WIND PRESSURE 101

You could be forgiven for getting the wind up about wind speeds, pressures and zones, but don't worry. Here, we go back to basics to explain how they relate to one another.

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A question that is frequently asked throughout the industry is, 'How do the wind speeds of NZS 3604:1999 *Timber framed buildings* relate to wind pressures?', in particular, the 2.5 kPa for claddings used in many BRANZ Appraisals and in the New Zealand Building Code E2/VM1.

Site wind speed

First, it's important to remember that the wind speeds in NZS 3604 (on which the zones are based) are site wind speeds. They are based on meteorological data, collected from a long series of readings of gust wind speeds. Site wind speed relates to an open site (such as an airfield) at a standard height of 10 m above ground.

These regional wind speeds are then adjusted for local effects such as ground roughness and topographical features that are specific to the site under consideration.

The procedure for doing this, which is given in Section 5 of NZS 3604:1999 *Timber framed buildings*, is a simplified version of the one in the loading standard (currently NZS 4203, but soon to be updated to AS/NZS 1170.2).

So the site wind speed is our best estimate of the maximum likely gust wind speed at the site 'as if no building was present'. The wind maps used by many local authorities indicate site wind speeds/zones at a fairly coarse level of detail.

Pressure and speed relationship

The dynamic pressure associated with the wind flow is related to its kinetic energy, so the basic pressure is proportional to the square of the speed. The formula used is pressure = 0.6 x speed^2.

A Pitot tube is used to measure dynamic pressure directly (see Figure 1).

The relationship between the NZS 3604 wind zones, site wind speeds and basic pressures, along with more widely used descriptions, is shown in Table 1. Note that the Metservice descriptions and the Beaufort scale are based on 10-minute average wind speeds, whereas site wind speeds are from 3-second gusts – an increase of about 150%.

Wind flow over bulidings

Once a building is erected on the site, the wind flow is altered in quite complex ways. Put simply, the flow speeds up as it passes over and round the building, and openings and small gaps in the cladding allow limited wind movements inside the building. The accelerated flow over the building causes lower local pressures. This provides the same effect as the 'lift' that allows aeroplanes to fly.

Because the approaching wind flow fluctuates highly and contains eddies, and because most buildings have sharp edges, turbulence and vortexes play a significant role (see Figure 2). These effects are concentrated at edges and corners, and around obstructions such as chimneys or appendages. This frequently results in roof cladding peeling from edges of roofs and tiles coming away from ridges or verges.

Wind flow around and through buildings is not easily predicted by calculation. As a result, most of the data currently available comes from wind tunnel testing, calibrated against in situ pressure measurements on test buildings. For many common building shapes, these test results have been simplified into pressure coefficients, which are listed in the loading standard. Careful interpretation of these is required to come up with realistic design values for any specific project.

Table 1: The relationship between NZS 3604 wind zones, site wind speeds and basic pressures.

Zone	Site wind speed		Basic pressure (kPa)	Metservice description	Beaufort scale
	(m/s)	(km/h)			
Low	32	115	0.61	Strong gale	9
Medium	37	133	0.82	Storm	10
High	44	158	1.16	Violent storm	11
Very high	50	180	1.50	Category 1 hurricane	12

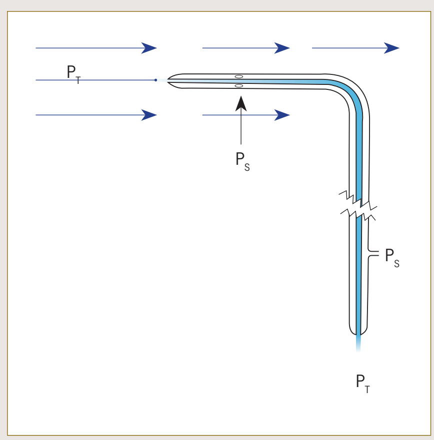

Figure 1: Pitot tube used to measure pressure directly.

