DESIGN WIND SPEEDS FOR *REALLY TEMPORARY STRUCTURES*

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**ABSTRACT:** The design wind speeds for temporary structures included in AS1170 cover the general situation where a structure is expected to sustain whatever wind might happen over the next 6 months. It does not provide guidance on wind actions that might occur in the next few hours or days. This paper suggests a method for establishing design wind speeds from forecasts. It draws on the writer’s experience to show a number of applications in construction, and makes suggestions where existing guidelines might be reviewed.

**KEYWORDS:** Wind, Cranes, Erection, Temporary Works

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1 INTRODUCTION

The design wind speed for normal temporary structures is set down in AS1170.0 [1] Table F2 as the 1/100year wind (non-cyclonic) or 1/250year (cyclonic). There are many circumstances where this speed is far in excess of what is practical or economic. This paper explores rational methods for design wind speed estimation in different circumstances.

Wind is variable. Even in windy Melbourne, it is calm 8% and less than 20kph for half the time. Constructors take advantage of this and erect structures in relatively benign conditions, but they need guidance on when they should stop erection to wait for the wind to abate, and exactly which parts of the structure must be in place before they leave site for the day. Similarly, operators of amusement rides, stadium owners, and event coordinators need to take steps to transform their structures to a “safe” state prior to the arrival of the design wind storm. And at a personal level, it would be nice to know when one’s umbrella should be furled before a wind gust induces structural collapse.

This paper will first look at the prediction of wind speeds, and then look at a range of structures where design for wind is significant. It draws inspiration from Wang and Pham [2] which looked at the same subject from a purely statistical basis.

2 PREDICTING WIND SPEEDS

The science of weather forecasting has made considerable advances in recent years following the development of Numerical Weather Prediction (NWP) software. Comprehensive forecasts of wind speed and direction hour by hour for up to two days ahead are available on the Internet, both from the Bureau of Meteorology (BOM) and commercial sources such as “PredictWind” and “WindGuru”. (The commercial sources exist to provide forward estimates of power output from wind farms as well as advice to sailors.) Longer range forecasts are available, but these are less reliable.

Forecasts are subject to error, and it is necessary to have some feeling for the likely magnitude of error. Because the different sources use different algorithms in their predictions, one can gain an indication of unreliability if the available forecasts differ. Figure 1 (from Scientific American) shows the various predicted paths for Hurricane Sandy in 2012. One of these predicted the hurricane would turn back to cross the coast at Long Island from 2 days before. The inherent warning was heeded by those in authority allowing a greater time to prepare for the calamitous weather event.

Forecasts of the arrival of a major wind event can be wrong in both magnitude and timing. These are correlated to a certain extent. If the weather pattern delivering the wind storm is stronger, it is likely to move faster, and so arrive at site earlier and stronger than predicted. In the past the writer has used “3 hours earlier, and 5 knots stronger”. “PredictWind” offers the comment that their forecasts are “generally within 3 knots”.

Whilst engineers might like the apparent precision of the NWP numbers, other users should only need to refer to the traditional BOM forecasts. The marine weather forecasts are the basic source of data for coastal areas. The Bureau has four levels of Warning:

- Strong wind warning: 26 to 33 knots.
- Gale warning: 34 to 47 knots.
- Storm force wind warning: 48 to 63 knots.
- Hurricane force wind warning: 64 knots or more.

For inland areas, Strong Wind Warnings are not issued, and the others are replaced by a single “Severe Weather Warning” message with details attached. Warnings are typically issued the day before.

BOM also issues “severe thunderstorm warnings”. By their definition, Severe Thunderstorms may produce

- A tornado
- Hail of diameter 2cm or greater
- Wind gusts of 90 km/h or greater
- Very heavy rain leading to flash flooding.
Individual thunderstorms are small-scale and short-lived phenomena – a thunderstorm is typically only about 10km across and lives for only 30 minutes or so. Thunderstorm warnings are typically issued only hours before, making the possibility of thunderstorms another matter for consideration.

