Your ref -
Our ref 259272-09
File ref -

ARUP

Level 10, 201 Kent Street
PO Box 76 Millers Point
Sydney, NSW 2000
Australia

t +61 2 9320 9320
d +61 2 9320 9921
m +61 416 161 856
f +61 2 9320 9321

graeme-s.wood@arup.com
www.arup.com

Mr. Rajiv Shanker
Lane Cove Council
48 Longueville Road
Lane Cove
NSW 2066

16 March 2018

82-90 Christie Street, St. Leonards

Dear Mr. Shanker,

Please find herein a review of the Windtech report entitled 'Pedestrian wind environment study 88 Christie Street, St. Leonards' dated 13 December 2017, ('the Report').

General comments

In terms of a wind assessment report, this is considered a poor example and deliberately confusing for the reader. There is insufficient information to independently work through the results. There is no discussion on flow mechanisms, hence any justification for the proposed amelioration measures is lacking. There are no photographs of the existing configuration. Photographs of the model are not conclusive of the surround model tested, a plan view of the turntable in all configurations with the building layout and heights is a more appropriate historic record of the testing. There is no defined Tower naming convention, nor detailed information on the geometry of the subject building such as height.

While the experimental and processing techniques appear to be sound and follow the recommended procedures of the Quality Assurance Manual of the Australasian Wind Engineering Society AWES (2001), there is no mention of AWES (2014), which is relevant to this type of study. A number of concerns have been identified with the content and presentation of the Report and these are outlined below.

Table 9 of the Report does not separate the performance of the space from a comfort and safety perspective, this is considered essential for developing amelioration for the space. The Report recommends potential amelioration measures to improve the wind environment, but does not quantify their effectiveness. Testing would be required to quantify the benefit of the proposed amelioration measures. The Report does not demonstrate compliance with the wind safety criteria for more than half of the tested locations in the public domain, and there are four locations (3, 9, 13, and 30) that exceed the less stringent safety criteria stated in the report. The conclusion presented in the Report is therefore considered by the reviewers to be unsubstantiated.

In Appendix A, it is frustrating that all the graphs do not have the same scale on the axis for ease of comparison between locations.

Specific Comments

Wind climate

The Report indicates statistical wind data from the years 1995-2016 obtained from the Bureau of Meteorology weather station located at Sydney Airport has been used to compile a wind climate model. This is considered a reliable set of data. However, with reference to our analysis of the 10-minute mean Sydney Airport weather data, the design wind speeds presented in Table 1 of the Report are low, which would underestimate the predicted wind speeds around the site. It is unclear whether the 10-minute mean data from the airport have been corrected in any way to a one-hour event, which is the basis of the analysis. Any correction applied to the data needs to be reported; as all 10 minute mean data cannot be considered as greater than the hourly event, which can only be used for an extreme value analysis.

It is unclear the probability used for the once per week and once per annum events. Strictly speaking a one hour mean wind speed occurring once per week or year would be 1/168 = 0.6% and 1/8760 = 0.011%. The Davenport comfort criteria used in the Report are for 5% of the time, but described as a 'weekly event'. Statistically, 5% of the time is a more like a storm event of about 4-hour duration occurring during daylight hours (4/84 = 4.8%). If this is the case, then the statistics are inconsistent with the wind climate used for the analysis, which should be daylight only hours. In Sydney, the daylight hours mean wind speed is faster than for all hours, hence the results presented in the Report would be non-conservative. The peak factor used in the analysis would similarly increase.

Similarly for the annual event, the 'once per annum' Melbourne criteria are based on the peak 3 s gust wind speed occurring in an hour for 0.1% of the time. The 0.1% of the time is justified as the worst gust event occurring in a 4-hour storm, during daylight hours.

The corrections for the wind data have used ISO4354 rather than the wind profiles in Standards Australia (2011). A reference height of 75 m has been used for the correction of the data. However, the height of the tallest tower is estimated at about 150 m. This would have an impact on Figure 3 in the Report, and the corresponding correction factors in Table 3. This data manipulation is not in accordance with Standards Australia (2011) as noted in Section 3 of the Report. It is not stated what the correction factors in Table 3 are related to, which is assumed to be the 3 s gust wind speed at 10 m in open country terrain. The report does not explain how the wind climate analysed at 30° increments is converted to the 22.5° increment directions used for testing.

