Designing "Healthy" into Green Environment for Taipei City

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Abstract. To achieve the goal of green environment related to an adaptive city of Taipei which is the World Design Capital 2016. We should discuss the effect of wind environment around the buildings at the beginning of design and planning phase of buildings first, for wind environment is the most important factor concerns with greenhouse and heat island effect. This research was based on a method of CFD done by Autodesk Ecotect Analysis software for simulating city building layout, study the two different building massing layout of Shezi Island in Taiwan. Results of simulation showed that the layout characterized by street block type, and therefore affect the residents' health, activities and psychological feelings; while the case of three-sided building layout surrounded by urban of open space, on the other hand, can provide more comfortable, healthy places for rest and outdoor activities.

Keywords: Healthy, Green environment, Wind environment, CFD Analysis, Shezi Island.

1 Introduction

Taipei is the World Design Capital 2016 with the slogan of "Adaptive City". It gives Taipei an opportunity to show how Taipei City to be a sustainable development city with respect to life quality and health, ecological sustainability, smart living and urban regeneration.

With excessive economic growth let the greenhouse effect and urban heat island effect issues become more seriously in recent years that lead to violent global climate change and natural disasters. Therefore, to achieve the goal of sustainable green environment and zero-carbon buildings related to a comfortable, healthy livable city, a new technical method must be used at the beginning of design and planning phase of buildings.

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The effect of wind environment around the buildings plays an important role in a complex mutualism environment relationship between comfortable, healthy, sustainable and natural ecosystems. To understand the natural mechanism by wind, proper measures must be taken to predict wind environment around the buildings. Open spaces and facilities around buildings must be reviewed for their usages and planned not to displease users from the perspective of wind environment. Additionally, wind environment change by newly constructed buildings must be reviewed in the design and planning stage to prevent negative influence to the existing building in terms of natural ventilation performance, human comfort, psychological feeling and pleasant wind environment for local residents [1-2].

Besides, the growing number of high-rise and high-density buildings due to drastic urbanization is causing a number of issues in urban wind environment, such as the heat island problem, etc. Among these issues, the strong winds that can arise around high-rise buildings cause difficulty for pedestrians, while weak winds owing to the blockage of window by high-rise buildings may stagnate the heat and pollutants, causing discomfort to pedestrians or people resting in the vicinity of the buildings [3-5]. To make comfortable, healthy, sustainable city possible, a building's performance in terms of energy consumption and environmental impact must be analyzed from the first stage of design and planning phase.

2 Adaptive Design Concept of Shezi Island

Shezi Island (Fig.1), located at the intersection of Keelung River and Tanshui River in Taipei, was originally a floodplain. A big urban park is planned to be built in the northern part of it. Meanwhile, a livable, productive, and eco-friendly community both to healthy environment and humanity for Taipei will develop from here, making Shezi Island the green ecological foundation in the city of Taipei. Traditional performance of eco-building performance analysis is based on research papers of questionnaires, observation and interviews and lacks scientific objective evaluation.

This study started from a different point of view of the ecological city, using CFD software as a new technical method to simulate the wind behavior around the building layout [6-11]. This study discussed two design plans of Shezi Island including the wind environmental impact created by different building layout and open space, and other impacts including environmental comfort, activity continuity and comfort level of pedestrian wind system.

In order to improve the quality of healthy environment, residents' requirements on daily working and activity space must be taken into consideration. According to principles of relevant surveys on comfort of open space, factors such as humidity, ventilation, and sunlight exposure are all closely related to wind environment [12-15]. Of all the related factors, building layout is the most important one [16-18].

Hong, Y.A. [19] in his research illustrated that Pedestrian Level Wind usually refers to the wind environment at the height of pedestrians' head that is about 1.5-2 meters above the earth. Therefore human beings are most sensitive to this wind level which makes it the anchor height when researching the flow fields in public spaces. Other factors such as wind characteristic, wind direction, wind velocity, the size of architecture itself, the geometrical shape and neighboring building complex, will also exert an impact on the wind flow around the building, hence, creating an instable turbulence flow field. The annoying Pedestrian Level Wind can directly influence the design of architecture and urban plan in the vicinity. Wind flow has a substantial effect in the comfort of pedestrians, the environmental conditions within public spaces and around building entrance and the activities that might occur there. Wind tunnel tests during the design development process are often critical, particularly where proposed buildings are significantly taller than the neighbor [20].

