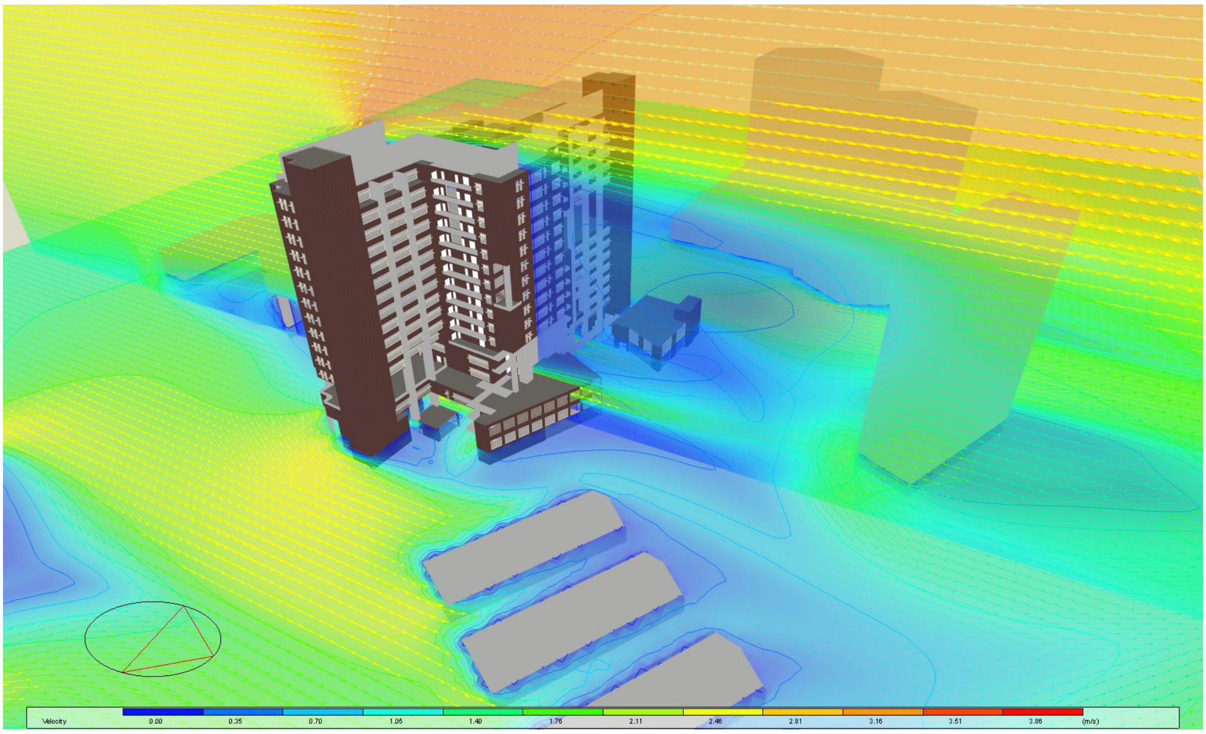
Integrated Intermediate Care Hub (IIHC)

Computational Fluid Dynamic Air Flow Analysis Report



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A. Table of Contents

A. Executive Summary

1. Introduction

This report presents and discusses the results of a Computational Fluid Dynamic Simulation for the proposed Integrated Intermediate Care Hub (IICH). This simulation was undertaken to evaluate and make recommendations regarding the ability of the natural ventilation design to provide occupants with thermal comfort. This report is prepared to fulfil the requirements of BCA Green Mark Healthcare, in order to achieve Platinum level certification.

2. Background of the development

The new Integrated Intermediate Care Hub (IICH) is part of the Health City at Novena Campus in Singapore. The new 875,000 square foot IICH project includes 635 tertiary rehabilitation, slow stream rehabilitation, sub-acute care and hospice care inpatient beds in a new 17 story building. The Specialty Surgical Training Center providing medical education simulation and parking for 540 cars are also accommodated.

The entire new hospital is designed to incent patients to get up, get out of their beds and make progress on their recovery journey with the goal of returning home as fully recovered as possible. The IICH provides for periods of recovery and convalescence within a healing and supportive environment. Comfortable and vibrant public spaces, a focus on environmental continuity and durability, a clear wayfinding and signage strategy and multi-functional spaces to promote culture, learning and health are all addressed in the planning and design of the new hospital. The hospital is being designed to achieve Platinum BCA Green Mark certification.

Figure 01: Master Plan images from Health City Novena

3. Main findings

Wind conditions for outside areas (such as lobby and sky terrace gardens) are sufficient for providing thermal comfort. North wind is obstructed by a condominium to the North restricting access to this wind for the proposed building affecting natural ventilation within the building.

Under the current design arrangement wind velocity is not high enough in naturally ventilated spaces to provide thermal comfort.

4. Conclusion

Currently the building is not be able to meet the Natural Ventilation prerequisite for Green Mark Platinum.

B. Background/Introduction

Natural Ventilation will provide an indoor environmental quality conducive to patient rehabilitation by providing plenty of fresh air and increasing human and thermal comfort as well as reducing energy consumption from mechanical ventilation.

CFD air flow analysis is performed to optimise the building design to ensure thermal comfort and provision of fresh air. Surrounding buildings and local meteorological conditions as well as building shape/orientation, opening size/location will determine the effectiveness of the Natural Ventilation strategies.

BCA Green Mark Version 4 requires wind tunnel testing or CFD simulation as a prerequisite for the Platinum rating. In order to achieve Green Mark Platinum 70% of selected typical dwelling units must have good natural ventilation performance (0.60 m/s). Results from the simulation have been used to give recommendation on Natural Ventilation effectiveness as well as determine compliance with Green Mark requirements.

C. Methodology

1. MACRO

- Make 3D model of proposed development
- Model surrounding buildings expected to directly impact air flow
- Set up the CFD Simulation with isothermal, computational domain, computational grid sizes, wind direction and speed, settings and parameters as per directions in “Annex C VENTILATION SIMULATION METHODOLOGY AND REQUIREMENTS” From BCA Green Mark Healthcare Facilities
- Run Macro CFD simulation for North and South Prevailing wind directions to assess wind flow conditions around the proposed building development and adjacent buildings
- Determine wind pressure taken at 0.5m from every assumed opening of all units and following “Annex C” guidelines.
- Derive average pressure differences for all units at mid-height or selected level
- Evaluate air flow conditions for entire building and relevant outdoor areas

2. MICRO

- Determine up to 5 typical unit design layouts that have the majority of units
- From each of 5 typical units select sample unit for simulation that represents an average pressure difference closest to the average pressure difference for that unit type (according to “Annex C” guidelines
- Run micro simulation for corridor areas and typical units. Determine area-weighted average wind velocity for each sample unit at 1.2m above floor level

- Calculate compliance of areas against BCA Green Mark requirements
- Evaluate and provide recommendations based on results

3. Sample Unit Selection

Naturally ventilated wards are located from levels 03-16. They contain naturally ventilated corridor space, multiple-bed and single bed wards, activity spaces and RETS (gym) space for rehabilitation.

Level		01 - 03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	Total
Type	Notes																
MP	5 and 6 bed: same plan	No NV Wards	4	4	4	10	10	5	5	5	5	10	10	10	5	AC Wa-rd	87
SP			10	10	20												40
AA						2	2	1	1	1	1	2	2	2	1		15
MG	Multipurpose Gym, various layouts,same location					1	1	1	1	1	1	1	1	1	1		10
MP(4)	4 bed plan (smaller than MP)														6		6
AC	combined Music, family living room (partitioned)		1	1													2
PP								2									2
AE	combined Music, family living room (partitioned)				1												1

FIGURE 02: Table showing number of typical units, 5 most common units and floor of selected sample units (based on location and average pressure difference)

The following sample units were selected (also see yellow highlight in Figure 02 above):

- 5-6 Bed Patient Room (MP): Level 08 - MP09
- Single Bed Patient Room (SP): Level 06 – SP19
- Activity Room (AA): Level 08 – AA01
- Multi-purpose Gym (MG): Level 08 - MG01
- 4 Bed Patient Room (MP[4]): Level 16 – MP04

Static Pressure for the openings under South and North wind case for each unit can be found in Appendix 1. Each sample unit was selected for having a close to average static pressure for each South and North wind cases. They were also selected from the mid-section of the building (Level 08) and in as close to normal design case as possible.

D. Geometric Model Parameters and Unit Visualisation

1. Surrounding context for simulation model

- Surrounding the site are a number of existing developments (see Figures XX and XX) including:
  - 20 storey 2 towers of the Ministry of Home Affairs to the West
  - 20 storey "Pinnacle 16" Condominium development
  - Low lying (1-2 storey) Ren Ci Nursing Home to the North East
  - Cluster of 3 buildings of "Pastoral View" Condominiums (tallest 15 storeys) further to the East
  - 4 Storey facility to the South East
  - 16 storey Ren Ci Community Hospital/Brahm Centre directly to the South

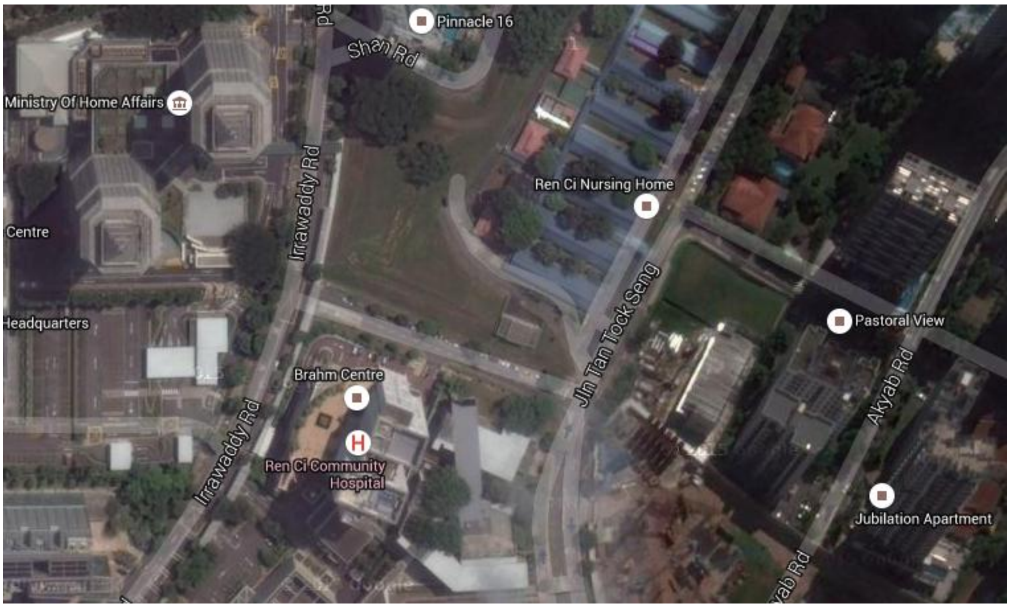


FIGURE 03: Google aerial view showing developments surrounding the proposed IIHC Project site

