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Indoor Air Quality Analysis for Renovating Building: A Case Study of Student Studio, Department of Landscape, Chiangmai, Thailand

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***Abstract*—**The rapidly increasing number of population in the limited area creates an effect on the idea of the improvement of the area to suit the environment and the needs of people. Faculty of architecture Chiang Mai University is also expanding in both variety fields of study and quality of education. In 2020, the new department will be introduced in the faculty which is Department of Landscape Architecture. With the limitation of the area in the existing building, the faculty plan to renovate some parts of its school for anticipates the number of students who will join the program in the next two years. As a result, the old wooden workshop area is selected to be renovated as student studio space. With such condition, it is necessary to study the restriction and the distinctive environment of the site prior to the improvement in order to find ways to manage the existing space due to the fact that the primary functions that have been practiced in the site, an old wooden workshop space and the new function, studio space, are too different. 72.9% of the annual times in the room are considered to be out of the thermal comfort condition with high relative humidity. This causes non-comfort condition for occupants which could promote mould growth. This study aims to analyze thermal comfort condition in the Landscape Learning Studio Area for finding the solution to improve indoor air quality and respond to local conditions. The research methodology will be in two parts: 1) field gathering data on the case study 2) analysis and finding the solution of improving indoor air quality. The result of the survey indicated that the room needs to solve non-comfort condition problem. This can be divided into two ways which are raising ventilation and indoor temperature, e.g. improving building design and stack driven ventilation, using fan for enhancing more internal ventilation.

***Keywords*—**Relative humidity, renovation, temperature, thermal comfort.

I. Introduction

THE propagation of the population causes the expansion in the city development. One of the most popular methods that have been used for support the ideology of city expansion is the "renovation". Such method creates impacts to the people's living condition because the space of the primary design which was created and anticipated the new additional function has been added after the renovation period. The negative impact occurring to the people thermal comfort has to be considered through environmental studies (around the renovation areas), the distinctive characteristics, restriction and design resolution for finding the suitable and optimal solution or designing guideline of such renovation.

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Faculty of Architecture Chiangmai University is one of the leading educational institutes in Thailand in the past twenty years. The faculty is continuously growing both in numbers of students and specialized departments. One of the most recent departments that have been lately introduced is the department of Landscape Architecture which opens for supporting the students who are interested in the field of landscaping design. Due to the limitation of the site, the internal area renovation is ideal for providing a space for the new students who will be joining the department, Landscape Architecture. The studio space for student will occupy the old wooden workshop area which is located in the ground floor of the faculty. Nevertheless, the space was not designed or anticipated for the "landscape architecture" learning environment. In spite of the activities that happened in the space (which are learning and teaching), the interior atmosphere of the location is not supporting the learning mentality for the architecture students. For example, the room was designed for the storage of the wooden equipment and furniture rather than an open stage for architectural discussion and consultation. Because of this issue, the study of the site surrounding such as existing environment, temperature and relative humidity, etc. are crucial in order to create and find the optimal design solution that is not only for the better quality of learning to students in Landscape Department but also as the sample of renovation quality that might standardize the later renovation project that might arise in the near future.

II. Literature Review

A. Thermal Comfort Condition

Thailand is characterized by high rainfall rate and high humidity and the temperature range is relatively high around 30-35 °C throughout the year [1]. Chiangmai is located in northern Thailand, latitudes 18.79° N and longitudes 98.98° E, where the climate is also tropical.

Olgyay reviews that the recommended thermal comfort levels of indoor humidity and temperature are in the range of 21-30 °C and 20-80%RH, respectively [2]. The recent study reviews that the perception of thermal comfort level of people who live in hot-humid region is increasing depending on their environment [3]. The range of thermal comfort is not fixed. It depends on the differences of people and climate factors as shown in many ecological and climate data that demonstrate varied temperature results [4]. Nittaya reviews Thai' thermal comfort condition is in the range of 21.9-29.4 °C and 20-

50%RH [5]. Karnchanawiroj asserts that Thai' thermal comfort condition is in the range of 25.6-31.5 °C and 37.7-62.9%RH [6]. Therefore, this study determines that comfort condition is in the range of 21-30 °C and 20-80%RH (Fig. 1) because these bands cover all range, which will be used to clarify in next step.