Wind tunnel model

There is no information on the existing model test configuration. The wind-tunnel model does not extend to the walls of the wind tunnel. This corridor of least resistance would encourage more flow to these areas, therefore reducing the amount of flow through the model. As the building heights are not significant in this area, this is not considered a major issue, however the topographical blockage would be more important.

From the photographs, the model topography looks to be modelled correctly. There is about a 30 m height difference around the perimeter of the model. A criticism would be the treatment of this artificial cliff at the perimeter of the model and the resulting downstream effects. The density of the buildings in the centre third of the turntable would reduce the importance of these effects.

The test area considered for the assessment is not considered great enough to capture the impact of the proposed development. The recommended assessment zone is shown in Figure 1. Such a large development would be expected to have a greater impact on the surrounding environment further from the site than the area tested, particularly on the south-west corner of the intersection of Christie Street and the Pacific Highway. Figure 5k in the report showing the location of the remote test locations on an aerial photograph is poor to get an appreciate of the exact test location.

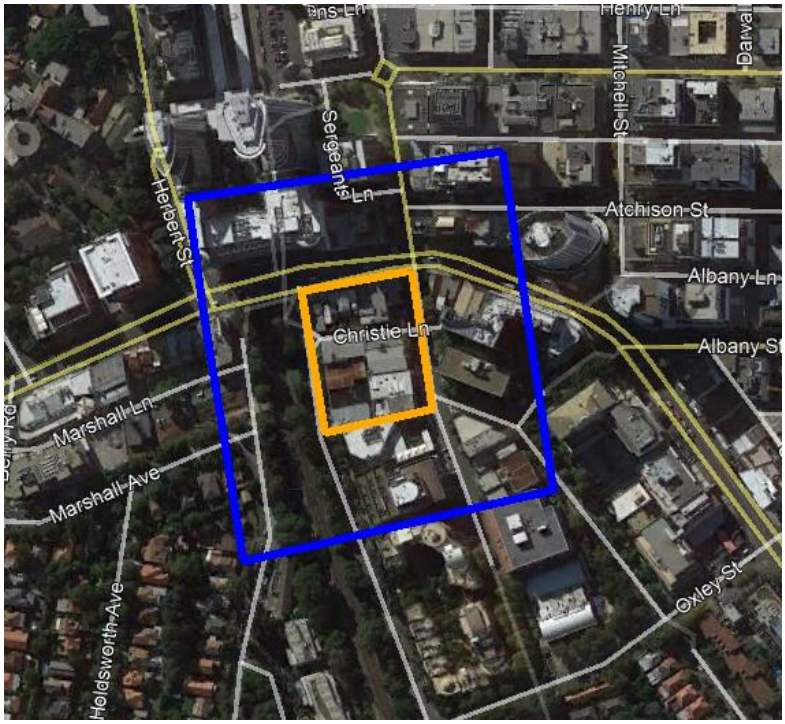

Figure 1: Recommended test area from AWES (2104)

Scale modelling of narrow laneways is prone to Reynolds number effects, which underestimate the real flow field through the space. There is no mention in the Report if the model geometry has been altered to account for such effects. This is crucial for the consideration of the wind conditions along Christie Lane and the central courtyard area.

Wind speed criteria

As discussed above, the Report uses a modified version of Davenport's criteria [3] for assessment of pedestrian comfort. The specified wind speeds are for a maximum one hour mean wind speed occurring for 5% of the time.

The comfort wind speed presented in the Report is the maximum of the hourly mean, or gust-equivalent mean (GEM). The safety criterion in the Report is based on the work of Melbourne (1978), with a maximum annual gust wind speed of 23 m/s in an hour. This is in accordance with the recommendations of [2], however, the relationship between the definitions of '0.1% of the time' and 'annual occurrence' is not made clear as discussed above as one hour per year has a probability of 0.011%. This has an impact of the peak factor used to estimate the gust wind speed, which is based on both the duration of the gust and the mean wind speed. The gust wind speed is of 3 s duration and is predicted from the mean and standard deviation wind speeds. These statistics are measured using a hot-wire. Windtech have published work showing that the **mean** wind speed measured using a hot-wire can be incorrect in areas of high turbulence, such as those around the site, yet there is no mention as to how this could affect the presented results. The peak factor used in the report, 3.0, is for the relationship between the maximum 3 s gust in the maximum hour.