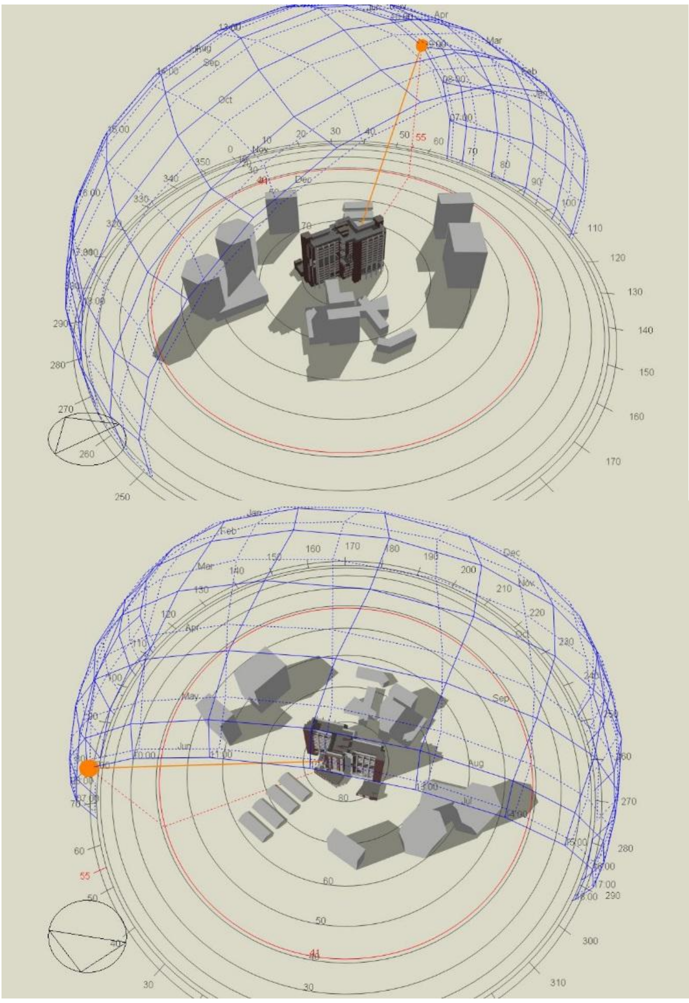


Figure 04: Global View of Model and Surrounds

- Domain size used

  1305m x 918m x 180m

- Plan and 3D isometric model of units from various angles

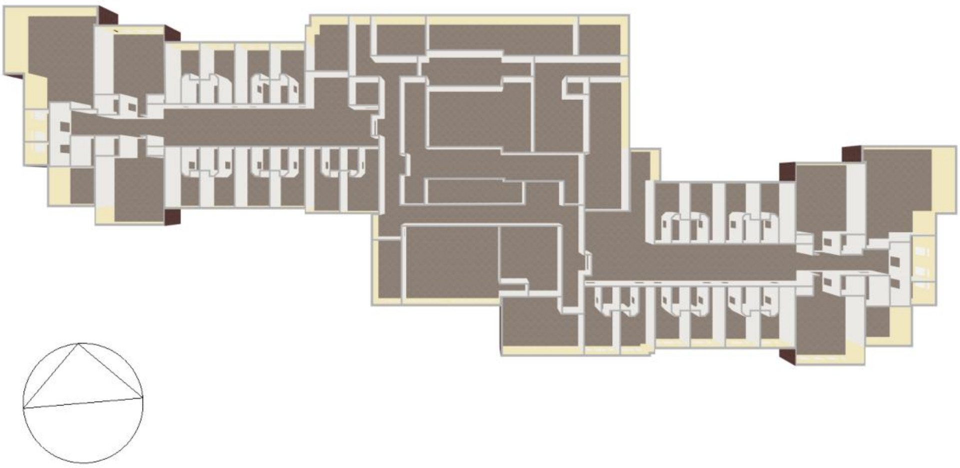
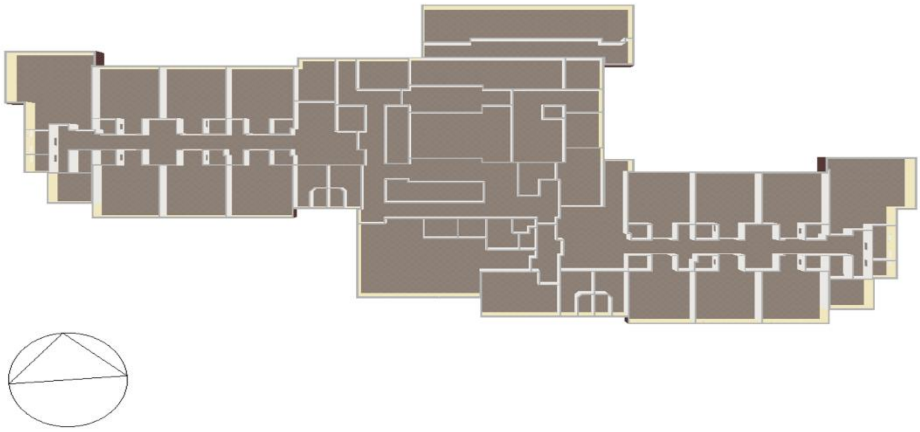


Figure 05:Level 6 Perspective Model Views



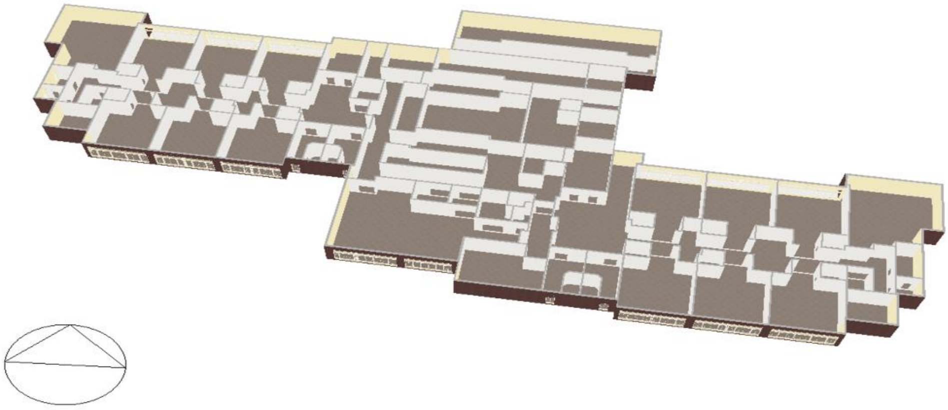


Figure 06: Level 8 Perspective Model View

E. Simulation Settings

1. Simulation Software

- Design Builder, coupled with Energy+

2. Numerical scheme

Turbulence modelling uses the k-ε model option

3. Conditions:

- Isothermal condition of 33.0°C, steady-state condition
- Prevailing winds and direction selected are North and South as these are perpendicular to the long façade of the building. Prevailing winds have been selected from the table below:

Wind Direction	Mean Speed (m/s)
North	2.0
North-East	2.9
South	2.8
South-East	3.2

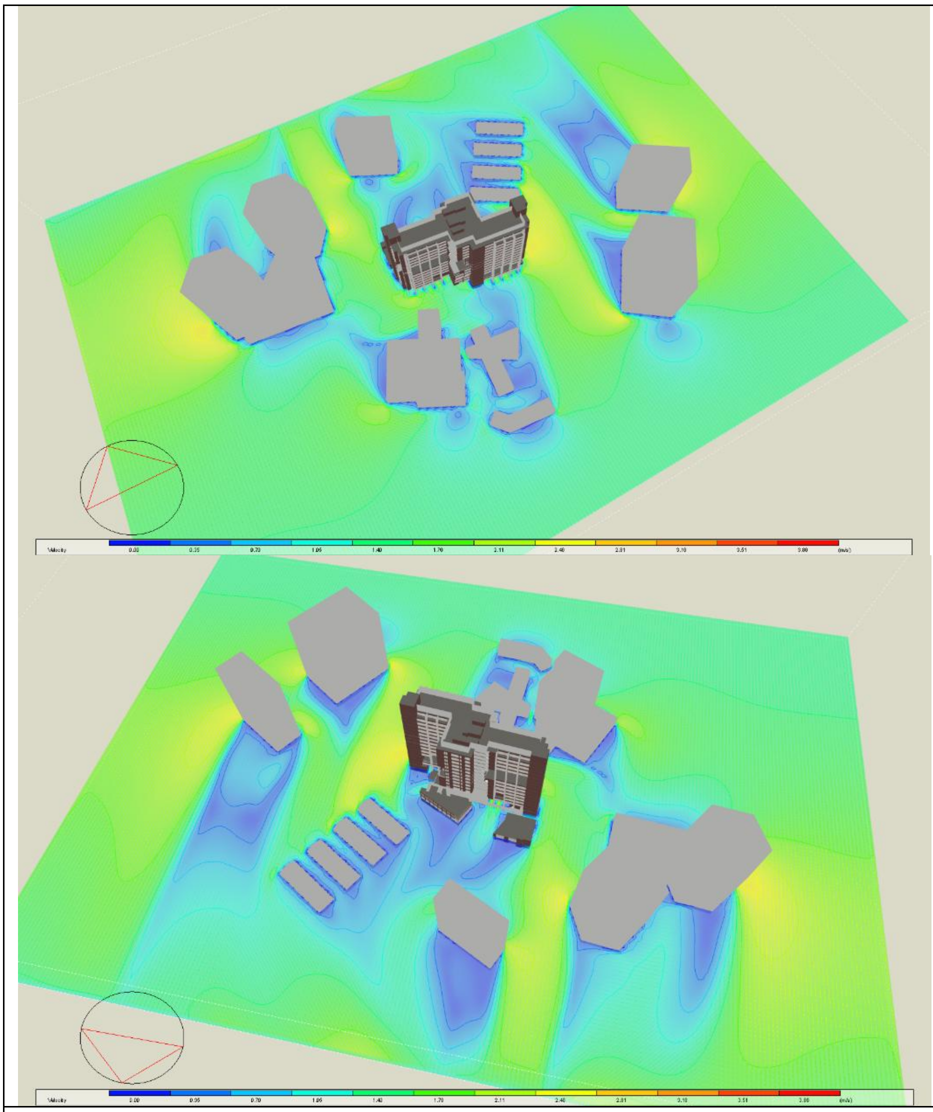
FIGURE 07:Tabulation of Prevailing Wind Direction & Speed obtained from NEA over a period of 18 years.

4. Mesh sizing

The mesh sizes used for this model follow the guidelines specified in “Annex C VENTILATION SIMULATION METHODOLOGY AND REQUIREMENTS” From BCA Green Mark Healthcare Facilities. Mesh size of 0.1-0.2 m in the building of interest, 0.7-1m for the surrounding buildings and 1-3m for the ground surface.

F. Result and discussions

1. Simulation Results: MACRO – South Wind, Low level-case

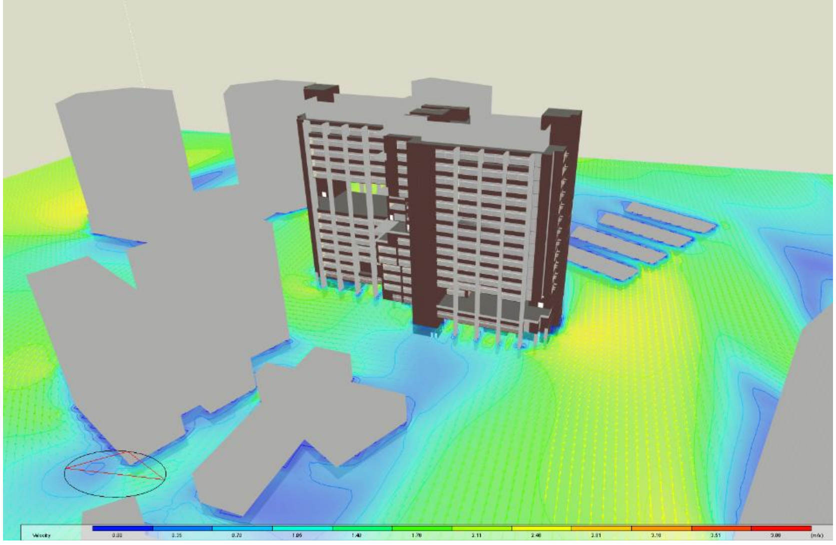


a. View from South

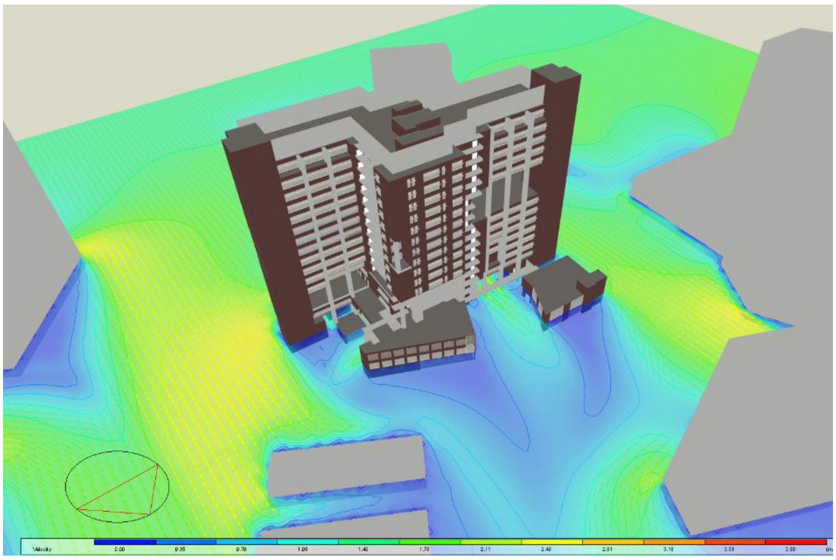
b. View from North

Figure 08: Regional View: South Wind Case (near ground level: +4.53m)

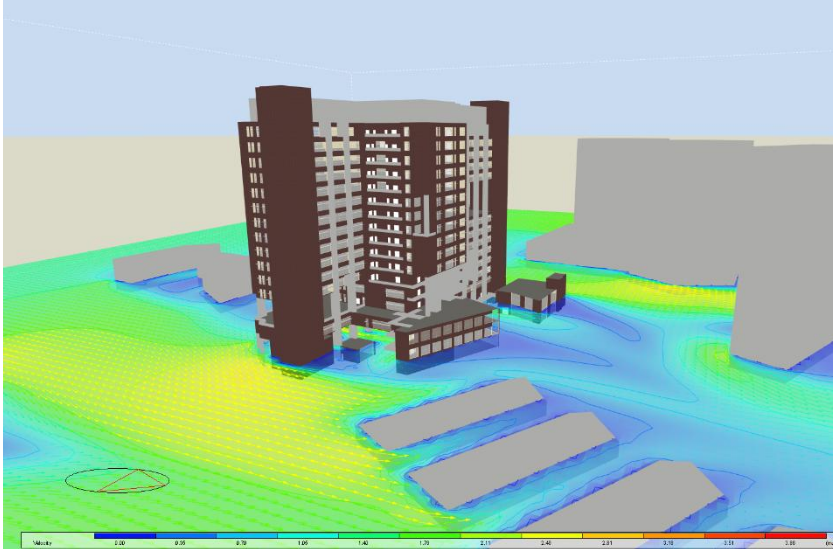
The 4 storey facility to the south-east of the development is low enough and the Brahm Centre is West enough that wind conditions for the proposed building are not impacted too much by surrounding buildings. Future master-plan development on the site South (directly across the road) in place of these 2 buildings could have a great impact on wind access from the South.