For cyclones, BOM offers a graduated series of forecasts – an “outlook” more than three days in advance, “information bulletin” at 2 days, and “watch” at 48-24 hours, and “warning” when the cyclone is expected to affect coastal communities within 24 hours. The typical Australian tropical cyclone season runs between 1 November and 30 April, but cyclones have occurred in September through June.

In situations where a rain storm is imminent, the radar at BOM can be viewed on the Internet to see where it is raining. Looping through the radar images for the last ½ hour gives a graphic indication of the direction and speed of the rain storm. This doesn’t give the wind speed directly, and it doesn’t give any indication of the wind speed or direction in front of the approaching rain storm. Hence, it should only be used for general planning associated with the influence of rain and not wind.

Anemometers are often suggested as useful in wind-critical situations, but they only show what is happening now, not what might happen soon. Similarly, reference to the Beaufort Scale gives a quick estimate: Beaufort 6 (large branches in motion) is 22-27 knots, 40-50 kph.

From all this information, the writer considers it is possible to make a conservative forecast of wind conditions for the next 2, 4 and 24 hours, and possibly 48 hours.

3 CONVERTING PREDICTIONS TO DESIGN WIND SPEED

The BOM forecasts are for wind averaged over 10 minutes. It is necessary to factor these to give the likely maximum gust. The statistical model built into AS1170.2 [3] provides a rational method for calculating this factor. This model assumes the wind varies with a normal distribution about a mean wind speed. The mean and standard deviation vary with terrain and height. The wind speed calculated in AS1170.2 is the peak 3-second gust which should occur in one hour of the average wind.

Take Terrain Category 3 at 30m (non-cyclonic) as a typical example. For this, $M_{(z,cat)} = 1.0$ [AS1170.2:2011, Table 4.1(A)]. The Turbulence Intensity ($I_z$) is 0.203 [AS1170.2:2011, Table 6.1]. It is necessary to refer to the 1989 edition of AS1170.2 for the hourly mean wind speed multiplier, $\bar{M}_{(z,cat)} = 0.57$. Further, there is an adjustment to be made for the difference between the hourly mean and the 10 minute average used by BOM (5% higher in ISO 4354 [4]).

If the forecast wind is 20 knots (10.3m/sec, 37kph), then the maximum gust likely in one hour at that wind speed is $20/1.05/0.57 = 33$ knots. This becomes the design permissible wind speed one might apply in mechanical design. For structural design to Limit State, apply a ULS factor of $\sqrt{1.5}$ to give 41 knots or 21 m/s, or close enough to say “forecast in knots = design wind speed in m/s”.

Referring back to the BOM “Strong Wind Warning” of 26 to 33 knots, and “Gale Warning” of 34 to 47 knots”, by the above process these convert to 27 to 35 and 36 to 50m/s. Clearly, there is a degree of conservatism in either the BOM forecasts or their conversion (especially the $\sqrt{1.5}$ factor), with the upper range of Gale Warning transforming to the 5,000 year wind in Region A!

Strict application of AS1170.0 [1] requires the designer to use the 1:100 year wind for all temporary structures with a service life less than 6 months. For Regions subject to cyclonic wind loads, AS1170.0 requires use of the 1:250 year wind for Level 2 Importance, giving design Regional Wind Speeds of 41, 53, 63, or 74m/s for Regions A, B, C, D.

Compare these to the figures suggested by Wang and Pham [2]. They relate the “one week” design speeds to the 1:500year wind (45,57,66,80m/s), with a reduction factor given in their Table 5 (75%,55%,55%,50%). Applying their process gives design wind speeds of 34, 31, 36, or 40m/s for Regions A, B, C, D.

Care needs to be taken with the application of these lower figures on a regular basis. If a temporary works designer adopts the Wang and Pham 75% figure for one structure, the risk of this wind speed being exceeded for that structure is comparable with the risk for the 100% figure being exceeded in its 50 year “life”. But if the temporary works designer applies this on a regular basis, say once a month for 25 years (the writer’s experience), there are 299 more opportunities for the design wind speed of one of his structures being exceeded.