Case 1 of Shezi Island plan design featured the one-side space of style (linear type) while case 2 highlighted a three-sides space of style (three-sided building layout) and both with 40% building coverage ratio and 60% floor area ratio [21].

This study based on the simulation and analysis of building wind environment of different layout done with the aid of Autodesk Ecotect Analysis CFD software. The experiment location and cases of Shezi Island plan design were showed in Fig.1. In both cases, the urban open space was divided into part A and part B. There were 10 measuring points distributed in Case 1 and 13 points in Case 2. Wind environment and its effect on space continuity, environmental comfort, activity continuity, and access, etc [22-23] were studying on at respective heights of 1.5m and 5m. According to the results of software simulation, further analysis and discussion on the plan design had been carried out.

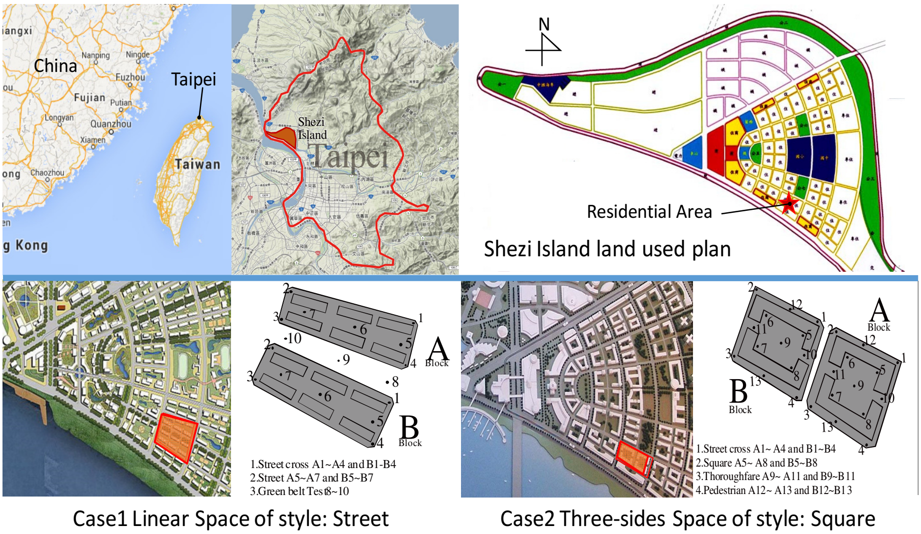

Fig. 1. Location of Shezi Island and two cases of Shezi Island development plan

3 Computational Analysis

This study calculated by the fluid dynamical equations, as suggested by Launder, B.E. and Spalding, D.B. [24], to simulate the incompressible turbulent flow act, under the condition of turbulent flow field.

The selections of simulated area were established on the street block around the base to improve credibility of simulation. In the setting of simulated boundary calculating area, the size of boundary area set by Bouyera, J., Inard, C. and Musy, M. [25] will be the parameter value (Fig.2, 3). For simulation calculation, the method of mean grid setting was adopted to verify the digital simulation.

The climatic condition (Table 1) in the study was provided by Tanshui observation stations from Central Weather Bureau [26]. Statistics of average wind speed, maximum instantaneous wind and wind direction from 2005 to 2011 for the setting of parameters were also collected.

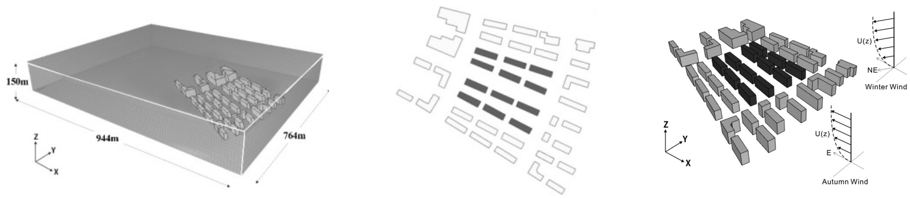

Fig. 2. Parameters setting of simulation model in Case1

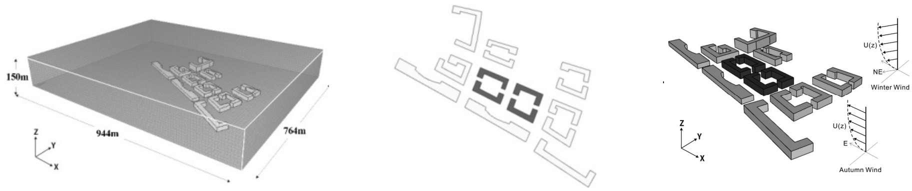

Fig. 3. Parameters setting of simulation model in Case2

Table 1. Tanshui observation stations weather information Velocity :(m/s)

