NATURAL VENTILATION CONSIDERATIONS

CPP Project 8253

22 February 2016

Lend Lease

30 The Bond, 30 Hickson Rd
Millers Point
NSW 2000

Attn: Ms. Jessica Paterson

Subject: **Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP), Darling Square South-East Plot, Preliminary Natural Ventilation Considerations**

Dear Ms. Paterson,

In light of the new Apartment Design Guide (ADG) that has superseded the existing Residential Flat Design Code (RFDC, SEPP 65) Cermak Peterka Petersen Pty. Ltd. (CPP) has been engaged by Lend Lease to provide comment on the natural ventilation performance of the South East Plot (SEP) within Darling Square, Sydney International Convention, Exhibition and Entertainment Precinct (SICEEP).

The New South Wales Planning and Environment 'Apartment Design Guide' (ADG) to be used in conjunction with the State Environmental Planning Policy 65 (SEPP 65), Part 4 Designing and Building – Amenity -4B Natural Ventilation, describes a new set of Design Criteria. In particular, this letter is in reference to Design Criteria No.1 of Objective 4B-3 which states:

At least 60% of apartments are naturally cross ventilated in the first nine storeys of the building. Apartments at ten storeys or greater are deemed to be cross ventilated only if any enclosure of the balconies at these levels allows adequate natural ventilation and cannot be fully enclosed.

Natural ventilation through an apartment is a function of a number of factors including:

- the wind and breeze resource at the site,
- differential pressures established between the dominant openings to the units and varying according to wind yaw angle relative to the façade,
- elevation of the unit above ground level,
- local façade geometry,
- upstream shielding, and
- turbulence levels.

The SEP has a relatively open exposure to available cooling breezes, including north-east and south-east sea breezes, and winds form the south of significant strength at the site. Furthermore, it has been found that the elevated position of most apartments within the podium and tower will benefit from higher breeze wind speeds.

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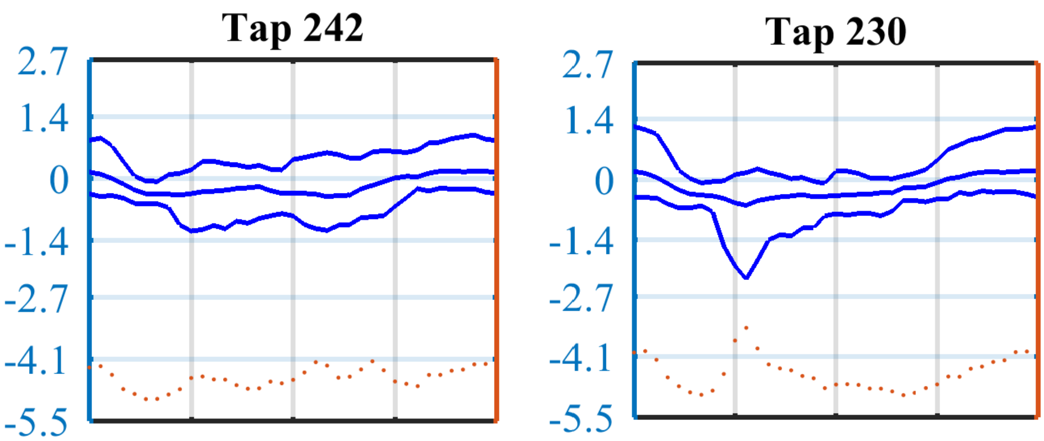
Designers have included open balconies with large sliding access doors to encourage ventilation into the apartments. Bedrooms fronting the exterior façade also include operable windows to encourage breeze paths to form inside the units between the balcony and bedroom windows. Façade articulation and privacy division walls will further assist establish pressure differentials between apartment openings to encourage cross-breezes.

Noting the above in CPP's view compliance for the SEP can be achieved as follows:

- **Level 10 and above:** 100% compliant (218/218 apartments) as supported by the Design Criteria No.1 of Objective 4B-3 of the ADG.
- **Level 8 – 9:** 57% compliance achieved (27/47 apartments) with the standard definition of cross-vent as outlined in Objective 4B of the ADG. Façade pressure modelling has been undertaken to test whether Levels 8-9 experience the same or similar wind pressures that would drive pressure driven natural ventilation flow which would allow the remaining 20 apartments being compliant as supported by Design Criteria No.1 of Objective 4B-3 of the ADG.