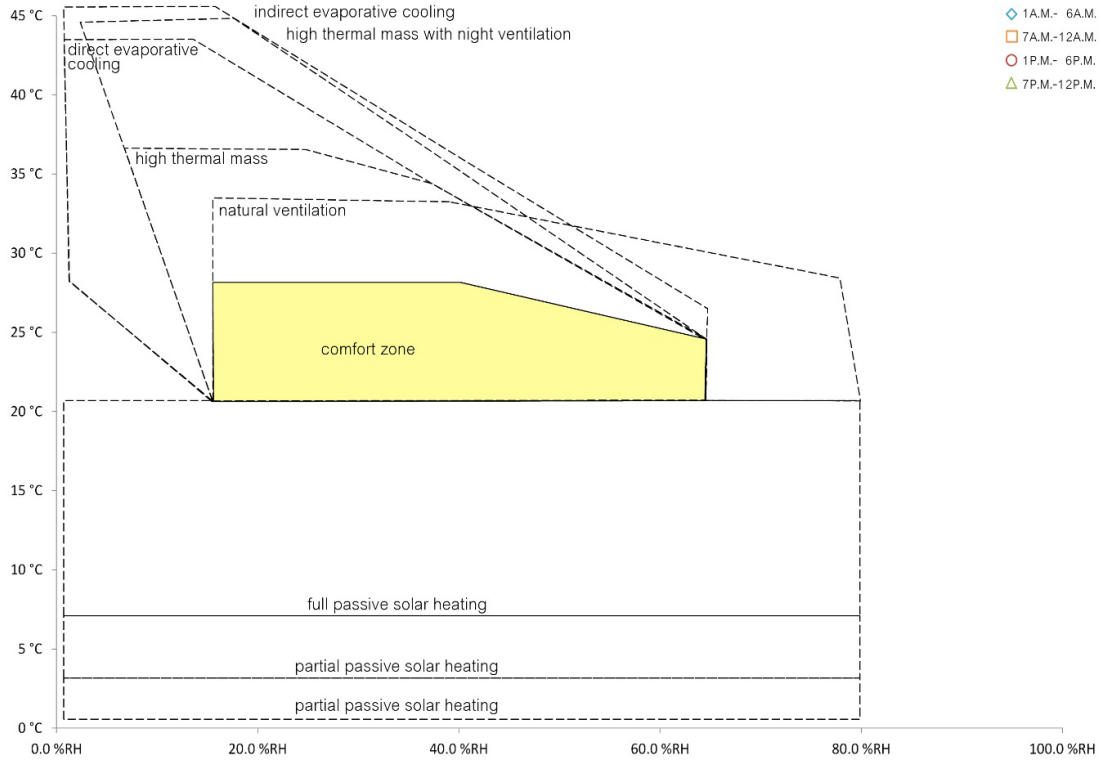


Fig. 1 Bio climatic chart [2]

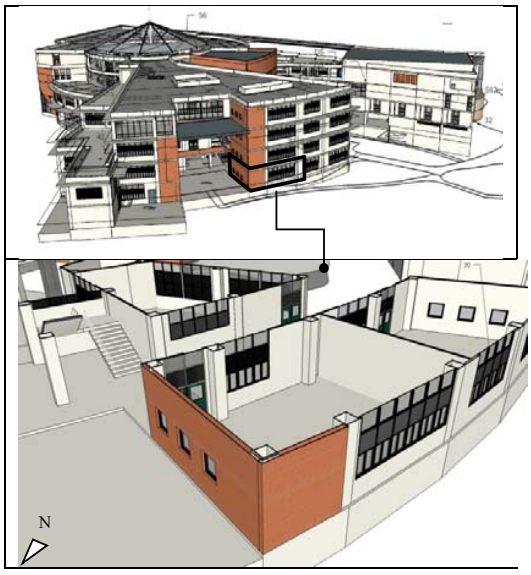


Fig. 2 Landscape Learning Studio Area, Faculty of Architecture, Chiangmai University, Thailand

B. Field Study of Case Study

Over the past few decade, with the geographical features of Thailand, architectures tended to be designed and planned to be compatible with the climate and life style of Thai people in different regions; houses and buildings are varied and distinctive throughout the country [7]. However, several buildings are merely planned according to the environment and geography which ignores to study living's comfort before renovating the existing building.

