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ASSESSMENT OF POTENTIAL EFFECTS FROM FLOW AIR POLLUTANT ON URBAN DESIGN AROUND NUCLEAR POWER PLANT

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KEYWORDS: Evaluating the dimensions of exclusion area boundary (EAB), GrBEST – CFD Validation.

ABSTRACT

The main objective of this research is to assess the impact of air quality on human health and the environment in an urban area near a nuclear power plant. Based on the spatial information model using the GIS database. Assumptions of concentrations of pollutants and modeling with respect to the distribution and height of buildings have been developed to reach a visual result that has the potential to provide valuable information to analyze the impact of pollution in the affected area and population.

Computational Fluid Dynamics (CFD) has been employed by the architectural and profession, as the modeling tool is able to provide detailed airflow analysis in aiding the incorporation of innovative natural ventilation concept into on urban design phase.

As a result of this study, we found that the relationships between climatic factors and urban engineering developed through visual representation were useful for assessing the expected spread of pollutants and decision-making for the design of urban planning.

INTRODUCTION

The promotion of mitigation policies that directly contribute to the suppression of global warming is an important issue in the buildings sector. Although various fields, including the buildings sector, are implementing mitigation to the best of their ability, global greenhouse gas concentrations will need time to decrease.

Therefore, when considering future countermeasures against global warming in the building industry, it is essential to promptly consider adaptation to the impact of future global warming and nuclear air pollution around nuclear power plant areas, to addition to strengthening mitigation measures. Fundamentally, to design rational plans for mitigation of air pollution and adaptation in the urban areas, it is desirable to obtain predictions and assessments of the effects of reducing future greenhouse gas emissions. Additionally, it is critical that this information be attained using simulations based on climate change scenarios founded on scientific evidence.

However, under these circumstances, although building engineers may be attempting to conduct a variety of impact simulations for future climate change on the buildings and equipment at the planning and design stages, climate databases that incorporate the effects of future climate change have not been established, which complicates those simulations.

This study synthesizes the climate change scenarios with hourly weather observation data to develop a method for creating hourly future weather data that can be used in building environment simulations. Based on this method, the study creates using hourly future weather data for the 20 years, this study will create hourly weather data for a reference weather year. Furthermore, this study applies hourly future weather data for the attempts to create quantitative predictions of the impact of future climate change on building air heat loads and desperation of air pollution.

In building design there are many basic criteria for air flow around buildings and wind conditions. for example, stress the need for locating, buildings and their air inlets and outlets to take advantage of the prevailing winds.

The ventilation inlets and outlets are frequently designed for nearly vertical which probably does occur in rare instances. Some building codes require outside air inlets to be located 15 to 25 ft. from exhausts so as to avoid re-entry of building fumes and odors. It is assumed that in this way only clean, invigorating air will be drawn into the inlets. Air flow over a building creates a positive pressure zone on the upstream side and negative pressure zones. Contaminants released at roof level may spread over the entire roof inside the cavity. Fumes carried over the deepside will be brought to the ground and back to the building, and may even flow up onto the roof. These contaminants will enter nearby ventilation intakes, frequently in unacceptable concentrations.

Emphasis on new applied trends and approaches used in defining the dispersion parameters at concerned site and expected concentrations and evaluation of nuclear power plant installation (NPP). According to the regulations of International Atomic Energy Agency (IAEA), the site proposed for NPP installation should have certain criteria. The estimation of concentration of radioactivity due to effluent releases in air during normal operation/accident conditions from a nuclear power plant is an important component of the regulatory safety assessment. So, the search discusses models used in Architectural Strategy for Public Spaces of dispersion Ventilation analysis, and these models take into account the effect of the following phenomena such as complex terrain, building conditions, pollutants accumulate in calm conditions. When radionuclide's are released from nuclear power plant into the environment There are a number of different ways in which they can lead to radiation doses to individuals and which should be taken into consideration in the dispersion studies, as a local wind conditions should be made as a part of any building design. Inlets, outlets, and ventilation systems must be designed to operate at the required conditions during all wind conditions.

METHEDOLOGY

Data Requirements

According to IAEA, 2003 the following data are required to conduct a complete dispersion analysis, see Fig. (1).

- Source data: location, emission rate, physical stack height, stack gas exit velocity, stack inside diameter, and stack gas temperature.
- Operational inputs include source elevation, building dimensions, particle size distribution with corresponding settling velocities.
- Release characteristics such as effluent temperature, humidity, exit velocity and wind speed at release level and chemical properties and physical properties of the material released.
- Deposition characteristics such as deposition velocity, nature of aerosol and precipitation intensity
- Dispersion characteristics such as atmospheric stability (very important parameter), wind speed and direction, air temperature, humidity and mixing height.

A case study of the GIS-based spatial analysis has been conducted using different geometric configurations for the same site, where various urban design proposals were compared using an essential parameter for climatic performance. The case study shows the advantages of precision and speed of computation, which can be achieved through the development of GIS-based spatial analysis tools. The approach can be implemented in not only the existing urban sites, but urban design proposals for the evaluation of alternatives. It also reveals a feasible procedure for bringing climatic considerations into evaluation process and makes decision-making more scientific and effective.

1. Criteria for determining the potential effects of the nuclear installation in the region. This requires the following studies;
a- Atmospheric dispersion of radioactive material
2. Criteria derived from considerations of population and emergency planning:
a- Population distribution and distance to centers of population including projections for the lifetime of the nuclear installation.
b- Physical site characteristics that may hinder emergency plan**s** c-Infrastructure characteristics related to the implementation of emergency plan.

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Evaluating the dimensions of exclusion area boundary (EAB) and outer boundary of low population zone (LPZ). *(7)

The dispersion studies have many applications at nuclear power plants. Defining whether the site selected for nuclear power plant satisfies national requirements as Fig 1. Flowchart of the tasks required when undertaking an air dispersion modeling assessment, and whether possible radiological exposure and hazards to the population are controlled within the limits set by regulatory body.

