BRANZ

ISSUE 620 BULLETIN

MANAGING WIND EFFECTS AROUND BUILDINGS

April 2018

- Reducing the impact of wind at a site improves the micro-climate around the building, reduces wind loads on the structure, improves energy efficiency by reducing heating demands and gives an improved, safer living environment.
- Wind impact can be reduced by the siting, layout and shape of buildings, planting, fences and screens and reshaping of land forms.
- This bulletin replaces Bulletin 321 *Reducing the impact of wind at building sites.*

1. INTRODUCTION

1.0.1 The elements of landscape, site layout and built form all combine to create the environment in which we live. The climatic conditions and nature of landforms in New Zealand make wind one of the significant environmental factors to be considered. Careful planning can provide protection from the less-desirable effects of wind but can also enhance the positive effects such as passive cooling breezes around and through a building.

1.0.2 Good design should result in an energy-efficient building that responds in a meaningful way to the natural environment. In many cases, the consideration of wind effects and detailed landscape design is left until the end of a building project, but at this stage, the project budget is often stretched. Thorough site analysis (wind directions, sun and topography) and landscape design should be considered at the commencement of a building project and not left until it is finished.

1.0.3 In most cases, reducing the wind on a site results in:

- an improved micro-climate and amenity (usable sheltered spaces) around the building
- increased energy efficiency of buildings by lowering heating demands – wind can be deflected to reduce wind chill in winter and increase cooling breezes in summer
- reduced wind loads on the structure
- reduced impact of rain on buildings for improved weathertightness
- lower noise levels
- increased property value.

1.0.4 This bulletin describes how wind behaves and discusses ways in which both the positive and negative effects of wind can be managed in site planning.

1.0.5 This bulletin replaces Bulletin 321 *Reducing the impact of wind at building sites*.

2. THE NATURE OF AIRFLOWS

2.1 WIND VELOCITY

2.1.1 Friction causes air speed to be reduced near the surface of the ground. Rougher ground surfaces, buildings and trees increase the surface resistance and reduce the speed of the wind close to the ground.

2.1.2 The effect of the surface roughness on wind speed reduces as the height above the ground increases. Wind speed is reduced where building development is more intense or there is significant mature vegetation. As a rule of thumb, for a wind speed of x m/sec measured 10 m above the ground, the speeds would be:

- 0.75x over scattered trees and hedges
- 0.67x over well forested areas with occasional buildings or a leafy suburb on rolling land
- 0.50x over city centres.

2.1.3 Wind speed is increased when air movement is restricted by an object in its path, channelled through a narrow gap or compressed by surrounding landforms such as valley sides and rising ground. The increase in wind speed caused by some form of constriction is known as the Venturi effect.

2.1.4 Rising ground increases wind speed close to the ground surface. At the top of a steep slope, the wind speed can be increased by up to 170% (Figures 1–2).

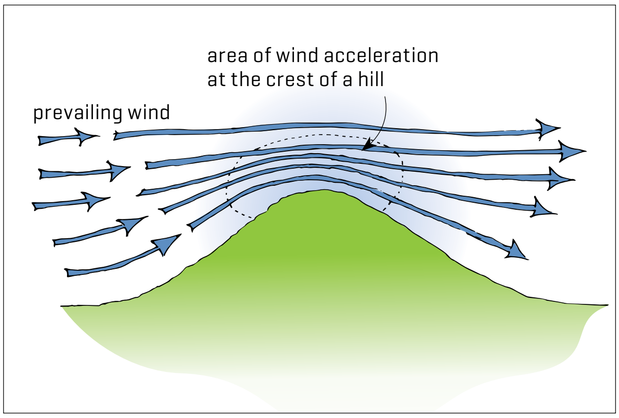

Figure 1. Wind speed over a hill.

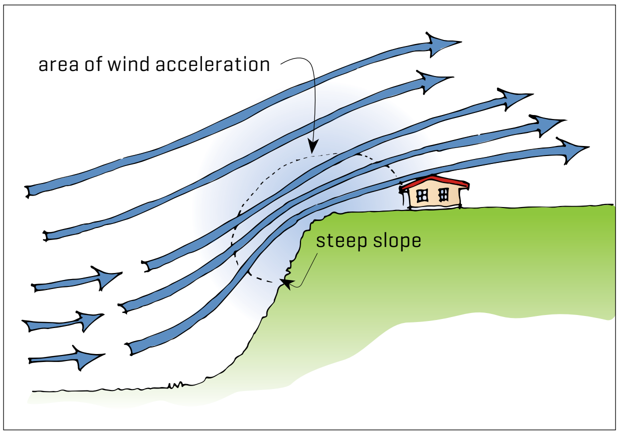

Figure 2. Wind speed over an escarpment. (An escarpment is a slope of 35% (19˚ or 1 in 3) or steeper over a vertical distance of 6 metres or more that separates two more gently sloping or flat areas.)

2.1.5 A building site that is close to a large expanse of water (lake or sea) will also be subjected to afternoon onshore breezes. During the day, the land mass will be heated by solar gain, which causes the warmer air over the land to rise. The cooler air over an adjoining expanse of water flows in to the lower pressure over the land mass. This results in offshore breezes, which can either be deflected or used to advantage for cooling.