In the field survey in the Landscape Learning Studio Area, Faculty of Architecture Chiangmai University, Chiangmai, Thailand, the area is located in the north-west side on the first floor of the Faculty of Architecture building (Fig. 2). The west side of the room is comprised with natural environment, e.g. forest with trees' height around 15.6 meters, canal, while other sides are surrounded with the concrete. While all windows in the room are opened, natural ventilation is impractical since the average air velocity is in the range 0.00-0.25 m/s. The average daylight value is lower than 120 luces, this means inadequate indoor daylight. Furthermore, mould can be found in this place.

The space will be occupied by students, in landscape department, for educational purpose which can be divided into two major time spans. The first time span is the daytime where the space will be used for the learning, discussing and consulting architectural design space mostly in groups with the tutor and colleagues and the second time span is the night time which will be occupied mostly for private working space,

leisure, relaxing, and meeting. Nevertheless, due to the dissimilarity of the primary and recent proposal of the space, it was used as a storage rather than for studio space, the need of study and understanding the area, surrounding and environment are important in order to find the optimal renovation guide-line for creating the suitable learning environment.

III. Research Methodology

A. Research Objectives

The purpose of this research is to analyze thermal comfort condition in the renovation site of the student studio, Landscape Department, Faculty of Architecture, Chiang Mai Thailand for finding the solution to improve indoor air quality and respond to local conditions.

B. Research Processing Steps

1) Studying and gathering related information, methodology, and theories
2) Exploring the case study building of the building, such as, form, exterior construction details, room planning, materials and the influence from surrounding room

C. Field Collecting Data

Determine variables:

1) Independent variable; the room of gathering data such as, exterior and interior
2) Dependent variable; relative humidity and temperature value of the indoor air
3) Controlled variable; the Landscape Learning Studio Area which opening window, gathering data in 4 months (September-December 2017), Collecting data with TGU-4500 (temperature and relative humidity collecting data equipment)

D. Analysing Information

1) Comparing temperature value and relative humidity between indoor and exterior air
2) Finding the relationship between relative humidity and temperature value
3) Creating mathematic model and simulating the model for predicting annual relative humidity and temperature level of the area
4) Analysing thermal comfort condition
5) Finding solution of the renovation which correspond with thermal comfort condition

E. Research Scope

This research is a comparative research on temperature and relative humidity value of the indoor and exterior air of Landscape Learning Studio Area, Chiangmai, Thailand, (latitudes 18.79° N and longitudes 98.98° E).

IV. Result and Discussion

From field collected data of outdoor and indoor temperature and humidity level in the "soon-to-be" Landscape Learning Studio Area, it is shown that the outdoor temperature level is more fluctuated than indoor temperature level. However, the result of relative humidity value in indoor area is more than 1.2 times of the outdoor values in the paralleling trend. Meanwhile, the indoor humidity level is fixed at 90% RH that exceeds the comfort condition (Fig. 3) The relation of the relative humidity and temperature values can be used for finding living comfort band, the bio-climatic chart. After the regression process, mathematical model was made for predicting the relationship between the relative humidity and temperature values of the whole year by referring to the annual weather data of Thai Meteorological Department in 2016. From the predicting, these can be categorized in two time spans (Fig. 4).

The relationships of temperature and relative humidity values of both day and night indoor air vary between the comfort zone and outer (Fig. 5). Obviously, both scatter charts show that obviously, the most values are clustered in high humidity zone which means occupants' indoor discomfort. This suggests that the rooms need to find the solution of improving the building user's comfort and health by decreasing humidity value in the room. The study of the site reveals that during a year the site experiences more than 72.9 percent of the time in high relative humidity which is considered to be out of the living's comfort zone; in contrast, the comfort hour is only 27.1 percent. This causes non-comfort condition for occupants which could promote mould growth.

