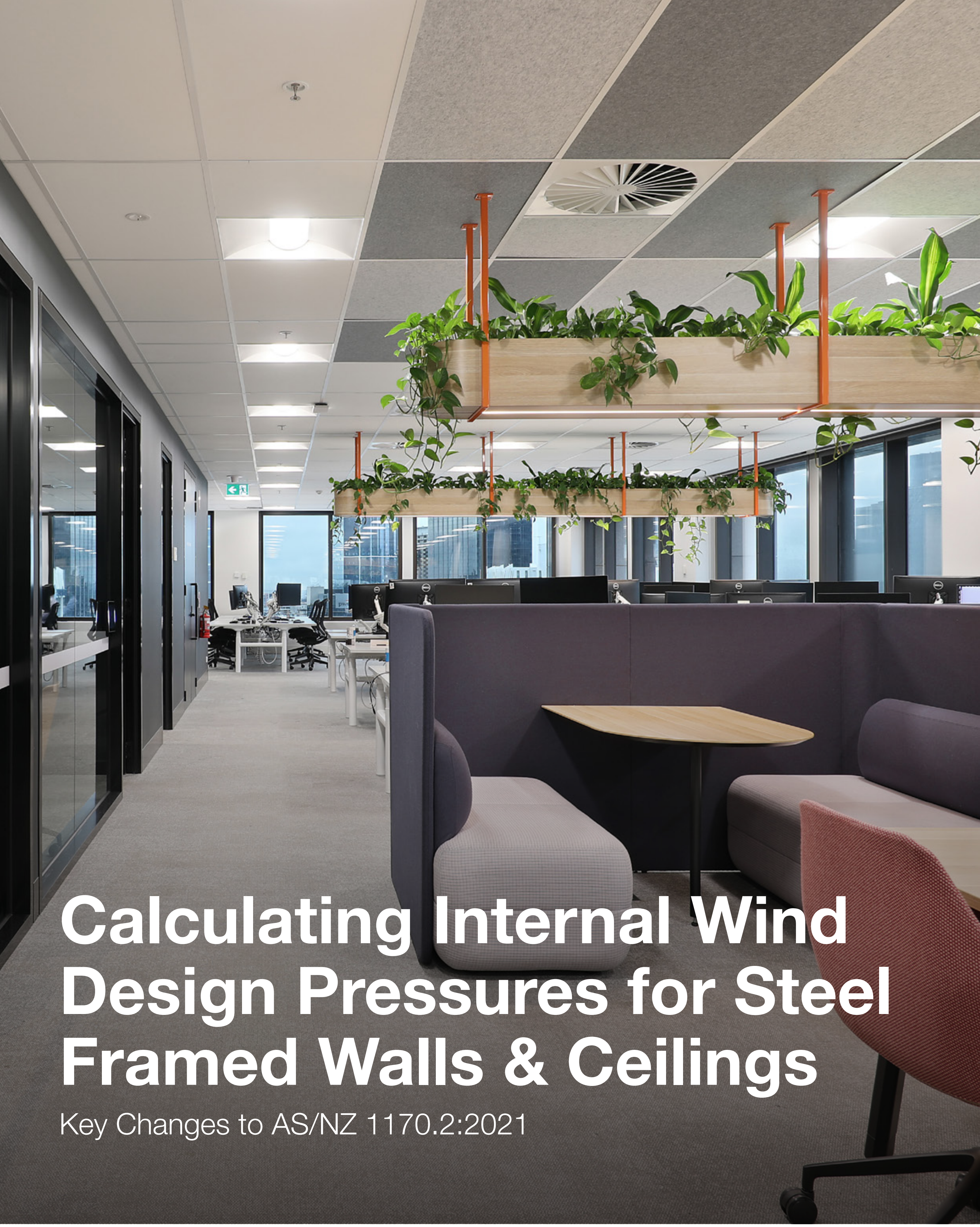

Calculating Internal Wind Design Pressures for Steel Framed Walls & Ceilings

Key Changes to AS/NZ 1170.2:2021

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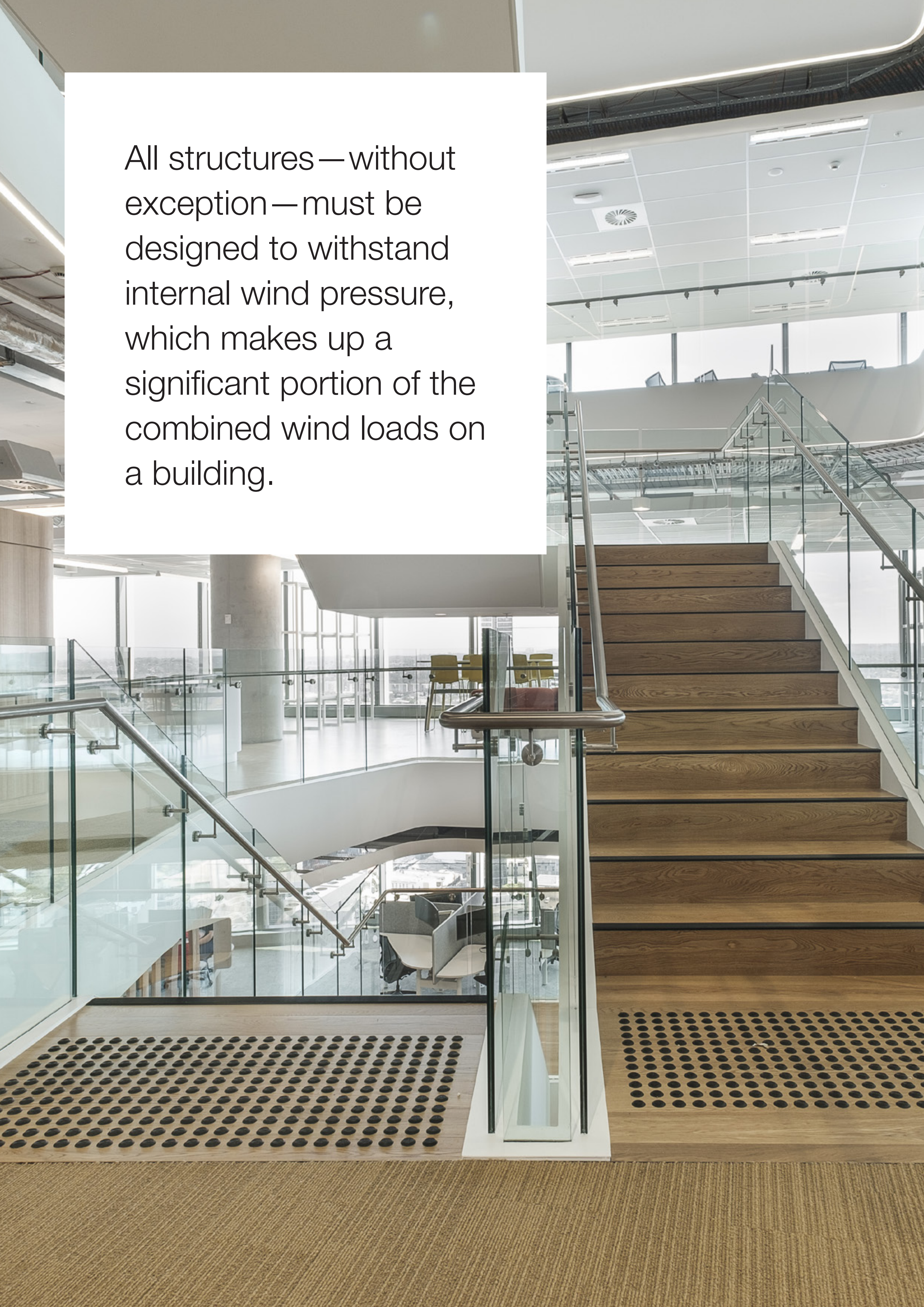

INTRODUCTION

A structure experiences forces on its surfaces when strong winds are present. If there are openings or facade leakages connecting a building's exterior to the interior, significant internal pressures may be created. This is why severe wind events in Australia and overseas are known to cause significant damage to the interior of buildings, sometimes resulting in widespread destruction, injury and death.

In Australia, all structures—without exception—must be designed to withstand internal wind pressure, which makes up a significant portion of the combined wind loads on a building. The design of steel-framed walls and ceilings in residential and commercial buildings must account for the proper internal design pressures in order to comply with the National Construction Code (NCC).

For the optimal structural design of all building types, accurate internal design pressures must be applied. Significant changes to load calculations were introduced by the recently updated AS/NZS 1170.2:2021 "Structural design actions: Wind actions" (referred to as AS/NZS 1170.2 or the "Wind Code"). Below, we discuss how these changes will impact practitioners when calculating internal design pressures for steel-framed walls and ceilings.

WIND LOADING AND THE NCC

In the NCC Vol. 1, Clause B1P1 provides that a building or structure, during construction and use, with appropriate degrees of reliability, must be capable of resisting the actions to which it may reasonably be expected to be subjected, including wind actions. Deemed-to-satisfy provision B1D3 refers to AS/NZS 1170.2 when determining wind actions.

The procedures for calculating wind speeds and resulting wind actions to be used in structural design are outlined in AS/NZS 1170.2. This Standard was recently revised with the publication of the 2021 version, superseding the previous 2011 version.

