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ISSUE 563 BULLETIN

BUILDING ON EXPOSED SITES

August 2013

- This bulletin outlines some important factors that should be considered when designing and constructing buildings on sites that are exposed to high winds.
- As wind speeds and the loads generated are higher, traditional practices may not be sufficient to prevent a building from structural or envelope damage or leaking.
- This bulletin replaces bulletins 405, 406, 407 and 408.

1.0 INTRODUCTION

1.0.1 Older established city and suburban areas have largely been exhausted of sites that are easily built on. Any remaining potential building sites are likely to be more challenging because of their exposure and topography and, in many cases, may be subject to high wind loads. Such forces are not easy to moderate through planting or shelter structures such as fences.

1.0.2 This bulletin outlines some important factors that should be considered when designing and constructing buildings on sites that are exposed to high winds.

1.0.3 Particular attention must be paid to the building structure and its envelope, fixing of cladding and roofing and the installation of windows and doors to resist wind forces and to keep water out. Many of the principles apply equally to forms of construction other than framed buildings.

1.0.4 This bulletin amalgamates and updates Bulletin 405 *Timber-framed buildings on exposed sites*, Bulletin 406 *Building on the coast*, Bulletin 407 *Walls on exposed sites* and Bulletin 408 *Roofs on exposed sites*.

2.0 THE EFFECT OF HIGH WIND ON BUILDINGS

2.0.1 The biggest factor influencing wind loads is the wind speed (wind pressures are proportional to the wind speed squared).

2.0.2 In strong winds, the building is subjected to frequent and large variations in pressure, either positive or negative (suction), as wind action fluctuates in direction and speed due to gusts and turbulence.

2.0.3 On exposed sites, wind speeds are higher. Therefore, the loads generated are higher, and traditional practices may not be sufficient to prevent a building from structural or envelope damage or leaking due to driving rain.

2.0.4 Wind speed increases:
- when its path is diverted by an object in that path such as a building – a sheltered lee zone may be created behind the object
- when it is channelled through a gap
- when it is compressed by the surrounding landforms, particularly valley sides and rising ground
- across the top of a ridge or escarpment.

2.0.5 Wind speed experienced on a building site is influenced by:
- the surrounding topography such as proximity to hilltops, coastal cliffs or escarpments and location within a valley
- the amount of shelter from surrounding objects such as buildings and trees (although trees may be later removed)
- proximity to major areas of open landscape or water such as coastlines or lake fronts
- proximity to major geographical features such as Cook Strait or lee zones adjacent to upwind mountain ranges.

2.0.6 The effect of wind on a building is also influenced by the:
- height of the building above the ground
- slope and shape of the roof
- orientation of the building to the wind
- area of the building exposed to the wind.

2.0.7 The effects of wind forces on a roof:
- Wind parallel with the ridge (Figure 1) creates uplift, with the greatest uplift forces being generated along the leading edge of the roof.
- Wind across the ridge creates an uplift or suction on the leeward side of the roof and a positive pressure on the windward side of a steeper roof (Figure 2).
- Wind forces are much greater on roof edges and corners.

