FORMAT AND DATA REQUIREMENTS FOR THE AUSTRALIAN STANDARD ON WIND FORCES

J D Holmes*

Background

Although the first codes or standards for wind forces were produced in about 1935, the development of such documents has mainly been a post-war phenomenon. In Australia and other countries, wind codes and standards, and other structural design codes, have grown in size and complexity, and assumed the status of legal documents. The first loading code in Australia was the Interim Standard 350 published in 1952 [1]. The wind load section of this document consisted of 12, 18 cm x 10 cm pages. The latest (1983) edition of the current Standard, AS 1170 Part 2, consists of some 55, 25 cm x 17 cm pages, including Appendices [2].

To attempt to satisfy the competing demands of simplicity, and additional data, Sub-Committee BD/6/2 of the Standards Association, proposes to split the next edition of the Standard into two versions - a simplified version (of the length of Interim Standard 350 or shorter) for low-rise buildings of simple geometry, and an 'advanced' code of perhaps 100 pages, including directional wind speed data, additional pressure and force coefficient data for structural shapes, and an expanded section on dynamic response. The advanced code would contain a substantial commentary on the derivation of the data, and references to other sources of information where appropriate.

The present paper will discuss the format of the present Standard, the areas where existing data need revision and where additional data are required.

Quasi-Steady Format

The basic formula for the determination of unfactored design pressures on a building due to wind is:

$$p = \frac{1}{2}\rho\hat{u}^2 \left(C_{p_e} - C_{p_i}\right) \qquad (1)$$

where $\hat{u}$ is the peak gust wind speed, at the height of the structures with a 50 year return period, corrected for height, terrain and topographic effects,

ρ is the density of air, and

C_{p_e}, C_{p_i} are external and internal pressure coefficients derived from Appendices B and C of the Standard.

The pressure coefficients C_{p_e} and C_{p_i} were, historically, the single deterministic 'steady' pressure coefficients measured in smooth flow wind tunnel tests. The natural successors to these coefficients are the mean and time-averaged coefficients measured in boundary-layer wind tunnel or full-scale tests.

The implications of equation (1) are that the pressure and load variations on the structure simply reflect the time varying characteristics of the wind speed upwind of the structure so that a peak value of wind speed is accompanied

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*CSIRO Division of Building Research, Melbourne, Australia.

by a peak value of pressure or load on the structure. This is the 'quasi-steady' assumption.

Despite complicating effects, such as the distortion of turbulence as the air flows around a building, and of the pressure fluctuations induced by vortex shedding and other phenomena in the separated flow regions around structures, the quasi-steady model has been found to be a fairly good model - at least for small structures. For example, Best and Holmes [3] found that approximately 70% of the pressure fluctuations on a house model could be explained by the quasi-steady source.

However, a few other countries, notably Canada and the United States, have based their Codes on an average wind speed or dynamic pressure - closer to the mean wind speed used in wind tunnel tests. Gust factors are then included to allow for the turbulence and gusting effects.

The main advantages and disadvantages of the quasi-steady/peak gust format, in the Australian context, can be summarized as follows:

Advantages:

(a) Simplicity.
(b) Continuity with previous practice.
(c) Pressure coefficients need no adjustment for different terrains.
(d) Existing meteorological data on wind gusts is used directly.

Disadvantages:

(a) The approach is not suitable for very large structures or for those with significant dynamic resonant response, such as tall buildings, guyed masts or long-span bridges.
(b) The response characteristics of the gust anemometers and the natural variability of the peak gusts tend to be incorporated into the wind load estimates.
(c) Additional factors such as Area Reduction Factors, or Local Pressure Factors, are required in circumstances where the quasi-steady assumption clearly breaks down.

In the opinion of the author, the advantages of the present format outweigh the disadvantages - certainly for smaller, stiff, structures for which the Standard is mainly intended.

Pressure/Force Coefficient Data Requirements

The second half of the present Standard [2] consists mainly of pressure and force coefficients for buildings and other structural shapes (Appendices B and C). The 1983 edition contains substantial revisions to the external pressure coefficients and local pressure factors for gable roof buildings. The background data on which most of these changes were based are described by Holmes [4].

Just about all of the remaining data in Appendix B, and the whole of Appendix C are candidates for revision over the next few years. When the original sources of the data in the present Standard can be identified, they have usually been found to have been smooth-flow/aeronautical-tunnel type tests, which show significant differences from those conducted in turbulent-boundary-layer type flow, or in full scale.

In the exceptional cases, where the data was derived from turbulent-boundary-layer testing, other problems may arise. For example, in the case of monoslope free roofs (Figure C1 in [2]), the original test results were carried out with two dimensional models spanning the test section - these have been found to give significantly different results from measurements on three dimensional roof configurations.

Fortunately, a fair amount of work that will assist in the necessary revision, has been carried out in the last year or two, or is being carried out at present. Some examples are:

(a) Free roofs - monoslope, pitch and troughed (Oxford Uni.).
(b) Multi-span roof buildings (CSIRO).
(c) Canopies and carports (James Cook Uni. and CSIRO).
(d) Arch roof buildings (James Cook Uni, Uni. of Western Ontario).
(e) Force coefficients on lattice frames (Uni. of Western Ontario).
(f) Circular section pressure and force coefficients at high Reynolds Number (Monash Uni.).