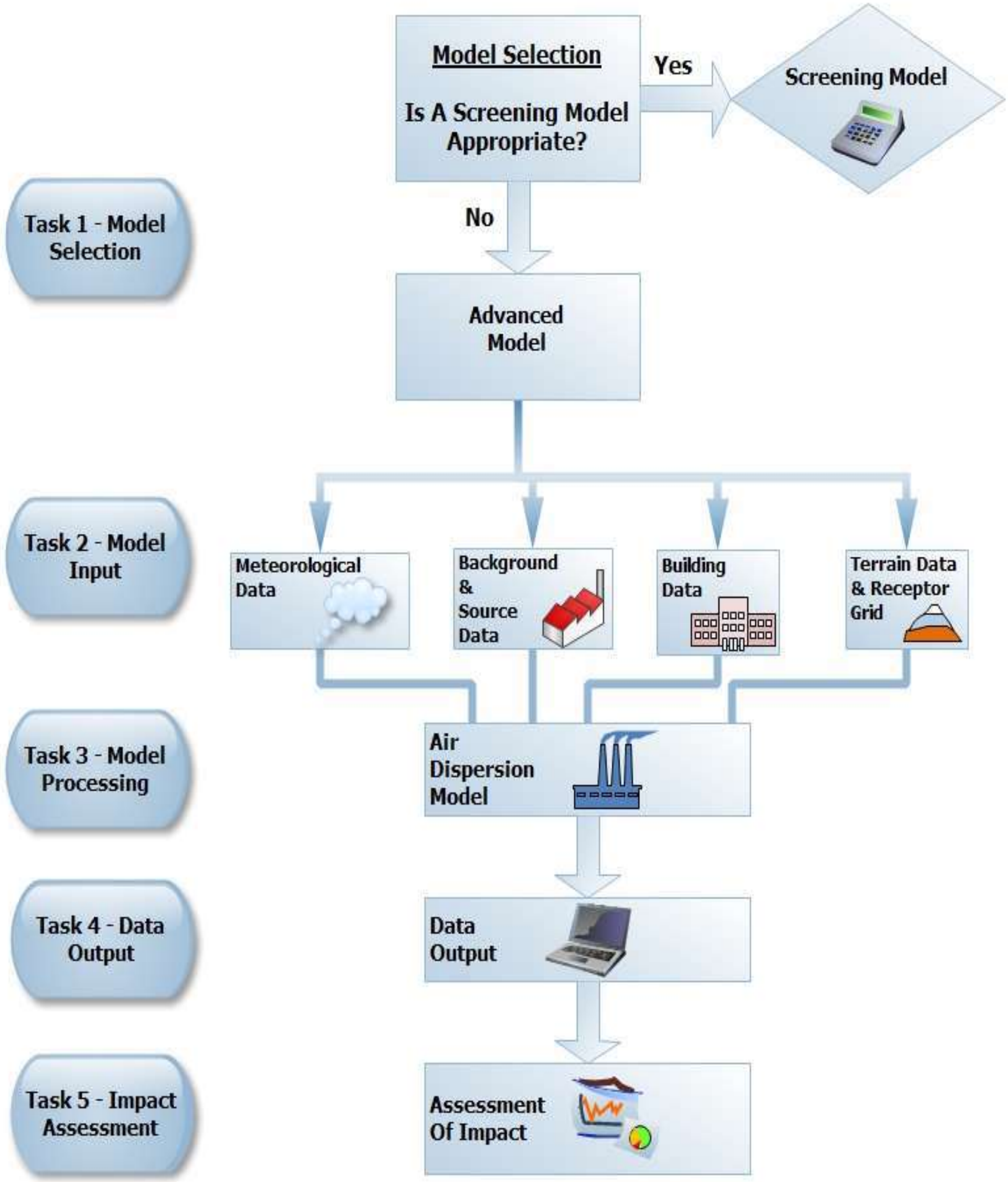

Fig 1. Flowchart of the tasks required when undertaking an air dispersion modeling assessment

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Introduction –Model Used

The GrBEST software* consists of Windows and UNIX-based components, where modeling and project management is performed on a Windows-based PC, and the more compute intensive tasks conducted on a multiprocessor UNIX-based workstation. Fig.2 shows the flowchart diagram representing the modeling and simulation process between the Windows and UNIX machines and consists of the following key stages:

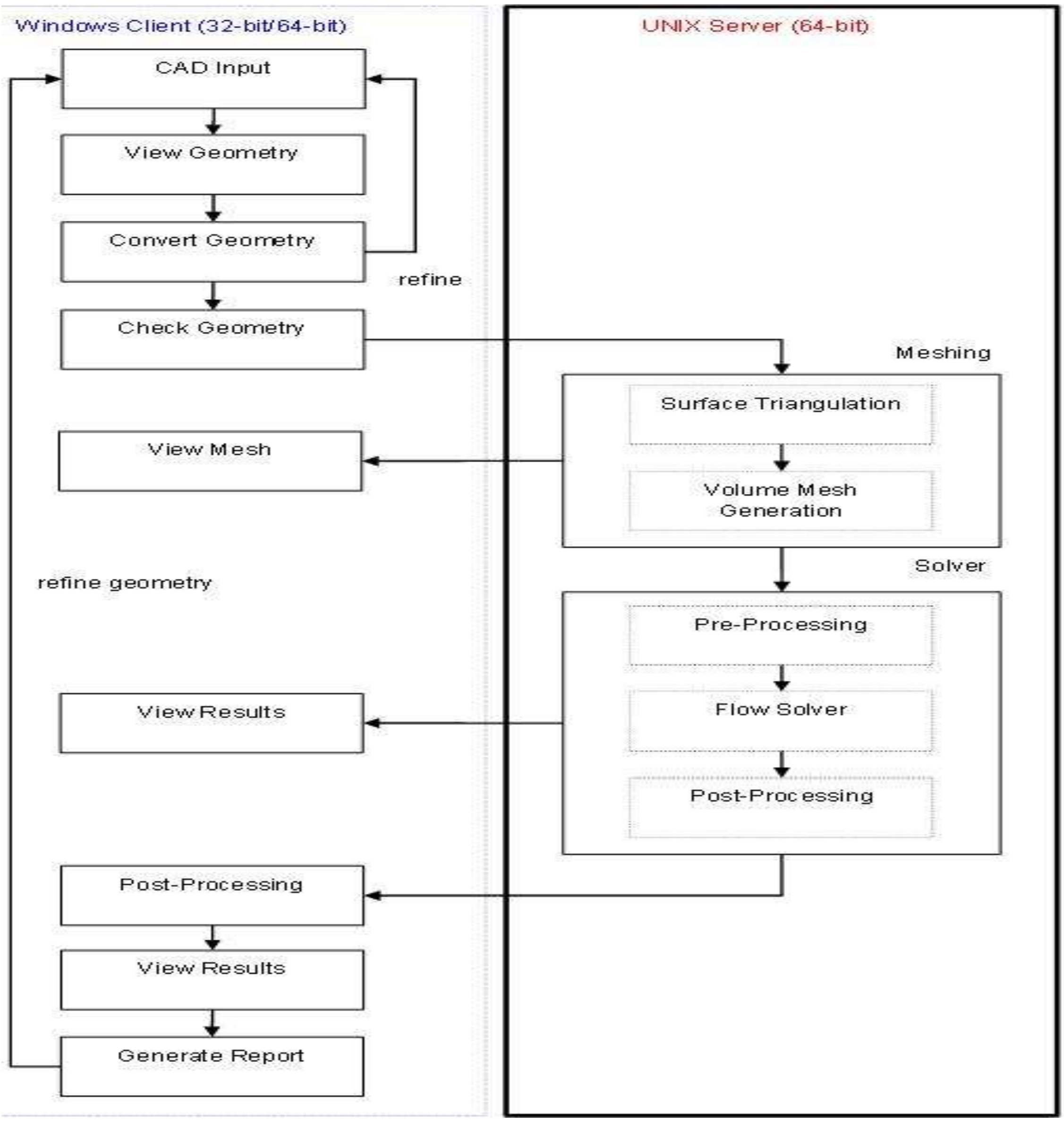

Fig 2. Windows-based client and UNIX-based server module execution workflow

1) geometry preparation, requiring geometry conversion and checking,
2) meshing, consisting of surface triangulation and volume mesh generation,
3) flow solution, involving pre-processing, computation, and automatic post-processing, and
4) Post-processing and report generation. The results of the meshing, solver and post-processing stages may be viewed on a Windows machine by using Para View, an open-source multiple-platform data analysis and visualization application (Para view, 2013).

* GrBEST Airflow Modeling Tool Dr. POH Hee Joo – IHPC 14 Mar 2014

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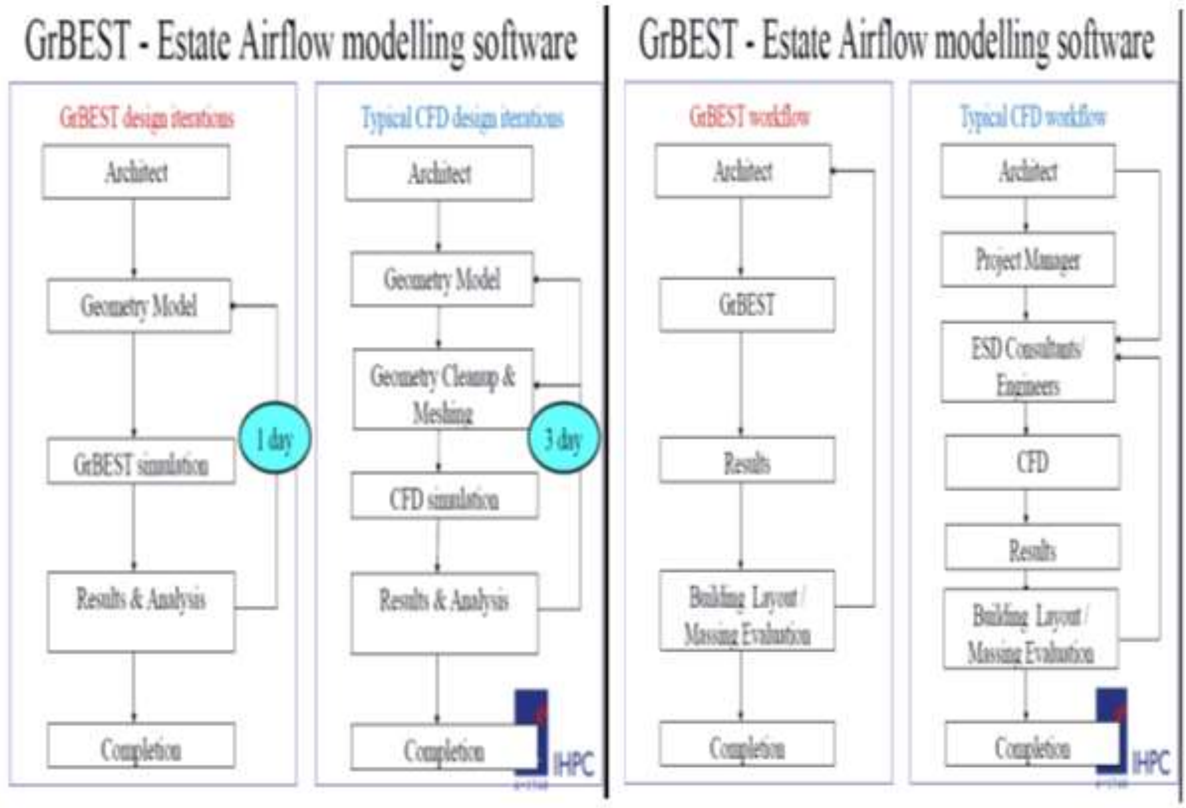
GrBEST – CFD Validation



CASE STUDY

Airflow modelling software for usage by green building industry are Develop an easy to use and cost effective. It is also an effective tool for usage by architect in the conceptual design stage. It is used for analysis of detailed design by ESD (*Electro Static Discharge*) consultants for Green Mark submission to BCA (*Bachelor in Computer Application*). For modelling methodologies and techniques for CFD (*Computational fluid dynamics*) air flow simulations is verified.

The main criteria for the operation

The case study described in Simulation and Scale is used as benchmark test case. The geometry is a typical building complex as shown in Figure 2A. Wind tunnel studies of surface wind around this building complex have been conducted. There are three main types of surface winds: vortex flows, corner streams and through flows.
*(That is internal equation which the software use it)

Surface winds expressed in terms of speed ratio R_H=V/V_H where V is the wind speed at pedestrian height (region A), V_H is wind speed at building height H. Dimensional analysis gives: R_H = f (L/H, W/H, D/H, H/h,Re) where Re is Reynold number. If D/H is small as in many tall buildings, then the effect of Reynolds number is insignificant.

Simulation using is depicted in Figure 3. Plots of V_A/V_H against W/H (aspect ratio) for a given L/H = 0.5, H/h = 5 on both experiment data and simulations is shown in Figure 3.

As can be seen from Figures a-b, the simulation results from capture all three types of building aerodynamic winds and are in good agreement with wind tunnel experiment data. The speed ratio R_H increases to a max with increasing W/H but changes less once W/H aspect ratio reached unity.