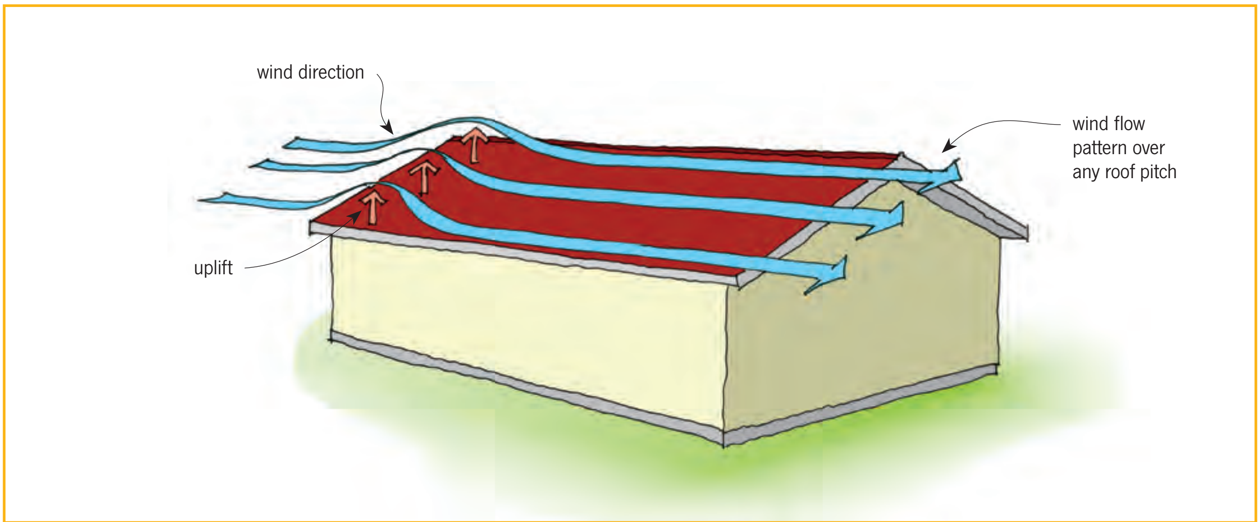

Figure 1. Wind parallel to ridge.

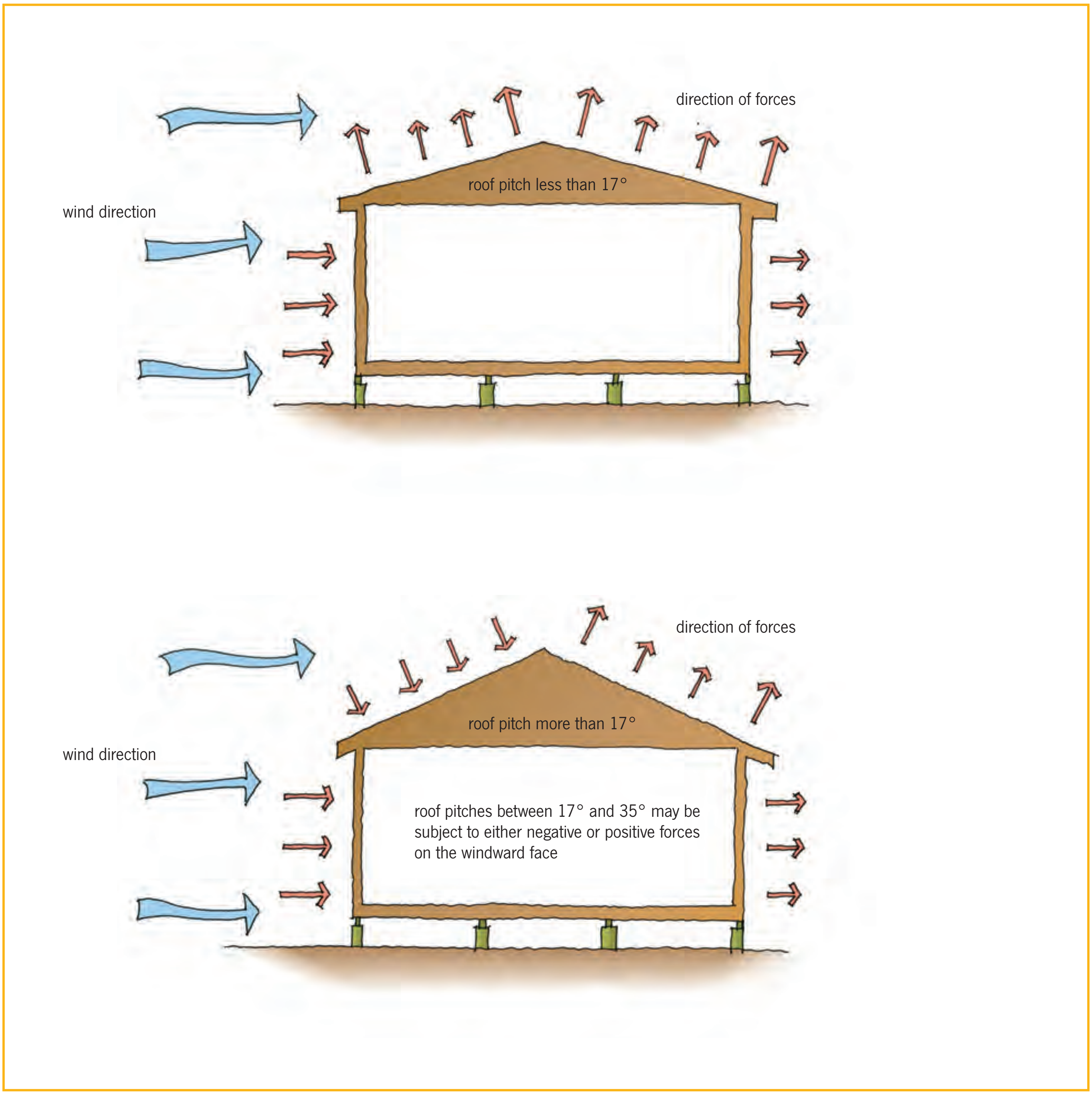

Figure 2. Wind at right angles to ridge.