Season	Spring	Summer	Autumn	Winter	The survey period
Average wind speed	0.6	0.5	0.6	0.6	2005-2011
Wind direction	Northeast	Southeast	East	Northeast	
Maximum instantaneous wind (month)	10.7	21	18.8	10.7	2005
	16.1	13	10.7	14.3	2006
	9.8	10.7	27.7	11.2	2007
	13	14.3	10.7	8.9	2008
	12.1	12.1	13.9	8.9	2009
	-	-	8.9	8.5	2010
	7.6	11.6	11.2	13.9	2011
Maximum instantaneous wind (average)	11.6	13.8	14.6	10.9	2005-2011

4 Results and Discussion

4.1 Street Open Space

The results of the CFD simulation was showed in Fig.4, it was clear to see that at the height of 1.5m, the wind flow of the street block went from northeast in winter. As the street block type of layout had formed an area of open space, which was called street canyon, the air flow through both sides of the building and generated a channel effect (Fig.4-e). Since the wind flowed from a wide area to the narrow street, the area of its flowing passage diminished, the wind speed at the end of the side of the building accelerated and formulated an area of high wind speed. In particular, when the wind velocity achieved the utmost, the wind velocity change became more obvious, developed the corner wind at the end of the lower part of the building wall (Fig.4-f).

In Test Point 8 at the windward side, the wind velocity was low due to the block of nearby building in most periods of time (Fig.4-a~b), only with an evident increased when it achieved the maximum instantaneous wind velocity. At the measuring point of Test Point 9, in the middle of the open space between buildings, the air flow was averagely distributed and the change of wind velocity was small. However, in Test Point 10 at the lee side, the building layout caused the air to flow through the side of the building and form a part channel effect at the far end of the open space.

In autumn (Fig.4), the wind came from east into the open space area and developed an evident corner wind, and hence a channel effect with great wind velocity. The whole wind field flowed into the building complex and street canyon from the east, made the wind flow steady along the west fall of the building so that the wind velocity above the pedestrian was low which provided the pedestrian system with activity continuity and space continuity. The channel effect exerted more influence in autumn than in winter with a higher wind velocity. Therefore, it was suggested that the axis of open space in street should avoid windblast to provide proper ventilation facility, creating an environment of comfort.

In case 2, the wind in the flow field at the height of 1.5m in winter came from the northeast (Fig.4-c). Due to the block of building layout, the wind velocity decreased to the speed of less than 1m/s even 0m/s at the foot of the wall in space between the square area in the building and the building walls near both sides of the square that provided comfortable environment for long-term stay and outdoor activities. Outside the west side of the building, where the wind passed by, flow field of swirling air is formed in the back of the building, of which the wind velocity was low and weak. There existed the building awake which meant the ventilation was not good. Therefore, the design plan of the square should consider the activities and matched facilities within the effect of windblast area and their connection with the environment around and the pedestrian system.