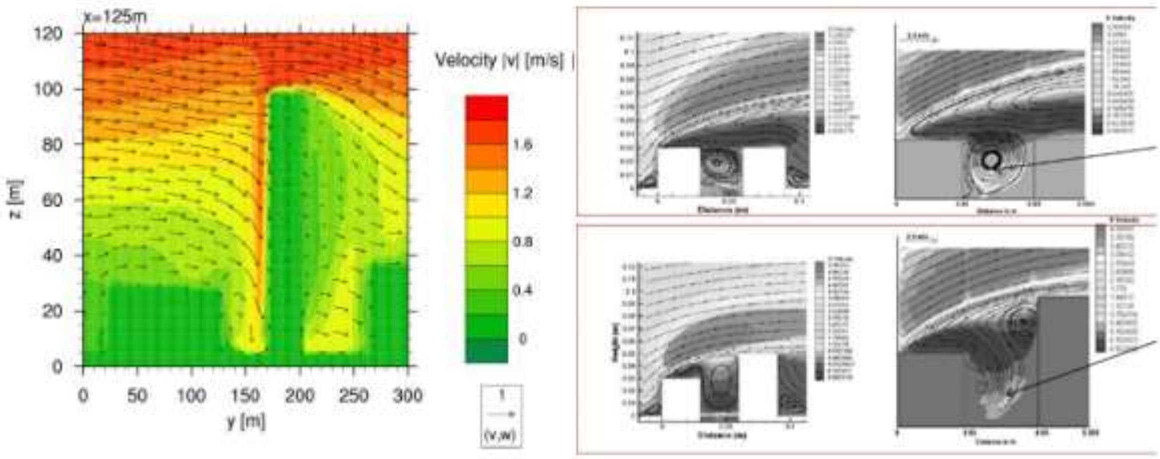


Fig 2A geometry is a typical building complex Urban Canopy Flow with different building height

GrBEST - Developed Capabilities - Estate Airflow modelling software* GrBEST Airflow Modeling Tool Dr. POH Hee Joo – IHPC 14 Mar 2014

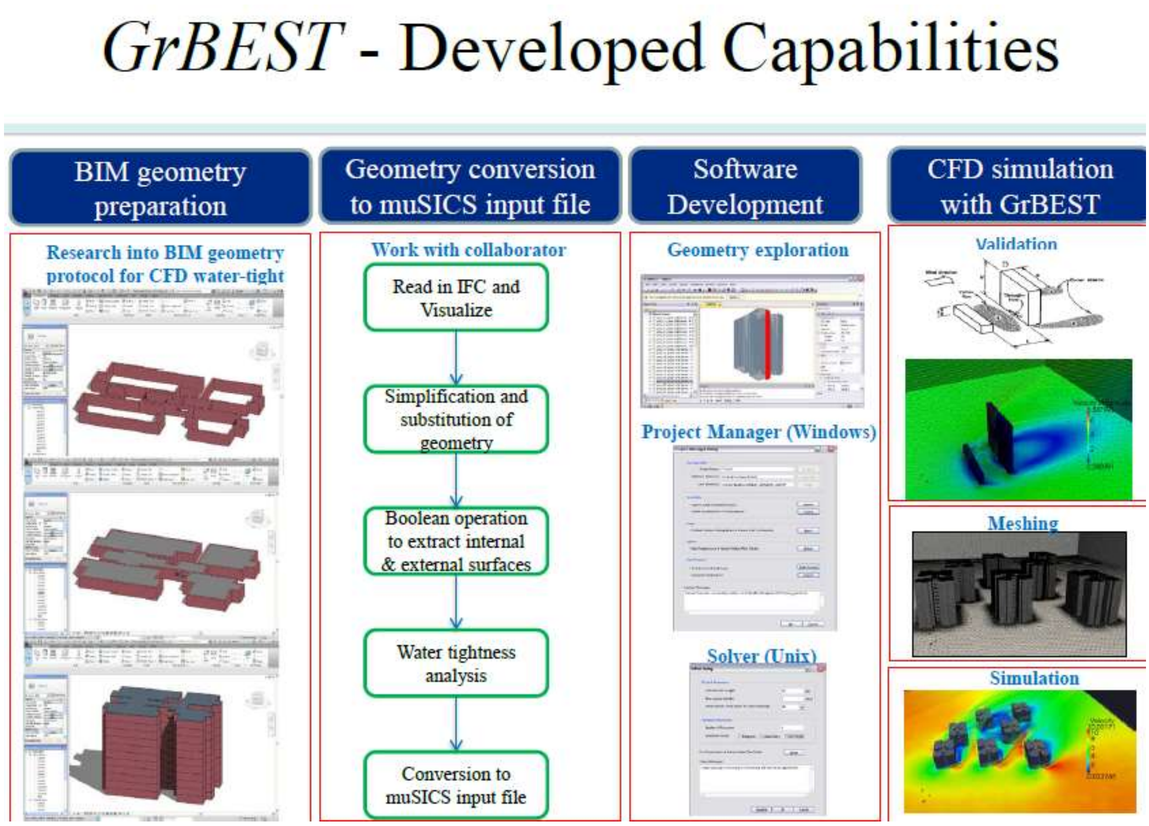
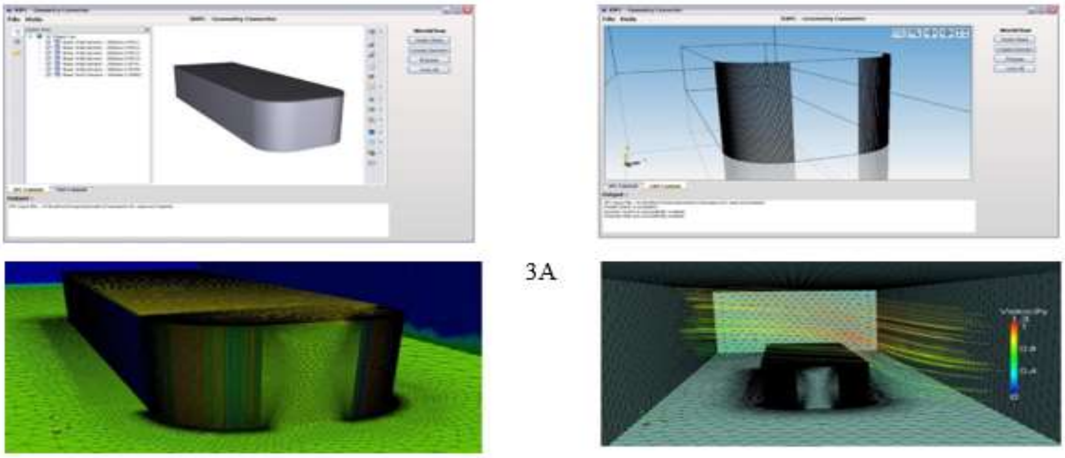


Fig. 3 Example 1 is presented here concerning the external airflow around a building with walls, a curved surface and a flat roof, as shown in

Natural Ventilation for External and Internal Airflow

Example 1 is presented here concerning the external airflow around a building with walls, a curved surface and a flat roof, as shown in Fig. 3A. The model geometry was prepared using Revit to create an IFC file. The IFC file is then converted into the necessary input files for CFD simulation (Fig. 3(a),(b)) thereafter, GrBEST is used to perform surface triangulation followed by CFD flow solution (Fig. 3(c),(d)) using the embedded CFD solver, mu SICS. The input parameters for the flow solver are shown in the Solver dialog (Fig. 3B) and the airflow is from the northeast (NE) to the southwest, as shown by the streamlines of Fig. 3(d).