2.0.8 For walls (Figure 3), wind exerts a:
- positive pressure on the windward face of the building
- negative pressure or suction on the side and leeward faces of the building – suction forces on building corners are likely to be up to twice the pressure acting on the centre of the wall.

2.0.9 The loads acting on a structure may be increased by the resulting increase in internal pressures from wind damage to windows and doors.

2.0.10 High wind forces may:
- overload framing member connections, particularly at critical points such as purlin to rafter/truss, rafter/truss to top plate, top plate to stud, lintels to stud connection, and top and bottom of isolated posts (such as veranda posts)
- create a greater risk of water being driven under flashings, through windward laps in the roofing or back along the underside of the roofing – as wind speeds increase, so should the amount of flashing cover or lap provided and the number or capacity of fixings
- prevent water from draining effectively from lower-pitch roofs
- deform claddings and allow the water to enter
- rack and twist the structure
- overturn tall or lightweight structures and create uplift forces on windward foundations.

2.0.11 Where the wind speeds are greater, they can:
- cause vibrations and noise in flexible elements of the building such as gutters, metal flues and sunshades, flexible wall and roof underlay
- increase the possibility of heat losses and the ventilation rates at vents and opening sashes
- increase the levels of salt deposited on building components for coastal locations.

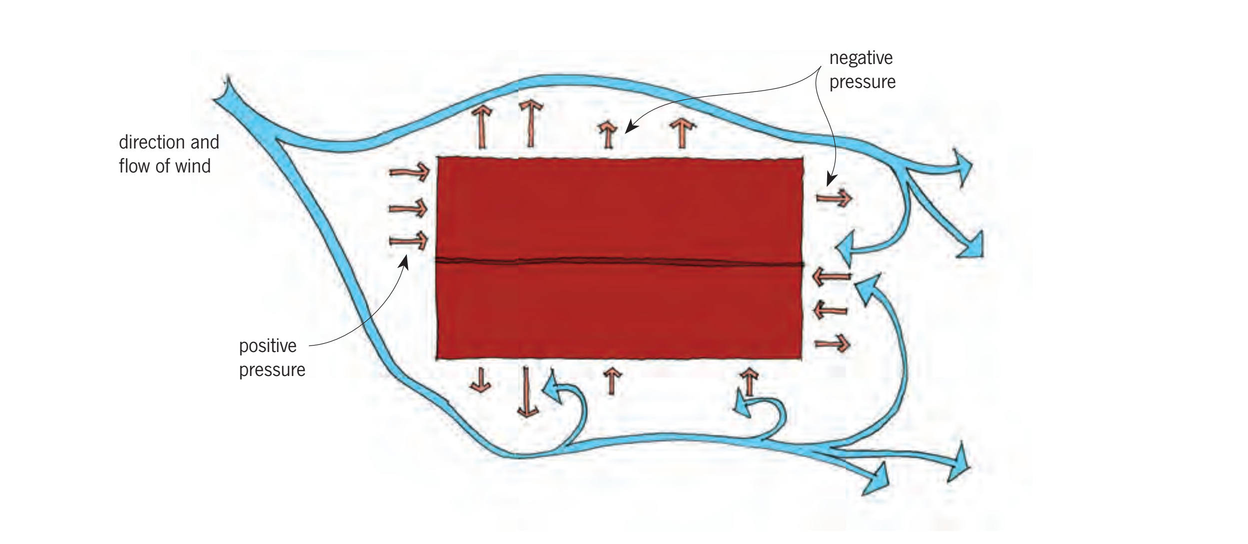

Figure 3. Wind pressure acting on walls.

3.0 DESIGN CONSIDERATIONS

3.1 COLLECTING SITE-SPECIFIC DATA

3.1.1 Before starting the design, it is important to establish the wind zone and the design wind speed the new building will need to be designed to because this will affect the design requirements for:

- the subfloor, wall and roof bracing necessary to resist wind forces
- roof and wall framing sizes/spacing
- fixings to resist uplift or suction on lintels, posts, beams, purlins, rafters, battens, wall cladding and roofing
- the support of and fixing of the cladding
- the weathertightness of the envelope.

