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The Australasian Wind Actions Standard AS/NZS1170.2 - recent & future developments

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Abstract

This paper describes the changes to AS/NZS1170.2 that have occurred since 1971, with emphasis on changes since the combined Australia/New Zealand Standard was first issued in 2002. In particular, the introduction of new terrain categories for over-water winds, and the recent changes to the provisions for internal pressure, are highlighted. The importance for users of the availability of supporting material such as worked examples, and the AWES Handbook is also described. Some ideas on topics requiring new revisions for the next edition will be presented.

Introduction

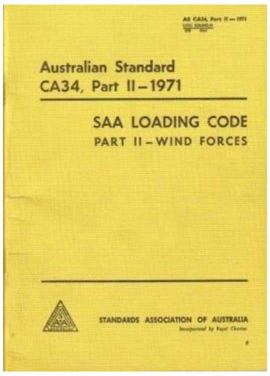
Wind loading codes and standards are the prime source of information on wind loading for the design of a majority of above-ground structures that are exposed to wind in the Asia-Pacific and elsewhere in the world. The Australian/New Zealand Wind Actions Standard AS/NZS 1170.2:2011 [1] is no exception to this.

AS/NZS 1170.2, and its forebears, have been in a process of continuous improvement since their inception. While users may often have difficulty in keeping up with the many revisions and amendments, the complexity of wind loading requires technical changes whenever extreme wind events, or new research indicates the need for it. Other changes have been required when it is apparent that there are ambiguities in clauses in the Standard.

This paper first briefly reviews the history of the Standard, including the predecessors of the present Standard CA 34 Part II [2], AS1170.2 [3] in Australia, and NZS 4203 [4] in New Zealand. The re-formatting of the Standard as the first bi-national document in 2002, and the subsequent amendments are discussed. Finally some thoughts on potential changes for the next version of AS/NZS 1170.2 are provided.

History of the Australian & New Zealand Standards

AS/NZS 1170.2 has a direct lineage that can be traced back more than forty years. AS CA 34 Part II [2] replaced the earlier Interim 350 [5], as the first modern wind loading wind loading code or standard published in Australia or New Zealand (Figure 1). At or about the same time, new wind loading codes were published in the United Kingdom [6], Canada [7], and the United States [8], and shortly after in Denmark [9]. These documents all had in common a recognition of the boundary-layer structure of synoptic scale winds, a selection of shape factors or pressure coefficients for both external and internal pressures on buildings, and, with the exception of the British CP3 Ch. V Part 2 [6], some provision for the dynamic effects of wind on tall structures.



AS CA34, Part II — 1971

Australian Standard
CA34, Part II–1971

SAA LOADING CODE
PART II – WIND FORCES

STANDARDS ASSOCIATION OF AUSTRALIA

Figure 1. Front cover of the first modern wind loading code in Australia or New Zealand, AS CA 34 Part II – 1971.

CA 34 Part II [2] was followed shortly after by a version in metric units, AS 1170.2-1973 [3]. Both these documents contained a contour map of 'regional basic wind speeds' with an annual probability of exceedance of 1/50, (i.e. a return period of 50 years). This was revised within a short time, as a result of Tropical Cyclone 'Tracy' that devastated the city of Darwin in the Northern Territory on Christmas Day, 1974.

There were smaller changes to AS 1170.2 up to the late 1980s – these largely involved the gradual incorporation of shape factors from wind-tunnel testing in boundary-layer wind tunnels, that emerged in the late 1960s, and started to 'multiply' through the 1970s and 1980s.

The 1989 version of AS 1170.2 [10] was a major re-formatting of that Standard, including incorporation of the Deaves and Harris strong wind model [11], updated multipliers for topography and shielding, and directional wind speeds for the capital cities of Australia. Many new shape factors were introduced including those for free-standing walls and roofs and lattice towers.