3A

Fig. 3A: Simple building geometry used for external airflow simulation: (a) IFC content, (b) curve structure, (c) surface triangulation, and (d) converged flow solution

Example 2, demonstrating internal airflow is presented in Fig. 4, where the building geometry consists of two floors, external walls, one lower-level internal wall, and four openings on the front and rear walls. The workflow procedure for this example is similar to that employed in Example 1, with the only difference being that the airflow direction is from the west to the east.

A Stream Tracer filter is created in Paraview to visualize the airflow as a set of streamlines colored by the magnitude of the velocity. The airflow is from the external to the internal region and the fluid flow is from the west to the east as specified (Fig. 3 (d)).

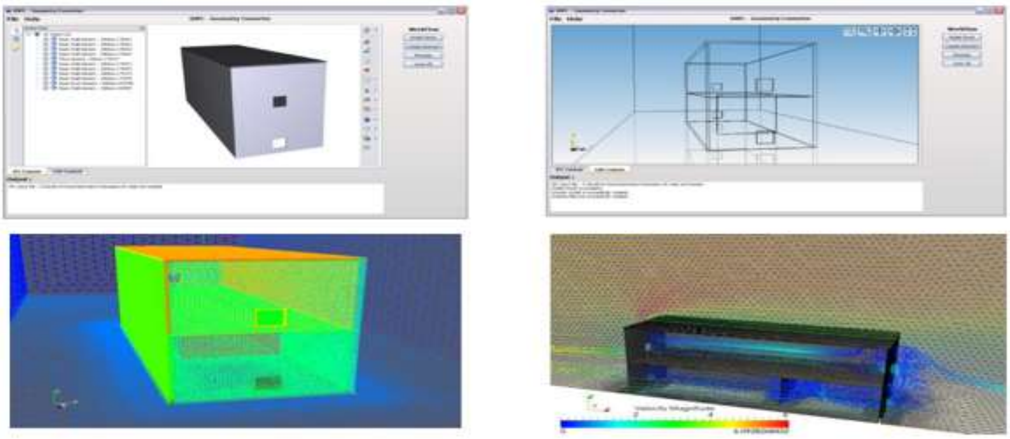


Fig. 4: (a,b,c,d) : Two-storey building geometry with openings and an internal wall used for internal airflow simulation
(a) IFC content, (b) curve structure, (c) surface triangulation, and (d) converged flow solution

Case Study – Community Facility

To generate a case study on situation airflow simulation work and evaluate the natural ventilation scenario is carried out. The results are used in determining the optimal building mass, geometry, orientation and layout to achieve good natural ventilation conditions. Upon receiving the Revit format of the model from RSP, simplification of the model to suit CFD discipline commenced with the aim of studying the natural ventilation on levels 1 and 2 in mind.

Geometry Simplification Steps

1) Vegetation, topology, doors, windows and basement levels are deleted.
2) Room separation lines, elevated floor, ramp, structural columns near to walls are removed. Enclosed spaces are replaced by solid blocks. Thin walls are replaced with 0.5m walls.

RESULTS AND RECOMMENDATIONS

Approximately 4.5 million cells are generated on meshing. The time taken for geometry simplification, meshing and solution generation is approximately two days. Under the present architectural design, it is observed that under North wind condition, the airflow movement on level 1 is slow or stagnant (illustrated by large regions of dark blue color). To further improve the natural ventilation performance on level 1, it is suggested that the gap move from the present location 1, further east, to location 2 (Fig. 5). This would allow the North wind to penetrate to the central region of level 1.

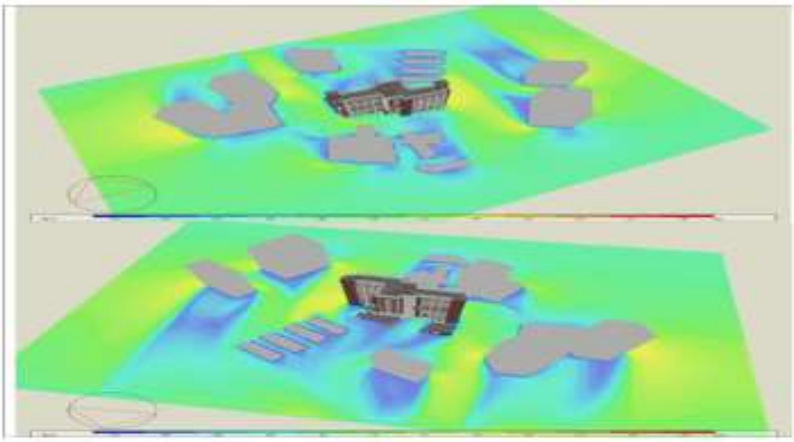


Fig.5: Simulation Result with North Wind, 3 m/s (left), South Wind, 3m/s (right)

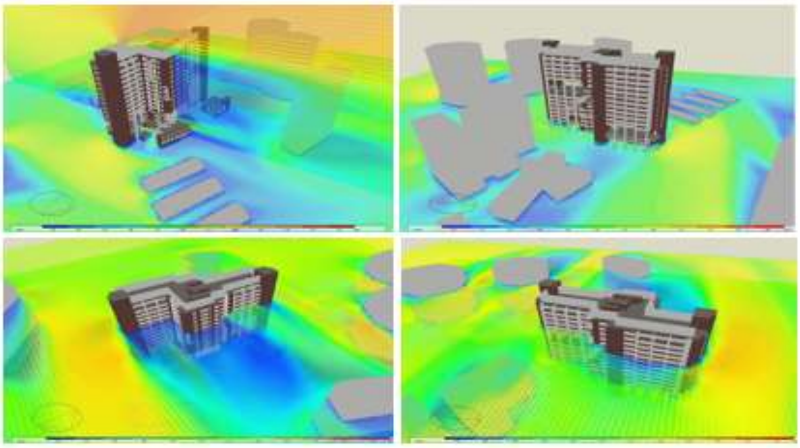


Fig. 6: Recommended changes during North Wind scenario (left) South Wind scenario (right (Level 10: +52.87)

The overall natural ventilation performance on level 1 under South wind is better than that of North wind. If the gap is moved from the present location 1, further to the east, to location 2 (Fig. 6), then under South wind condition, it is anticipated that the highlighted stagnant zone would be eliminated.

Architectural Strategy for Public Podium Spaces Ventilation

To reduce pollution remediation cost, only air-conditioning is planned for working spaces which necessitate full environmental control and to adopt naturally ventilation strategies where possible in transition spaces Fig. 7.