The writer’s habit has been to apply the 41m/s figure for all structures beyond a particular “weather window”, but this is for non-cyclonic Melbourne. If working in the cyclonic regions, the writer would apply the 41m/s figure through the winter months, and only adopt higher figures where a temporary structure was to be in existence through the cyclone season.

A designer needs to reflect on the overall process of forecasting prior to deciding the limits he wishes to impose upon the constructor or operator. The writer has used the BOM Port Phillip Bay warnings as the basis for his restrictions when preparing
construction designs, selecting Strong, Gale or Storm Wind Warnings as appropriate. Instructions for construction sequence specify that a particular part of the erection sequence “must be completed in a weather window where the BOM forecast is for winds less than Strong/Gale/Storm Winds”.

4 EFFECT OF WIND ON PRODUCTIVITY

To assess the effect of different wind speed levels on production rates on a construction site, data from BOM records for four representative sites was collected. The data selected was the maximum gust experienced day by day, with a year’s records taken as representative.

The four sites chosen were all airports (typically Cat2 at 10m). Melbourne and Sydney were selected to represent southern latitudes near the coast, Canberra to represent inland areas, and Townsville to represent tropical Australia.

The table below was prepared by counting the number of days where the peak gust recorded exceeded the nominated level. A proportion of wind storms peak after working hours during the evening, so the numbers are discounted by 25% to account for this. Further the duration of excessive winds is not necessarily the complete day. In some cases rain will occur at the same time, but this hasn’t been allowed for.

Table 1: Lost time due to wind

<table>
<thead>
<tr>
<th>Gust Speed (m/s)</th>
<th>Melbourne</th>
<th>Sydney</th>
<th>Canberra</th>
<th>Townsville</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>37%</td>
<td>37%</td>
<td>33%</td>
<td>37%</td>
</tr>
<tr>
<td>10</td>
<td>28%</td>
<td>28%</td>
<td>21%</td>
<td>24%</td>
</tr>
<tr>
<td>15</td>
<td>11%</td>
<td>11%</td>
<td>5%</td>
<td>1%</td>
</tr>
<tr>
<td>20</td>
<td>3%</td>
<td>2%</td>
<td>1%</td>
<td>0</td>
</tr>
<tr>
<td>25</td>
<td>1%</td>
<td>0.2%</td>
<td>0.1%</td>
<td>0</td>
</tr>
<tr>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

From this it can be seen that a gust design speed of 20m/s has only a 2-3% effect on production and 15m/s is a tolerable 11% effect in the southern coastal region. Gust design speeds at 10m/s or less would result in lost time of more than a quarter, making it necessary to consider starting at sun-rise or working at night for critical lift.

The 20m/s figure is commonly adopted for operation of mechanical equipment such as moving roofs and amusement rides. For Melbourne it occurs roughly once a fortnight.

5 CONSTRUCTION EQUIPMENT

5.1 OPERATING WIND SPEEDS FOR CRANES

Crane design in Australia is generally covered by AS1418 [5], with “safe use” requirements set down in AS2550[6].

Out-of-service loading is generally covered by application of AS1170.2, assuming (logically) that the load is off the hook.

Minimum design wind speeds for permissible stress design are given for particular types of crane as follows:

- Mobile cranes 10m/s
- Concrete Placing Equipment 15m/s
- Tower cranes 20m/s (was 15m/s until 2004)
- Builders’ Hoists 20m/s
- Building Maintenance Units 20m/s
- Gantry Cranes not specified

These numbers are used in the design of the crane for strength and stability. A designer has the discretion of using a higher figure to improve utilization of a particular crane.

Forces arising from the effect of wind on the lifted load should be included in the analysis.

The crane code is a permissible stress design. So the quoted wind speeds are the expected peak gust without a ULS factor. The wind speed restrictions in the typical Operator’s Manual nominate these figures, but rarely (if ever) note that the highly likely chance of a gust or squall in excess of the wind speed registering on the anemometer at the start of the lift. Taking the normal distribution factor from the code, the 3-second gust in the next hour is likely to be 1/0.57 = 175% of the current average speed. This will produce 3 times the design forces on the structure.