2.1.6 Wind speed over open water can be increased by up to 200%. In coastal areas, windblown salt spray can also burn leaves and limit growth of plants so wind is also an important consideration when selecting planting.

2.1.7 Wind speeds that are comfortable and safe for people are those below 5 m/sec (below 18 km/hr) for most of the time. In wind of 5–8 m/sec (18–30 km/hr), dust and debris is blown about.

2.1.8 It is important to consider not just the mean wind speed but also the peak gust wind speed.

2.2 WIND PRESSURE AND DENSITY

2.2.1 Wind is the effect of air moving from an area of high pressure to one of low pressure. Wind moves from positive pressure on the windward side of a structure to a negative pressure area (a suction zone) on the leeward side. (See BRANZ Bulletin 563 *Building on exposed sites* for a more detailed discussion of the effects of wind on buildings.)

2.2.2 Air movement by convection is a product of the temperature and density of the air. Air density decreases as altitude increases and also changes with variation in temperature and humidity. Air moving from a forested area to open ground or a paved roadway, for example, will rise because it is more exposed to the sun. This makes that air warmer, less dense and more buoyant.

2.2.3 In mountain areas, as the sun warms the air in valleys during the day, it becomes less dense and moves upwards to the head of the valley. At night, air flows back down the valley as it cools and becomes heavier.

2.3 WIND AND TEMPERATURE

2.3.1 Changes in wind speed can have a marked effect on how people perceive temperature. In windless conditions, the minimum desirable comfortable temperature is about 12°C. For a wind speed of 6 m/sec, the comfortable temperature is 15.5°C. A constant temperature of 12°C would feel like 9.5°C in a 4 m/sec wind and 8°C in a 6 m/sec wind.

2.3.2 Winds generated from the south are generally colder than winds from other directions, and the stronger a wind is, the colder it generally feels.

3. SITE ANALYSIS

3.1 GENERAL WIND INFORMATION

3.1.1 In the process of site analysis, two aspects of wind direction that need to be considered are the prevailing wind direction and the frequency and direction of the strongest winds.

3.1.2 NZS 3604:2011 *Timber-framed buildings* divides New Zealand into two wind regions (A and W) and several lee zone areas. These are areas where the landforms create localised wind acceleration resulting in higher wind speeds than the rest of the region.

3.1.3 NZS 3604:2011 classifies wind zones into categories according to maximum wind speeds:

- Low (L) – below 32 m/s
- Medium (M) – 37 m/s
- High (H) – 44 m/s
- Very high (VH) – 50 m/s
- Extra high (EH) – 55 m/s
- Specific design (SD) – over 55 m/s.

3.1.4 Table 5.1 in NZS 3604:2011 describes a method for determining wind zones for a specific site. The procedure is summarised with examples in *Build* article 'Wind zones and NZS 3604' (*Build* 128, pages 24–25). BRANZ Maps also provides information on wind zones and more. This will influence the building design and construction specification of a building.

3.2 LOCAL TOPOGRAPHY AND WIND

3.2.1 While not site specific, a wind rose diagram (Figure 3) gives background and is a useful way to visualise local wind patterns. The diagram shows the frequency and speed of wind blowing from each direction. However, wind patterns measured at a specific site can be very different from other sites nearby.

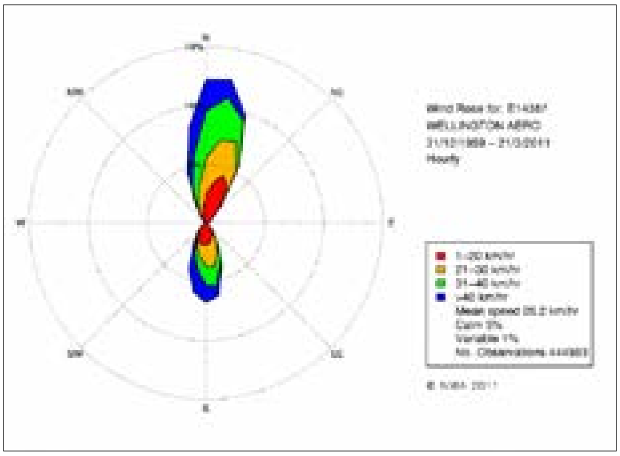

Figure 3. Wind rose (direction, strength and frequency) diagram for Kelburn, Wellington, which shows that strong winds generally blow in a northwest to north or southerly direction. (Source: NIWA.)

3.2.2 NZS 3604:2011 describes the conditions that must be considered when evaluating wind speed for a site:

- Ground roughness – urban terrain, open terrain.
- Site exposure – sheltered, exposed.
- Topographic class – ground heights and gradients.

3.2.3 Surrounding natural landforms and local built development can have a major impact on wind:

- Sites at the top of a ridge or at the head of a valley facing into the prevailing wind will be windier.
- Elevated sites are subjected to a greater frequency of windy days.
- Sites on the edge of a built-up area or adjacent to a large open area (playing fields or farmland) can expect to be subjected to higher winds.
- Sites in a depression are usually more sheltered.
- Wind speeds will be higher in areas of new greenfield building development because of the scarcity of buildings, fences and planting. Wind speeds can be expected to moderate with further local building development.
- Wind can be funnelled up valleys, between adjacent buildings, through gaps in planting or fencing or between a building and a fence or planting.

