A Study on the Air Environment Performance of Building Openings in Taiwan

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ABSTRACT: This research is to improve, Taiwan’s high temperature and high humidity climate environment located at the subtropics area. This study proposes an appropriate opening design and implementation method for buildings in Taiwan, with the aim to improve such environment. The subject of this study was a three-story atrium-style building, and 8 residential units were investigated. The two-sided openings were formed by shutters and glass, and could be categorized into 4 models. The measuring results on temperatures and relative humidity inside the units showed that two-sided shutters are more effective to dissipate heat at night in summer than two-sided glass windows are. In winter, full-closed openings with small gaps could make the indoor temperature 2°C higher than the outdoor temperature, and the relative humidity could reduce by 10%.

KEYWORDS: micro environment wind field, temperature, humidity, subtropics zone.

1. INTRODUCTION
Since the year 1998 the first Green Building Challenge was held in Vancouver, the trend of sustainable or green building issues became the future step for the architects. The most serious crisis of human in the early period of the 21st Century must be the rage of SARS all around the world. SARS has caused a large impact on the society, economy and development of industry of Taiwan. Especially in the mainland, the epidemic caused the nosocomial infection in many major hospitals all around the province. Because of that epidemic, people felt terrified about their life and their living spaces. Buildings located in Taiwan’s city are quite intensive that causes the circulating of wind is difficult. However, the climate in Taiwan is always hot and wet, which also means the ventilation in a building is very important, that because
proper ventilation can adjust indoor air environment and make occupants healthier and feel comfortable. As for that in Taiwan, the Green Building Evaluation System (GBES) developed by Architectural Building Research Institute (ABRI) was also revised in 2003 and integrated into the indoor environmental index. At the same time, ABRI actively pushed forward the Housing Performance Evaluation System (HPES), and among the indices, indoor air environment and building ventilation are regarded very important.

In order to dig out the best mode according to the time sequences of life, and then provide references to the residents, this study has discussed the physical environment performance in summer and winter (utmost module), and the study is based on the different on-off control modes of the different openings of units in ARCHILIFE Research Foundation. The influence of different openings of units on the health and comfort of the indoor environment under natural ventilation is discussed to evaluate its essential application pattern and benefit.

2. METHOD

2.1 Outdoor Environment

The Archilife Research Foundation has built the experimental building in northern part of Taiwan. North Taiwan locates at the north of Tropic of Cancer, and Northern Taiwan is subtropical. Taking Fulong as an example, the solar term of the highest temperature in summer is “great heat”. Analyzing the weather data of this solar term in three years, the average highest temperature is 31.7 ℃. The temperature difference is clear in four seasons. In the aspect of humidity, Fulong region is humid all the year, and all the relative humidity of the whole year is above 70%. The average value of the highest relative humidity is above 80%, and the high humidity is mostly in winter and spring. Because of the excessive-humid outer air, the process of moisture-absorption is necessary when natural ventilation is needed before the air is channeled into the room. What’s more, the wind direction of Fulong, whether the north-east wind in winter or the south-west wind in summer, because of the local micro-terrain, most of the wind directions would turn into north-south. The wind direction is just parallel with the outdoor openings. Therefore, it is difficult to introduce wind into room, and the eduction of the hot air isn’t very easy.

2.2 Experimental spaces

The experimental building of this case is located in Fulong of northern Taiwan which is built by Archilife Research Foundation. This building has 24 living unit spaces, and it is a design case of an age-long healthy building. Four different types of natural ventilation systems were taken to be installed in eight rooms with the
same characteristics, including room volume, openings, shapes, furniture and bathroom (see Figure 1).