5.2 HANDLING LOADS ON CRANES IN WINDY CONDITIONS

Cranes are typically designed for an off-vertical lift with the horizontal load equal to 4% of the lifted load. This represents a conservative lower bound to the crane’s capacity to resist wind forces.

Some examples of lifted loads with the back-calculated wind speed for drag equal to 4% of self-weight:

- Concrete Panel 250 thick: 16.4m/s
- Concrete Panel 150 thick: 12.7m/s
- Steel Truss 375kg/m: 10.4m/s
- 700WB130 x 18m: 8.4m/s
Tables such as this can be calculated for particular jobs as a guide to limiting wind speeds. If these limits severely impact on production, a less conservative figure may be obtained from the crane design data.

Tag lines can be added to a lifted load. These are typically polypropylene 20mm diameter for ease of grip. Tag lines control the spin of the load round the hook. Tag lines are held by hand (only) while lifting. With a limit of about 25kg force for the average rigger’s arm strength, they really do not contribute to resisting wind movement during the lift. Once the load is in position, they might serve to assist in holding the load while the first bolt is inserted, but they are not really useful for that task.

With erection of trusses and box girders, the time to make the permanent end connections can be measured in hours. In such circumstances, one must wait for a suitable weather window dictated as much by the crane as the load. Sometimes “preventers” can be used to secure the load and isolate the crane boom from wind actions outside its envelope.

5.3 CRANE MAN-BOXES

A Crane Man-Boxes (or more correctly workboxes) is a personnel-carrying device, designed to be suspended from a crane, which provides a working area for persons elevated by and working from the box. Because there is a wide variety of hazards associated with them, use of Man-Boxes is regulated by WorkSafe and the provisions of AS2550.1. This includes a provision “Workboxes should not be used in winds in excess of 7m/s”.

Referring to Table 1, earlier, this restriction results in about 30% lost production time. On exposed sites this could well double. (The writer was involved with construction at Point Henry, where they achieved an average of 3 hour’s work per day for a 2 month construction period.)

Assuming porous walls, this has a Wind Area (C_D) of 2.5m². Adding 2 men at 0.7m², and allowing for the associated crane hook, gives a total of 4m². All-up weight is about 500kg (5kN). At 7m/s wind speed, the drag force is 118N, or 2.4% of the weight. In the steady state, this is resisted by inclining of the hoist rope. Assuming a pendulum length of 10m for the hoist rope, the sway is 240mm.

With two men in the box, one is there to carry out the work on the structure, and the other is the dogman directing the crane driver. It seems to the writer, that the dogman could assist the crane driver by using his free hand to steady the man-box against the adjacent structure. Such action should only be necessary when the wind speed varies in gusts or squalls. This should allow an increase in the permitted wind speed, without compromising safety.

Note that the man-box should not be secured to the adjacent structure, as this introduces a tipping hazard if it remains in place when the man-box is moved.

5.4 ELEVATING WORK PLATFORMS

Elevating Work Platforms for use outdoors must be checked for stability with a design wind speed of 12.5m/s in combination with dynamic effects on motion and out-of-level of 0.5°. A factor against overturning at this wind speed of only 1.1 is required. To the writer, this doesn’t seem enough to overcome the vagaries of wind speed estimation, but it must be remembered that most work operations with such machines are well within the operating envelope.

6 ERECTION OF BUILDING ELEMENTS

This section of the paper discusses the erection of discrete building elements such as beams, columns, and bracing (typically steel or timber) and panels (light gauge steel, concrete, plywood, glass, plasterboard etc). As noted earlier in discussion of loads on the crane hook, there could be a restriction associated with the lifting operation. But once the element is fixed in place in accordance with the construction drawings, the erector would have a reasonable expectation that there would be no restriction on the wind speed that the structure might then need to sustain.

6.1 STEELWORK ERECTION


- It recommends that column base plates and hold-down bolts be designed to resist wind
loads on the column (alone) during construction.