In a world first for wind loading at the time, high return period wind speeds were introduced for design for ultimate limit states. In AS1170.2-1989, 1000-year return period were specified for all buildings in place of the previous 50-year values. To compensate the wind load factor was adjusted to 1.0 from the previous 1.6, elsewhere in the design process. The main justification for this was removal of the 'cyclone factor' that had been introduced following Cyclone 'Tracy'. It can also be shown to remove the need for higher load factors for tall structures when significant dynamic response to wind is expected [12]; in those cases wind loads and response increase to a power greater than 2.

Prior to 1992, New Zealand had separate loading standards published in 1976, 1984 and 1992 [4]. While the wind loading sections of 1976 and 1984 editions appear to have been derived from the British Standard [6], the wind loading part of NZS 4203:1992 [4] (Figure 2) was very similar to AS 1170.2-1989 [10]. However, there was a different treatment of the topographic multiplier, and no method for dynamic response to wind loading. A common Australian/New Zealand Standard for Wind Actions was eventually published jointly by Standards Australia/ Standards New Zealand in 2002 [13].

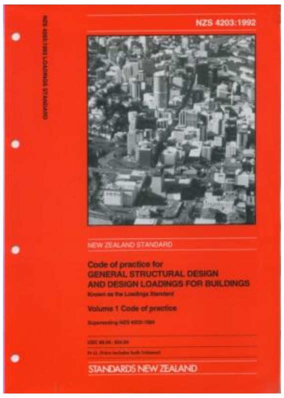


Figure 2. New Zealand Loading Standard NZS 4203:1992, [4].

The 2002 revision

The use of joint Australian/ New Zealand Standards generally has resulted from the Common Economic Relations (CER) free trade agreement between the two countries that was established in the 1980s. The first common wind loading standard was AS/NZS 1170.2:2002 [13].

AS/NZS 1170.2:2002 introduced a new format which was partly based on the ISO Wind actions Standard then current. In addition, the specification of annual recurrence intervals (return periods) depending on the importance of the structure, and in some cases the design life were removed from the wind standard. Then, as now, these are specified either in the Building Code of Australia [14], or in another standard in the 1170 series, AS/NZS 1170.0 *Structural design actions, Part 0: General principles* [15].

A number of other significant changes were introduced in AS/NZS 1170.2:2002 [14], including:

- The concept of separate regional, site and design wind speeds was introduced,
- A variable annual exceedance probability (return period) was adopted for the regional wind speeds,
- A single design approach based on a gust wind speed was adopted, (the ‘simplified procedure’ and ‘detailed procedure-dynamic analysis’ in AS 1170.2-1989 [10] were removed),
- ‘Wind direction multipliers’ were included for both Australia and New Zealand, replacing the directional wind speeds for capital cities in AS 1170.2-1989,
- A method based on a mathematical formula replaced the tabular method for determining topographic (hill-shape) multipliers,
- The lee multiplier and site elevation term from NZS 4203 were incorporated into the topographic multiplier calculations,
- For the cross-wind response of tall buildings (with rectangular cross-sections), mathematical formulae for the ‘crosswind force spectrum coefficient’ replaced the previous graphical format.

There were also many smaller changes and additions to the shape factors specified in the 2002 edition.

The 2011 version and 2012-16 amendments

The format of AS/NZS 1170.2:2002 was not changed for the 2011 edition. However there were many minor changes and additions including a new section defined the size and speed of windborne missiles, a fatigue cycle profile for high-cycle fatigue, and a redrafting of the section on the action combination factor, K_c. More significant were the subsequent amendments to the standard, several of which resulted from the assessment of the effects of Severe Tropical Cyclone ‘Yasi’ which struck the North Queensland coast in February 2011 [16].

No change was made to the design wind speeds or the regional boundaries, although an assessment of the long-term effects of climate change [17] suggested that the latter should be re-assessed in the future.

One significant change in 2012, re-allocated over-water winds to Terrain Category 1 or 1.5, rather than Terrain Category 2 as assumed prior to the change. This change resulted from the assessment of gust factors measured at automatic weather stations in the Coral Sea, as ‘Yasi’ approached the coast [18], as well as from the findings of aircraft surveillance of hurricanes in the North Atlantic.