3.2.4 The shape of existing vegetation (such as stunted tree and shrub growth) can give a clue or will identify the major wind directions and give some indication of the wind strength.

3.2.5 The possibility of existing shelter from vegetation or landforms surrounding the site being removed or

Coastal vegetation sculptured by strong prevailing winds.

modified if further development occurs must also be considered. Planning maps should be consulted to provide a guide to the type of future development permitted for the area. If time allows, visit the area during a variety of seasons and weather conditions.

4. SITE PLANNING

4.0.1 When site planning for groups of buildings (such as in a new subdivision), the effects of wind can be controlled or mitigated in various ways (Figure 4):

- Providing shelter to the buildings on the edges of the development and to areas where acceleration of wind may occur.
- Creating sheltered zones within a subdivision.
- Arranging the buildings in an irregular pattern to remove direct wind paths. This site planning method increases the ground roughness (due to each building providing its own shelter and the complexity of the layout) and contributes to lower wind speeds.
- On sites where the wind always comes from one direction and on very exposed sites, arranging buildings in a line along the wind direction so that each building shelters the one in its lee. This method can successfully improve shelter provided that the first house is protected by a suitable windbreak.
- Arranging buildings with the minimum possible area facing into the wind (i.e. with the longest dimension of the building along the predominant wind direction).
- Modulating the façades of buildings to create drag and to create courtyard recesses that are protected from wind.
- Keeping building heights relatively uniform so that wind flow over the top is uninterrupted. Abrupt differences in the height of structures can result in strong local downdraughts.
- Maintaining distances between buildings in the range of 1.5–2.5 times the overall building height. Avoid small gaps that can act as wind funnels, or if the gaps cannot be avoided, provide wind barriers by way of planting or structures.
- Maintaining the ground roughness character of open spaces in the built-up area through the use of landscaping.
- Avoiding long, wide and straight streets.

Figure 4. Site planning to reduce wind effects. Screens can manage wind and provide sheltered outdoor living environments.

5. BUILDING DESIGN

5.0.1 The shape of buildings and their placement both affect wind patterns. With careful planning, it is possible to create small micro-climate zones that protect outdoor living spaces and provide comfortable shelter for building users for an improved environment with minimal additional cost.

5.0.2 Buildings should be designed to minimise the disturbance of wind flow patterns near the ground. This can be done by aiming for a uniform surface roughness, avoiding features that create localised wind acceleration and downdraughts and providing shelter at areas of localised wind acceleration.

5.0.3 When designing a new building, the effect of wind can be moderated by:

- locating the building below the ridgeline or back from the edge of an escarpment or bank (Figure 5)
- keeping the height of the building as low as possible
- stepping back façades as the building rises and using verandas to reduce the effect of downdraughts at ground level
- avoiding flat and low-pitched roofs, especially in low-rise construction as they may increase leeward turbulence
- using hip roofs in preference to gable roofs
- providing windbreaks to reduce wind speed around exposed corners
- introducing roof canopies, enclosed walkways and verandas to provide shelter
- creating sheltered recesses or courtyards.

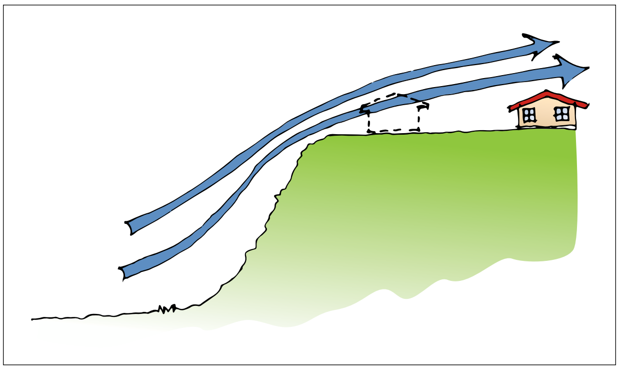

Figure 5. Locating the building back from the edge of a slope.

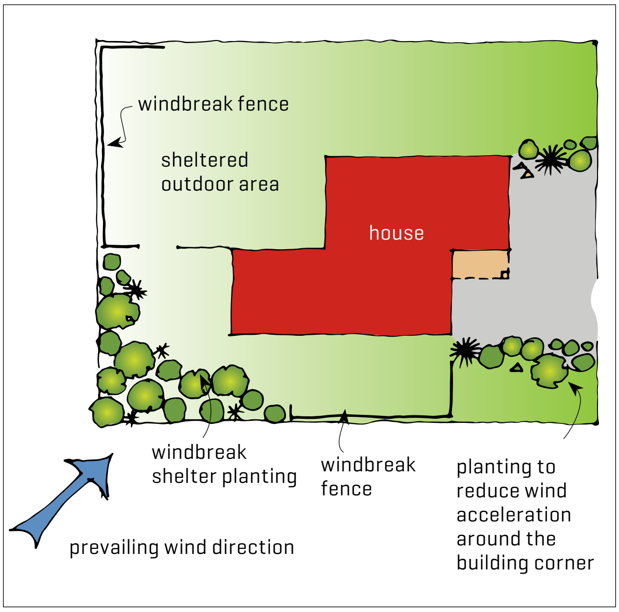

Figure 6. Fences and planting to provide leeward shelter.