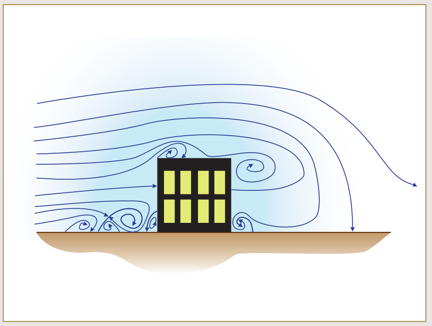

Figure 2: Wind flow over buildings.

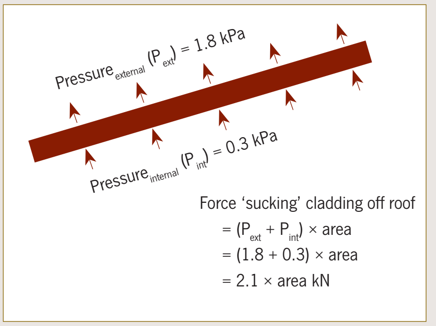

Figure 3: Force on an area of roof.

Force on building components

The total force on the building is the result of the pressures acting on the upwind and downwind faces (remembering that the wind may blow from any direction). This is what creates the bracing demands in Section 5 of NZS 3604.

The force on a building component is the result of the differential air pressures acting on each of its faces, multiplied by the area exposed to the wind. For example, in the case of a window or a structural member, the force is based on the differential pressure between the inside and outside faces (see Figure 3). For a cladding component, it will often be the exterior pressure alone, as the internal pressure may be resisted by the interior lining.

Because the scope of buildings within NZS 3604 is limited (for example, a maximum height of 10 m), it is possible to estimate a maximum likely value of the differential pressure. For cladding, this is 2.5 kPa. The loading standard and NZS 3604 give cladding design pressures assumed to be constant in the bands shown in Figure 4.

Sites with higher wind speeds and buildings greater in size than NZS 3604 or E2/VM1 will experience much higher pressures than these (up to 5 kPa in extreme cases). This is the realm of specific design.

For the technically minded

Pressures quoted in this context are all relative to atmospheric pressure (approximately 114 kPa, depending on the weather and altitude). This is the p_s in the picture of the Pitot tube (see Figure 1) . A 'suction' is a pressure lower than atmospheric pressure.

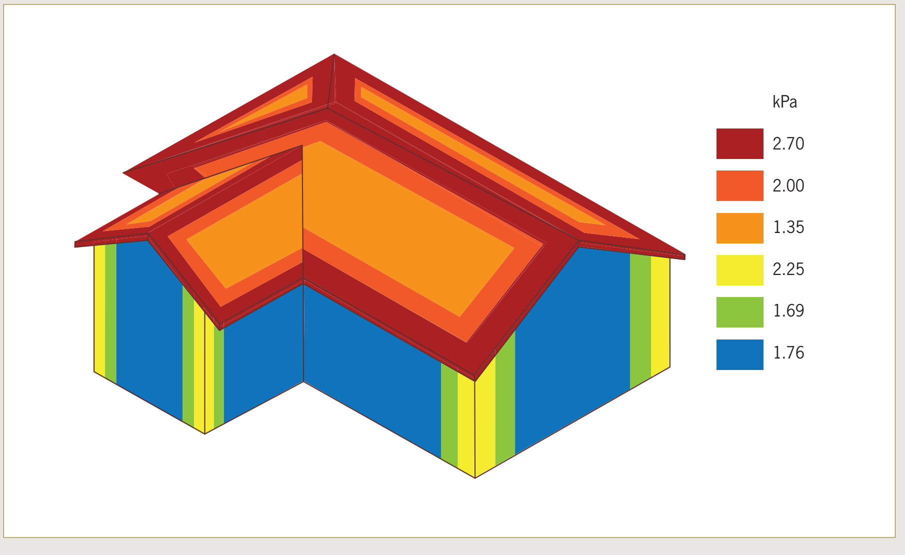

Figure 4: Cladding design pressures. Where roof pitch is less than 10°, there is no increase for ridge and hips.