More parametric studies on the factors affecting wind path through atrium space of the big buildings should be carried out in order to from the database for architect and building designers for further references

1) Relative position and opening size between inlet & outlet
2) Restriction of wind flow in the wind passage
3) Alignment of building opening to prevalent wind direction
4) Depth of atrium space between inlet and outlet
5) Size and shape of building adjacent of inlet & outlet
6) Positions and shapes of neighboring blocks

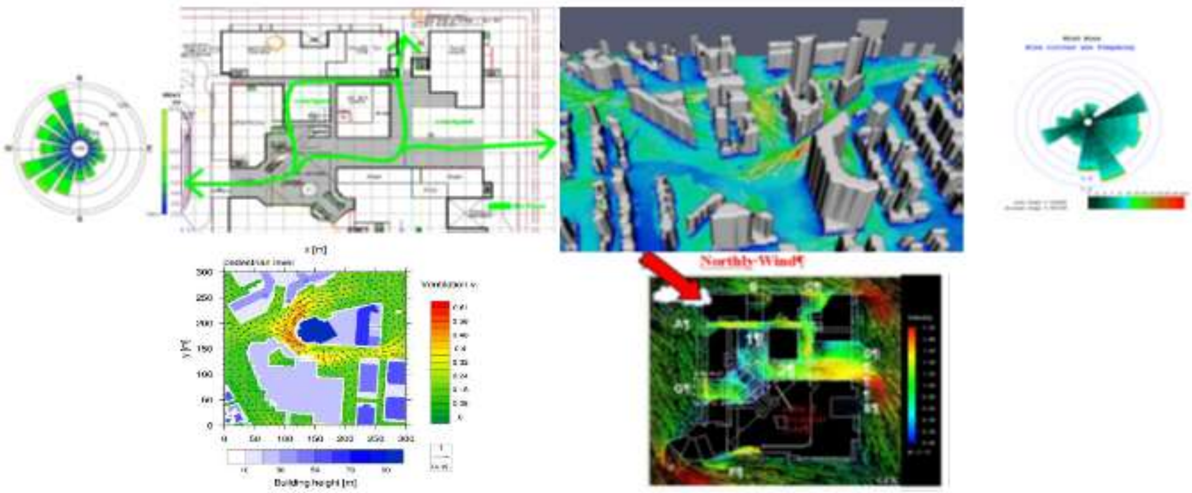


Fig. 7. Flow recirculation/wake and trapping of pollutant Low pressure regime is generated as "suction pump" to remove the pollutant

VALIDATION

The case study described in Simulation and scalable is used as benchmark test case. The geometry is a typical building complex as shown in Figure 4. Wind tunnel studies of surface wind around this building complex have been conducted. There are three main types of surface winds: vortex flows, corner streams and through flows.

Surface winds expressed in terms of speed ratio $R_H=V/V_H$ where V is the wind speed at pedestrian height (region A), V_H is wind speed at building height H. Dimensional analysis gives: $R_H = f(L/H,W/H,D/H,H/h,Re)$ where Re is Reynold number. If D/H is small as in many tall buildings, then the effect of Reynolds number is insignificant.

CFD simulation using muSICS is depicted in Figure 4. Plots of V_A/V_H against W/H (aspect ratio) for a given L/H = 0.5, H/h = 5 on both experiment data and CFD simulations is shown in Figure 7. As can be seen from Figures 4-5, the simulation results from muSICS can capture all three types of building aerodynamic winds and are in good agreement with wind tunnel experiment data. The speed ratio R_H increases to a max with increasing W/H but changes less once W/H aspect ratio reached unity.

Also that, It was important to use GIS (Geographical Information System) as show in Fig. 8 to develop efficient measure air quality with certain urban geometry (either existing site or proposal), is an important issue before can be incorporated into Sustainable urban development design considerations.

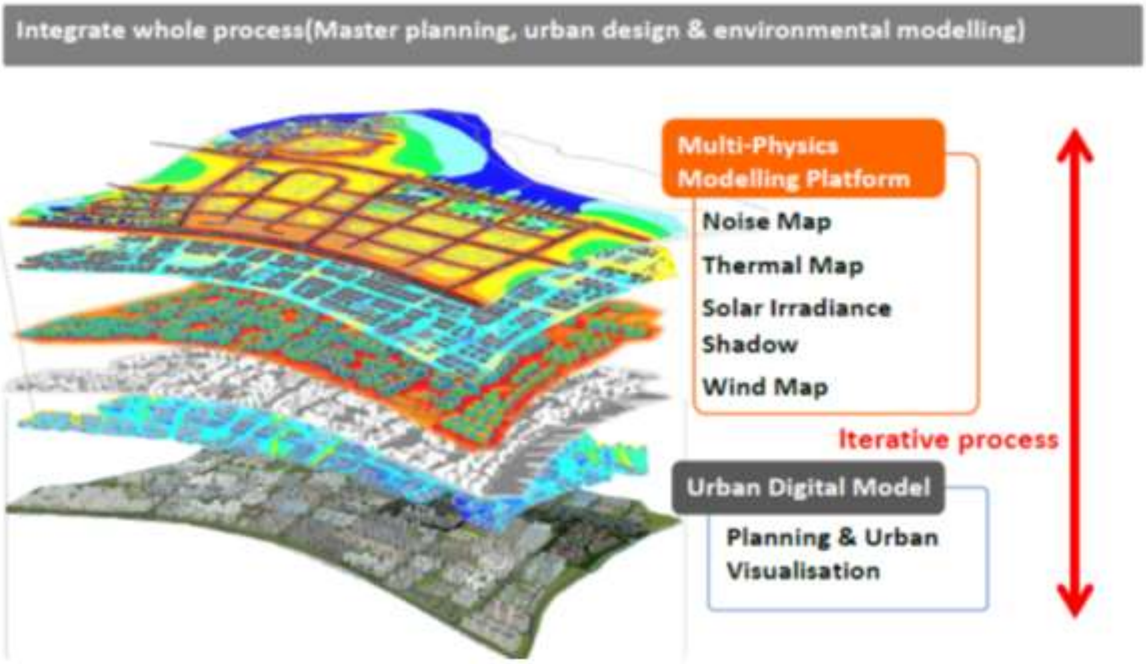
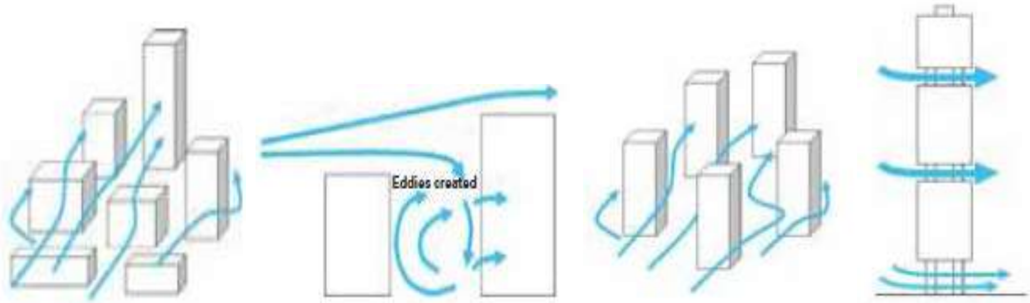