3.1.2 Information on site wind conditions can be obtained from:

- the territorial authority (TA), which may have climatic records and be able to identify the site's wind zone – many TA websites include wind zone information on planning maps or webmaps
- visiting the site during severe wind conditions and observing the effects of the wind such as leaning trees, wind-blown dirt and salt spray
- talking to occupants of adjacent existing houses about the wind effects – microclimatic conditions should be taken into account
- using the methods outlined in NZS 3604:2011 *Timber-framed buildings* Section 5
- engaging an engineer to determine site wind speeds using AS/NZS 1170.2:2011 *Structural design actions – Part 2: Wind actions*. (This may result in a less conservative solution than TA wind maps or the use of NZS 3604:2011.)

3.1.3 The site's wind zone depends on the wind region, ground roughness and topography and determines if the building can be designed in accordance with NZS 3604:2011 and E2/AS1 for wind speeds up to 55 m/sec or requires specific engineering design (SED) in accordance with AS/NZS 1170.2:2011.

3.1.4 If SED is necessary, employing a chartered professional structural engineer (CPEng) will give the opportunity for consultation on other structural features that can enhance the building's performance.

3.2 MITIGATING WIND EFFECTS

3.2.1 The effect of strong winds on the building may be moderated at the design stage by:

- avoiding building on the ridge or hill tops
- siting and orienting the building to take advantage of natural shelter
- using heavy wall claddings to reduce noise
- specifying materials and components that will be robust and more easily handled in windy conditions
- avoiding abrupt changes in roof level (split-level roofs), which can produce local areas of high wind uplift
- avoiding features that may trap wind – wide verandas, carports and roof overhangs provide shelter but can be subject to significant uplift
- minimising the height of the building
- developing a building form that minimises the effect on wind flows.

3.2.2 To moderate the environment around the building:

- plan the building to shelter entrances and opening windows
- position quiet rooms such as bedrooms on the sheltered side
- incorporate wind breaks
- provide sheltered outdoor areas or glazed patios
- avoid features that may create noise when windy, such as open pergolas, outriggers and deep eaves
- securely brace and keep as low as practicable elements that could vibrate, such as flues, vent pipes and aerials
- consider the potential for turbulence around dormers and chimneys.

3.3 STRUCTURAL DESIGN

3.3.1 High winds increase loads and movement in the building structure.

Structural design considerations include:

- closing up spacings and increasing sizes of structural members to provide stiffness
- tying down structural members to resist uplift
- ensuring windows and other external components have the appropriate rating for the building wind zone
- increasing the number of cladding fixings to resist suction
- specifying gutters with external brackets
- ensuring bracing is symmetrical across the building
- avoiding complex geometry
- selecting glass (thickness for window size) to accommodate the wind loads
- for profiled metal roofs, incorporating load-spreading washers at fixing points (Figure 4).

3.4 WEATHERTIGHTNESS

3.4.1 Cladding types and flashing details that are satisfactory in sheltered situations may not perform well with higher wind exposure, with large pressure differentials where rain may be driven horizontally or even upwards. However, E2/AS1 cladding details may not be sufficiently robust where wind speeds exceed the extra high wind zone limits.

3.4.2 Factors such as widths of eaves, building complexity and so on can be manipulated early in the design stage to try to achieve the lowest possible E2/AS1 weathertightness risk matrix score.

3.4.3 Principles to minimise the likelihood of cladding leaks on exposed sites include:

- not exceeding the recommended framing spacing for the selected cladding for the wind exposure, as strong wind pressure can deform claddings and allow the water to enter through joints
- incorporating a rigid underlay or proprietary rigid air barrier
- incorporating a drained and vented cavity

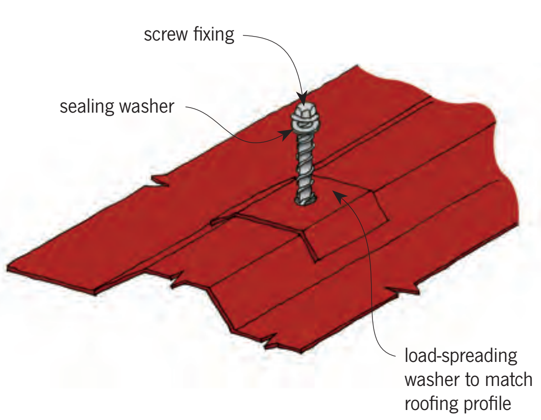

Figure 4. Load-spreading washer to metal roofing.