6. FENCING

6.0.1 Fences and screens provide the simplest and most immediate form of shelter, either as a permanent solution or as temporary or permanent protection for planting (Figure 6).

6.0.2 An impermeable solid barrier that completely blocks the wind will provide limited protection immediately adjacent to the fence but will also result in downwind turbulence (Figure 7). Angling the top of a fence or installing a strip of lattice across the top of the fence can reduce the turbulence (Figure 8).

6.0.3 A permeable or porous fence can reduce wind speed. For maximum shelter, a fence should have about 40–50% of its face area open and be constructed with gaps, fewer at the base and increasing with height (Figure 9). Such a fence should provide a sheltered lee area with a width of four to five times the fence height.

6.0.4 A fence constructed of planking or palings as shown in Figure 10 diffuses the wind as it passes through the fence. Even where a fence may have more than 50% permeability, the effect of draughts is minimised because the wind cannot pass directly through the gaps.

6.0.5 Lattice or trellis fences typically have an even distribution of gaps to moderate air flow. They are usually constructed with uniform spacing in both directions and therefore are not increasingly permeability towards the

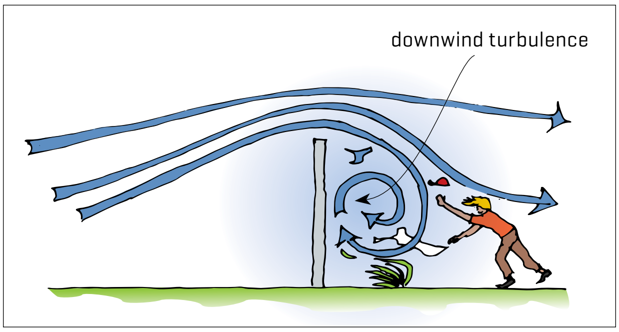

Figure 7. Solid fence.

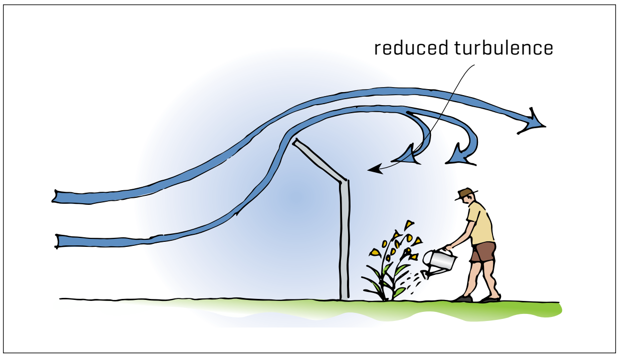

Figure 8. Angled top of fence.