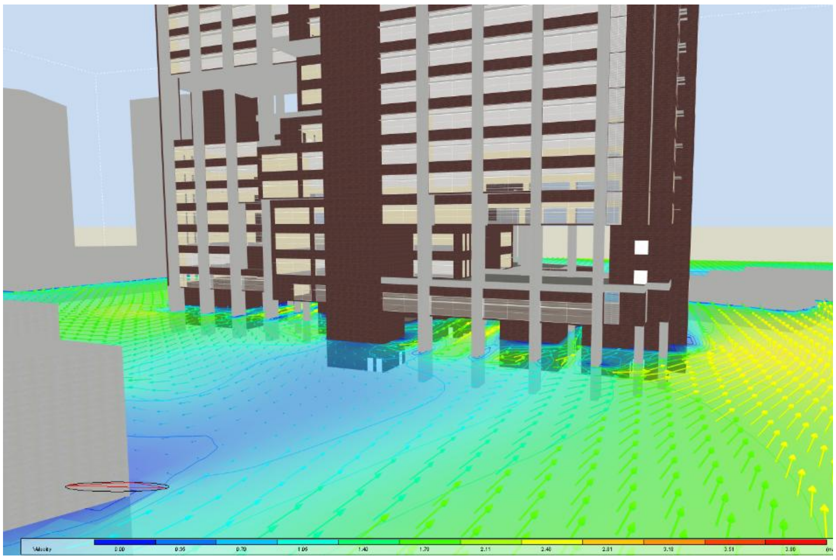
c. View from South



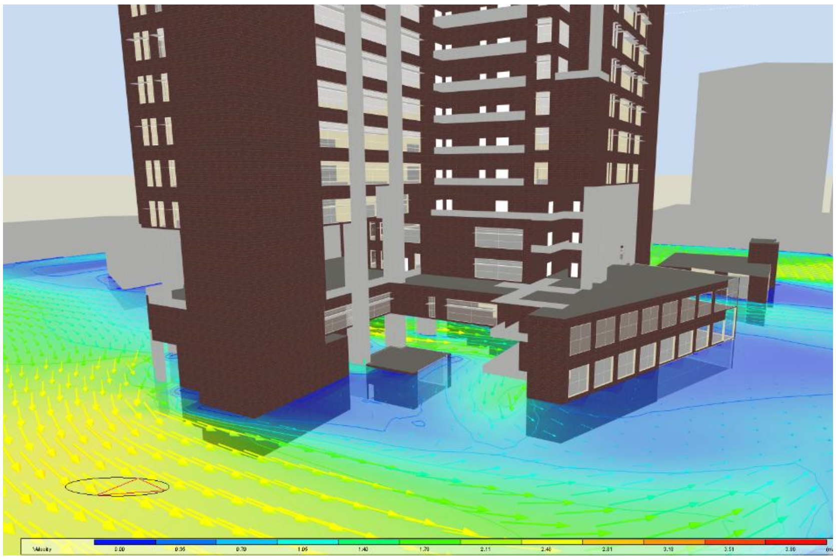
d. View from North



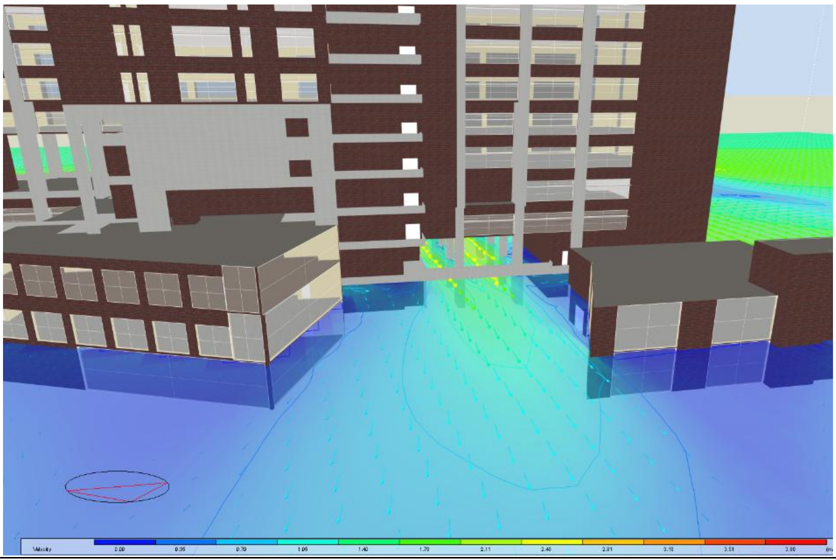
e. View from North-East



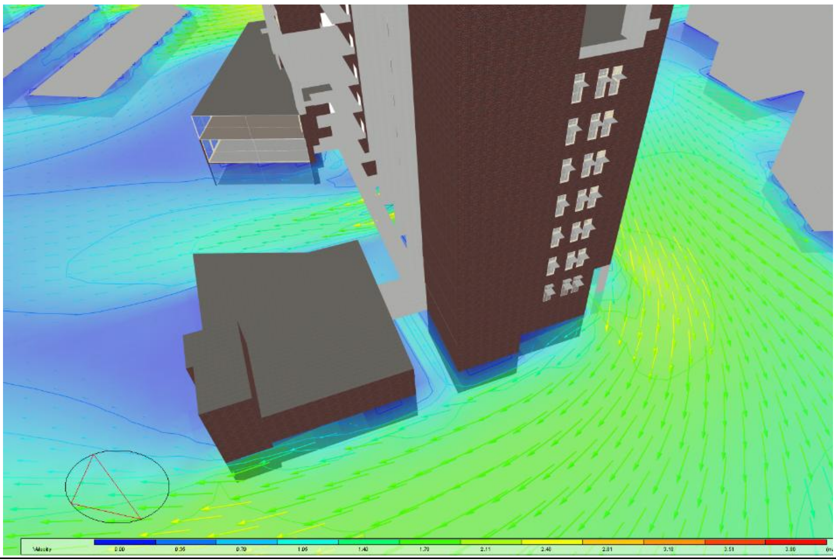
f. Close up from South



g. Close up from North-East



h. Close up from North

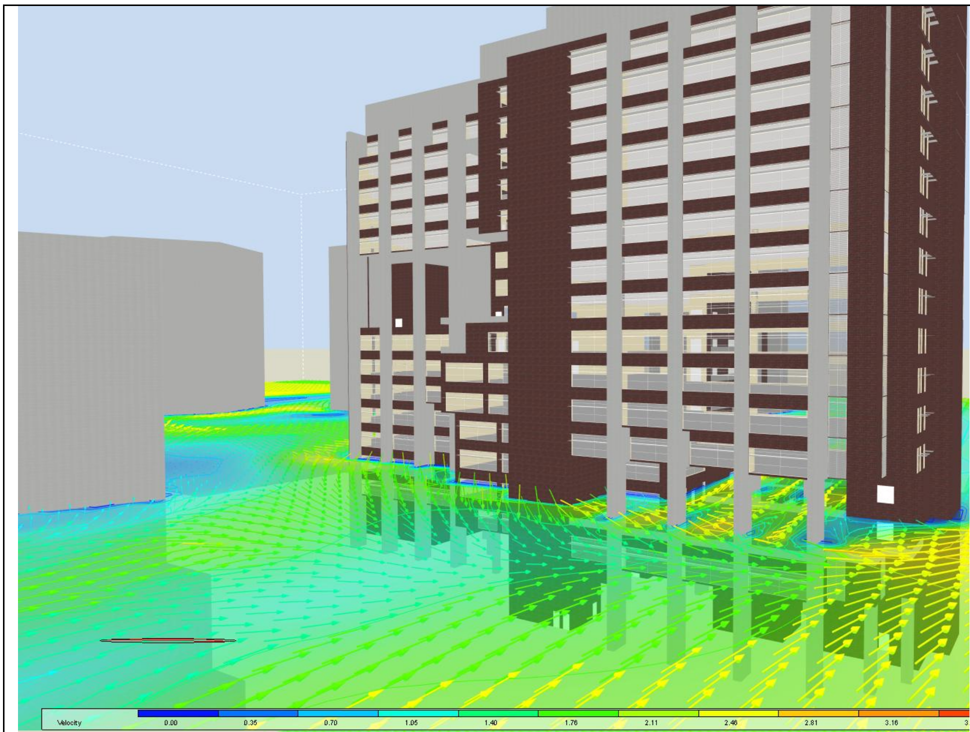


i. Close up of "Promenade" from North-West

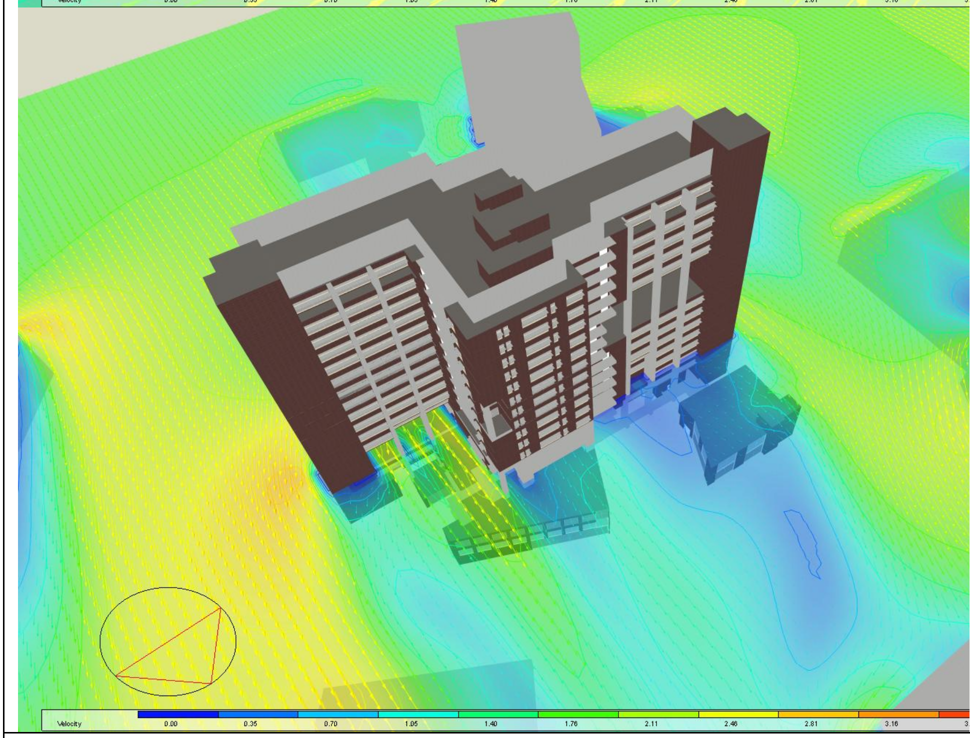
Figure 09:Local View: South Wind Case (near ground level: +4.53m)

The entry area on the Southern side of the development can achieve a good level of Natural Ventilation for the South wind case. Low wind flow zones to the South correspond with the car circulation area in front of the building and the undercover area outside the toilets. The areas around the drop off zone, the lift lobby and the information kiosks benefit from the increased velocity as the wind passes through the 2 gaps in the building at the lower level, providing good natural ventilation (see c., f.).
To the north of the building, velocity contours in the garden are between 0.35-1.40m/s providing a comfortable level of natural ventilation (see h.). As expected low velocity zones appear to the North of the hospice and food court off site (see h., g.) and also to the North of the Car Park Lift Lobby which has not been designated for any specific outdoor activity so is satisfactory.
Due to the columns , the placement of 2 ground level gaps and plan of North buildings the promenade, even where sheltered is able to achieve greater than 0.70m/s velocity, a reasonable result for comfort under this wind condition.

2. Simulation Results: MACRO – South Wind, upper level case



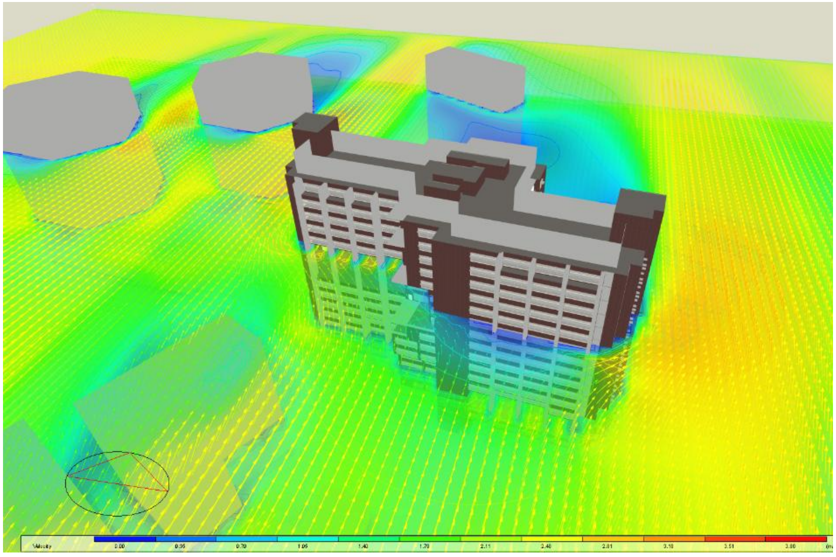
a. View from South



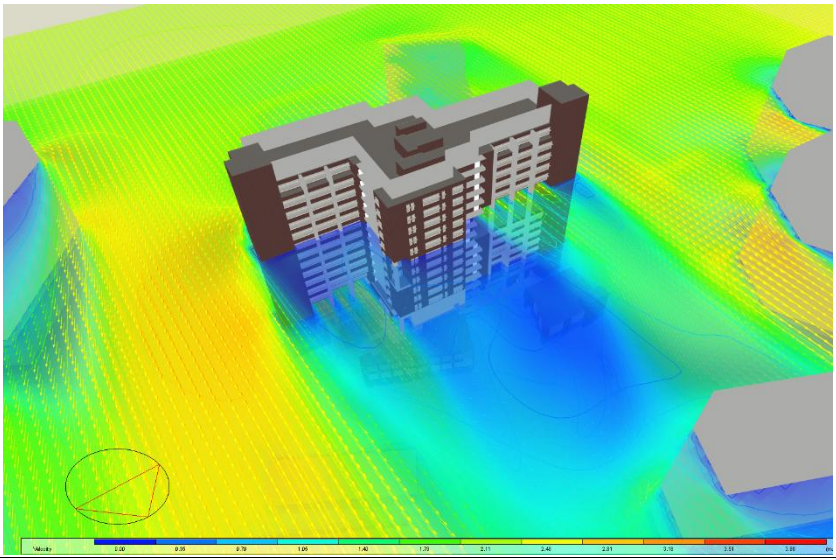
b. View from North

Figure 10: Regional View: South Wind Case (Level 4: +16.62m)

The sky terrace on the fourth floor breaks the low pressure region at the leeward side of the building, causing a stream of air flow (at increased velocity, up to 2.46m/s) over the sky terrace and good natural ventilation for this space. The eastern half of the windward face of the building experiences a more gentle air flow due to the obstruction of the 4 storey facility to the south-east of the development and the taller Brahm Centre to the South.