- “The designer should design all bracing members to cater for all load conditions including wind load during frame erection.”
- Appendix B “Erection Procedure for Portal-Framed Buildings” describes a sequence starting at a braced bay, and gives requirements for the minimum number of purlins to connect each frame back to the braced bay.
- “The erection should not be commenced if there is a forecast or likelihood of strong winds during the erection period.”
- “The designer should endorse the drawing that building is suitable to be erected by the erection procedure as written…”

Compliance with this code by designers is not compulsory, and many designers divorce themselves from erection by a General Note, such as “The Contractor shall provide and leave in place until permanent bracing elements are constructed such temporary bracing as is necessary to stabilize the structure during erection.”

The evidence from the writer’s experience as expert investigator in two portal frame building collapses is that applying this code could be effective in the prevention of collapses. Lives have been lost.

WorkSafe Victoria has issued an Industry Standard “Safe erection of structural steel for buildings” [8]. This follows the outline of AS3828, but separates the task of erection bracing to an “Erection Engineer”. The writer is of the opinion that this separation should only be considered for the most complex of structures; in other cases the permanent works designer, as the one with the most intimate knowledge of the structure, should shoulder this responsibility. Examples of complex structures will be given later in this paper.

Erection of steelwork is normally at a rate of 20 to 40 simple members per day. The aim of the erection scheme planning should be to erect discrete portions of the structure each working day. Forecasting wind speeds will allow some discretion on the bracing requirements for some elements, but good practice is to have a structure braced to sustain design winds at the end of each day.

Generally beams from the standard UB, UC, WB, WC, PFC, RHS, and CHS ranges can be erected without the need for intermediate bracing. For very long lengths (installed before bracing to other construction), the simple rule of thumb is to limit the \((l/r_y)\) ratio to no more than 300. Beyond this, intermediate bracing will be required to sustain the full design wind, and must be installed before leaving site that day. (Whilst checking such beams, make sure that the beam can carry its own weight and 2.5% lateral “robustness” load, and that the slinging arrangement is such that the beam will not buckle below the crane hook.)

In large portal frame construction, rafters are likely to need installation of some purlins back to the previous bay before releasing the load from the crane. Refer to AS3828 for portal frame bracing, but appreciate this is not sufficient for high winds, especially where several portals are reliant upon the purlins to resist wind loads.

Seven portal frames collapsed on 2 April 2008 after erection the previous day. Figures 3 and 4 show details of the collapsed structure. Figure 5 shows the forecast from the morning before.

![Figure 3: Aerial view of collapsed portal frame, with purlins in bundles in preparation for installation.](image1)

![Figure 4: Braced bay intact, with buckled bracing purlins hanging down in front.](image2)

![Figure 5: Synoptic charts from The Age, 1 April 2008.](image3)
The portals collapsed in an estimated wind gust of 15m/s. Analysis of the braced bay suggested it would have collapsed later in the day when gusts exceeding 30m/s were experienced.

Columns should have base plates with sufficient overturning moment capacity to resist wind on the column alone, as recommended by AS3828. The common method of erection of column bases is to use packing shims at the middle of the base plate. (These shims are placed by the surveyor establishing levels for the underside of base plate.) With such an arrangement (as illustrated in Figure 3), four bolts are required to plumb the column in the north/south and east/west directions.

![Figure 6: Typical base plate arrangement](image)

Frequently with long-span portal frames and roof trusses, some intermediate bracing is required to sustain the full 41m/s wind. In such cases, the writer back-calculates the sustainable wind-load, and then makes a decision on whether the bracing has to be installed before the frame/truss is released from the crane hook. If so, another crane must be mobilized to lift the bracing members. If not, the erection sequence is annotated with a note “to be completed in a weather window” with forecast winds not exceeding (typically) 25 knots.