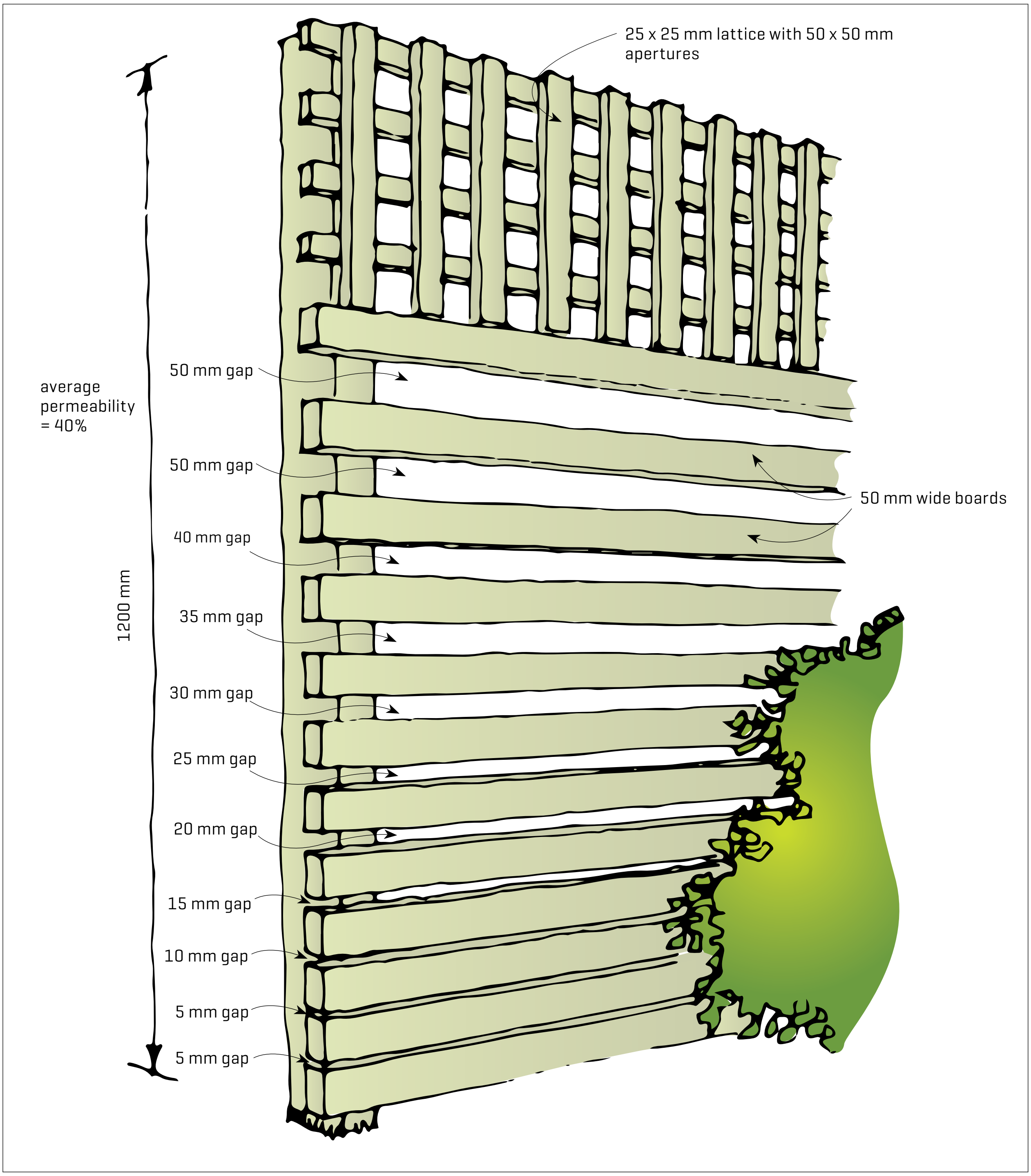

Figure 9. Fencing designed for maximum shelter.

top of the trellis as recommended in 6.0.3. Depending on the size of the slat and gap, the approximate permeability of lattice fences are:

- 20 mm lattice with 20 mm apertures – 23%
- 50 mm lattice with 50 mm apertures – 25%
- 25 mm lattice with 50 mm apertures – 42%.

6.0.6 Paling or board fences provide greater protection from the wind when the gaps and palings are narrower and of similar sizes. Where wide palings are used, the wind passing through the gaps will be more noticeable. Where the screen is used as a barrier to protect from falling, the maximum gap between horizontal slats is 15 mm to comply with F4/AS1.

A timber batten fence forms a sheltered entry on a windy street corner.

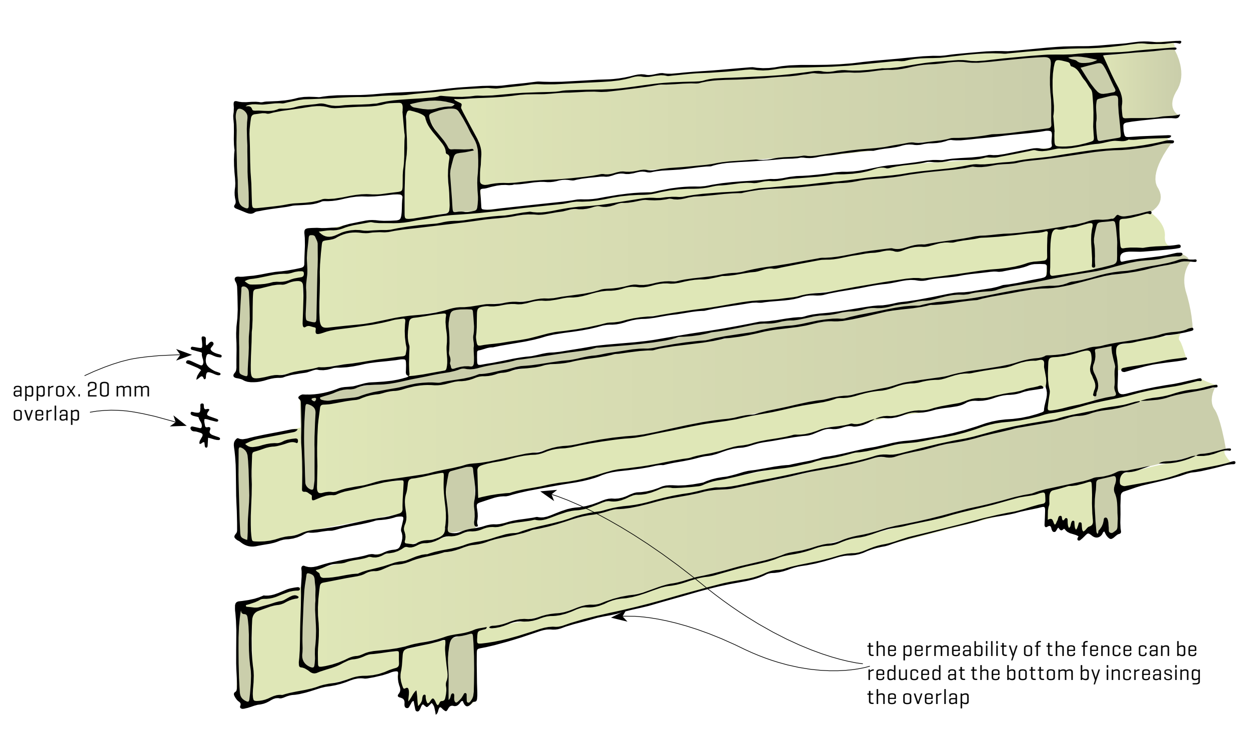

Figure 10. Alternative fence design.