Note that Part B2 of the NCC Vol.1 sets out the changes necessary to the application of AS/NZS 1170.2 in Western Australia for wind Region B2. For further information, please refer to that provision.

METHODOLOGY FOR DETERMINING INTERNAL DESIGN PRESSURES

To determine internal design pressures applicable to any system, three basic steps need to be followed:

- **Step 1. Determine the basic external design pressure for project location and geometry. This step involves** considering basic project variables such as building location, building importance level, type of terrain, and building height. In addition, factors like topography, wind directionality, and shielding will affect basic design pressure.
- **Step 2. Determine how the basic external design pressure gets into the building.** This step considers the facade type, openings, and permeability of the structure.
- **Step 3. Determine how the now 'internal' pressure acts 'across' a framing system such as a wall or ceiling.** Steps 2 and 3 depend on a variety of factors, including whether the facade is a fully sealed curtain wall system, has large operable openings, or is somewhere in the middle. Other relevant considerations include whether the wall or ceiling system being considered provides a pressure seal between two spaces, and whether it is a single stud or discontinuous construction.

IMPACT OF THE REVISED WIND CODE

Note: Below, we discuss several important changes in the Wind Code that are relevant to Steps 1 to 3 of the general methodology outlined in the previous section. This is not intended to be a comprehensive list of all relevant changes. For more information on all the relevant factors in calculating external and internal design pressures, refer directly to AS/NZS 1170.2.

Step 1. Determining basic external design pressure.

Building location

Certain wind regions across Australia and New Zealand experience stronger winds than others, and this information is used to determine a site's wind speed and basic external design pressure. The revised Wind Code includes new region maps that will impact this calculation. Some of the key changes include the following:

- Central Australia is now covered by the new Wind Region AO and Terrain Category 2 instead of Wind Region A4;
- Melbourne no longer has its own region;
- Wind Region A1, which covered most of the south coast of Australia, has been divided into Regions A1 and A5;
- Tasmania is now classified under Wind Region A4;
- Wind Region B, which covered Northern New South Wales, Gold Coast, Sunshine Coast, and Gladstone, has been divided into Region B1 and Region B2; and
- Wind Region B1 now encompasses more inland cities around the Brisbane area.

Terrain Category

Terrain Category is used in AS/NZS 1170.2 to describe how exposed a site is to wind—the higher the category number (from 1 to 4), the lower the final design pressure. The smoothness of the approaching terrain determines how much wind is disturbed before it contacts the building. Smoother terrain results in less wind disturbance, which, in turn, results in higher design pressures.

Under the revised Wind Code, the main changes to Terrain Categories are:

- Terrain Category 2.5 has been added, and Terrain Category 1.5 has been removed;
- buildings in areas with few to no trees, such as industrial parks, can now be classified as Terrain Category 2.5; and
- linear interpolation is permitted for Wind Regions C and D based on distance from the coastline.

Climate change multiplier

The revised Wind Code adds a new factor that will increase wind pressures in areas that are going to be greatly impacted by climate change. For cyclonic regions, the previous standard included Uncertainty factors Fc and Fd to account for extreme weather. With extreme weather becoming more frequent, a Climate Change Multiplication Factor (Mc) has been introduced in Clause 3.4 to replace the Uncertainty factors for all regions.

Steps 2 and 3. Determining internal design pressures.

The design and construction of the building facade control how the basic external design pressure enters the structure. For example, if the building has curtain wall glazing, which effectively seals the structure, internal pressures can only originate from facade leakage. Large openings in the facade, such as sliding doors for open balconies, will allow more pressure into the building when the doors are open.

Once inside the building, wind pressure acts across building elements such as interior walls and ceilings. Different types of internal walls are subject to different design pressures. For example, a fire-rated wall that forms a pressure seal is subject to generally higher design pressures than a wall that does not form a pressure seal.

Internal pressure coefficient

Internal pressure coefficient (Cp,i) refers to the pressure inside a building. The revised Wind Code introduces a new factor that will adjust Cp,i for buildings with “dominant” wall openings based on the internal volume exposed to that opening.

Where buildings have a ratio of openings on one surface to the total open area on the roof or other wall surfaces greater than or equal to 2, the calculation of Cp,i includes the multipliers, Ka (area reduction factor) and Kl (local pressure factor). See Table 5.1(B) of AS/NZS 1170.2, reproduced below.

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.

NOTE 2 K_a is the area reduction factor related to the total area of the opening(s), A, on the surface under consideration treating the “tributary area” as the area of the opening. See Clause 5.4.2.

NOTE 3 K_ℓ is the local pressure factor, based on the area and location of the opening on the surface under consideration, treating the “Area, A” as the area of the opening. See Clause 5.4.4.