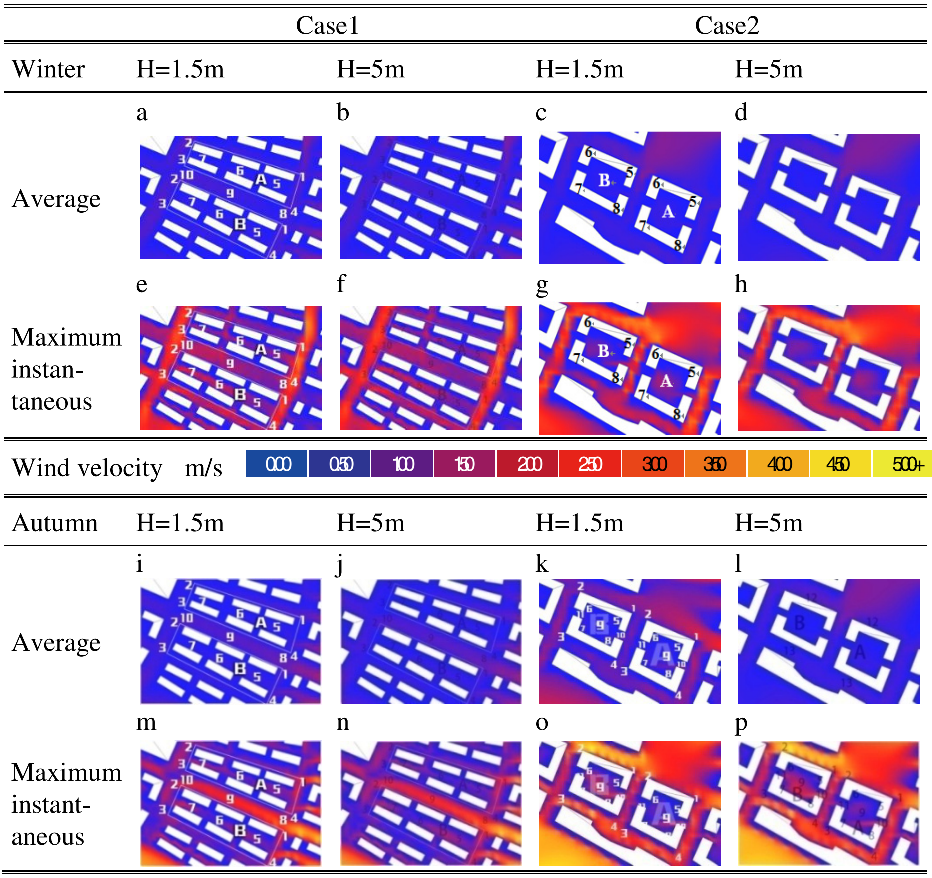

Fig. 4. Diagrams of digital simulation from measuring points in winter and autumn

4.2 The Environmental Comfort of Open Space Area to Street Area

Wind velocity at windward side of open space was high therefore reducing the comfort under the condition of short-term stay both in winter and autumn (Fig.5 a-a’, c-c’ section). Street of open space was affected by the building layout on each side which could generate a channel effect, higher wind velocity at the side of street, and wind circulations in the middle when wind velocity achieved the maximum in autumn (Fig.5 d-d’ section).

In conclusion, the using of space area should take into consideration the environmental comfort while the facade design of the building layout at street side should consider the windblast including plans of trees, plants, and necessary facilities to go with it against the possible windblast.

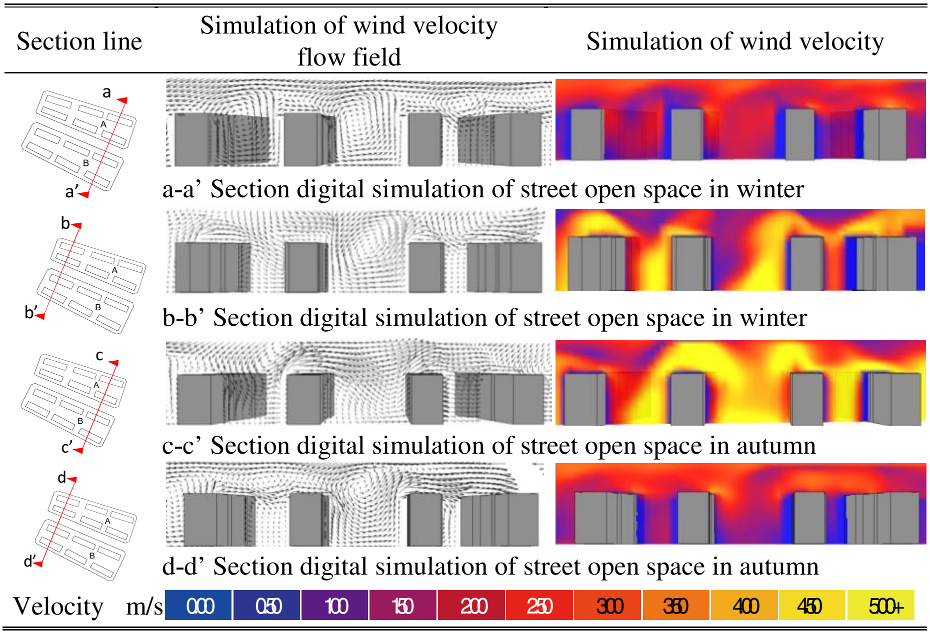

Fig. 5. Diagram of digital simulation of wind velocity in street open space

4.3 The Environmental Comfort of Open Space Area to Square Area

The simulation result of wind environment showed that, in winter, wind flows in from northeast and affected by the windward side and the building layout, wind field created circulations at its entrance. The wind field changed a lot and the wind velocity was high (Fig.6 b-b' section). Rest of the area didn't have such a changing situation of wind field while maintaining a low wind velocity and environmental comfort which was suitable for long-time sitting as relaxation and other relaxing activities (Fig.6 a-a' section). In autumn, at the entrance of open space in square, wind velocity was high and changed a lot because of windward side air flow, corner wind of the building and the entrance of nearby streets or neighborhoods (Fig.6 d-d' section). Rest of the wind field above the pedestrian didn't change much with low wind velocity and enjoyed the environmental comfort.

