Wind Loading – History of Changes

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Wind loading of structures is a complex phenomenon and a major consideration when ensuring the safety and design of industrial assets. However, standards have changed over the years to incorporate the latest research findings, and the knowledge obtained from recent severe weather events. This article aims to investigate the historical changes to Australian wind loading standards, and the rationale behind them.

The first modern wind loading code published in Australia in 1971, was the CA 34.2, which replaced an earlier interim document, the SAA Int 350. Whilst printed in Imperial units, all subsequent standards have descended from it, with notable changes being made in each new edition. In 1973, the CA34.2 was converted to metric units in the AS 1170.2: 1973 edition, whilst the occurrence of Cyclone Tracy which hit Darwin in 1974, created many modifications relating to the findings following the severe weather event. The AS 1170.2: 1989 was a major revision of previous standards, with the conversion to limit state design which is still implemented in the following 2002 and 2011 editions.

To recognise the modifications made to Australian standards over the years, it is necessary to understand the underlying concepts wind interaction with structures, and how this is accounted for in the design process.

Using the current limit state design method, Australian Standards design for an ultimate wind speed, on a probability basis where the wind speed has a small chance of being exceeded in the life of the structure. Wind speed data is collected from anemometer stations around Australia, and was defined as a gust of 2-3 seconds duration, recorded at the meteorological height of 10m in flat open terrain. However, it has been since found that the averaging time of the peak gust was considerably less than 2-3 seconds, (Holmes, 2012), with the recent 2011 version redefining the peak gust as having a moving average time of approximately 0.2 seconds, (Standards Australia, 2017). CA 34.2-1971 contained a contour map of ‘regional basic wind speeds’ with a 50-year return period, and a table of wind velocities for 48 locations where data had been obtained. However, many of these values are identified as ‘short record’, as less than 15 years of records were available from the anemometer station, making 50 and 100-year return period estimates fairly tentative, (Australian Standards, 1971). This edition of the standard included a cyclone factor of 1.15, to be applied to the wind speed of locations within a ‘Tropical cyclone area’. The need for cyclone factors was eliminated in the 1989 edition of AS 1170.2, with the specification of high return-period design wind speeds, (i.e. 1000 years). Additionally, the need for importance multipliers in the 1989 edition was eliminated as variable annual probability of exceedance was adopted for wind speeds in the 2002 version.

Once regional wind speed has been decided, other factors must be considered such as the increase in wind speed which occurs with height. Taller structures have higher wind loads than low level structures, which is considered by applying height multipliers. It must be realised that standards prior to 1971 did not account for this effect and assume a single value over two central and coastal regions.

When strong winds interact with a structure, pressure and forces are generated, with the characteristics of these pressures being defined by the characteristics of the approaching wind, geometry and permeability of the structure. Due to the turbulent and gusty nature of wind, these pressures are not constant but highly fluctuating, and the interaction with the shape of structure itself, such as local eddies at the edges, causes the pressure distribution to vary over the surface of the structure.

The distribution of pressures is determined by aerodynamic shape factors, which have been developed and modified over the years reflecting new research findings. Additionally, for tall structures the dynamic response of the building must be considered. Information regarding the dynamic response has been expanded over the years, from an informative annex in 1971, to inclusion of a dynamic response factor in design pressure calculations in the current standard.

Considering all the above factors, in the table below it can be seen that the wind design pressure for a structure located in Central Queensland, varies with each standard. There is a particularly large increase in design pressure between a structure built in 1971, compared to a structure built in 1989, highlighting the changes in regional wind speeds post Cyclone Tracy. It can also be noted that the elimination of importance multipliers and instead the use of variable return periods in the 2002 edition, allows for a slightly decreased basic wind velocity.

Year	Australian Standard	Basic Wind Velocity	Height Multiplier	Formula for Design Pressure	Design Pressure (kPa)
Pre 1971	SAA Int 350	90 mph	None	$P = V^2/100$	0.97
1971	CA 34.2-1971	100 mph	1.08	$P = C_p q_z$ $q_z = {V_z}^2/400$	1.3
1973	AS 1170.2:1973 1st Edition	45 m/s	1.08	$P = C_p q_z$ $q_z = 0.6V_z^2 \times 10^{-3}$	1.42
1989	AS 1170.2:1989 3rd Edition	49 m/s	1.12	$q_z = 0.6V_z^2 \times 10^{-3}$	1.82
2002 & 2011	AS 1170.2:2002 2nd Edition AS 1170.2:2002 5th Edition	44 m/s	1.12	$P = (0.5\rho_{air})V_z^2 C_{fig} C_{dyn}$	1.46

Note:
The values assume the following:

- 50-year Return Period
- 10m structure located in Central Queensland, (Region B)
- Pressure coefficients $C_p, C_{fig}, C_{dyn} = 1.0$

Clearly, historical changes to the wind loading standards are important to understand when assessing existing structures as it can have a direct effect on the design specifications. Therefore, it is useful to know what standard for which the structure has been designed, to evaluate its susceptibility to wind based on the current wind standard.

1. References

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