  Inspection of façade wind pressure coefficients measured in the CPP wind tunnel test (see CPP8253_Darling Harbour Live Reduced Scheme_INTREP_PR_R00 dated February 2016) demonstrate patterns of mean façade pressures as measured on Levels 8-9 are very similar to locations above Level 10, e.g. pressure tap 242 on level 8 and pressure tap 230 on level 15 both near the centre of the north façade. The distribution of pressure coefficient with direction for each tap is shown in Figure 1 and can be seen to be very similar from a mean perspective, i.e. similar potential to drive pressure driven natural ventilation flow. Façade wind pressure modelling supports 100% compliance can be reached on Levels 8 and 9.



Level 8 Level 15

Figure 1: Façade pressure coefficient with wind direction measured in wind tunnel

- **Level 7 (podium):** 44% compliance achieved via corner apartments (11/25 apartments) as supported by Objective 4B-3 of the ADG. Modelling supports an additional 3 will achieve compliance with the retracted bi-fold screens as discussed above to provide 14/25 apartments or 56%.

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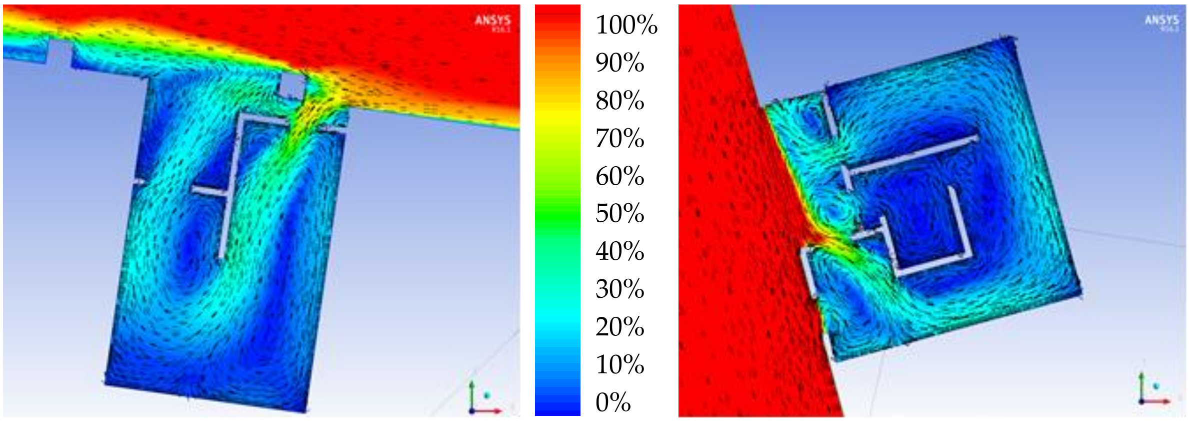
Levels 2-6: 33% compliance achieved (33/101 apartments) with natural cross ventilation via corner apartment method. CFD modelling (see Appendix 1) was undertaken to test whether additional apartments on these levels could achieve natural cross ventilation via architectural elements.

Three north facing apartments on SE2 stack have bi-fold screens that can retract to create an effective 'vertical fin' which can create both a positive and negative pressure zone. This pressure differential has a positive impact on the amount and quality of ventilation within the apartment. This can be seen in Figure 2 with external flows diverted into the apartments by the fins (represented as a box in the figure) with open windows and achieving velocities in the order of 25% of the external flow magnitudes immediately outside the façade and circulating the depth of the apartments.

With reference to the results of the environmental wind tunnel test (see CPP8253_Darling Harbour Live Reduced Scheme_REP_PW_R00 dated February 2016), steady breezes have been measured along the Boulevard and Little Hay Lane (at Lawson Pedestrian Standing and Walking criteria levels) and will be at least as strong up the podium façade; this represents a plentiful wind resource.