Due to the psychometric chart, high internal humidity can be controlled by raising ventilation or indoor temperature [8]. Variable solutions have been raise including increasing wind-flow ventilation and adjusting thermal temperature. Raising ventilation solution in order to decrease humidity is more practical and also eliminates heat from indoor spaces in term of the building that have efficiency wind flow. There are various methods to employ wind flow, for example firstly, improving building design such as types, shape and size of openings, window typologies and operations, building form. According to the condition of the room, if the natural ventilation is inadequate flow, another active solution has been raised using mechanical generating wind flow, such as fan. For enhancing indoor temperature or increasing mean radiant temperature, daylight can be passive solution for the room for reducing humidity and enhances the illumination of indoor space. In terms of active solution, this can use heater for improving thermal comfort of living.

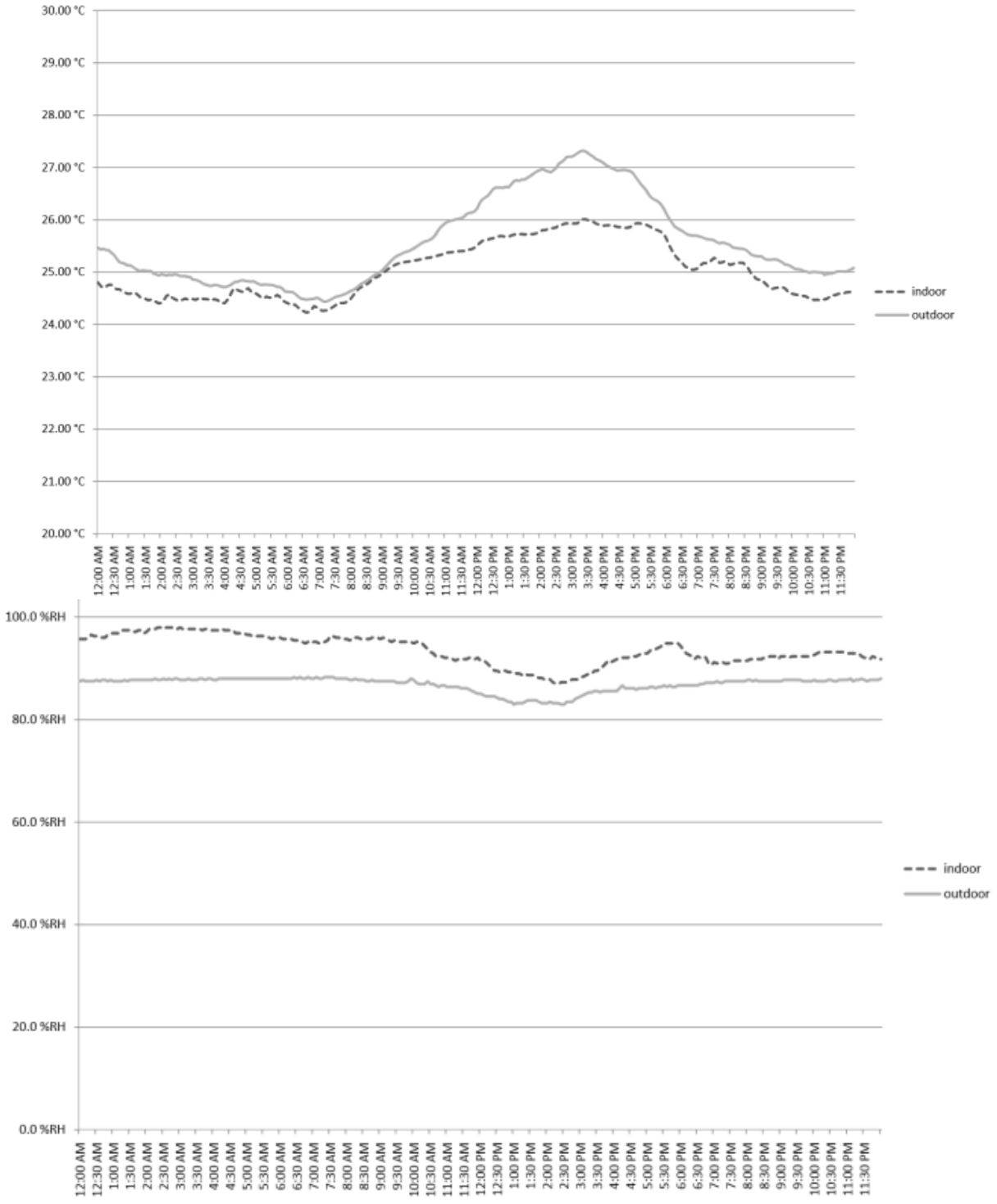
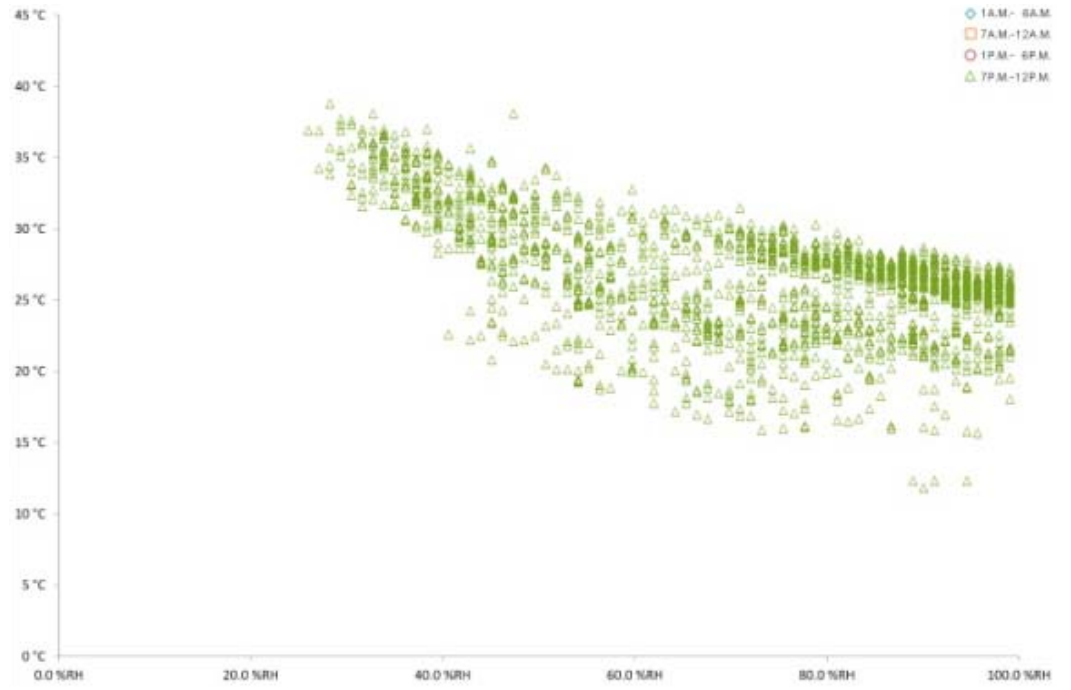
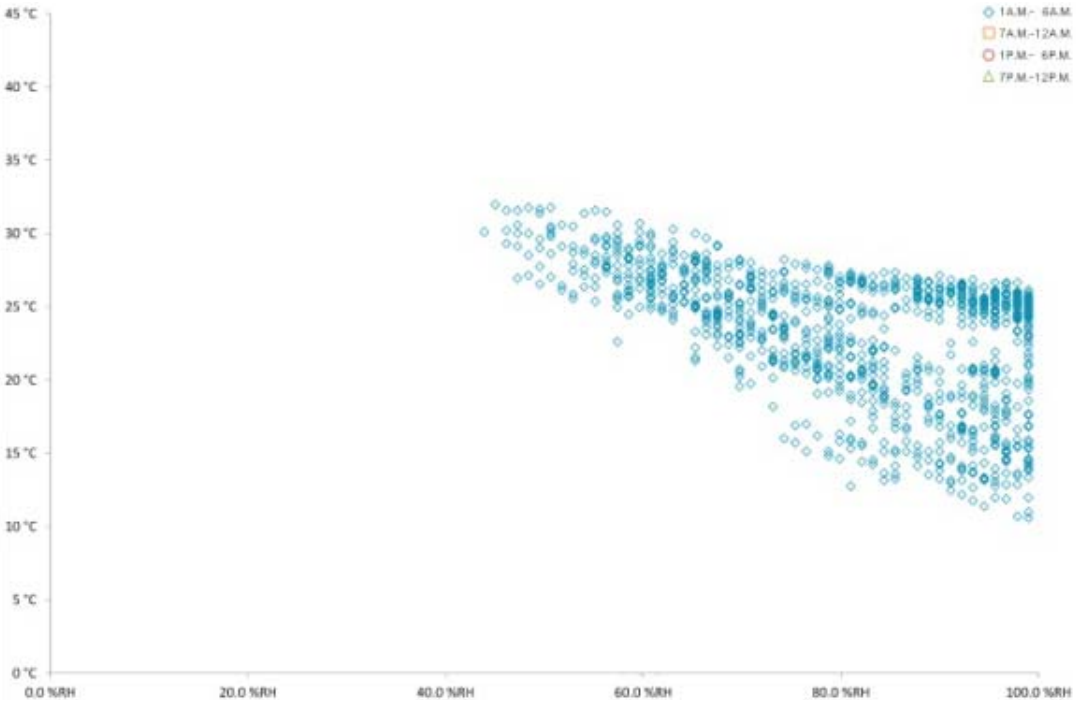