Figure 1. The experimental building in northern part of Taiwan

2.3 Experimental Model set-up

In order to discuss more the physical environment of experimental building, from the view of the utilization of day-light and wind-resistance, the outer shutters should be replaced with glass modules for the discussion of the feasibility of this utilization. It is necessary for the analysis of the local climate conditions to research the physical environment of units, so that the problems of high temperature and high humidity could be solved. This unit is built with replaceable material and the structure is flexible unit. For the study of the control mode of the openings according to the changes of outer environments, the shutters of some units are to be replaced with glass. The advantages are as following: (1) glass has better air-tight quality, and its thermal insulation is good; (2) The use of glass could increase the utilization of day-light, and the daylight section of the same acreage of glass doubles the same acreage of shutters’, therefore the problem of scarce of day-light caused by the light block of pot-planting could be remedied; (3) a broader view could be rendered; if the actual need of ventilation should be considered, a certain angle of open on the top of glass module is tolerable. Figure 2 shows is the unit shape after the replacement of modules, and there are 4 types in total.
2.4 Field Study
Long-term thermal sensors were put in different target model room for at least 24 hours. Relative humidity was also measured through sampling tube with capacitive humidity sensor. Long-term and moveable weather station was also set to monitoring the outdoor micro-climate situation.

3. RESULTS AND DISCUSSION
3.1 Temperature
The following is the actual measurement of temperature of living unit in summer. According to the 24-hour time change chart of Type A, it can be seen that when outside temperature went down rapidly, the indoor temperature fell too. The main reason is that shutters are inside and outside of Type A, and can form cross-ventilation, which can remove large amount of indoor heat to make the temperature fall quickly. Other types of nighttime ventilation and hypothermal effect are relatively insignificant, mainly because of the inadequacy of open area and deficiency of ventilation (see Figure3.). Deduction comes below according to the above conclusion: 1) Bidirectional shutter can utilize the nighttime ventilation to remove the cumulative heat indoors more efficiently than bidirecitioal glass does. 2) Nighttime ventilation is especially important in summer, and each type should keep open bidirectionally.

The actual winter measurement results are during measuring, nobody is in eastern side while some persons are in a part of units in western side. However, it was found from the actual measurement results that regardless of the window-opening module,
certain heat-insulation (indoor temperature is 2~3℃ higher than outdoor temperature) and moisture keeping (indoor moisture is 10% lower than outdoor moisture) can be rendered, suggesting good air tightness achieved even with shutter module. Major living units are subject to air tight treatment at window frame. According to the comparison of heat source at the west side, indoor temperature with heat source is 1~2℃ higher than that without heat source, or about 4℃ higher than outdoor temperature and is maintained at 17~18℃ (13~14℃ for outdoor), whilst indoor relative humidity with heat source is 3-8% further lower than that without heat source, or about 15% lower than outdoor relative humidity and is maintained at 65-70% (80-85% for outdoor) The following can be deduced based on above results: 1) Regardless of the type of full-closure status, generally speaking, indoor temperature is about 2℃ higher than outdoor temperature with relative humidity 10% lower than outdoor relative humidity. 2) Indoor temperature with person, furniture and heat source inside can be 1 to 2℃ higher with relative humidity further lowered by 3~8%.

**Figure 3.** Measurement results of temperature in summer.

### 3.2 Humidity

In summer, in terms of relative humidity within the living unit, the major issue is how to prevent excessive moisture and coldness at night; with large amount of ventilation of type A and prevention of outside moisture from entering indoors by Type D, the indoor relative humidity can be maintained within 80%; on the contrary, in case of insufficient ventilation and outside moisture entering indoors, indoor relative humidity will certainly be enhanced, therefore the performances of Type B and Type C would be less than those of Type A and Type D. Deductions can be made based on above results: 1) space should be ventilated as much as possible in summer
to lower humidity; 2) relocating pot-planting according to different time segments can reduce opening areas and slow the entering of moisture.

4. CONCLUSIONS
The design mode of “tailoring methods to the needs” as well as the symbiotic mode of harmonic ecological environment coordination will gain more weight in the future construction design, thus lowering the damage to the harmonic natural environment and creating a sense of actively constructing symbiotic environmental ecology. Based on the above winter and summer actual measurement results, different window-panelling modules can be integrated and modes suggested according the difference between day and night. Because experimental building major wind direction is in parallel with the window plane of living units, insufficient wind pressure can be caused. Therefore in summer both sides should be opened to maintain ventilation as much as possible while in winter, full-closure is advisable. The following table 1 can serve as references for residents.

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REFERENCES