The measurements were taken for a full-scale equivalent of 30 minutes and therefore the peak factor would be slightly lower. This would make the results conservative, but since there is no presentation in the report as to what conditions were governed by the mean or GEM, the importance of this inconsistency cannot be ascertained.

The Melbourne criteria are split for comfort (peak 3 s gust of 13, and 16 m/s occurring in an hour for 0.1% of the time from any direction) and safety (peak 3 s gust of 23 m/s occurring in an hour for 0.1% of the time from any direction). The results and particularly the discussion of these two conditions should be separate, as planting should not be used to mitigate against safety issues.

The target comfort criteria for large areas are the same, and for certain areas it would be more appropriate to change the intended use of the space to more transient activities rather than including amelioration that would make the area less appealing for the remainder of the time.

Presented Results

The Report summarises the results of the wind tunnel testing in a table listing the desired criteria for each measurement location and whether it is satisfied (Table 9, p.34). For cases where the target rating is not achieved, it is not specified whether it is the comfort (Davenport or Lane Cove) or safety (Melbourne) criteria (or both) that have not been met. The same issue is found in interpreting the wind directionality plots (Figures 6a-k, p.36-46) – it is not stated whether the directions indicated in red have failed the target 5% comfort criteria (mean or GEM), or the 0.1% gust safety criteria, or both, or either. This information is important as it should be used to determine the final design of the space.

The justification that if the proposed wind conditions are better than existing that no mitigation is required is considered flawed, as the intended use of the space, and density of pedestrian traffic will change post-construction.

As discussed above, the impact of such a large development on areas further from the site should be investigated more fully.

Locations 1 and 2 in the existing configuration would appear to be inside buildings, Figure 2. As there is no data for the existing configuration in the Report, it is impossible to check.

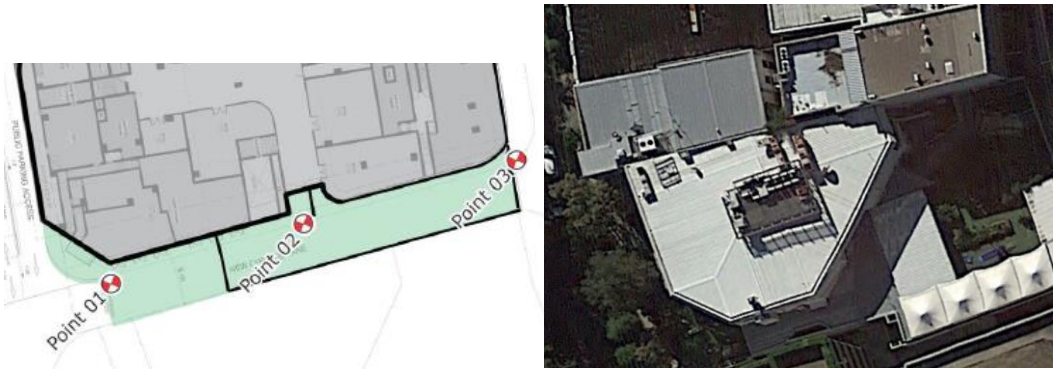

Figure 2: Test Locations 1 and 2 (L), and aerial image (R)

As there is insufficient detail in the report and no discussion around the results, there are some uncertainties as to the cause for some of the trends in the results. The inclusion of such large buildings on the fringe of a built-up area would be expected to have a significant impact on the local wind climate, particularly around the corners, such as Location 3, Figure 2, where the impact of the development has a significant impact on the wind conditions Figure 3. However, for example Locations 5, and 21, Figure 4, illustrate that the

proposed development offers significant protection from all wind directions. The change in measured mean wind speed between Locations 5 and 6 in the existing configuration for winds from the south goes from 7 to 11 m/s. This gradient of wind speed in a relatively benign area requires some level of explanation.