### 6.2 CONCRETE PANEL ERECTION

Erection of concrete panels is covered by AS 3850 [9], which is currently under revision. The current edition simply refers to AS1170.2. The revision includes reference to AS1170.0 Table F1 and F2, prescribing minimum importance level 2 for calculating wind, and suggesting the importance level of adjacent structures be assessed when the panel could fall outside the boundary of the construction site.

Design of props is not a difficult task once the essence of wind loads on free-standing walls is understood. The peak pressure on a panel is when it is at the leading edge with wind at nominally 45° and is given in AS1170.2 Table D2(C) as $C_{p,n} = 2.40$. Away from the leading edge, or in a situation where construction has continued round a corner of a building, the peak pressure is much reduced.

Suppliers of Panel Props include values for the axial capacity of the props, but appear reluctant to estimate the wind action. The Shisham website has a “Prop Calculator” but it includes the caveat “This is just a guide as size may change due to load. Please check with your engineer.” The writer believes a complete “Prop Calculator” is possible, and would allow panel erectors to select props without reference to an engineer.

In terms of design wind action, there is potential for a saving in prop hire costs by allowing removal of one of the two props normally required once construction proceeds further along the wall, or round a corner.

With construction in cyclonic zones out of the cyclone season, it appears reasonable to use the Region A design wind speed, rather than the higher speed required by AS1170.0 Table F. In the cyclone season, the prop designer might consider only installing sufficient props for the Region A wind, with a proviso that extra props be installed where necessary in the 72 hour warning period.

### 6.3 HOARDINGS AND FENCES

Wind load on hoardings is covered by the same free-standing wall provisions of AS 1170.2 as
concrete wall panels. The “wind on the quarter” $C_{p,n}$ of 2.40 normally governs.

The failure of the hoarding in Swanston Street Melbourne that resulted in three fatalities has drawn attention to the need for proper engineering guidance on such matters. Perhaps the industry needs simpler guidance on the design of propping systems for hoardings.

Many construction sites now feature shade-cloth covered fencing and scaffolds, with the shade-cloth printed with the builder’s name. The shade-cloth is typically 70 to 80% solid, which only makes a marginal reduction to the design pressure for the supporting scaffold. The practise is to connect the shade-cloth with a limited number of electrician’s cable ties. These cable ties typically fail at about 20kg tension, making them an ideal “frangible link”. Applying the frangible link process for calculating the design load for the supporting structure gives the temporary works designer a rational basis for the loads on scaffolds.

For chain-wire fences, fixing with a small number of cable ties only works if the wind is blowing the fabric away from the chain-wire. Figure 7 shows the fence at a Preston construction site in the morning and afternoon of 9th February 2014. The maximum gust recorded at Melbourne Airport that day was 22.5m/s.

![Figure 7: Shade-cloth fence at Preston Workshops](image)

### 7 SPECIAL CONSTRUCTION CASES

The writer has designed the temporary works for construction of a number of very large roof structures, including the movable roofs covering four of Melbourne’s sporting venues. These roofs have a large wind area, producing substantial forces to be resisted by the temporary supports.

At Docklands, the 500t roof modules were assembled at ground level, jacked 40m up to working level, and then rolled 40m to the end of the permanent runway. Horizontal wind forces had to be transferred down the 40m to ground then another 35m down through silt to bedrock. Placing a restriction on wind speeds during the lift and roll operations (48 hours in total) reduced the cost of temporary structures substantially. One of the four modules was delayed one day by weather conditions.

Jacking was also used to lift the roof trusses on the Biman Airlines Hangar at Dhaka Airport, Bangladesh. The construction programme had the first lift scheduled at the end of the cyclone season. The wind area of this first lift was about 40% of that of the total building, but included only 10% of the bracing. Not wanting to delay the project, the writer designed additional temporary bracing to be pre-fabricated and installed in the 48 hours’ warning period expected for a cyclone. No cyclone arrived, and the bracing was not needed.

At the Hisense Arena, the two 250t roof modules were lifted by a crawler crane. The Bureau of Meteorology was consulted when the modules were ready. Their advice was that the 25 knots of breeze that afternoon would abate to less than 5 knots by 9pm. Their prediction was accurate.