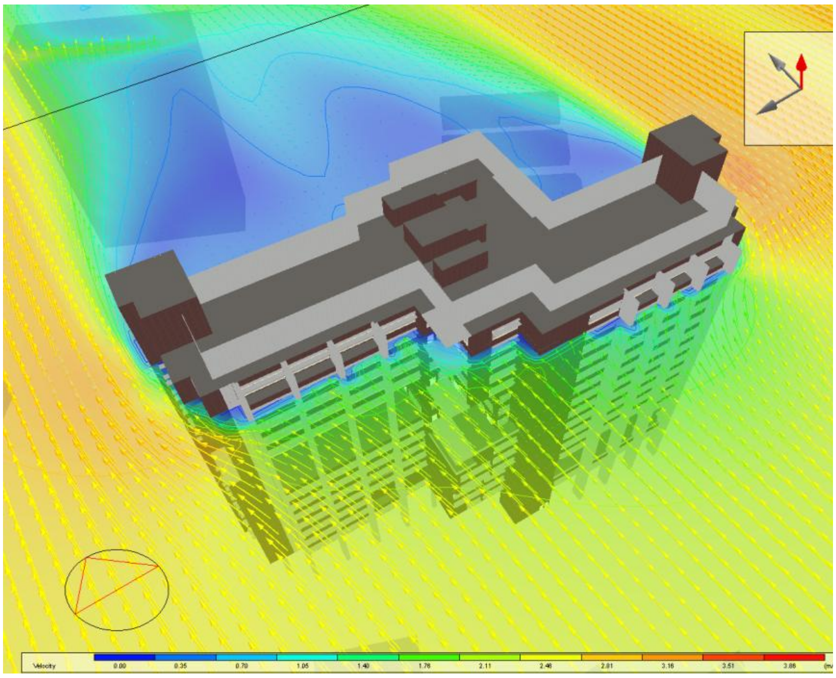
c. View from South



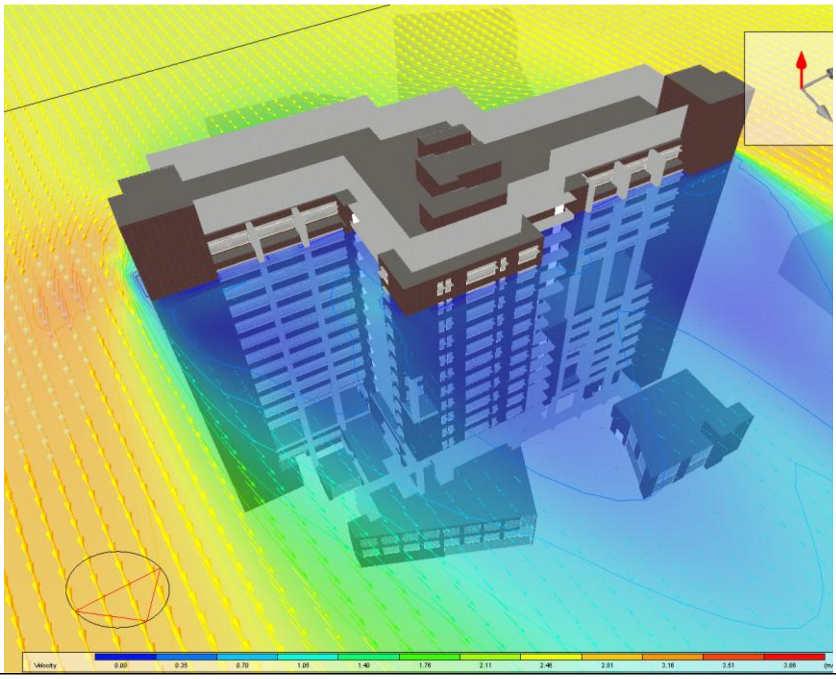
d. View from North

Figure 11: Regional View: South Wind Case (Level 10: +52.87m)

The sky terrace on the tenth floor sky terrace also receives a high velocity air flow up to 2.46m/s providing good natural ventilation as with the 4th floor. The leeward face of the building has a stronger negative pressure compared with the 4th floor. The windward façade of the building has a more even distribution of wind due to less obstruction from surrounding buildings.



f. View from South

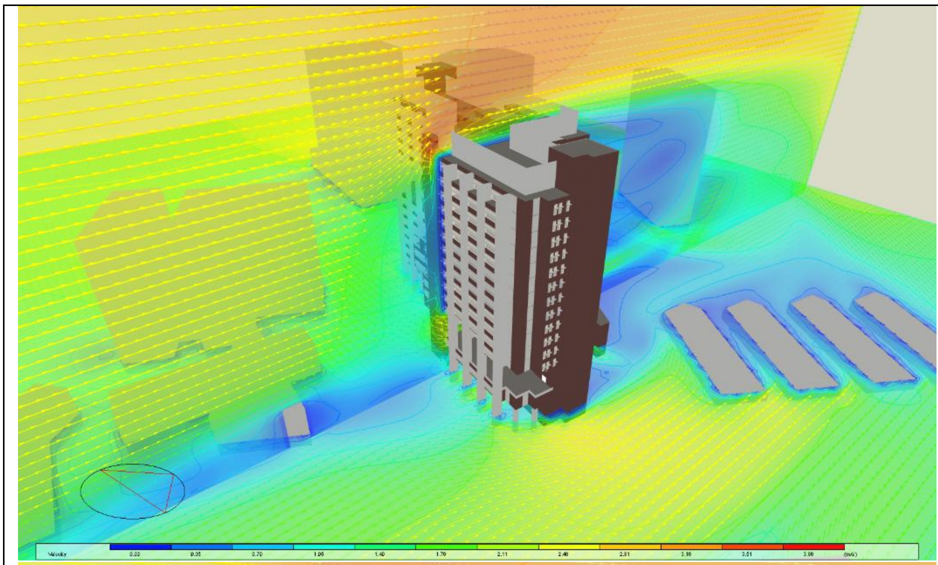


g. View from North

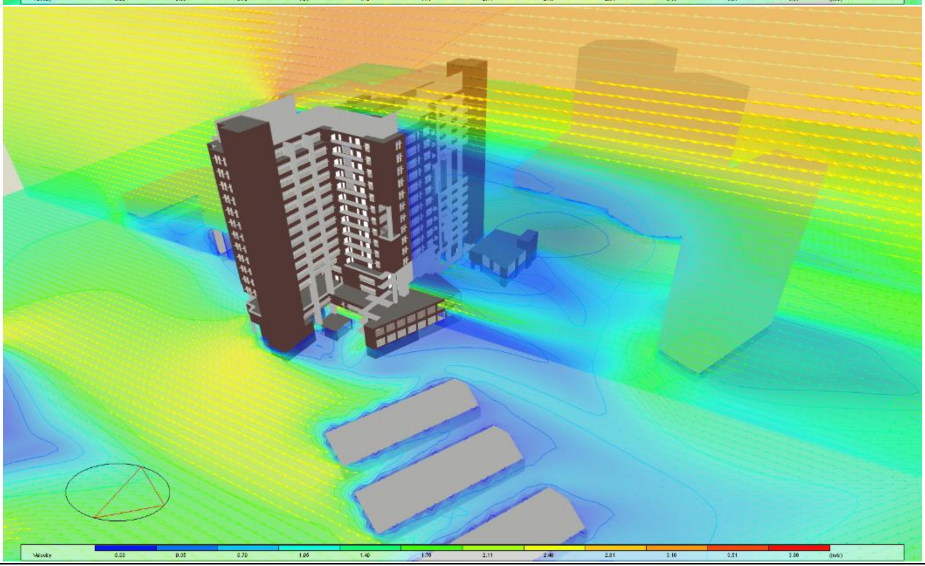
Figure 12: Local View: South Wind Case (near Level 16: +70.99m)

The wind conditionsat this height are much more predictable due to lack of sky terraces and surrounding obstructions. The windward side has an evenly spread positive pressure and the leeward side has a negative pressure. Wind velocity increases as it is moves past the ends of the building.

3. Simulation Results: MACRO – South Wind Case, Vertical Slice



a. View from South-West



b. View from North-West

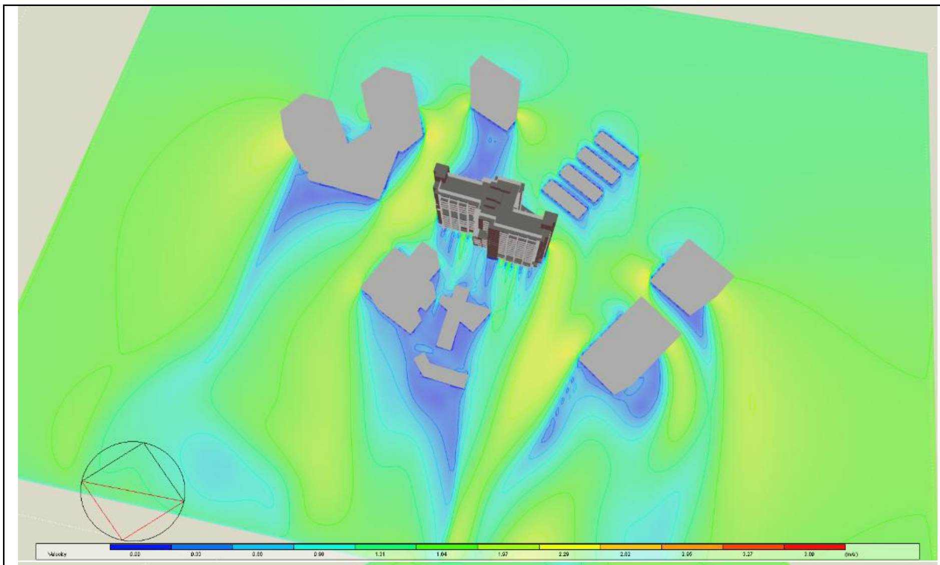
Figure 13 Regional View: South Wind Case (Vertical profile)

Diagrams a. and b. show the wind conditions as a vertical profile at the middle of the proposed building. Air flow is obstructed at lower levels by the 4 storey facility to the south. Otherwise the building shows a lot of direct wind against the south façade and typical movement over and around the building from mid to higher levels. A large negative pressure cavity zone fills the space between the northern façade and the Pinnacle 16 Condominiums to the north.

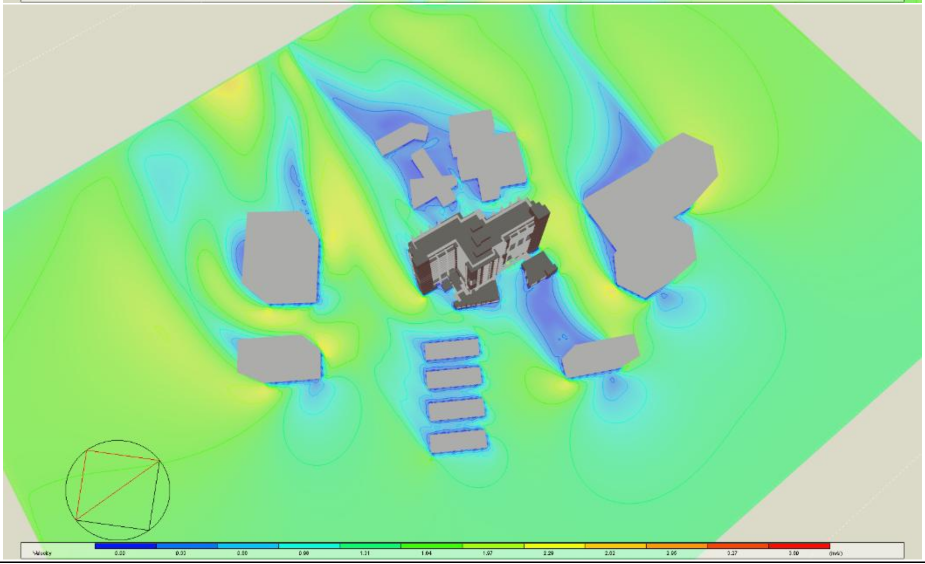
4. Simulation Results: MACRO – South Wind Case, Summary

In general the South wind case creates air flow around the building with some obstruction at lower levels, but sufficient to provide thermal comfort at sky terrace gardens, drop off zone, 1st floor lift lobby and kiosk information area. Gaps at the ground, 4th and 10th floor of the building help distribute the wind more. The building benefits from a lack of obstruction surrounding it, with open space to the north and low buildings to the South and East. The wind conditions for the proposed building would likely be heavily influenced if future development were to take place to the South, directly across the road.