6.0.7 Windbreak fabrics can be fixed over wire or timber fences to provide additional wind protection.

7. PLANTING

7.0.1 Planting design with careful selection, placement and maintenance can provide excellent wind protection. When selecting and locating shelter plants, consider that they may also result in negative shading effects.

7.1 SELECTION AND PLACEMENT OF PLANTS

7.1.1 A common (and wasteful) mistake in planting design is to specify plant materials that have little or no chance of surviving in a particularly windy environment. Many local authorities publish lists of recommended trees and shrubs that are suitable for a specific region. There is also an abundance of useful information online.

7.1.2 Some factors to consider when specifying plants for wind design include:

- native versus exotic plants
- plant wind resistance/hardiness
- density and texture of foliage – shrub plantings should be of mixed species to give height and density variations
- deciduous versus evergreen trees and shrubs – deciduous trees will provide less protection from the colder winter winds but may be used to advantage to admit maximum sun.
- plant small-grade plants (with some shelter) that will establish more quickly and grow together to form a sheltering mass. Large-grade plants can fail if they are not hardened to the local conditions or don't get a chance to establish before being hit by strong winds.

7.1.3 Using trees and shrubs in close proximity to buildings (particularly around subfloor areas) is a good strategy to deflect wind or reduce wind speed and so help with thermal performance of buildings. However, it's best to keep planting at least 1 metre from any building, and any planting close to buildings may need to be kept low where appropriate to admit sun (especially in winter).

7.1.4 An obvious disadvantage of using planting for wind protection is that trees and shrubs may take several years to develop into an effective screen. In many cases, overplanting and/or using a mix of fast-growing species at the initial stage may be a useful method to get planting quickly established. Trees and shrubs can then be selectively phased out as the hardy slower-growing shelter plants develop over successive years.

7.2 SHELTER BELTS AND HEDGES

7.2.1 Shelter belts provide optimum shelter when the average porosity of the belt is about 50–60%, with denser planting over the lower third of the height. Allowing some wind to pass through reduces the amount of turbulence occurring on the lee side (Figure 11). However, large gaps in shelter belts can lead to funnelling of the wind and increased wind speeds. Underplanting between the trees or perimeter low-level planting may be required to fill gaps as the trees grow. Shelter belts should also be positioned to deflect wind rather than dam it (Figure 12). Tall trees planted further apart allows smaller ones to establish between them, but the smaller trees must be tolerant of the conditions that the larger ones create in the long term

7.2.2 Low dense hedges can provide effective shelter for seated people in the lee side while still allowing visual connection to the landscape beyond. Hedges generally

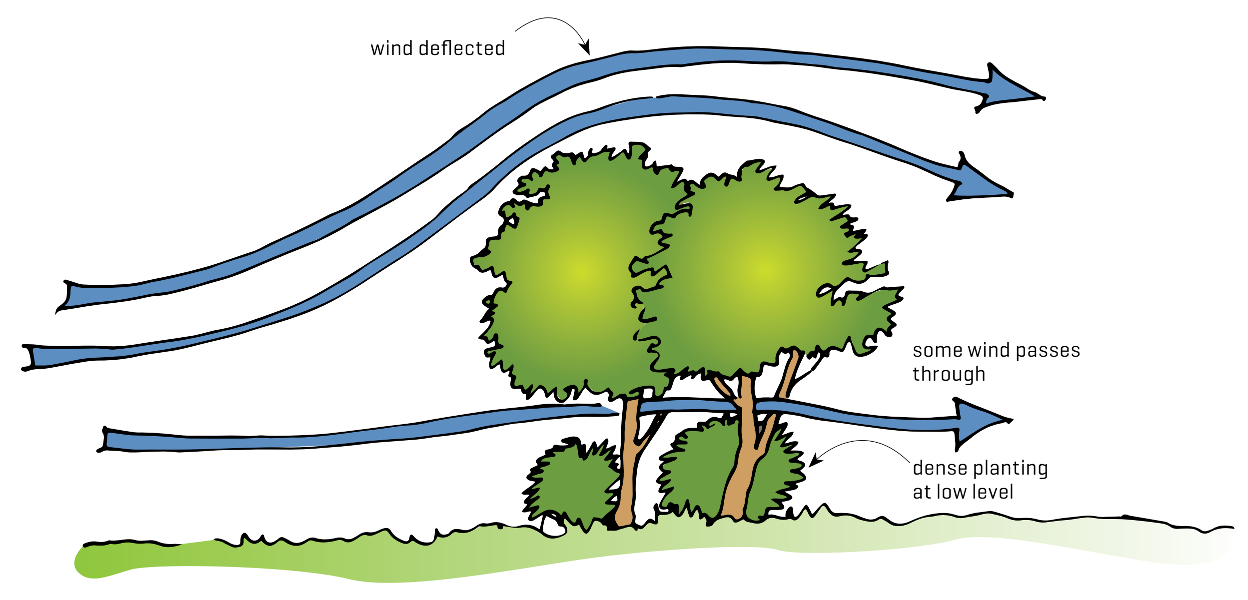

Figure 11. Shelter belt effect on wind. The height of shelter planting needs to be considered so that it does not create a shading issue, but that might be a positive if deciduous trees give summer shade but allow some winter sun.