Supervision and verification is part of the construction process. There have been occasions where project management has attempted to override restrictions, but fortunately strong site supervision at the sub-contractor level has generally avoided these issues.

In other cases, restrictions introduced early in the design process have been reviewed in the light of experience on site. For instance, movement of the gantry for renovation of Westgate Bridge approach spans had a restriction of 25 knots wind, as this forecast wind speed resulted in a design gust sufficient to push the gantry up the 4% grade. When it became apparent this restriction was affecting production, the design was changed to include a “preventer” to control up-grade motion, allowing relaxation of the wind speed restriction.

On the Western Ring Road Princes Freeway interchange, the erection gantry was pushed over sliding bearings. Calculations indicated that the friction in the sliding bearings would be insufficient to control lateral movement whilst pushing the gantry to the next span. When weather conditions degenerated to worse than forecast, the writer went to site and personally monitored the movement.

### 8 SPECIAL BUILDING CASES

Different wind speeds at the top and bottom of the building can result in significant differences in static pressure between the top and bottom of lift wells which is sometimes sufficient to jam lift doors. To counter this, tall office buildings are effectively sealed. Apartment buildings with individual balconies and operable windows have a more difficult problem, with building managers given the authority to close apartment windows and doors.

Aircraft hangars are normally designed assuming the doors are closed at the time of the design wind
event. The Biman Hangar referred to earlier was designed as a cyclone-proof shelter for the airline’s fleet.

In all these situations, the designer needs to provide the occupier with explicit instructions on the actions to be taken and when these must be completed. The writer recommends reference to the BOM Warnings as described earlier.

9 AMUSEMENT RIDES AND DEVICES

These have a standard 20m/s design wind speed (working stress design). Such speeds occur only in significant storm conditions, so are relatively easy to forecast and address in operation.

The only case where serious consideration is necessary is with large Ferris Wheels, such as Melbourne’s Southern Star. This revolves at 20 minutes per revolution, so it takes at least that time to unload the riders, and engage the storm locks. With an overall height of 110m, the difference in wind speed between top and bottom is of the order of 30%, causing the machine to spin if the brakes are not locked.

The writer designed the structure for the Geodome that featured in the Sydney Olympic Closing Ceremony. With a strict limit on the gross weight to be lifted by the converted amusement ride, the moving petals of the dodecahedron were predicted to “flap” at 20m/s gust. The long-range forecast (2 years ahead!) was for much less than that at 8pm on the day, and proved to be correct. It was, however, blowing at 30 knots earlier in the afternoon.

10 SAFETY IN DESIGN

“Safety in Design” is a new headline for an old responsibility – if a structure collapses during construction, its design will be placed under a microscope, and the designer may be called upon to show why his design did not address the particular cause of that collapse.

A quote from the Report of the Royal Commission into the Failure of West Gate Bridge [10], dated 14 July, 1971 is pertinent, “There was a failure to give any adequate check on the stresses set up during the various stages of erection. Even where contractors are responsible under the terms of a contract – it is essential that consultants satisfy themselves independently that work is being done safely – because men’s lives are at stake.”

Reference should also be made to AS4100 [11] Section 1.6.2 Design Details, “The drawings … shall include … (f) “Any constraint on construction assumed in the design”. If the structural design of the permanent works assumes the complete structure will be erected in benign wind conditions, the designer has a duty to include this on his drawings, as otherwise he may be held liable in the event of a wind-induced collapse.

11 CONCLUSIONS

The adoption of Numerical Weather Prediction software has resulted in a significant improvement in the accuracy of wind-speed forecasts. This allows the designer to consider using reduced design wind speeds for really temporary structures existing for up to 48 hours. Warnings from the BOM serve as a ready reference for when particular activities can or cannot be carried out.

Nevertheless, the designer needs to consider the risks associated with adopting reduced wind speeds, making sure the resulting savings are not at the expense of a much more likely collapse.

The writer’s 25 years’ uneventful experience in construction indicates that it is possible to make such savings.

REFERENCES