After re-assessing the response characteristics of the anemometers previously used in Australia to record daily maximum gusts, the nominal duration of the gust in the Standard was re-defined as 0.2 seconds - based on the moving average definition, as is the convention in the digital age [19]. This duration also conveniently provides a filtering of atmospheric turbulence that is equivalent to the averaging by the frontal area of a small building at design wind speeds, as shown in Figure 3.

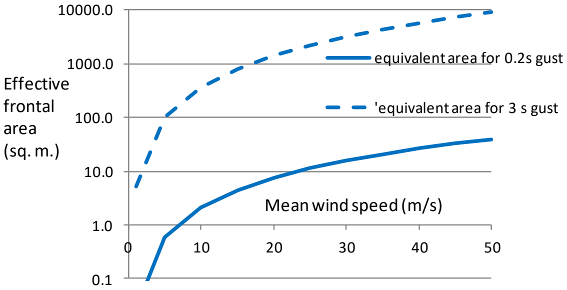


Figure 3. Effective frontal areas for 0.2 sec and 3 sec moving-average gust durations

Another change of significance that indirectly resulted from investigations following Cyclone ‘Yasi’ was the complete re-writing of *Clause 5.3* concerning the assessment of internal pressures. From 2016 it is not possible to design a building in a cyclonic region without considering large openings in the building envelope, either accidental (e.g. from windborne debris) or deliberate.

Dynamic response

Unlike earlier versions, the 2002 and 2011 versions of AS/NZS 1170.2 are completely based on gust wind speeds, including when dynamic response factors (d.r.f.) are calculated. Earlier versions based dynamic response calculations on an hourly mean wind speed with gust response factor (g.r.f.) calculations. There is a fundamental difference between the d.r.f. and g.r.f. approaches. In the latter case the mean wind load distribution is factored upwards, whereas in the former case the d.r.f. factors a distribution with height based on a 'gust envelope'.

A comparison [20] of the base bending moments on a benchmark tall (180m) building for both along-wind and cross-wind response calculated by AS/NZS 1170.2, and from several different boundary-layer wind-tunnel groups was very favourable (Figures 4 and 5). In particular, for along-wind response, AS/NZS 1170.2 performed very well (Figure 4).

Since AS1170.2-1989 [10] (unlike most other codes and standards), cross-wind response calculations have also been available. Figure 5 shows that good agreement is shown with a range of wind-tunnel test results for a benchmark building.

Supporting documents and design aids

The Australasian Wind Engineering Society (AWES) has supported the Standard with supporting documents since 1990 [21]. For the current Standard, a 'Wind Loading Handbook for Australia and New Zealand' was published in 2012 ([22] and Figure 6).

A Guide containing worked examples of wind load calculations for nine structures was published to support the 2002 edition of AS/NZS 1170.2 [23]. This was not revised in hard-copy format for the 2011 edition, but the examples have been revised, and are now available in a digital format.

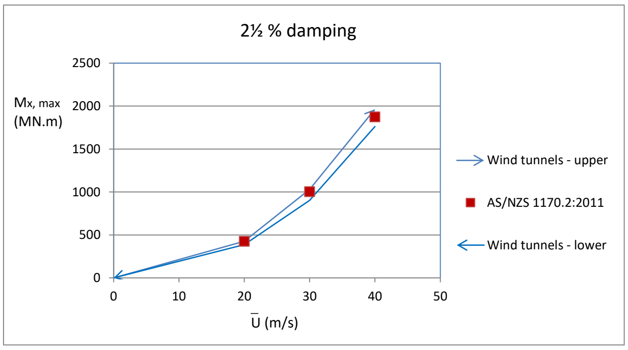


Figure 4. Along-wind response of a benchmark tall building – comparison of base moments from AS/NZS 1170.2 with the range of predictions from seven wind tunnel groups [20]