Similar levels of ventilation are found on the west facing podium apartment given the shallower apartment depth to width ratio; an additional 2 apartments per podium levels will be adequately naturally ventilated. Overall the CFD modelling supports 55/101 apartments or 54.5% would comply on the podium levels.



Level 4 Wind from the south

Level 4 Wind from the north-east

Figure 2: CFD velocity vectors Level 4 apartments – percentage of external flow

Using the corner apartment method as well as the assumption that Level 8 and Level 9 have the same wind pressures as Level 10 and above, cross natural ventilation is achieved at 54% at levels 9 and below (93/173 apartments).

In addition, CFD modelling supports an additional 23 apartments to be counted as compliant, taking the overall percentage to 67% (116/173).

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We trust this technical note provides sufficient information for this phase of the design. Please do not hesitate to contact the undersigned if you need any additional information.

Yours sincerely

Matthew Glanville

Director

Cermak Peterka Petersen Pty. Ltd.

Wind Engineering and Air Quality Consultants

cc: G. S. Wood, CPP

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Appendix 1: Apartment Natural Ventilation Numerical Study (CFD)

Natural ventilation through the apartments can be driven by differential pressures established between the dominant openings to the units and will vary according to the angle between the wind and the façade, elevation of the unit to ground level, local façade geometry, upstream shielding and turbulence levels.

CFD model description

The current study uses a numerical finite volume method known as Computational Fluid Dynamics (CFD) to provide an indicative assessment of the natural ventilation within typical apartments for prevailing wind directions likely to provide cooling breezes. A CFD model was assembled for both the apartment internal volume geometry as well as the environment surrounding the building as shown in Figure 3. This allows the mean air flow to be modelled both internally and externally to the subject apartments, thereby generating suitable boundary conditions at apartment ventilation openings. This combined approach is not possible with a wind tunnel test due to Reynolds number of the small scale model and other practical constraints. Model geometry was simplified where appropriate to minimize mesh size and improve convergence efficiency. Four representative apartments were modelled in the current study, Table 1. Flow patterns inside the selected apartments are expected to be representative of units with similar geometries and location.