5. Simulation Results: MACRO – North Wind Case



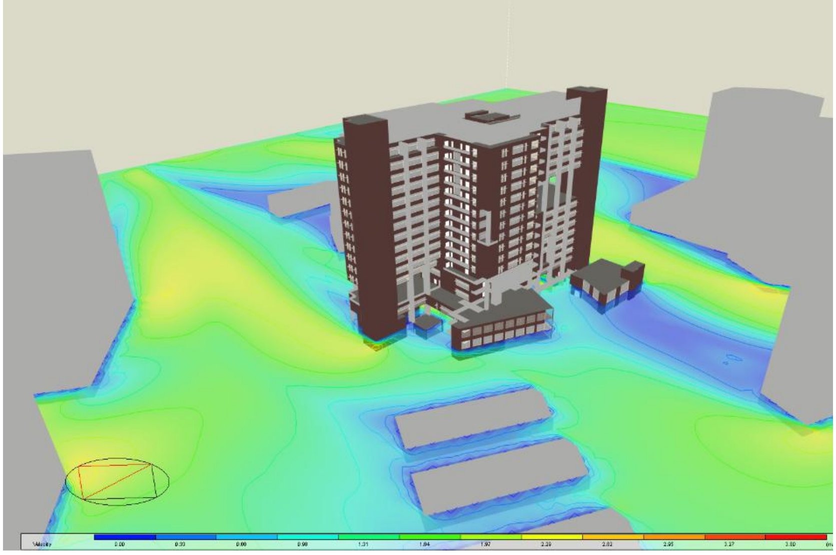
a. View from South



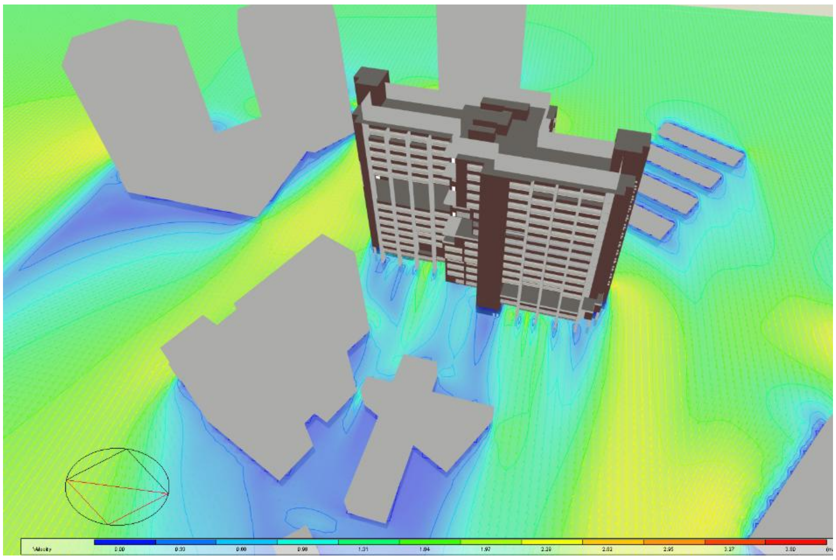
b. View from North

Figure 14: Regional View - North Wind Case (near ground level: +4.53m)

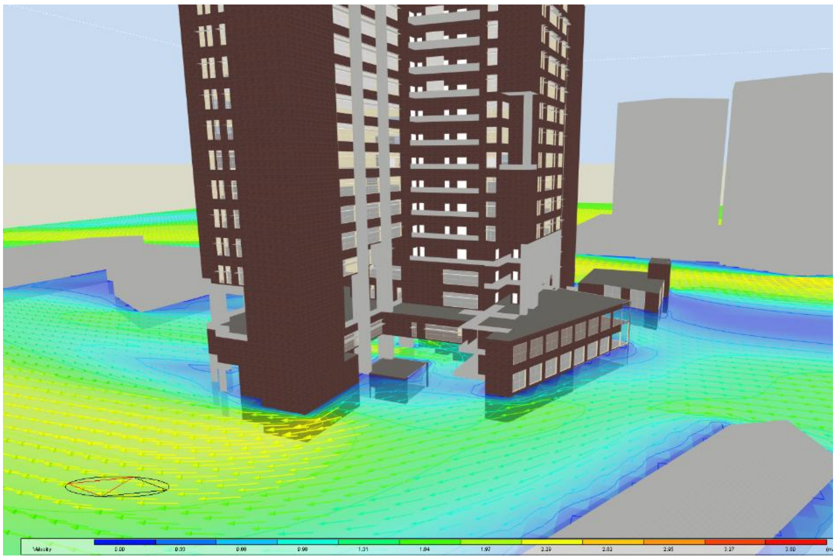
The Pinnacle 16 Condominium due North affects the wind conditions of the proposed building as it is located in its wake. The proposed building will obstruct winds to the south including the 4 storey facility and the Brahm Centre. The north wind is able to pass by the East and West sides of the building without obstruction.



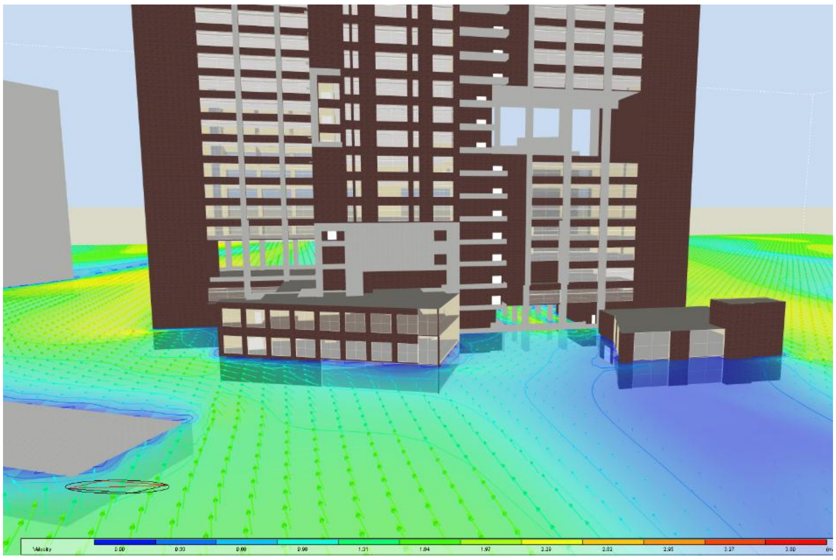
c. View from North



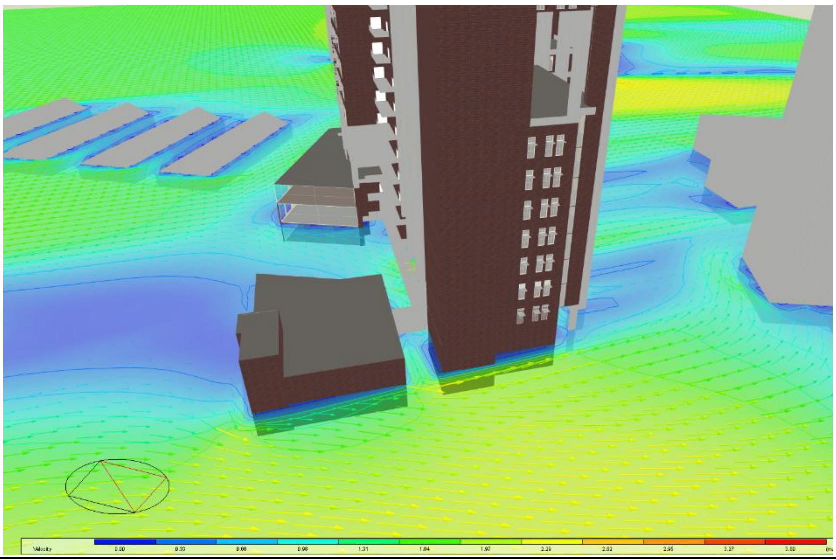
d. View from South



e. View from North-East



f. Close up from North

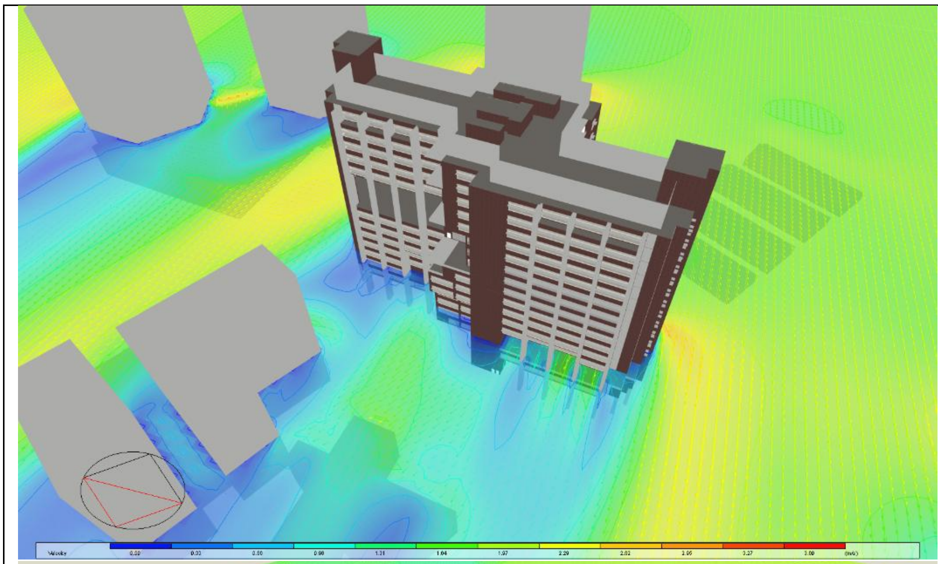


g. Close up from West

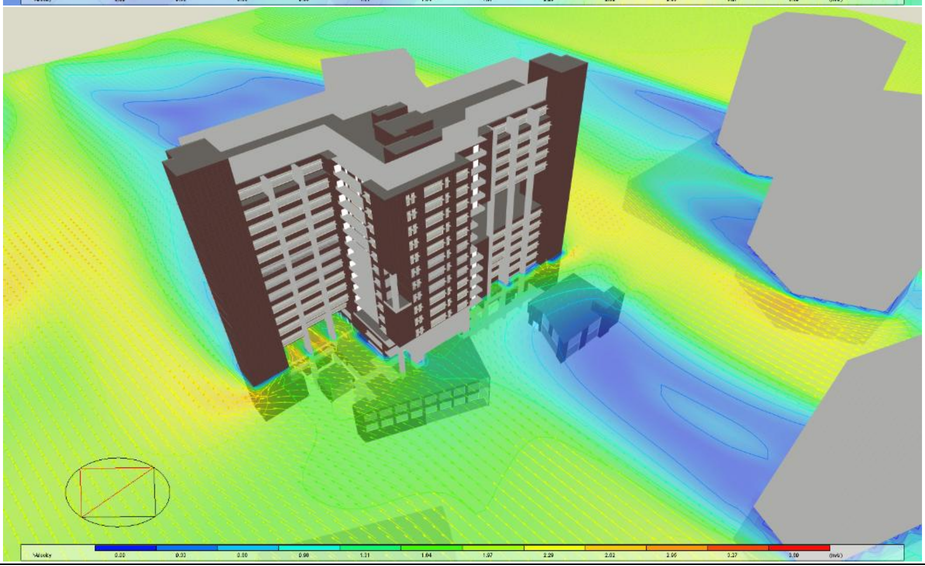
Figure 15: Local View-North Wind Case (near ground level: +4.53m)

The garden area to the North of the proposed development has a low air flow because of the obstruction of the Pinnacle condominium to the North. The contours show much of the space will have less than 0.66m/s (see c. and f.). The promenade has less air flow when compared to the south wind case but still much of the area is able to achieve up to 1.64m/s and is good for natural ventilation. The part of the promenade between the main building and the hospice has the least air flow, less than 0.33m/s in many areas (see e. and g.). Despite less availability of wind on the windward side, the ground floor area under the building manages to funnel the air flow through at a velocity good for comfort under natural ventilation, achieving 1.31-2.29m/s throughout. This achieves good natural ventilation for the information kiosk, lift lobbies and main entrance areas.

6. Simulation Results: MACRO – North Wind, upper level case



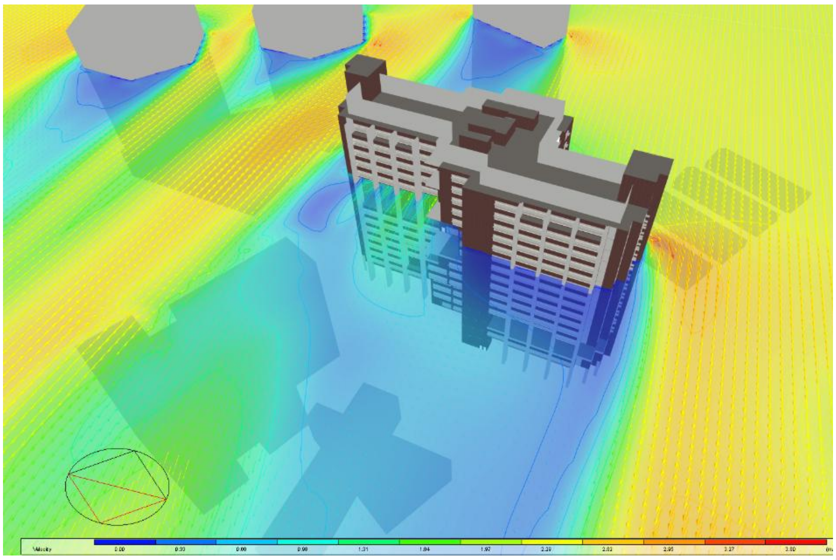
a. View from South



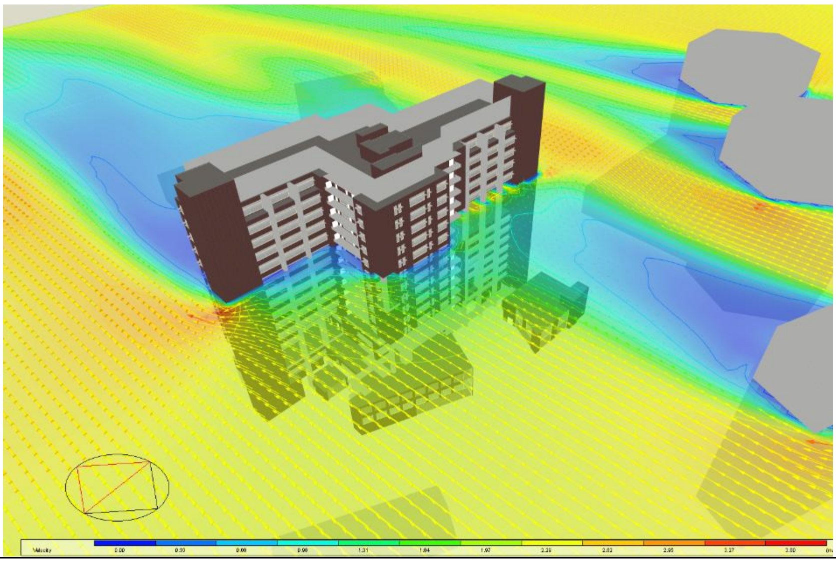
b. View from North

Figure 16: Regional View-North Wind Case (Level 4: +16.62m)