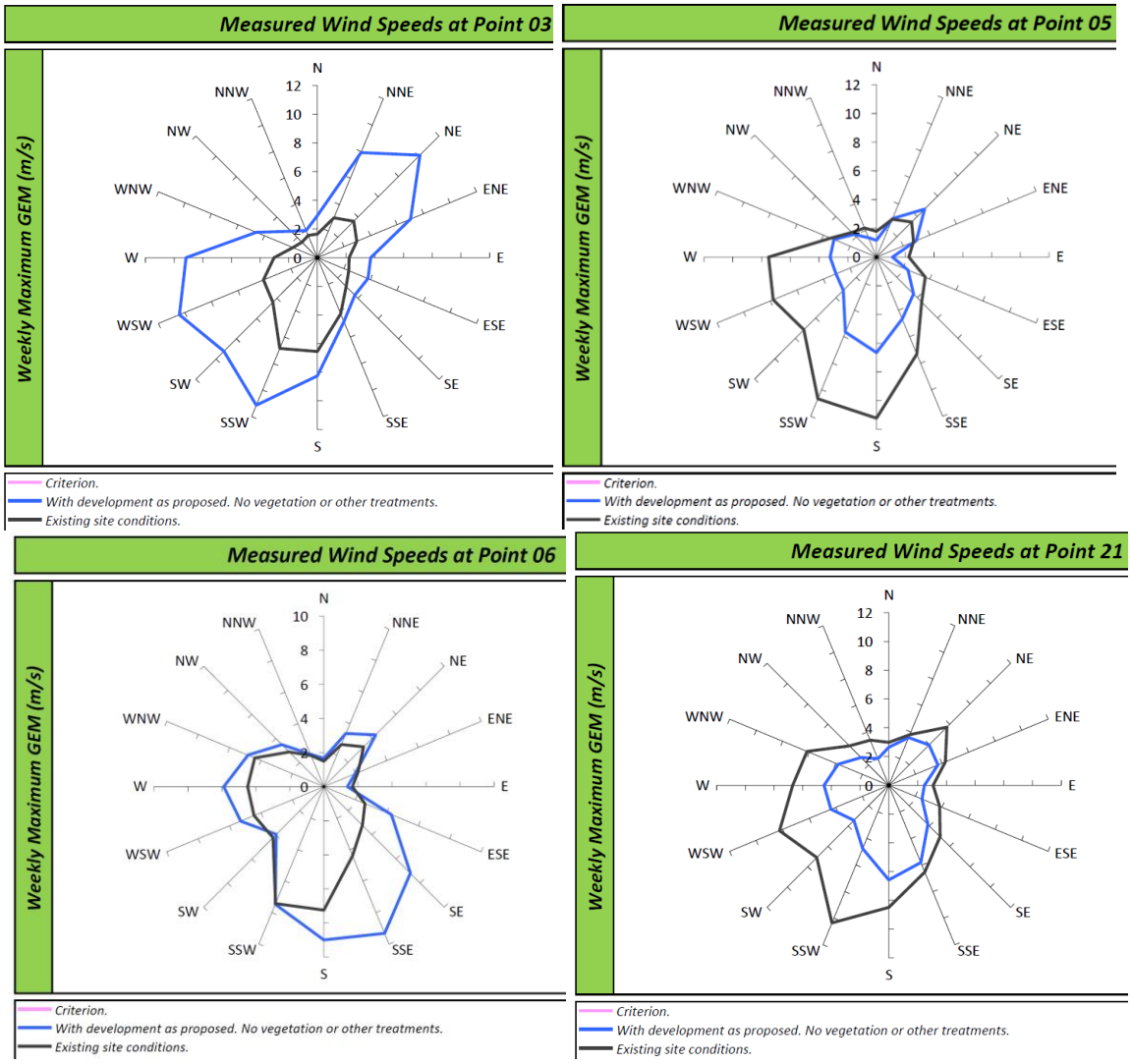

Figure 3: Comfort results from the Report for various positions on the ground plane

Wind conditions at higher levels are in the private domain and residents will use them when convenient. However, as presented in the report the wind conditions on corner balconies are exceptionally windy and not ideal without some ability to close the spaces. Furniture and other loose items in communal areas should be fixed in place, be exceptionally heavy, or the development should have a management plan for items to be brought inside during a strong wind event. Otherwise there is the potential for personal items and furniture to be blown from the building onto the Pacific Highway or railway line.