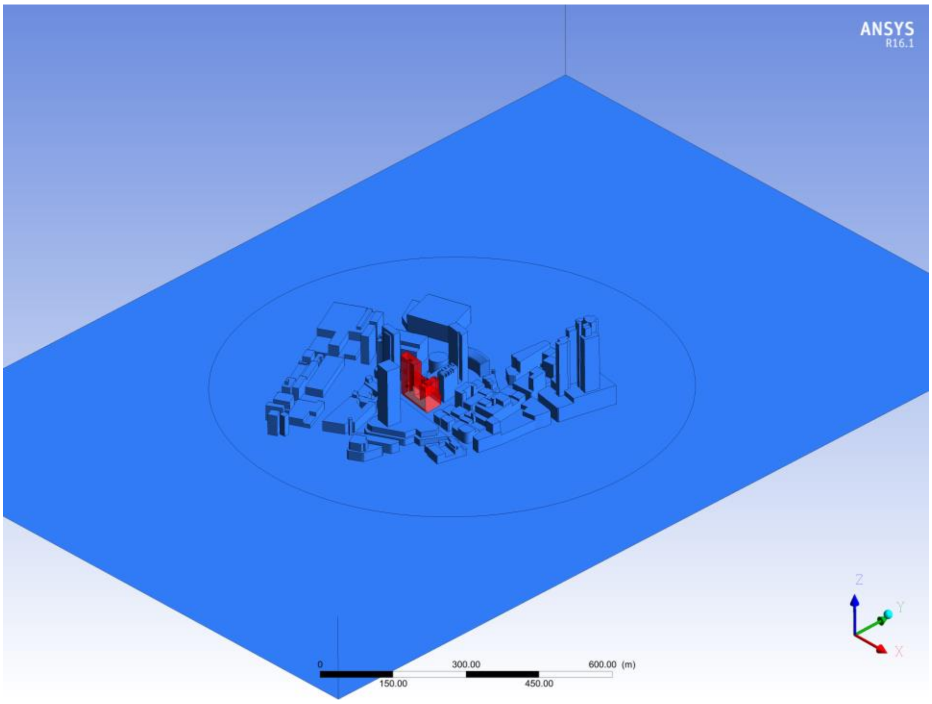

Figure 3: View from the south-east of the CFD model, SE plot coloured red

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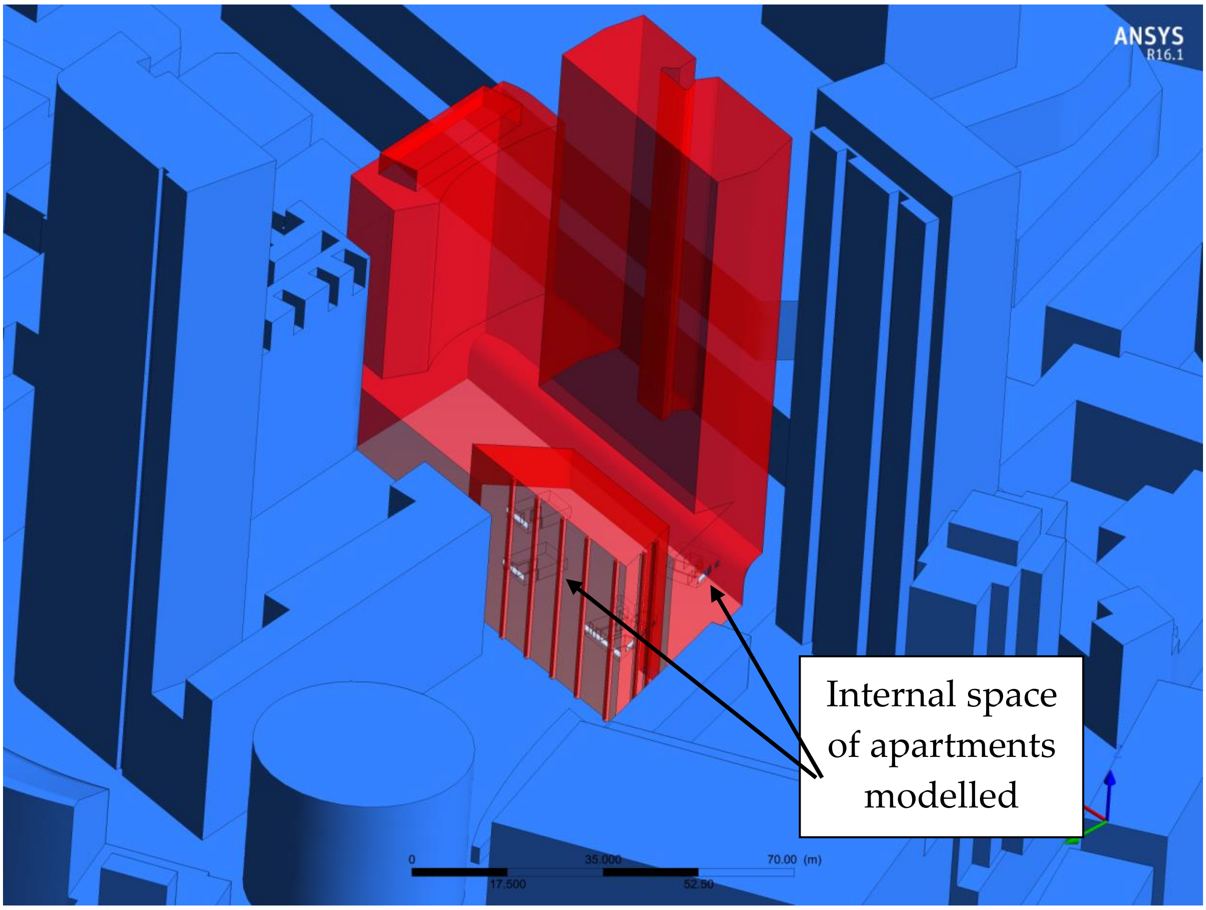