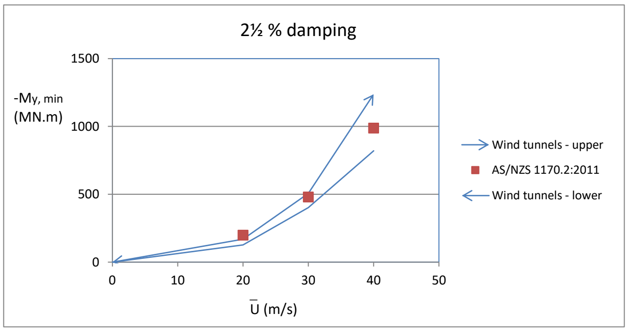


Figure 5. Cross-wind response of a benchmark tall building – comparison of base moments from AS/NZS 1170.2 with the range of predictions from seven wind tunnel groups [20]

Figure 6. The AWES Wind Loading Handbook (AWES-HB-001-2012) published in 2012 [22].

Towards AS/NZS 1170.2:2020

Any new amendments to AS/NZS 1170.2:2011 need to coincide with a new edition of the Standard. For work starting in 2017, it is likely that a new edition would not be published until 2020.

Some issues that may need to be addressed in the next few years are suggested below. Note this is just the author's personal list, and is not intended to be exhaustive.

- *Terrain-height and other multipliers for local storms*. It is well known that thunderstorm-induced downdrafts are the dominant extreme wind event for many parts of Australia and New Zealand. For example, Figure 7 (from [22]), suggests that most of Australia, away from the coastline, is governed by those storms. Although it has been known that this is the case for many years, terrain-height and other multipliers in AS/NZS 1170.2 have been developed over the years only for large scale synoptic wind events. There are now quite a lot of full-scale data available on downdraft profiles, and it is timely that this issue now be addressed. A starting point might be the Australian/New Zealand Standard for Overhead Line Design [24], which does include design information for downdraft winds.

Figure 7. Zones in Australia showing dominant wind types for ultimate limits states (from [22])

- *Shape factors for renewable energy structures.* With the recent rapid expansion of renewable energy, a demand has arisen for AS/NZS 1170.2 to be made more applicable to structures such as wind turbine towers and ground-mounted, or tracking, solar panels.

- *Roofs of large low-rise distribution buildings.* There are now many large low-rise distribution centres for supermarket chains, or other major corporations, constructed, or under construction, on the outskirts of the capital cities in Australia. For these buildings, the horizontal dimensions are considerably greater than five times the roof height. This results in the step down in the external pressure coefficient ($C_{p,e}$) coinciding with the step change in the local pressure factor K_{ℓ}, with both occurring at a distance from the windward roof edge equal to the roof height. This is an unrealistic step change in the shape factor for external roof pressures, and gives un-conservative design pressures for cladding and immediate supporting structure over large areas of roof.

- *Industrial structures.* AS/NZS 1170.2 was developed primarily for enclosed buildings. In recent years it has been applied widely for industrial structures such as those in the telecommunications, mining, power generation, and oil and gas sectors. Although additions to *Appendix E* of the Standard have gradually been introduced, more needs to be done. A particular need is to review the data on structures composed of large circular cylinders. Data for these structures at high Reynolds Numbers is sparse, and some recent 'spot checks' has indicated that some wind tunnel data from the 1970s to be suspect – probably due to errors caused by end effects, uncorrected blockage errors or small-scale turbulence.

In addition to the above major issues, there are the inevitable minor errors and ambiguities that surface at frequent intervals that require amendments every few years.

Conclusions

This paper has attempted to review the development of the Australasian Wind Actions Standard AS/NZS 1170.2, with emphasis on the more recent changes of the 21st Century. The supporting material such as a Handbook, Guide and worked examples that are now available are mentioned. Some areas that clearly need attention in the near future are listed, and this is likely to result in a new edition of the Standard in about 2020.

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