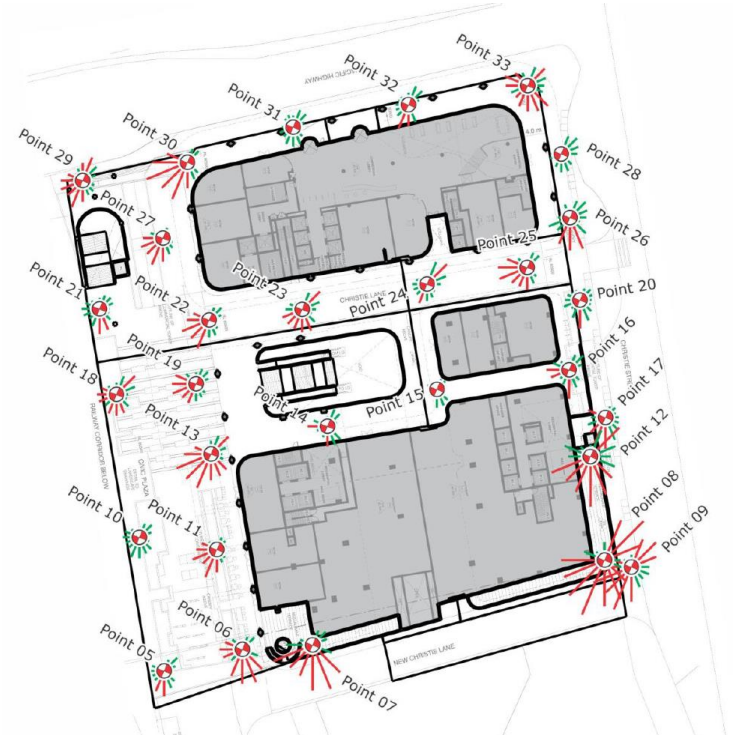

Figure 4: Ground floor test point layout from the Report

Wind conditions remote from the building have been measured at only four locations, Figure 5. The results presented in the Report, surprisingly show the large development to have a minimal impact on the wind conditions remote from the site, for virtually all wind directions. The site is windy, with 3 of the four locations exceeding the Lane Cove comfort criterion, and Location 102 exceeding the Melbourne safety criterion. The only major changes are at Location 103 and 104. At Location 103, for winds from the south-south-west, the proposed development, downwind of the test location, increases the wind speed to above the Lane Cove Council criterion of 16 m/s: this exceedance has not been captured in Table 9 of the Report. At Location 104, the proposed development offers shielding to winds from the north-west quadrant.

Figure 5: Remote test Locations

Amelioration measures

Amelioration both for comfort and safety will be critical for this site. The report does not separate which amelioration is used for which purpose and therefore it can be assumed that the proposed planting is to be used for mitigating safety concerns. The use of planting to mitigate wind speeds is discussed in AWES (2014):

> *The use of trees, shrubs and the like to reduce exceedences of the minimum criterion for public safety is strongly discouraged. Experience in many locations has shown the short-comings of this approach. Trees planted in locations where the 0.1% probability 3 second gust wind speed at pedestrian height is in excess of 23m/s will tend to experience wind speeds at the height of the tree canopy once every 5 years or so sufficient to destroy or severely damage many trees. Trees planted in windy locations rarely mature to their normal full height as modelled in the wind tunnel for a range of reasons including loss of limbs, the drying effect of the wind and the natural tendency of trees to remain stunted in such locations to provide the best chance of survival.*
>
> *In many cases trees placed in high wind areas to protect pedestrians tend to shed limbs during the highest winds causing a public danger and a public nuisance by damaging power lines, vehicles etc.*
>
> *Furthermore, trees planted to reduce adverse wind conditions are frequently located on public footpaths. As such they become the responsibility of the local municipality. The frequent pruning of damaged limbs, removal and replacement of damaged or destroyed trees is unfairly onerous on the municipality and cannot be guaranteed.*
>
> *These Guidelines therefore recommend that the built form be designed in such a way that wind conditions meet the recommendation for public safety without recourse to planting of vegetation.*

Appendix A of the Report contains directional test results at each point. Two graphs are presented for each location, the upper one relating to the Davenport comfort criteria, and the lower one relating to the Lane Cove Council criteria. As discussed in the Report, the Lane Cove criteria is really a comfort criterion, but there is no recognition in the discussion of the Melbourne safety criterion. Of the 33 test locations on ground floor, there are four exceedances of the Melbourne safety criterion with the proposed development (Locations 3, 9, 13, and 30). All exceedances of this criterion, which is the recommended safety criterion in AWES (2014), need to be addressed. Of greatest concern is Location 30, on the corner of Pacific Highway and Lithgow Street, where the wind conditions are considerably stronger than existing conditions and predominantly from the south-west quadrant. Local amelioration through planting along Lithgow Street, and porous screens along the Pacific Highway wrapping into Lithgow Street are proposed. Planting is not recommended for mitigating safety concerns and the screen alone would offer minimal protection. The wind conditions just exceed the criterion level, but they are similar for the entire south-west quadrant, which would make the wind conditions on this corner exceptionally uncomfortable.