perform better when they consist of a single row of plants. They should be trimmed to taper towards the top to allow sunlight to the lower levels and encourage denser foliage at the base. In most cases, frequent pruning to shape will encourage thicker foliage.

7.2.3 Where taller shelter is required (and can be used without causing shading or possible conflict with neighbours), single-row windbreaks using hardier species can be used. It can be difficult to achieve an efficient single-row barrier with mixed species because of differing forms and growth habits. Where space is available, wider multiple row windbreaks allow a greater flexibility of species. Outer rows must be hardy to withstand the wind.

7.2.4 For gardens up to 16 m wide (on the north, east and west sides), the maximum height of the planting should be approximately 40% of the width of the adjacent garden. A shelter belt will perform best if the length of the belt is at least 15 times its height and continuous.

7.2.5 Selection of plant materials should be made to minimise future maintenance, although planting may need to be regularly trimmed to minimise shading and protect outlook. Some form of initial protection may need to be provided (a fence, windbreak cloth) to allow the screen planting to become established.

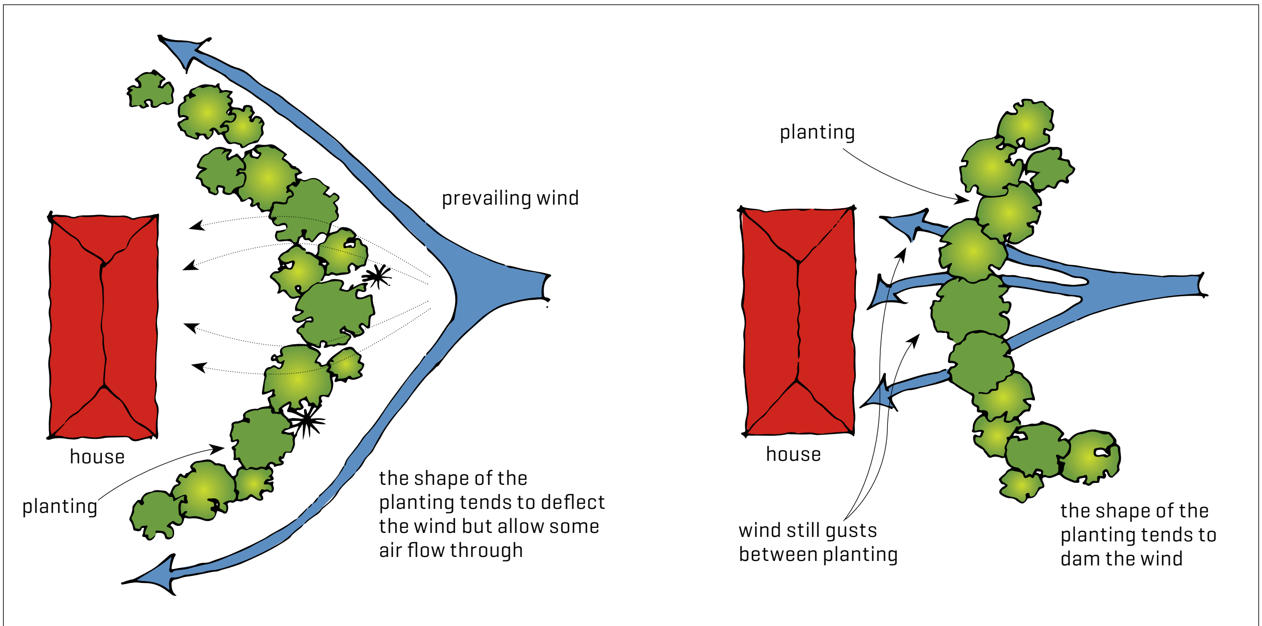

Figure 12. Deflect wind rather than dam it.

