**Appendix B**

**VENTILATION SIMULATION METHODOLOGY**

**AND REQUIREMENTS**

**B1 General**

The natural ventilation simulation shall be carried out using computational fluid dynamics (CFD) modelling to identify the most effective building design and layout for the development. The simulation results and recommendations derived are to be adopted to meet the intent of the criteria.

**B2 Simulation Software**

The CFD modelling shall be carried out using well validated software. The CFD solver shall have the minimum capability of solving the Navier-Stokes fluid flow equations for a three-dimensional incompressible flow at steady state on a body conforming computational grid. Turbulence modelling shall also be included with the minimum requirement of using the standard k-ε turbulence model, coupled with standard wall function.

**B3 Ventilation Simulation Methodology**

B3.1 All simulation shall be carried out under isothermal condition of 33.0°C air temperature at steady state condition.

B3.2 The computational domain shall include the development of interest, the characteristics of the immediate surroundings and buildings reside within the proximity of minimum 3 times or more the length of the longest distance measured across the boundary of the development. In the event that the building and surrounding development are located within hilly terrain, the topography information shall also be included in the simulation models. The computational domain shall be further extended from the outer edge of the proximity regions to the boundary such that it would not result in non-physical airflow solution, after the solution has converged. The computational domain shall also be aligned along with the wind flow direction. The domain height shall be extended, approximately 3 times the height of the tallest building within the defined vicinity.

B3.3 The computational grid generated for all simulations should resolve the salient flow features in the apartment units and around the development. As a guide, the dimension of the computational elements should be set at 0.1 to 0.2m in the apartment unit, 0.5 to 1.0m at all buildings and ground level and 10m at the far field boundary with a minimum 50m away from the ground.

B3.4 Based on local climatic wind condition, meteorological data on the precise wind direction and velocity of the proposed site location for the month of December, March, June and September shall be used for the CFD simulation. The prevailing wind condition such as the mean speed and direction for Malaysia shall be taken from Table B3.4 below. The inbound vertical wind profile shall assume to be given by the Logarithmic Law reference height at 15.0m

**Table B3.4: Tabulation of Prevailing Wind Direction & Speed obtained from Malaysian Meteorological Department (MMD) over a period of 18 years**.

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

B3.5 There shall have two large scale simulation models using the specified computational domain and grid stated in paragraph B3.2 and B3.3, to assess the wind flow conditions and air-flow pattern within the development and units. The simulation modelling can be conducted based on the two best prevailing wind directions for the building development that is North or North-East ( N or NE) and South or South-East (S or SE).

|  |  |
| --- | --- |
| Stage 1  CFD Simulation model for development | 1. Determine up to five (5) typical unit design layouts that have the majority number of units. If the proposed building development comprises less than 5 typical types, all the typical unit design layout are to be selected for the simulation. 2. Conduct a large scale CFD simulation to assess the wind flow conditions around the proposed building development and adjacent buildings. Natural ventilated corridor linked to the unit should be taken into consideration for the simulation models. 3. From the simulation results, determine the wind pressure taken at 0.5m from every assumed opening of all units at mid height level (capped at 20 storey height) and the pressure difference (i.e. the difference of the maximum and minimum wind pressure) of each unit. In instances, where all or some of the typical unit layouts are not designed at mid-height level, the average wind pressure and respective pressure differences should be determined for these typical units located at the level closest to the mid-height level. 4. Derive the average pressure difference of all units at mid-height or selected level. 5. Select the unit with pressure difference that is closest to the average pressure difference derived in B3.5 (iv) from each typical unit design layout as determined in B3.5 (i) for Stage 2 simulation. The maximum allowable margin of ± 10% difference from the average pressure difference is deemed acceptable. |
| Stage 2  CFD Simulation model for units | 1. Conduct a large scale CFD simulation to assess the air flow conditions of these five (5) selected units. All living or functional spaces in the unit are to be included in the simulation modelling except for enclosed spaces such as storeroom or CD shelter. For the simulation model, all windows and doors are assumed to be fully opened except for the main door (unless security grill provided) and toilet / storeroom window, which is assumed to be closed at all times. 2. From the simulation results, determine the area-weighted average wind velocity of each selected unit by considering the air flow conditions of the applicable areas. |

B3.6 The selected unit is deemed to have good natural ventilation if the area-weighted average wind velocity of the unit is not less than 0.6 m/s. The overall percentage of units achieving good natural ventilation is given by:

∑(No. of Selected Units for Each Layout x Area-Weighted Average Wind Velocity x 100

Total Number of Selected Units x 0.60 m/s

**B4 Documentation Requirements**

B4.1 The Qualified Person (QP) and the other appropriate practitioners shall ensure that the following report is available as evidences to demonstrate compliance with the ventilation simulation framework. The report should comprise the following items:

1. Cover page with a proper title, photo of development, developers’ information (including developers’ name and address and person-in-charge), Consultant’s detail (including the principal’s name and authorized signature, firm’s address and person-in-charge)
2. Table of Content
3. Executive Summary

* Background of the development
* Main findings
* Concluding remarks

1. Background/Introduction
2. Methodology

* Describe methodology used in the study
* Provide the rationale for the units selection as well as salient information such as the total no. of units and different design units layout and location

1. Geometrical Model should include

* Isometric view of the development from various angles
* Domain size used
* Plan and 3D isometric model of units from various angles

1. Simulation settings

* Boundary conditions
* CFD software/models used/numerical scheme
* Mesh/cell sizing
* Solution control-converge criteria

1. Result and discussions

* Simulation results for development for all directions showing the main graphical plots of the plan pressure and velocity vector and salient findings
* Tabulation showing the listing and details of all typical unit types and the selected unit types as well as the corresponding number of units and the area-weighted average wind velocity within each selected unit where applicable.
* Calculation of percentage of units with good natural ventilation and area-weighted average wind velocity of 0.60 m/s or more.

1. Conclusion
2. The following plots are to be placed in the appendixes

* Simulation results for the development (done for each direction)
* Static pressure (plan view-ground & mid elevation, isometric views on building facade)
* Velocity vectors and contour showing the plan view at ground & mid elevation and a few isometric sectional cut plans to show air-flow patterns across the development
* Simulation results for the units for each direction
* Static pressure (plan view-ground & mid elevation)
* Velocity vectors and contour showing the plan view at ground & mid elevation