The 4th floor level air flow shows less effect from the obstruction of Pinnacle 16 Condominium to the north. The sky terrace on the fourth floor as with the South wind case causes an increase in wind velocity, up to 2.66m/s providing good natural ventilation for this space. The leeward side has reasonably consistent negative pressure except where the wind is flowing through the sky terrace.



c. View from South

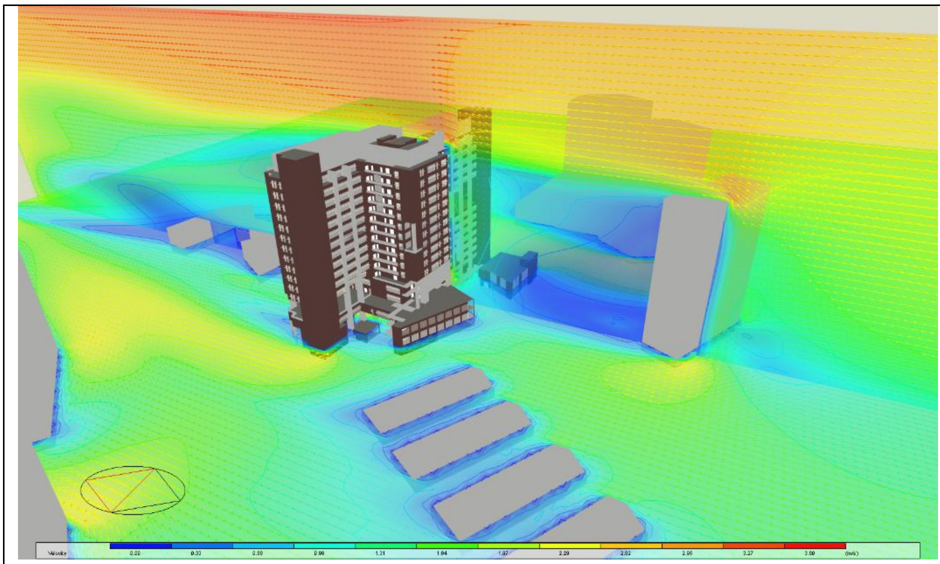


d. View from North

Figure 17: Regional View-North Wind Case (Level 10: +52.87m)

The sky terrace on the tenth floor sky terrace also receives a high velocity air flow up to 2.66m/s providing good natural ventilation as with the 4th floor. The windward side has a pocket of low velocity as the wind is diverted by the corners to the west end of the north façade. The leeward face of the building has a stronger negative pressure compared with the 4th floor. The windward façade of the building has a more even distribution of wind due to less obstruction from surrounding buildings.

7. Simulation Results: MACRO – North Wind Case, Vertical Slice



a. View from South-West

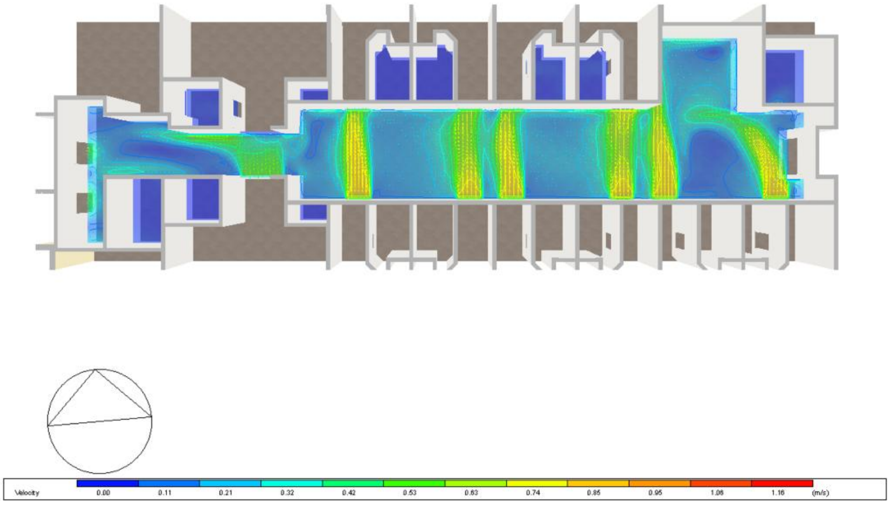
Figure 18: Regional View-North Wind Case (Vertical profile)

The a vertical profile at the middle of the proposed building shows the effect of the Pinnacle 16 Condominium to the North of the building, which is causing the wind especially at lower and mid-level to be diverted above and around the proposed building. A large negative pressure cavity zone fills the space between the northern façade and the Pinnacle 16 Condominiums to the north. This means there is less wind reaching the north façade except at the top few levels. It also causes a greater velocity of wind diverted above the proposed building compared to the South wind case.

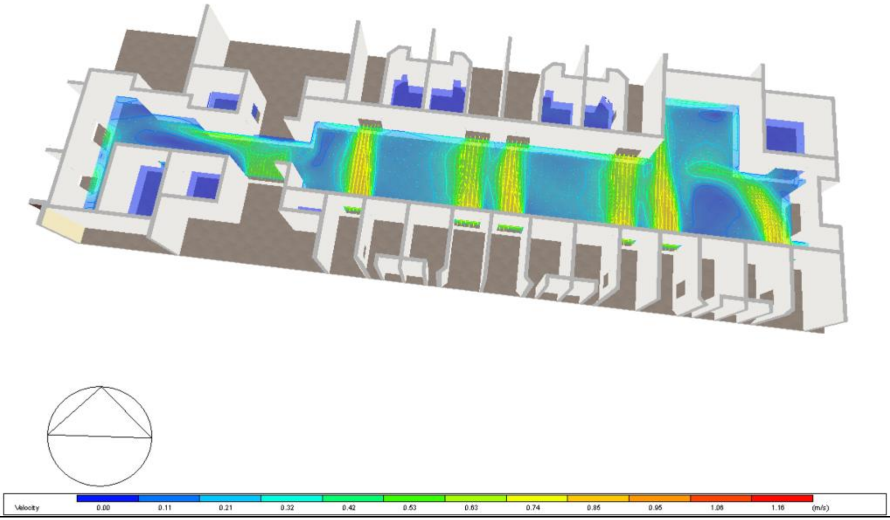
8. Simulation Results: MACRO – North Wind Case, Summary

In general the Northern wind is obstructed by the Pinnacle 16 Condominiums for ground up tomid-level natural ventilation. There is sufficient air flow for thermal comfort at sky terrace gardens, drop off zone, 1st floor lift lobby and kiosk information area due to the wind tunnel effect in the design through the “gaps” in the building. Some outdoor areas such as the garden and parts of the promenade may not be able to achieve thermal comfort under the North wind case. As these areas are not likely to be occupied for extended periods of time, this is satisfactory. Low levels and the corner of the building from which the Eastern Wing protrudes from the core could suffer from a lack of access to the north wind.

9. Simulation Results: MICRO – Level 6 air flow



a. wind velocity in corridor plan view

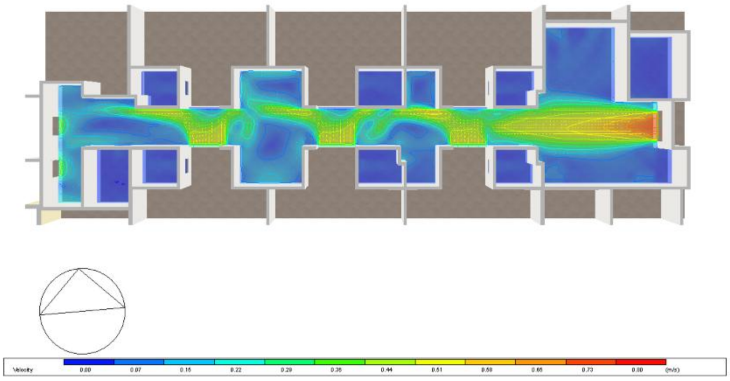


b. corridor air flow perspective

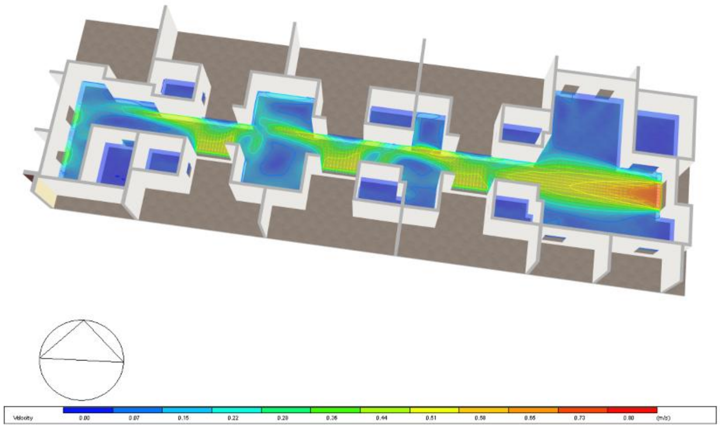
Figure 19: Level 6 - Eastern wing corridor air flow (South Wind)

Simulation has been conducted on the East wing for the south wind case on level 6 as the results are quite similar for the case for the West wing and for the north wind case. Air flow can be seen across the corridor between open doors of patient rooms, with doors facing each other. In these areas velocities are consistently up to 0.76m/s providing a good level of thermal comfort. Some air flow is entering from the external corridor connecting the wards to the lift core and moving to the openings at the ends of the building. Besides these areas air flow in the corridor is 0.21m/s or even less. To achieve thermal comfort in these spaces (for nurse charting, nurse station, reception, etc) mechanical ventilation or design changes allowing more cross ventilation will be required.

10. Simulation Results: MICRO – Level 8 air flow



a. wind velocity in corridor plan view

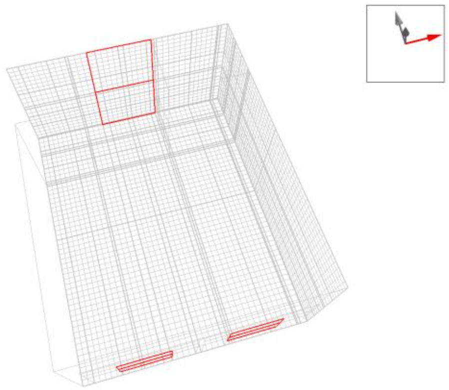


b. corridor air flow perspective

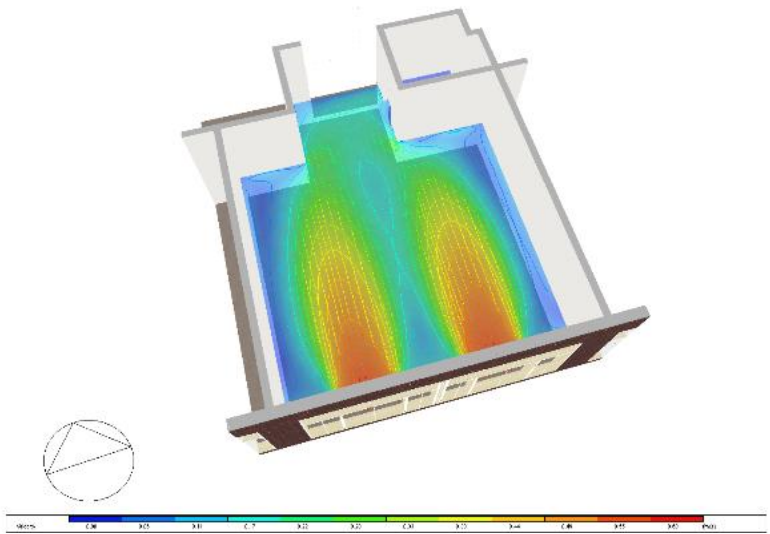
Figure 20: Level 8 - Eastern wing corridor air flow (South Wind)

Simulation has been conducted on the East wing for the south wind case on level 8 as the results are quite similar for the case for the WEst wing and for the north wind case. Air flow can be seen across the corridor between open doors of 5-bed patient rooms, with doors facing each other in a much less direct path than on level 6. In these areas velocities are between 0.44 and 0.76m/s providing good thermal comfort under natural ventilation. A high air flow from the external corridor connecting the wards to the lift core is achieved just by the reception with velocities from 0.73m/s tapering off to 0.51m/s where the corridor narrows again. This air flow is caused by the positive pressure built up in the connecting corridor. Besides the wing's main corridor axis, air flow in the corridor is 0.21m/s or even less. To achieve thermal comfort in these spaces (for nurse charting, nurse station, etc) mechanical ventilation or design changes allowing more cross ventilation will be required.