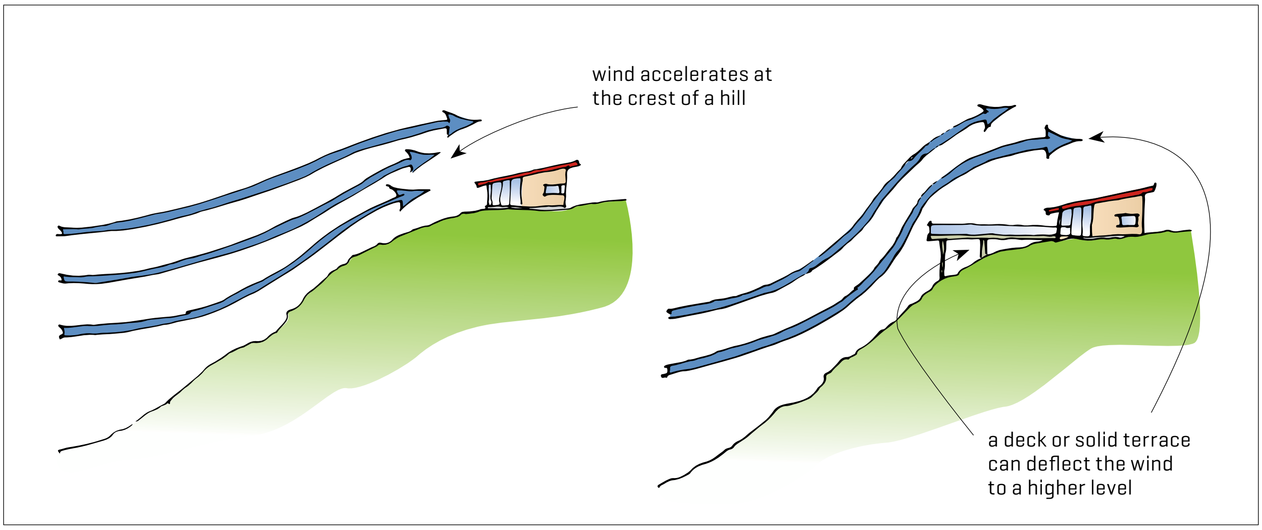

Figure 13. Using a terrace or deck to deflect wind.

8. MODIFYING LANDFORMS

8.0.1 Even relatively small changes in ground contouring can have a significant effect on creating sheltered outdoor living spaces around a building.

8.0.2 The wind effects on a sloping or hilly site can be modified by:

- using a terrace or deck to deflect the wind (Figure 13 – any deck barrier to prevent falling can also deflect wind
- locating the building as far back as possible from the edge of the slope
- excavating into the slope for the house site together with protection from plants and/or fences to provide a sheltered area (Figure 14)
- benching or terracing a slope to form sheltered zones
- constructing low earth mounds with planting of carefully selected plant materials to deflect wind (Figure 15).

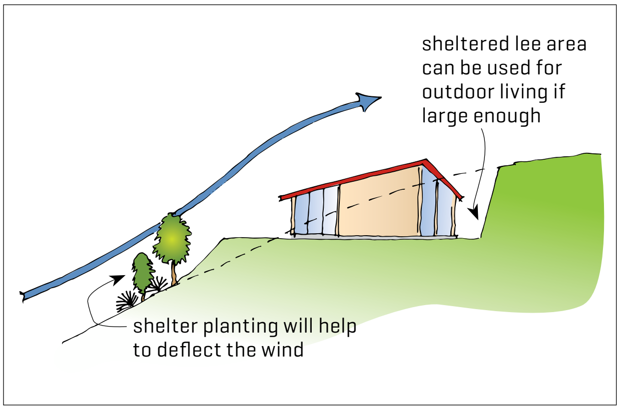

Figure 14. Wind protection by excavating the site.

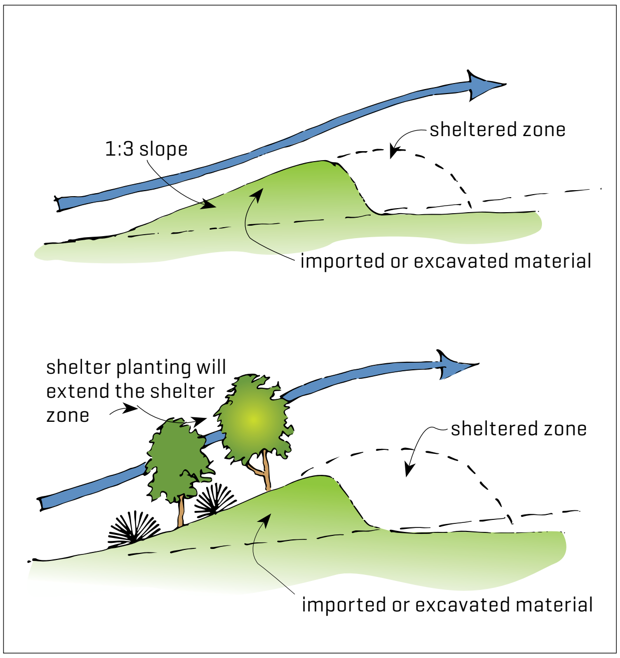

Figure 15. Earth mounding to provide shelter. The imported material can also improve the ground conditions to get the shelter planting established as well as acting as a wind management tool.

9. FURTHER INFORMATION

BRANZ

Landscape Construction (2nd edition)

Wind zones and NZS 3604 (*Build* 128, pages 24–25).

Bulletin 563 *Building on exposed sites*

Bulletin 588 *BRANZ Maps and wind zone calculations*

BRANZ Maps (www.branz.co.nz/branz-maps)

Level – Site Analysis (www.level.org.nz/site-analysis)

OTHER RESOURCES

AS/NZS 1170.2:2011 *Structural design actions – Part 2: Wind actions*

NIWA climate summaries (www.niwa.co.nz/education-and-training/schools/resources/climate/summary)

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