As a result, design plan for outdoor activities in square open space should consider the wind flow created both at the entrance and in the middle of the square, the windblast and environmental comfort. The architecture design should take into consideration the wind direction, wind velocity and entrance size of the building. As for the building layout, the sides and lee side of the building complex should face the autumn wind while the closure part facing the winter wind so as to block the windblast, meanwhile the comfort of pedestrians was also an important index, so that a comfortable, healthy place for outdoor activities could be built for the residents.

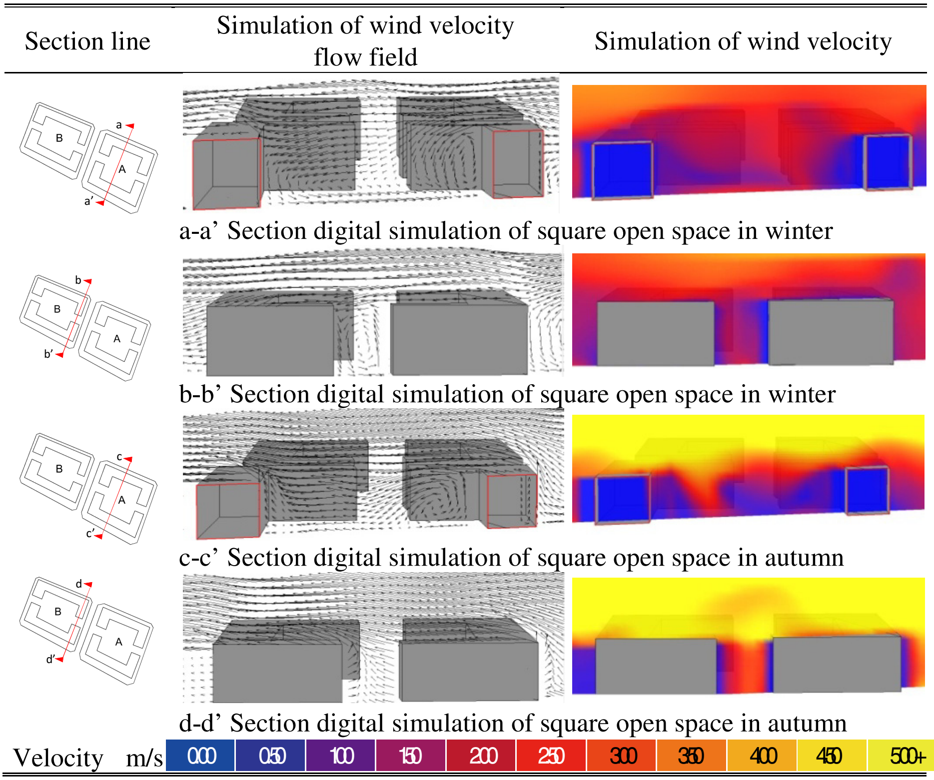

Fig. 6. Diagram of digital simulation of wind velocity in street open space

5 Conclusions

This study showed a new adaptable technology for designing healthy into green environment at the beginning of design and planning phase that we adopted the method of wind simulation and proved that building layouts affected the flow field of open space which was main area for outdoor activities and rest. Wind speed of the monsoon and building layout had an influence on the wind environment of urban open space. Therefore the design of building complex should take into consideration the prevailing wind direction and avoid facing the windward side or an enclosed building compound for the sake of natural ventilation simulation could improve efficacy of advanced evaluation of urban design plan and hence, provided important references to quantifiable projects in the original plan as well as the principles and influence of the design plan. As a result, different urban building layouts and forms of open space had an influence on the usability of the area.

The urban heat island effect was growing significantly related to the growing number of high-rise and high-density buildings. Using CFD simulation in design and planning phase, we could both to consider external and internal airflows, also knew about the behavior and change of the wind environment. It could accurate comparison of different design options quickly. The other purpose of this study was to investigate the incorporation of reality and Ecotect and how they interact in the process. Helps people feel healthy and comfort with graphic presentation in advance of construction, as well as avoided wrong decision and improved the quality of environment for sustainable city. And more efficient materials handling and waste recovery. The results could feedback to the planner and designer to modify the layout of buildings to have a more healthy, comfortable new town and better environment.

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