NOTE 4 Surfaces with openings have a ratio of total open area, A, to the total area of that surface related to the internal volume (Vol) under consideration, greater than 0.5 %.

Calculation of Cp,i for all structural elements (cladding and non-cladding) must consider situations where Kl is greater than 1.0. Clause 5.4.4 of AS/NZS 1170.2 sets out the calculation procedure for getting the Kl in such cases.

Area reduction factor

Previously only applied to roofs and side walls perpendicular to the direction of wind, area reduction factor (Ka) can now be applied to windward and leeward walls. See Table 5.4 of AS/NZS 1170.2 below.

Volume factor

Volume factor (Kv) is a new addition in the revised Wind Code that is intended to modify Cp,i for structures with dominant wall openings based on the internal volume exposed to that opening. The factor Kv can act to reduce or increase Cshp (aerodynamic shape factor) depending on the area of the opening and the internal volume of the building when the largest opening in a building is on a wall and the open area is greater than the sum of the total open area on the roof or other wall surfaces by a factor of six or more. Clause 5.3.4 of AS/NZS 1170.2 provides the equation for Kv.

Action Combination Factor

The effect of the wind load acting simultaneously on different surfaces, such as walls, roofs, and internal pressures, is calculated using action combination factors (Kc). In the revised Wind Code, under Clause 5.4.3, internal surfaces are no longer considered effective if |Cp,i| < 0.4, which is an increase from |Cp,i| < 0.2.

Table 5.4 — Area reduction factor (K_a)

Tributary area (A), m^2	Roofs and side walls (K_a)	Windward walls (K_a) $h < 25$ m	Leeward walls (K_a) $h < 25$ m
≤ 10	1.0	1.0	1.0
25	0.9	0.95	1.0
≥ 100	0.8	0.9	0.95

5.3.4 Open area/volume factor, K_v

When the largest opening in a building is on a wall, and the open area is greater than the sum of the total open area on the roof and other wall surfaces by a factor of six or more, then the following Equation 5.3(1) applies:

$$K_v = 1.01 + 0.15\left[\log_{10}\left(100\frac{A^{3/2}}{Vol}\right)\right] \text{ for } 0.09 \le \left(100\frac{A^{3/2}}{Vol}\right) \le 3 \qquad 5.3(1)$$

$$K_v = 0.85, \text{ for } \left(100\frac{A^{3/2}}{Vol}\right) < 0.09$$

$$K_v = 1.085, \text{ for } \left(100\frac{A^{3/2}}{Vol}\right) > 3$$

where A is the open area on the wall and Vol is the internal volume.

For all other cases, K_v shall be taken as 1.0.

NOTE 1 Openings on side walls exposed to relatively small volumes (e.g. partially enclosed balconies on high-rise buildings) may generate significant cavity pressure oscillations.

NOTE 2 Internal volume means the volume of the enclosed space exposed to the opening.

The revised Wind Code introduces a new factor that will adjust Cp,i for buildings with “dominant” wall openings based on the internal volume exposed to that opening.

MEET WALL AND CEILING DESIGN CHALLENGES

HOW RONDO CAN HELP

To ensure they use the correct internal pressures, Rondo customises wall and ceiling designs every single time. From the beginning concepts through to construction, the Rondo team ensures their designs are code compliant from the start. They either confirm the pressure provided on the project engineering documents before starting, or one of Rondo’s professional qualified engineers calculate it as part of their complimentary design service.

Design pressures differ depending on the project. Rondo strongly believes in developing and designing customised and compliant solutions using the correct internal pressures. This tailored approach contributes to compliance and protects the safety of occupants and the reputation of all parties involved in the project. It also avoids years of rework costs, liquidation damages and rebuilding of reputations if a failure occurs.

With their state-of-the-art wall and ceilings systems, Rondo can help you navigate the changes in AS/NZS 1170.2. Contact their technical support team for advice on how to meet the new requirements at https://www.rondo.com.au/support/product-support/technical-support.

HOW CSR GYPROCK CAN HELP

After the calculation of the internal wind pressures and completion of the wall and ceiling framing designs by Rondo, CSR Gyprock can then assist with the selection and fastener requirements of the internal linings.

Increased internal wind pressures can see reduced spanning capacities and decreased fastener spacings for internal linings. CSR Gyprock can assist with the nomination of relevant framing spacing and fixing requirements for the internal linings to suit the internal wind pressures.

CSR Gyprock is Australia’s leading manufacturer of gypsum-based products such as plasterboard and cornice, as well as compounds, adhesives, specialty plasters and associated finishing materials and accessories. Visit their website at https://www.gyprock.com.au.

All information provided correct as of September 2023