- incorporating overhangs or verandas to provide a degree of protection to the cladding elements
- avoiding cladding penetrations (overflows, vents) if possible or at least locating them in a sheltered situation plus incorporating flanges/flashings
- increasing flashing dimensions and adding facings, incorporating hooks and hems
- installing back flashings to critical junctions and corners
- not relying solely on sealants to keep out the water
- specifying airtight internal linings (flush-stopping wall or wall/ceiling junctions) will also help reduce airflow and possible water entry through the cladding
- specifying products and systems that have been appraised for weathertightness and structural performance for the wind zone of the site.

3.4.4 For windows and doors in high wind areas:

- select aluminium windows to comply with NZS 4211:2008 *Specification for performance of windows*, tested and certified for wind pressure and air leakage appropriate to the wind zone – the NZS 4211:2008 test for windows applies a steady air pressure difference while, in reality, wind pressures fluctuate as the gust passes and allow drainage to occur, so protection from wind pressure is necessary to limit direct entry of water
- specify head flashings plus jamb and sill flashings as recommended by the cladding/window supplier
- detail additional or wider facings/flanges to claddings
- provide an effective air seal between windows and framing to prevent airflow
- ensure the drain holes are big enough or protected from direct rain wetting, as the wind pressures generated may periodically stop water draining out of window drains and open-draining joints
- avoid low-sloped copings or window sills, as rain may be prevented from draining freely from them
- specify formed hoods over the exterior outlets of condensation drains and offset the exterior drain from the interior inlet point to prevent blowback
- specify windows that incorporate anti-blowback shutters to condensation drains.

3.4.5 For roofs in high wind areas:

- keep roof forms simple
- increase rather than reduce roof slope
- increase flashing cover and upstands
- ensure profiled roofing has stop-ends to the profile trough and downturns at the gutter
- specify gutters with a high front edge to reduce blowback of water under the cladding
- install roof underlay to clay and concrete tile roofs – E2/AS1 requires roof underlays for all concrete tile roofs for sites with very high and extra high wind conditions
- provide sheet sarking to the roof plane
- provide adequate freeboard in gutters – wind-generated waves within a gutter, particularly internal gutters, can cause leaks.

3.5 INSULATION AND VENTILATION

3.5.1 Interior comfort on windy sites can be affected by:
- increased draughtiness through walls, roof and windows
- loss of insulation performance due to wind wash in the roof or under the floor.

3.5.2 To maintain comfort on exposed sites:
- design windows to meet the expected design wind speeds
- ensure an air barrier is an integral part of the wall construction
- specify a rigid lining fixed under the joists (together with bulk insulation) for open subfloor spaces (such as pole houses)
- specify increased framing depth to allow higher performance insulation to be fitted
- consider that flue performance (blowback) can be affected by differential pressures caused by wind pressures over the roof.

3.5.3 To provide ventilation, it may not be practical to open large awning or casement windows during high winds. Sliding windows and doors are not at risk of being wrenched from hinges in high winds. Ventilators can be provided within aluminium window frames/ sashes.

4.0 EXPOSED COASTAL SITES

4.0.1 On windy coastal fringe sites, the potential for corrosion of metal components is greater because of the presence of windborne salt and the risk of wind-blown sand eroding or abrading surfaces and finishes.

4.0.2 While durability zones are not directly related to wind zones, in coastal areas, the presence of both high wind and salt spray requires careful specification of materials and fixings and their future maintenance. Applicable exposure zones are likely to be either:
- zone D – coastal with a high risk of wind-blown sea spray salt deposits (within 500 m of the coast, including harbours, islands and other coastal areas)
- zone E – adjacent to breaking surf.

4.0.3 Select materials to comply with Building Code clause B2 *Durability*. E2/AS1 Table 20 *Materials selection* includes a comprehensive list of materials suitable for various exposure zones as defined in NZS 3604:2011 and building situations (hidden, sheltered or exposed).