Fig. 8. Integrate whole process (Master planning, urban design & environmental modelling)

Modifications

Three simulation stages are proposed. The first stage consists of the following three scenarios. In Scenario 1, the corridor is widened to 3.5m. Preparation area enclosed. In Scenario 2 – Option 1, the corridor is widened to 3.5m and the walls at two ends of area are changed to 900mm high wall with opening above. In Scenario 2 – Option 2, the corridor remains at 2m and the walls at two ends of area are changed to 900mm high wall with opening above and Fig 9

1. Strategies At building Level To Achieve Good Natural Ventilation
Create flow paths.
– Link open spaces
– Create open plazas at road junctions
– Low-rise structures along routes of prevailing wind
– Greater road widths to increase overall permeability



2. Arrange buildings according to ascending heights.

Lower rise buildings in front and towards direction of prevailing wind.
3. Staggered buildings.
Blocks behind should be able to receive the wind penetrating through the gaps between the blocks in the front row.
4. Create downwash wind.
Building design should consider capturing the downwash wind to reach the street level. Eddies may form in the canyon and this may assist in providing air movement within the canyon as well as into the buildings.
5. Improve building permeability.
Buildings should be as permeable as possible to channel airflow to the blocks in the back row. Sky gardens and double volume void decks can increase the permeability of blocks.

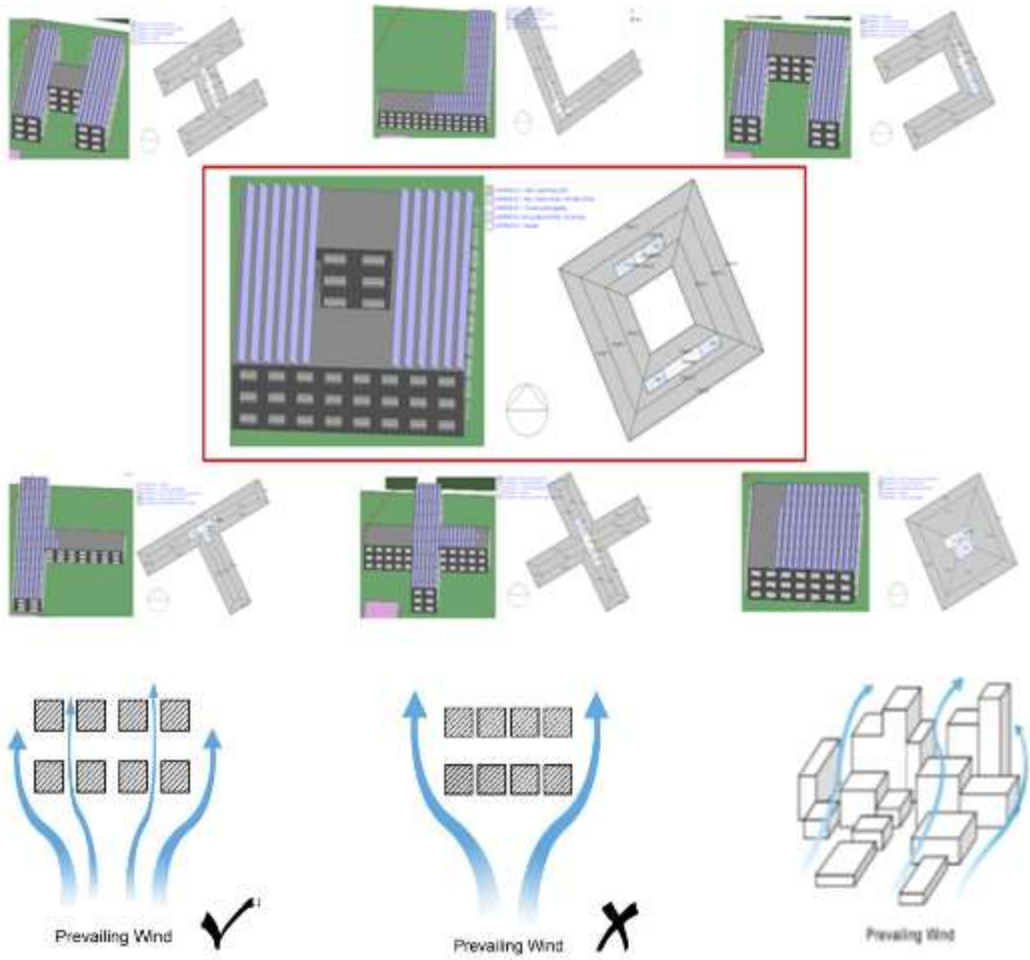


Fig 9 The 7 different building forms optimized to identify minimum loads.

RESULTS
Natural Ventilation for External and Internal Airflow
Example 1 is presented here concerning the external airflow around a building with walls, a curved surface and a flat roof, as shown in Fig. 3-4. The model geometry was prepared using Revit. File is then converted into the necessary input files for simulation (Fig. 6(a),(b)) thereafter, GrBEST is used to perform surface triangulation followed by flow solution (Fig. 5(c),(d)) using the embedded solver. The input parameters for the flow solver are shown in the Solver dialog (Fig. 3) and the airflow is from the northeast to the southwest, as shown by the streamlines of Fig. 3(d).

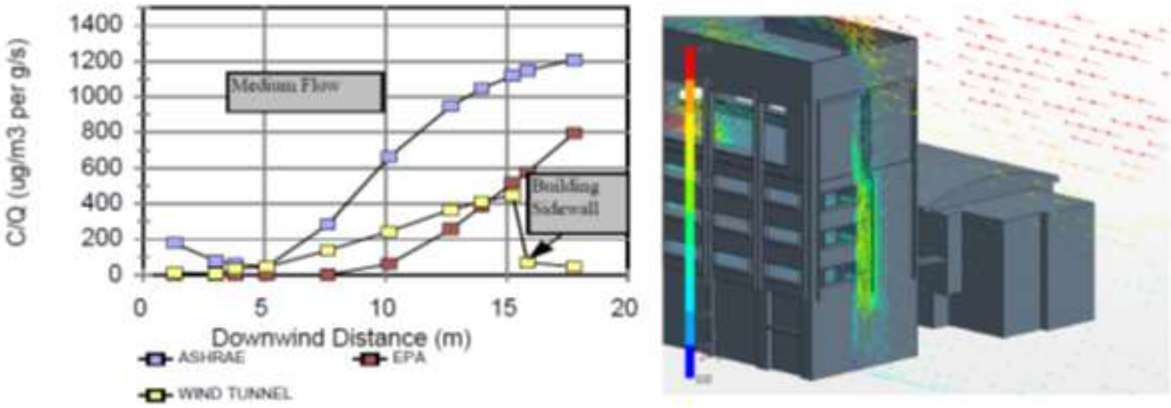


Fig. 10: Speed ratio of surface wind: wind tunnel data (left), CFD simulations (right)

As compared to the current CFD software (e.g. ANSYS FLUENT, CFX, STAR-CCM+ and etc), it can be concluded the GrBEST can produce the estate level natural ventilation result that is of equivalent standard to the commercial and validated version. This is because our GrBEST estate airflow simulation is able to capture all essential features of wind aerodynamic phenomena across the buildings such as through flow, corner wind, stagnation region and vortex flow; as well as give comparable wind velocities within the natural ventilation premises. In addition, the CFD turnaround time for GrBEST is about 1 – 2 days, and can be rated as “fast wind modeling tool”.