Figure 4: View from the north west of the site model used in CFD study

Table 1: Representative apartments presented in this report

Unit Name	Level
Unit 1BM	4
Unit 2B1B	4
Unit 3BM	4
Unit 1BM	7

A computational grid was designed comprising of several million elements. Prismatic elements were used in a structured mesh near all walls to adequately capture the physics of boundary layer flow when coupled with the appropriate turbulence model. The grid resolution is finest inside the apartments and site building, with sizes growing with distance from the site. Other mesh sizing controls were used to accurately capture the effects of surrounding buildings and terrain on the approach flow to the site. The site and surrounding buildings were placed in a much larger virtual wind tunnel outer domain to prevent blockage effects. The upstream fetch roughness and inlet profile was calibrated to create an AS/NZS 1170.2 terrain category 3 boundary layer profile at the edge of the inner domain. Mean inlet wind speed was set to an

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arbitrary magnitude of 10 m/s at 200 m height, corresponding to a gentle breeze on the Beaufort wind scale, typical for a summer evening in Sydney.

The simulation was solved using the Fluent CFD solver to obtain a solution to the equations of fluid motion. A steady-state Reynolds Averaged Navier-Stokes (RANS) turbulence model was used and is deemed appropriate for flow-visualisation purposes in natural ventilation studies.

Buoyancy forces resulting from stratification of the internal apartment temperature profile will also contribute to air movement throughout the apartment. Typically, however buoyancy flow is dominated by wind pressure driven flow and has not been included in this study. It is considered additional buoyancy driven flow would be a small, but beneficial supplement to the predicted wind pressure driven flow described herein.

CFD Results

Velocity vectors and coloured contours indicating speed and direction of flow are provided in horizontal sections cut through the subject apartments approximately 1.5 metres above floor level, Figure 5 to Figure 8. It is assumed that modelled apartment windows and balcony doors are fully open, which may not necessarily represent the maximum natural ventilation capability for the apartment.

Three north facing apartments on SE2 stack have bi-fold screens that can retract to create an effective 'vertical fin' which can create both a positive and negative pressure zone. This pressure differential has a positive impact on the amount and quality of ventilation within the apartment. This can be seen in Figure 5 to Figure 8 with external flows diverted into the apartments by the fins (represented as a box in the figure) with open windows and achieving velocities in the order of 25% of the external flow magnitudes immediately outside the facade and circulating the depth of the apartments. With reference to the results of the environmental wind tunnel results, steady breezes have been measured along the Boulevard and Little Hay Lane (at Lawson Pedestrian Standing and Walking criteria levels) and will be at least as strong up the podium façade; this represents a plentiful wind resource.

Stronger natural ventilation is seen in the modelled corner apartment of Figure 7 and there will be regular instances where these flows need to be reduced by sealing one perimeter of the unit. In Figure 8, circulation of natural ventilation could be improved with the introduction of a window opening on the right hand side of the figure as plotted.

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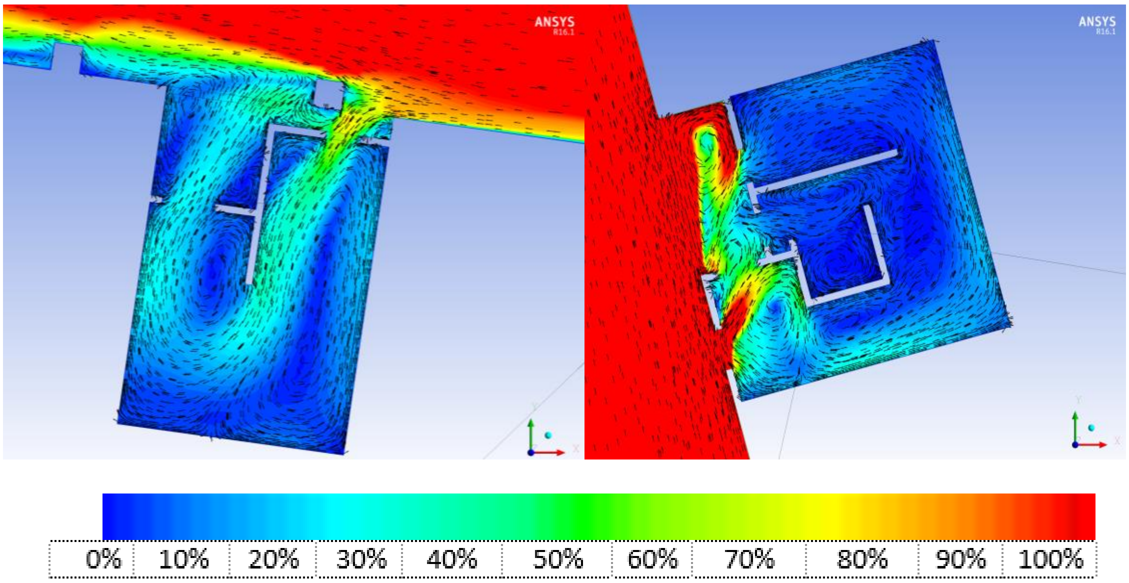