4.0.4 To minimise corrosion risk:
- consider adjacent landforms and their effects on wind flows – inland distribution of salt-laden air is influenced by the adjacent landforms that may channel onshore winds, increasing both their speed and the distance inland the salt is carried
- ensure the building layout and detailed design provides for regular rain-washing of all metallic surfaces
- select corrosion protection and surface finishes to metal components (fixings, claddings) that are suitable for use in exposure zones D or E
- select materials that are not affected by salts – uPVC is often preferred over metal for gutters and downpipes in coastal areas
- ensure concrete strength meets the requirements of NZS 3604:2011 for the exposure zone
- make owners aware of the building's maintenance requirements – providing a detailed exterior maintenance programme is highly recommended
- ensure the building design allows surfaces exposed to salt to be easily accessed for regular washing (particularly if sheltered from rain-washing) and removal of sand build-up for beach sites – in exposed coastal areas, consider automatic drenching systems to wash down windows and exterior surfaces.

4.0.5 To protect against erosion:
- avoid soft materials such as cedar, or use these only in sheltered locations
- select applied coatings for their abrasion resistance.

4.0.6 Higher ultraviolet exposure may occur as a result of reflectance of ground or water. Materials such as plastics, rubbers and sealants should be carefully selected and, where possible, protected from exposure to direct sunlight.

5.0 WORKING ON WINDY SITES

5.0.1 Construction is likely to take longer on windy sites due to downtime and delays, as it is more difficult to:
- erect frames and trusses
- install and keep in good condition flexible underlays and damp-proof membranes, wall and roof cladding and windows
- carry out wet trades such as concreting, plastering or external painting – concrete and plaster finishes can dry out too quickly, causing plastic cracking
- protect partially finished work – strong winds can cause severe damage, and wind-driven rain can wet interiors even when the roof is on.

5.0.2 When choosing materials and methods for use on exposed sites, consider:
- that it is easier to handle smaller building units and sheets in a high wind – large sheets such as polystyrene and fibre-cement can be difficult to handle and are easily damaged
- that the application of spray-applied materials may be difficult or may cause delays
- that flexible sheet materials such as underlays, roofing membranes and polythene are difficult to handle in windy conditions
- the time of year, as some months are windier than others.

5.0.3 Measures that should be taken to limit damage during construction include:

- fitting adequate temporary bracing until linings are fixed
- not relying on cut-in metal angle bracing as temporary bracing – while this may prevent the frames from racking during handling, it may be insufficient to prevent collapse of the framing in high winds
- not removing temporary bracing until permanent bracing is in place
- incorporating rigid underlay or proprietary RAB on all external walls – it provides bracing and shelters the interior of the building, improving working conditions
- informing all subcontractors and suppliers of the site conditions
- providing adequate storage sheds
- ensuring that materials stored outside are properly stacked and firmly tied or weighted down
- arranging 'just in time' deliveries of materials so that they are used immediately and not left lying about.

5.0.4 Site management on exposed sites can be more difficult because:

- buildings are susceptible to weather damage until closed in
- windy conditions can be debilitating and slow down work
- wind-borne dust and rubbish can cause problems
- health and safety issues arise, for example, working on roofs and ladders and scaffolding can be dangerous – even working in a trench with eyes level with ground-blown dust can be a hazard
- cranes cannot be used
- site facilities (toilets, huts) need to be anchored.

Tied down portaloo on windy site.

6.0 FURTHER READING

Ministry of Business, Innovation and Employment (MBIE)
New Zealand Building Code Handbook and compliance documents:
B1 *Structure*
B2 *Durability*
E1 *Surface water*
E2 *External moisture*

Standards New Zealand
AS/NZS 1170.2:2011 *Structural design actions – Part 2: Wind actions*
NZS 3604:2011 *Timber-framed buildings*
NZS 4211:2008 *Specification for performance of windows*

BRANZ publications
BRANZ *House Building Guide 3rd edition 2011*
BRANZ *House Insulation Guide 4th edition 2010*

BRANZ bulletins
556 *Internal gutter design*
553 *Aluminium joinery installation in cavity construction*
549 *Lintel and Beams Calculator*
527 *Drained and vented cavities*
494 *Thermal insulation of new houses*
479 *Planning for maintenance*
470 *Wall underlays*
382 *Curing concrete*
321 *Reducing the impact of wind at building sites*

Other publications
Code of Practice for Weathertight Concrete and Concrete Masonry Construction (CCANZ)
NZ Metal Roof and Wall Cladding Code of Practice (NZ Metal Roofing Manufacturers Inc)

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ISSN 1170-8395