CONCLUSION

The objectives of this study are to develop an efficient vehicle to measure air quality with certain urban geometry (either existing site or proposal) using GIS (Geographical Information System), and to examine the sensitivity in different urban cities geometry configurations, which is an important issue before can be incorporated into Sustainable urban development design considerations, the result of this study will contribute to further researches in various aspects.

It can be concluded that: The dispersion studies have a great important in the site selection of nuclear power plant since it is contributed in defining the following tasks.
To assess the radiological risk to individual members of the public and to populations as a whole from predicted routine releases at the design and licensing stage.

- To assess the consequences of accidents at the design stage for the purpose of preparing offsite emergency plans.
- To have the capability for assessing off-site impacts in the unlikely event of a real accident.
- It is used in defining the exclusion boundary area and low population zone around the nuclear power plant.

REFERENCES

1. Singapore Energy Statistics 2012 & 2013, www.ema.gov.sg/media/files/publications, Energy Market Authority,(accessed in June 2014)
2. Wang, L and Wong, N.H., Applying Natural Ventilation for Thermal Comfort in Residential Buildings in Singapore, Architectural Science Review, Vol. 50 (3), pp 224-233, 2007.
3. Buildingand Construction Authority Green Mark Scheme, http://www.bca.gov.sg/greenmark/green_mark_buildings.html (accessed in Sep 2013).
4. Autodesk Revit Architecture (Revit), Building Information Modeling software application, http://usa.autodesk.com/revit/, Autodesk Inc., 2013.
5. ParaView – Parallel Visualization Application, www.paraview.org/, (accessed in 2013).

6. Simiu, E. and Scanlan, R., Wind Effects on Structures: Fundamentals and Applications to Design, Dover Publication, 2011
7. New Trends In Dispersion Studies For Site Selection Of Nuclear Power Plants . F.S. Tawfik And M.A.H. Abdel Aziz.
8. Air Pollution--A Special Report, Power, December 1960. Air Pollution Manual, Part 1, Chapter 13, American Industrial Hygiene Association, 1960. Clarke, J. H., The Design and Location ofBuilding Inlets and Outlets To Minimize WindEffect and Building Reentry of Exhaust Fumes, American Industrial Hygiene Journal, Vol. 26,pp. 242 (1965).
9. Collins, G. F., Applications of Meteorology inthe Evaluation and Control of Air Pollution, Refresher Course, American Industrial HygieneAssociation, Annual Meeting , Houston, Texas,May, 1964.Halitsky, J., Diffusion of Vented Gas AroundBuildings, Journal of the Air Pollution Control Association, Vol. 2, p. 74 (February 1962).
10. Halitsky, J., Estimation of Stack HeightRequired To Limit Contamination of Building Air Intakes, American Industrial HygieneAssociation Journal, vol. 26, p. 106 (1965). Halitsky, J., Gas Diffusion Near Buildings, ASHRAE Transactions Vol. 69, p.464 (1963).
11. Halitsky, J., Barrett, J. C., and Hama, G. M., “Open for Discussion," Heating, Piping & Air Conditioning, Vol. 35, No. 8 (August 1963).
12. Held, B. J., Planning Ventilation for NuclearReactor Facilities, American Industrial Hygiene Association Journal, Vol. 23, p. 83 (January- February 1962). Hewson, E. W.,.Stack Heights Required ToMinimize Ground Concentrations, Transactions ASME, Paper No. 54-A211, October 1955.
13. How To Design Drain Type Stacks, Heating, Piping & Air Conditioning, Vol.36, No. 6, pp. 143-144 (June 1964).
14. McElroy, G. E., Brown, C. E., Berger, L. B., and Schrenk, H. H., Dilution of Stack Effluents,Technical Paper No. 657, U. S. Bureau of Mines, Washington, D. C., 1944. Nolan, R. W., Design of Stacks To Minimize
15. Smoke Nuisance, Transactions, Society of Naval Architects and Marine Engineers Vol. 54, p. 42 (1946).
16. IAEA, Safety Aspects in Siting for Nuclear Installations, Draft Safety guide, DS433,(2011).
17. IAEA, "Dispersion of Radioactive Material in Air and Water and Consideration ofPopulation Distribution in Site Evaluation for Nuclear Power Plants", Safety StandardsSeries No.NS-G-3.2, Vienna, (2002).
18. IAEA, “Generic Models for Use in Assessing the Impact of Discharges of RadioactiveSubstances to the Environment”, Safety Reports Series No. 19, IAEA, Vienna, 2001.
19. 15th International Conference on Nuclear Engineering "Atmospheric Dispersion Analysisin Preparing Permit Applications For The New Nuclear Power Plants in The UnitedStates", Nagoya, Japan, April 22-26, (2007).
20. Atomic Energy Regulatory Board, "Atmospheric Dispersion And Modeling "', AERBSafety Guide NO. AERB/NF/SG/S-1, India, (2008).
21. Environmental Protection Agency (US EPA), Proposed Guidance for Air DispersionModeling, Lakes Environmental Consultants Inc., November 10, (2003).
22. Airflow Modelling Software Development For Natural Ventilation Design. Hee Joo POH*, Meow Win TAY, Petrina Shu Hui TAY, Hoang Huy NGUYEN and Bud FOX
23. Singapore Energy Statistics 2012 & 2013, www.ema.gov.sg/media/files/publications, Energy Market Authority, (accessed in June 2014)
24. Wang, L and Wong, N.H., Applying Natural Ventilation for Thermal Comfort in Residential Buildings in Singapore, Architectural Science Review, Vol. 50 (3), pp 224-233, 2007
25. Building and Construction Authority Green Mark Scheme, http://www.bca.gov.sg/greenmark/green_mark_buildings.html (accessed in Sep 2013).
26. Autodesk Revit Architecture (Revit), Building Information Modeling software application, http://usa.autodesk.com/revit/, Autodesk Inc., 2013.
27. ParaView – Parallel Visualization Application, www.paraview.org/, (accessed in 2013).
28. Simiu, E. and Scanlan, R., Wind Effects on Structures: Fundamentals and Applications to Design, Dover Publication, 2011.