The proposed mitigation for Locations 3 and 9 on the south-east corner of the site, is not expected to significantly change the wind conditions, which are governed by the sheer face of the large south-east tower.

The proposed mitigation for Location 13 to the south-west of the site for winds from the south-west quadrant are through trees planted around the south-west corner. Despite

planting not being recommend for ameliorating safety wind conditions, the proposed planting is too far from Location 13 to be effective, and does not address the expected flow mechanism, which is downwash; vertical flow coming down the façade.

Mitigation for the safety exceedances should come through reforming the overall massing of the building, such as a podium setback, setbacks, tapering the façade, or suitable placed local obstructions.

From a comfort perspective, of the 33 test points located at ground level in the public domain, 11 of the locations exceed the Davenport criteria and 25 exceed the Lane Cove Council criteria for the intended use of the space. The proposed comfort mitigation uses excessive planting around the development. From previous studies with landscape architects, the level of wind for plant comfort is similar to mid-range of the Davenport 'Strolling, skating' category. Planting in such conditions would be expected to struggle to survive. The report does not provide sufficient information to assess whether planting would be suitable for intended café style usage, but would not be advised for meeting the comfortable walking comfort criterion of 7.5 m/s for 5% of the time.

The café on the south-east corner terrace of the site should only be used when conditions are suitable and the tenant should rely on these covers for success. Being L-shaped, there should be some calm conditions on the terrace for most wind directions.

The wind flow direction along Christie Lane would be expected to be east-west, directly along the laneway. Hence the proposed inclusion of shrubs along the centreline of Christie Lane is expected to have minimal impact on mitigating the wind speed.

Conclusions Presented

The Report states that:

"With the inclusion of these recommended in-principle treatments to the final design, we expect that wind conditions for all outdoor trafficable areas within and around the proposed development, to be suitable for their intended uses. The inclusion of additional densely foliating vegetation within and around the outdoor trafficable areas of the subject development is expected to further enhance the localised wind conditions."

The reliance of significant planting to mitigate safety issues is not considered a good long-term solution. It is recommended to amend the building design to improve the wind conditions.

Summary

The major issues with the Report are:

- lack of detailed building information,
- no ability to independently check the output,
- the statistical wind speeds in the climate analysis is lower than expected, which would underestimate the wind conditions around the site,
- an incorrect building height has been used to assess the site specific wind conditions,
- insufficient investigation of the impact of the development on remote locations,
- the report results on images are not fully explained – it is not clear which criteria (comfort or safety) are exceeded, nor by which wind event (mean or GEM), as this has implications on the proposed mitigation technique,

- exceedances of the safety criterion are proposed to be mitigated by planting, which is strongly discouraged by the AWES (2014),
- several proposed mitigation measures would not be considered to offer sufficient amelioration to the spaces,
- no discussion of results to justify the proposed mitigation,
- photographs don't show necessary details of model, and no information provided on the existing configuration, and
- the Report concludes that all tested areas are suitable for their intended use, despite presenting evidence to the contrary.

Conclusions

The review of the Report indicates the wind-tunnel modelling techniques are sound.

However, the presentation and interpretation of results is considered poor. The wind conditions exceed the safety criterion at four locations around the site. The proposed mitigation measures have not been quantified, nor even justified through discussion of the flow patterns causing the effects. The use of planting to mitigate safety issues, or for comfort in windy location is of concern. At an absolute minimum the proposed mitigation measures should be retested for the Locations exceeding the Melbourne safety criterion.

I hope this is of assistance, please do not hesitate to contact me on (02) 9320 9921, if you have any questions regarding any aspect of this report.

Yours sincerely,

Graeme Wood
Associate Principal

References

AWES (2011) Wind Engineering Studies of Buildings, Australasian Wind Engineering Society Quality Assurance Manual QAM-1-2001.

AWES (2014) Guidelines for Pedestrian Wind Effects Criteria, Australasian Wind Engineering Society, 2014.

Davenport, A. G., (1972), An approach to human comfort criteria for environmental wind conditions, Colloquium on Building Climatology, Stockholm.

ISO (2009), Wind actions on structures, International Standard ISO4354.

Standards Australia (2011), Australian/New Zealand Standard, Structural design action, Part 2: Wind actions, AS/NZS 1170.2:2011.