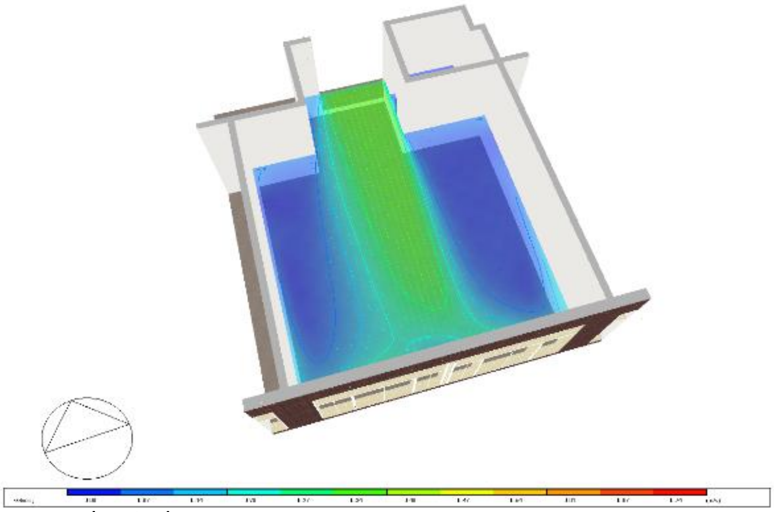
11. Simulation Results: MICRO – 5-6 bed patient room (MP)



a. Mesh view



b. South wind case

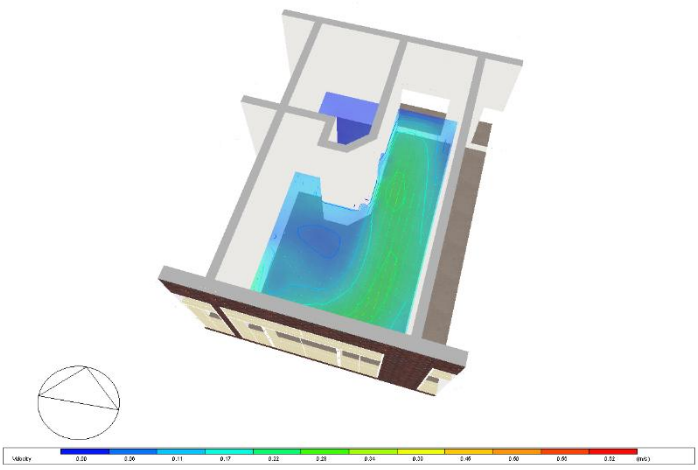


c. North wind case

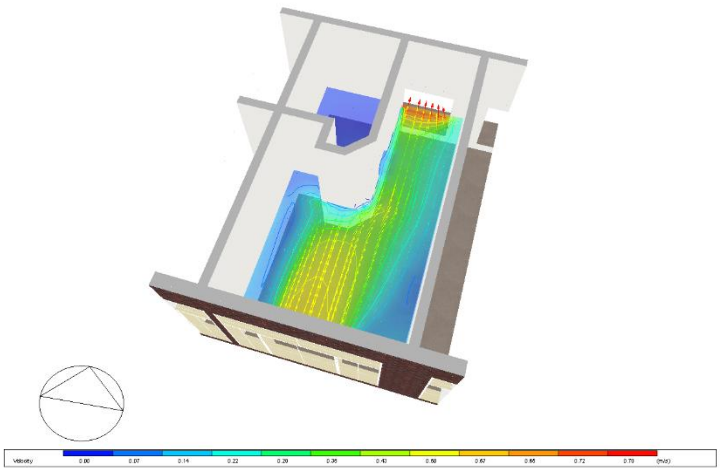
Figure 21: Unit micro simulation- 5-6 bedroom patient room (MP)

The 5-6 bed patient room is located facing South. North facing rooms have quite similar results. There are 2 windows evenly spaces along the wall. The south wind case provides 0.33-0.60m/s across the beds. The average air velocity in this unit for the south wind is 0.23m/s too low for thermal comfort under natural ventilation. The north caseonly provides 0.4m/s concentrated in the aisle between the beds. The bed areas are almost all less than 0.1m/s and the overall average air velocity is 0.14m/s, not enough for effective natural ventilation. Mechanical ventilation supplementing natural or larger windows to promote cross ventilation would be advisable. For both cases the average wind velocities are too low to meet BCA Green Mark requirements.

12. Simulation Results: MICRO – Single Bed Patient Room (SP)



a. North wind case

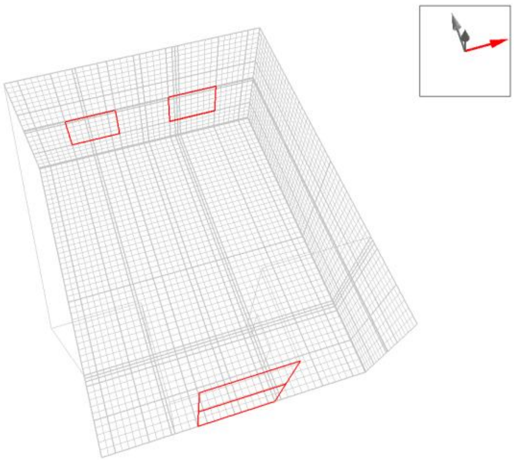


c. South wind case

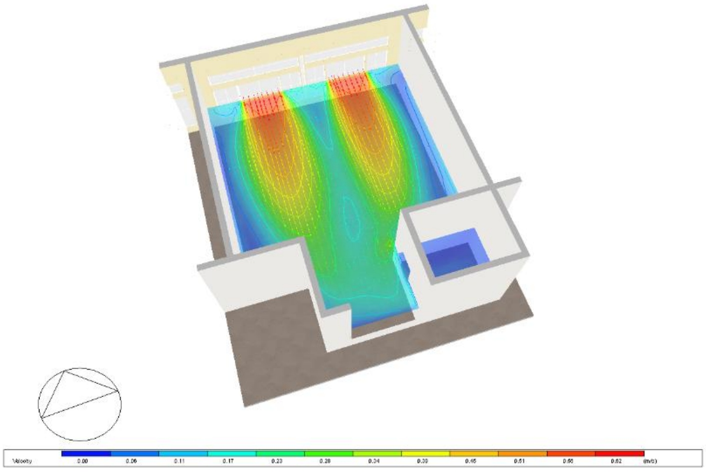
Figure 22: Unit micro simulation- Single Bed Patient Room (SP)

The single bed patient room is located facing South. North facing rooms have quite similar results. There is one window opening in the centre of the room. The south wind case provides 0.43-0.50m/s across the bed. The average air velocity in this unit for the south wind is 0.30m/s, better than the 5-6 bed patient rooms but still too low for thermal comfort under natural ventilation. The north case only reaches 0.28m/s maximum near the end of the bed. The bed is misses all the ventilation with less than 0.1m/s for the North wind case and the overall average air velocity is 0.15m/s, not enough for effective natural ventilation. Mechanical ventilation supplementing natural or larger windows to promote further cross ventilation would be advisable. The average wind velocities are too low to meet BCA Green Mark requirements.

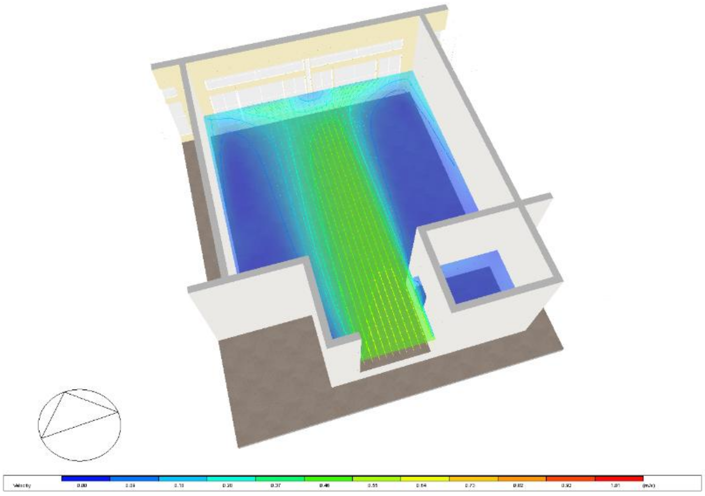
13. Simulation Results: MICRO – Activity Area (AA)



a. Mesh model view



b. North wind case

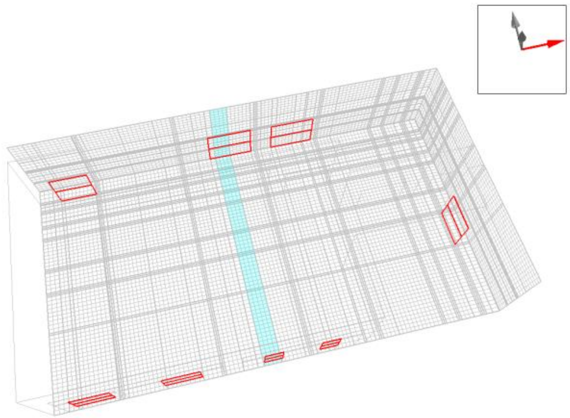


c. South wind case

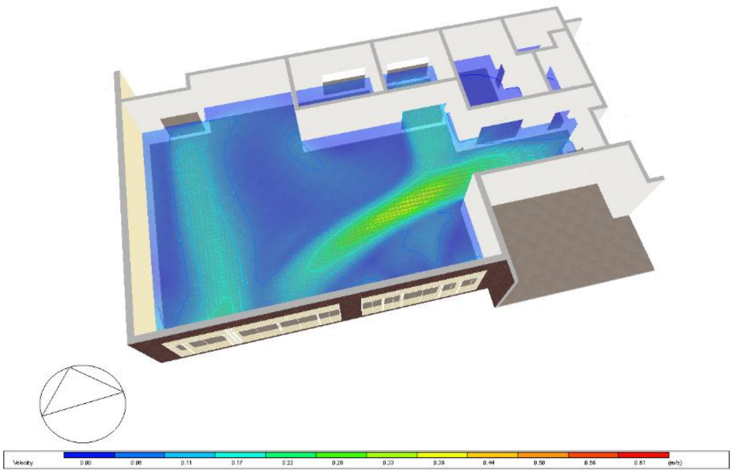
Figure 23: Unit micro simulation- Activity Area (AA)

The Activity Areas are all facing North. There are 2 window openings evenly spaced on the external wall and a door opening to the corridor in the centre as in the 5-6 bed patient rooms.The North wind case provides 0.33-0.60m/s reasonably well distributed across the activity space. The average air velocity in this unit for the North wind is 0.25m/s too low for thermal comfort under natural ventilation. The South wind case only provides 0.28-0.55m/s largely concentrated in the central third of the room. The left and right thirds of the room drop to less than 0.1m/s and the overall average air velocity is 0.20m/s, not enough for effective natural ventilation. Mechanical ventilation supplementing natural or larger windows to promote cross ventilation would be advisable. For both cases the average wind velocities are too low to meet BCA Green Mark requirements.

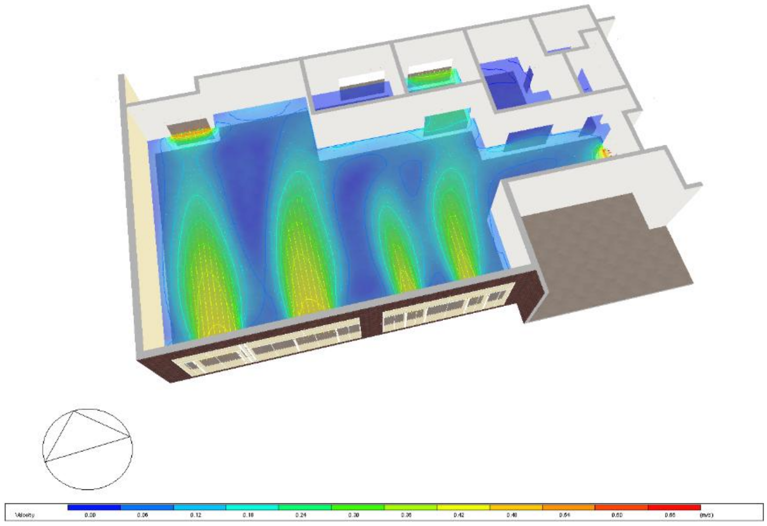
14. Simulation Results: MICRO – Multi-purpose Gym (MG)



a. Mesh view



b. North wind case

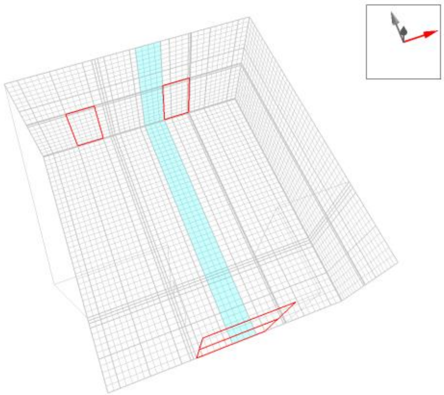


c. South wind case

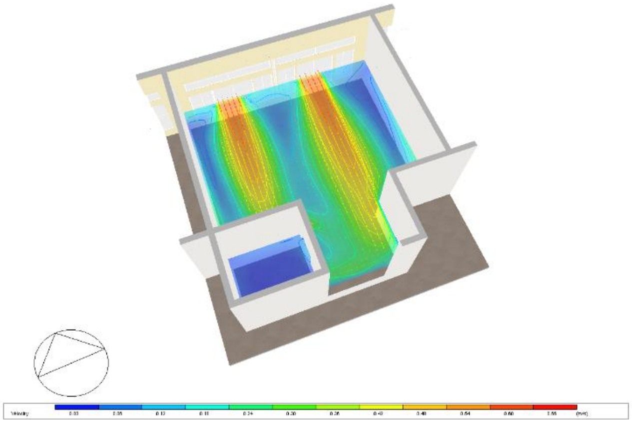
Figure 24: Unit micro simulation: Multipurpose Gym (AA)

The Gym Areas are all facing South, the selected gym room is on the 8th floor. There are 4 small window openings on the southern external wall and 3 door openings to the corridor. On some levels the gym is smaller, but it is always in the same position. The South wind case provides 0.24-0.42m/s reasonably well distributed across the space. The average air velocity in this unit for the South wind case is 0.14m/s, too low for thermal comfort, in particular for exercise under natural ventilation. The South wind case only provides one small concentration of up to 0.39m/snear the bend in the room. The rest of the room is mostly less than 0.1m/s except for some areas reaching 0.17m/s, with an overall average of 0.08m/s for the South wind case, much too low for effective natural ventilation, especially for exercise. This unit has the poorest natural ventilation of all unit types simulated. Mechanical supplementationof natural ventilation or larger windows to promote cross ventilation would be advisable. If significant improvement cannot be made Air conditioning should be considered. For both cases the average wind velocities are too low to meet BCA Green Mark requirements.