Figure 5: Velocity vectors and contour plot on Level 4, Unit 1BM (L) and Unit 2B1B (R) (South wind direction)

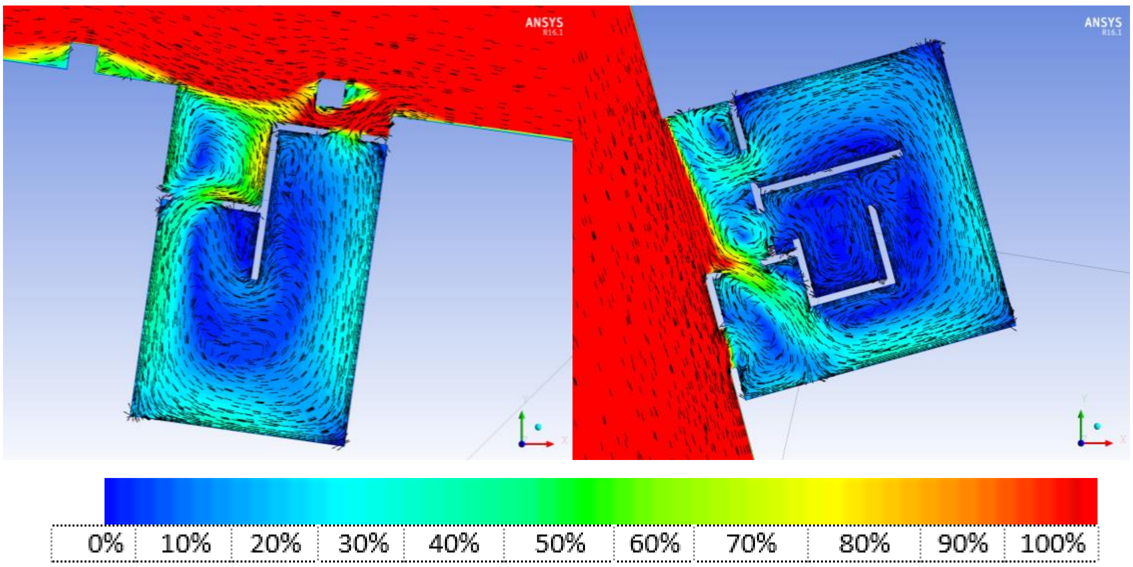

Figure 6: Velocity vectors and contour plot on Level 4, Unit 1BM (L) and Unit 2B1B (R) (North east wind direction)