Areas for which there is little or no good data can be identified as follows:

(a) Mono-slope and hipped-roof buildings.
(b) Pressures on low-rise buildings of non-rectangular planform.
(c) Pressures on grandstand roofs.
(d) Drag coefficients on low walls or hoardings.
(e) Effect of roof ventilators on external and internal pressures.
(f) Effect of edge details, such as guttering, on low-rise buildings.
(g) Pressure on bins and silos.

Data on force and pressure coefficients for structures situated in terrain other than open country, would also be useful to check the validity of using the same pressure coefficients in all terrain types. A more rational approach to cladding loads on high- and low-rise buildings seems overdue, also. At present, a variety of measurement techniques and criteria for peak pressures are in use in wind tunnel laboratories. A clear definition of peak pressure is required, with some consideration of the time dependency of the resistance characteristics of cladding materials such as glass.

It should also be noted that it will be necessary to include basic external pressure coefficients for oblique wind directions to make use of the directional wind speed data discussed earlier. Figure 1 shows a Table prepared for possible use in the Standard, with data for oblique directions included.

Wind Tunnel Test Requirements

The test requirements for wind tunnel tests of wind loads on structures is too complex and lengthy a subject for adequate treatment in this paper. However, the detailed requirements are widely available in the literature, and a very useful state-of-the-art summary is available in the Proceedings of the International Workshop held at Gaithersburg, USA, in 1982 [5].

The three most important considerations for accurate simulation and measurement of wind loads in wind tunnels are as follows:

(a) Adequate simulation of the atmospheric boundary layer.
(b) Proper statistical treatment of the fluctuating pressures and forces.
(c) Adequate measurement systems for pressures and forces.

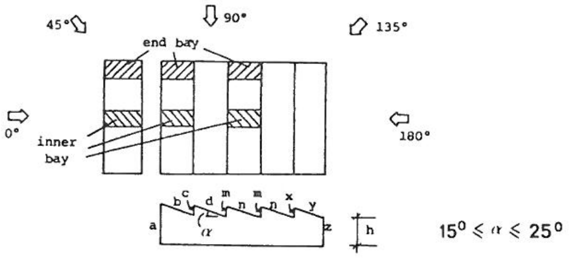
It may not always be possible to achieve the desired criteria such as those published in [5] or elsewhere. However, it is important that sufficient data on measurement techniques be provided in reports so that results can be corrected if necessary.

Conclusions

This paper has attempted to record the thinking of the SAA Sub-Committee BD/6/2 concerning the format and data requirements for future versions of the Australian Standard on Wind Forces. The acquisition and collation of the necessary data, particularly in the section concerned with pressure and force coefficients, will be a fairly lengthy process, which would be assisted by the use of all available facilities and expertise in the country.

References

1. Standards Association of Australia, 'Interim Code for Minimum Design Loads on Buildings', Interim Standard 350, 1952.
2. Standards Association of Australia, 'SAA Loading Code, Part 2 - Wind Forces', Australian Standard AS 1170 Part 2, 1983.
3. R.J. Best, and J.D. Holmes, 'Use of Eigenvalues in the Covariance Integration Method for Determination of Wind Load Effects', J. Wind Engg & Ind. Aerodyn., 13, pp.359-370, 1983.
4. J.D. Holmes, 'Wind Loads on Low Rise Buildings - A Review', CSIRO Division of Building Research, Research Report, 1983.
5. T.A. Reinhold (ed.), 'Wind Tunnel Modeling for Civil Engineering Applications', Proceedings of International Workshop, Gaithersburg, Maryland, USA, 1982, Cambridge University Press.



Wind direction	Bay	External pressure coefficients C_p								
		a	b	c	d	m	n	x	y	z
0°	End Inner	+0.6 +0.8	-0.9 -0.9	-0.8 -0.9	-0.4,+0.4 -0.5,+0.2	-0.6,+0.6 -0.4,+0.4	-0.6,+0.6 -0.4,+0.4	-0.3,+0.6 -0.3,+0.5	-0.4 -0.5	-0.2 -0.2
45°	End Inner	+0.8 +0.6	-1.3 -0.7	-0.5,+0.5 -0.7,+0.3	-0.7 -0.4	-0.6,+0.3 -0.3,+0.4	-0.8 -0.4	-0.6,+0.3 -0.3,+0.3	-0.8 -0.6	-0.5 -0.5
90°	End Inner	-1.1 all surfaces use Table B2.1								
135°	End Inner	-0.4 -0.4	-0.6 -0.3	-0.7 -0.3	-0.7 -0.4	-0.9 -0.4	-0.7 -0.4	-0.9 -0.4	-0.5 -0.3	+0.6 +0.5
180°	End Inner	-0.3 -0.3	-0.2,+0.2 -0.2,+0.2	-0.3 -0.3	-0.2,+0.2 -0.2,+0.2	-0.4 -0.4	-0.4 -0.4	-0.7 -0.5	-0.3,+0.2 -0.3,+0.2	+0.6 +0.8

Figure 1 Typical table of pressure coefficients, including oblique wind directions