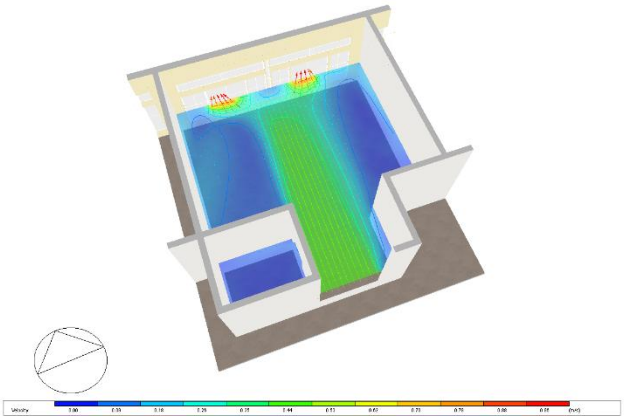
15. Simulation Results: MICRO – 4 Bed Patient Room (MP [4])



a. Mesh model view



b. North wind case



c. South Wind case

Figure 25 Unit micro simulation: 4-Bed Patient Room (MP-4)

The unit simulated is facing North. Units facing South have very similar results. There are 2 window openings evenly spaced on the external wall and a door opening to the corridor in the centre as in the 5-6 bed patient rooms. The North wind case provides 0.24-0.66m/s reasonably well distributed across the patient bed areas. The average air velocity in this unit for the North wind is 0.25m/s, too low for thermal comfort under natural ventilation. The South wind case only provides 0.53m/s largely concentrated in the central third of the room. The left and right thirds of the room drop to less than 0.1m/s and the overall average air velocity is 0.20m/s, not enough for effective natural ventilation. Mechanical ventilation supplementing natural or larger windows to promote cross ventilation would be advisable. For both cases the average wind velocities are too low to meet BCA Green Mark requirements.

16. Simulation Results: Average wind velocity for units

					Avg velocity			
Module	Type	No. of units	U Area (sqm)	Area Tot (sqm)	N (m/s)	S (m/s)	N+S (m/s)	Area weighting
1	MP	87	77.44	6737.28	0.14	0.23	0.19	1246.3968
2	SP	40	24.63	985.2	0.15	0.30	0.23	221.67
3	AA	15	77.46	1161.9	0.25	0.20	0.23	261.4275
4	MG*	10	153.01	1046.46	0.08	0.14	0.11	115.1106
5	MP(4)	6	51.62	309.72	0.25	0.20	0.23	69.687
		Total Area		10240.56	Area weighted average velocity			0.19 m/s

* Multipurpose Gym (MG) unit areas vary level to level

Figure 26: Simulation average wind velocity result

As can be seen in above Figure 26, none of the sample units are currently compliant with BCA Green Marks Platinum Pre-requisite to meet 0.60m/s in 70% of spaces for Natural Ventilation. The area weighted average wind velocity for all units is 0.19m/s. For compliance with Green Mark, the Area weighted average velocity would have to be greater than 0.42m/s. Units that perform the best are the Single Patient, Activity Area and 4-Person Patient Rooms.

17. Recommendations

In order to improve Natural Ventilation in indoor areas in the proposed building, it is suggested that a number of strategies are considered. These include increased areas of openings, higher openings as well as lower ones and consideration of the layout for patient areas to ensure optimum natural ventilation.

Mechanical ventilation will also be important to provide comfort for occupants of the building, even when there is wind available outside.

G. Appendix 1: Pressure Differentials for all Units

Level	SPACE CODE	TYPE	N ΔP [PA]	S ΔP [PA]	N+S ΔP	N+S ΔP - ave ΔP
04	MP-1	Patient Room (5-Bed)	0.854	0.231	0.543	33.2%
	MP-2		0.854	0.231	0.543	33.2%
	MP-3		1.206	0.932	1.069	-19.4%
	MP-4		1.206	0.932	1.069	-19.4%
	SP-1	Patient Room (Single)	0.854	0.231	0.543	33.2%
	SP-2		0.854	0.231	0.543	33.2%
	SP-3		0.176	0.932	0.554	32.1%
	SP-4		0.176	0.932	0.554	32.1%
	SP-5		1.206	0.932	1.069	-19.4%
	SP-6		1.206	0.932	1.069	-19.4%
	SP-7		1.206	0.932	1.069	-19.4%
	SP-8		1.206	0.932	1.069	-19.4%
	SP-9		1.206	0.932	1.069	-19.4%
	SP-10		1.206	0.932	1.069	-19.4%
	AC-1	Music Activity	1.206	0.231	0.719	15.6%
	AC-2	Family/Living/ Dining/Activity	0.176	0.932	0.554	32.1%
05	MP-1	Patient Room (5-Bed)	0.854	0.231	0.543	33.2%
	MP-2		0.854	0.231	0.543	33.2%
	MP-3		1.206	0.932	1.069	-19.4%
	MP-4		1.206	0.932	1.069	-19.4%
	SP-1	Patient Room (Single)	0.854	0.231	0.543	33.2%
	SP-2		0.854	0.231	0.543	33.2%
	SP-3		0.176	0.932	0.554	32.1%
	SP-4		0.176	0.932	0.554	32.1%
	SP-5		1.206	0.932	1.069	-19.4%
	SP-6		1.206	0.932	1.069	-19.4%
	SP-7		1.206	0.932	1.069	-19.4%
	SP-8		1.206	0.932	1.069	-19.4%
	SP-9		0.176	0.932	0.554	32.1%
	SP-10		0.176	0.932	0.554	32.1%
	AC-1	Music Activity	1.206	0.231	0.719	15.6%
	AC-2	Family/Living/Dining/Activity	0.176	0.932	0.554	32.1%
06	MP-1	Patient Room (5-Bed)	0.854	0.231	0.543	33.2%
	MP-2		0.854	1.393	1.124	-24.9%
	MP-3		1.206	0.932	1.069	-19.4%
	MP-4		1.206	0.932	1.069	-19.4%

	SP-1	Patient Room (Single) (SP-16 selected sample unit)	0.854	0.231	0.543	33.2%
	SP-2		0.854	0.231	0.543	33.2%
	SP-3		0.854	0.231	0.543	33.2%
	SP-4		0.854	0.231	0.543	33.2%
	SP-5		1.206	0.231	0.719	15.6%
	SP-6		1.206	0.231	0.719	15.6%
	SP-7		0.176	0.231	0.204	67.1%
	SP-8		0.176	0.231	0.204	67.1%
	SP-9		1.206	0.932	1.069	-19.4%
	SP-10		1.206	0.932	1.069	-19.4%
	SP-11		1.206	0.932	1.069	-19.4%
	SP-12		1.206	0.932	1.069	-19.4%
	SP-13		1.206	0.932	1.069	-19.4%
	SP-14		1.206	0.932	1.069	-19.4%
	SP-15		1.206	0.932	1.069	-19.4%
	SP-16		1.206	0.932	1.069	-19.4%
	SP-17		1.206	0.932	1.069	-19.4%
	SP-18		1.206	0.932	1.069	-19.4%
	SP-19		1.206	0.932	1.069	-19.4%
	SP-20		1.206	0.932	1.069	-19.4%
	AE-1	Music/Activity/ Family events	1.206	0.932	1.069	-19.4%
	AE-2	Family Living/Dining	0.176	0.932	0.554	32.1%
07	MP-1	Patient Room (5-Bed)	0.854	0.231	0.543	33.2%
	MP-2		0.854	0.231	0.543	33.2%
	MP-3		0.854	0.231	0.543	33.2%
	MP-4		0.854	0.231	0.543	33.2%
	MP-5		0.176	0.932	0.554	32.1%
	MP-6		0.176	2.095	1.136	-26.1%
	MP-7		0.176	2.095	1.136	-26.1%
	MP-8		0.176	0.932	0.554	32.1%
	MP-9		1.206	0.932	1.069	-19.4%
	MP-10		1.206	0.932	1.069	-19.4%
	AA-1	Activity Area	0.854	0.231	0.543	33.2%
	AA-2		0.854	1.393	1.124	-24.9%
	MG-1	Multipurpose Gym	1.206	0.932	1.069	-19.4%
08	MP-1	Patient Room (5-Bed)	0.854	0.231	0.543	33.2%
	MP-2		0.854	0.231	0.543	33.2%
	MP-3		0.854	0.231	0.543	33.2%
	MP-4		0.854	0.231	0.543	33.2%
	MP-5		1.206	0.932	1.069	-19.4%

	MP-6		0.176	2.095	1.136	-26.1%
	MP-7		0.176	2.095	1.136	-26.1%
	MP-8		0.174	0.932	0.553	32.2%
	MP-9		1.206	0.932	1.069	-19.4%
	MP-10		1.206	0.932	1.069	-19.4%
	AA-1	Activity Area	0.854	1.393	1.124	-24.9%
	AA-2		0.854	0.231	0.543	33.2%
	MG-1	Multipurpose Gym	1.206	0.932	1.069	-19.4%
09	MP-1	Patient Room (5-Bed)	0.854	0.231	0.543	33.2%
	MP-2		0.854	0.932	0.893	-1.8%
	MP-3		0.176	1.393	0.785	9.0%
	MP-4		0.176	2.095	1.136	-26.1%
	MP-5		0.176	2.095	1.136	-26.1%
	PP-1	BMIR Patient Room (Private)	0.176	0.932	0.554	32.1%
	PP-2		0.176	0.932	0.554	32.1%
	AA-1	Activity Area	0.854	1.393	1.124	-24.9%
	MG-1	Multipurpose Gym	0.176	0.932	0.554	32.1%
10	MP-1	Patient Room (6-Bed)	0.854	0.231	0.543	33.2%
	MP-2		0.854	0.932	0.893	-1.8%
	MP-3		1.206	1.393	1.300	-42.5%
	MP-4		0.176	2.095	1.136	-26.1%
	MP-5		0.176	2.095	1.136	-26.1%
	AA-1	Activity Area	0.854	1.393	1.124	-24.9%
	MG-1	Multipurpose Gym	0.176	0.932	0.554	32.1%
11	MP-1	Patient Room (6-Bed)	0.854	0.231	0.543	33.2%
	MP-2		0.854	0.932	0.893	-1.8%
	MP-3		0.176	1.393	0.785	9.0%
	MP-4		0.176	2.095	1.136	-26.1%
	MP-5		0.176	2.095	1.136	-26.1%
	AA-1	Activity Area	0.854	1.393	1.124	-24.9%
	MG-1	Multipurpose Gym	1.206	0.932	1.069	-19.4%
12	MP-1	Patient Room (6-Bed)	0.854	0.231	0.543	33.2%
	MP-2		0.854	0.932	0.893	-1.8%
	MP-3		1.206	1.393	1.300	-42.5%
	MP-4		0.176	2.095	1.136	-26.1%
	MP-5		0.176	2.095	1.136	-26.1%
	AA-1	Activity Area	0.854	1.393	1.124	-24.9%
	MG-1	Multipurpose Gym	1.206	0.932	1.069	-19.4%

13	MP-1	Patient Room (6-Bed)	0.854	0.231	0.543	33.2%
	MP-2		0.854	0.231	0.543	33.2%
	MP-3		0.854	0.231	0.543	33.2%
	MP-4		0.854	1.393	1.124	-24.9%
	MP-5		1.206	0.932	1.069	-19.4%
	MP-6		1.206	2.095	1.651	-77.6%
	MP-7		0.176	2.095	1.136	-26.1%
	MP-8		0.176	0.932	0.554	32.1%
	MP-9		1.206	0.932	1.069	-19.4%
	MP-10		1.206	0.932	1.069	-19.4%
	AA-1	Activity Area	0.854	0.231	0.543	33.2%
	AA-2		0.854	1.393	1.124	-24.9%
	MG-1	Multipurpose Gym	0.176	0.932	0.554	32.1%
14	MP-1	Patient Room (6-Bed)	0.854	1.393	1.124	-24.9%
	MP-2		0.854	0.231	0.543	33.2%
	MP-3		0.854	0.231	0.543	33.2%
	MP-4		0.854	1.393	1.124	-24.9%
	MP-5		1.206	0.932	1.069	-19.4%
	MP-6		0.176	2.095	1.136	-26.1%
	MP-7		0.176	2.095	1.136	-26.1%
	MP-8		0.176	2.095	1.136	-26.1%
	MP-9		1.206	0.932	1.069	-19.4%
	MP-10		1.206	0.932	1.069	-19.4%
	AA-1	Activity Area	0.854	0.231	0.543	33.2%
	AA-2		0.854	1.393	1.124	-24.9%
	MG-1	Multipurpose Gym	0.176	0.932	0.554	32.1%
15	MP-1	Patient Room (6-Bed)	0.854	1.393	1.124	-24.9%
	MP-2		0.854	0.231	0.543	33.2%
	MP-3		0.854	0.231	0.543	33.2%
	MP-4		0.854	1.393	1.124	-24.9%
	MP-5		0.176	0.932	0.554	32.1%
	MP-6		0.176	2.095	1.136	-26.1%
	MP-7		0.176	2.095	1.136	-26.1%
	MP-8		0.176	2.095	1.136	-26.1%
	MP-9		1.206	0.932	1.069	-19.4%
	MP-10		1.206	0.932	1.069	-19.4%
	AA-1	Activity Area	1.884	0.231	1.058	-18.3%
	AA-2		0.854	1.393	1.124	-24.9%
	MG-1	Multipurpose Gym	0.176	0.932	0.554	32.1%
16	MP-1	Patient Room (6-Bed)	0.854	1.393	1.124	-24.9%

	MP-2		0.854	0.231	0.543	33.2%
	MP-3 (4)	Patient Room (4-Bed)	0.854	0.231	0.543	33.2%
	MP-4 (4)		0.854	1.393	1.124	-24.9%
	MP-5 (4)		0.854	1.393	1.124	-24.9%
	MP-6 (4)		1.206	0.932	1.069	-19.4%
	MP-7 (4)		0.176	2.095	1.136	-26.1%
	MP-8 (4)		0.176	2.095	1.136	-26.1%
	MP-9	Patient Room (6-Bed)	0.176	2.095	1.136	-26.1%
	MP-10		1.206	0.932	1.069	-19.4%
	MP-11		1.206	0.932	1.069	-19.4%
	AA-1	Activity Area	1.884	0.231	1.058	-18.3%
	MG-1	Multipurpose Gym	0.176	0.932	0.554	32.1%

Total	Average N+S ΔP 0.875

H. Appendix 2: Labelling of Units and Static Pressure