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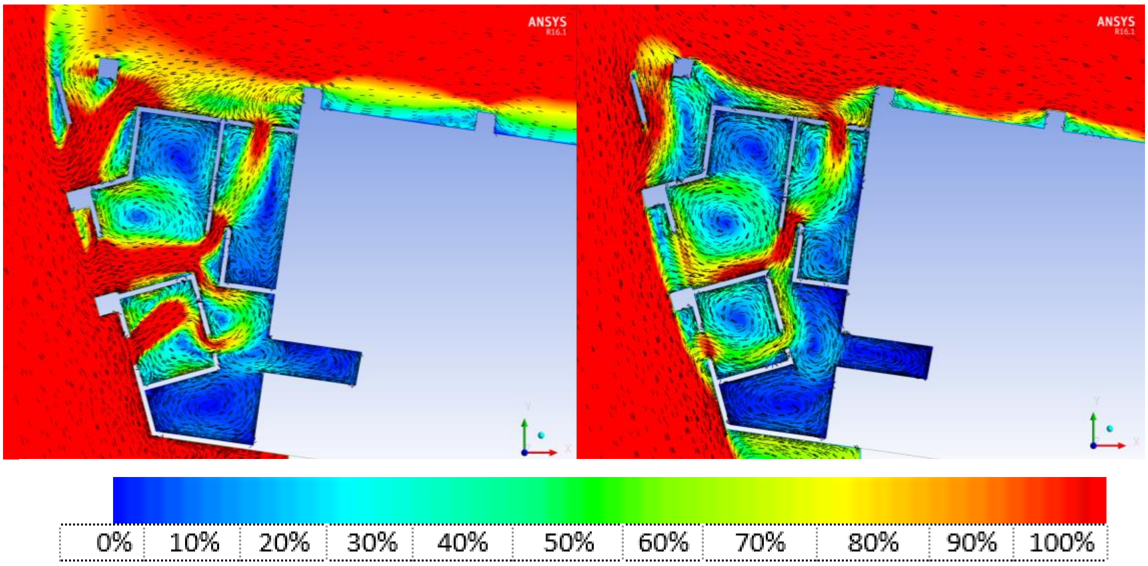

Figure 7: Velocity vectors and contour plot on Level 4, Unit 3BM (South wind direction, L) and (North east wind direction, R)

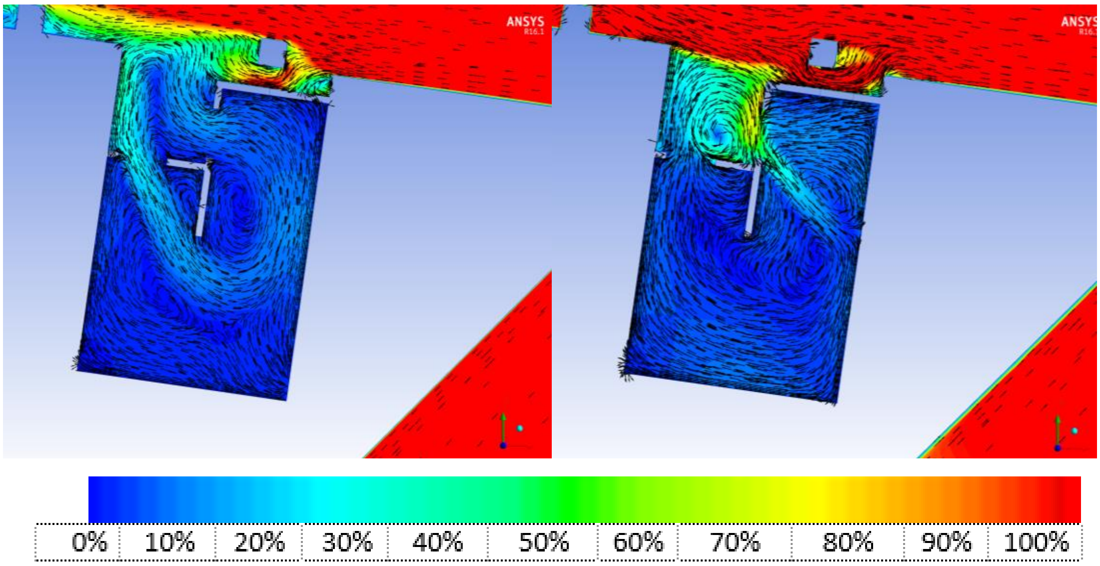

Figure 8: Velocity vectors and contour plot on Level 7, Unit 1BM (South wind direction, L) and (North East wind direction, R)

It is important to note that these idealised steady flow scenarios do no illustrate time-variant air movement about the flow paths and it is reasonable to assume useful velocities will fluctuate about the main flow paths shown.

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