Fig. 3 Comparing temperature and relative humidity value of the Landscape Learning Studio Area



Night (7P.M.-12P.M.)



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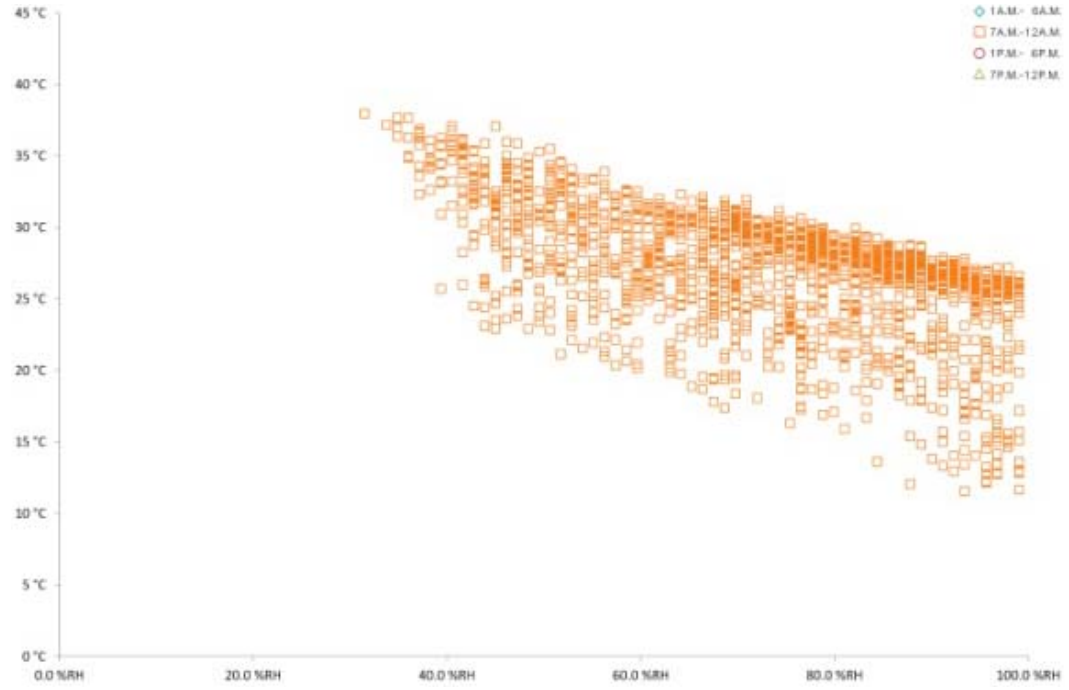

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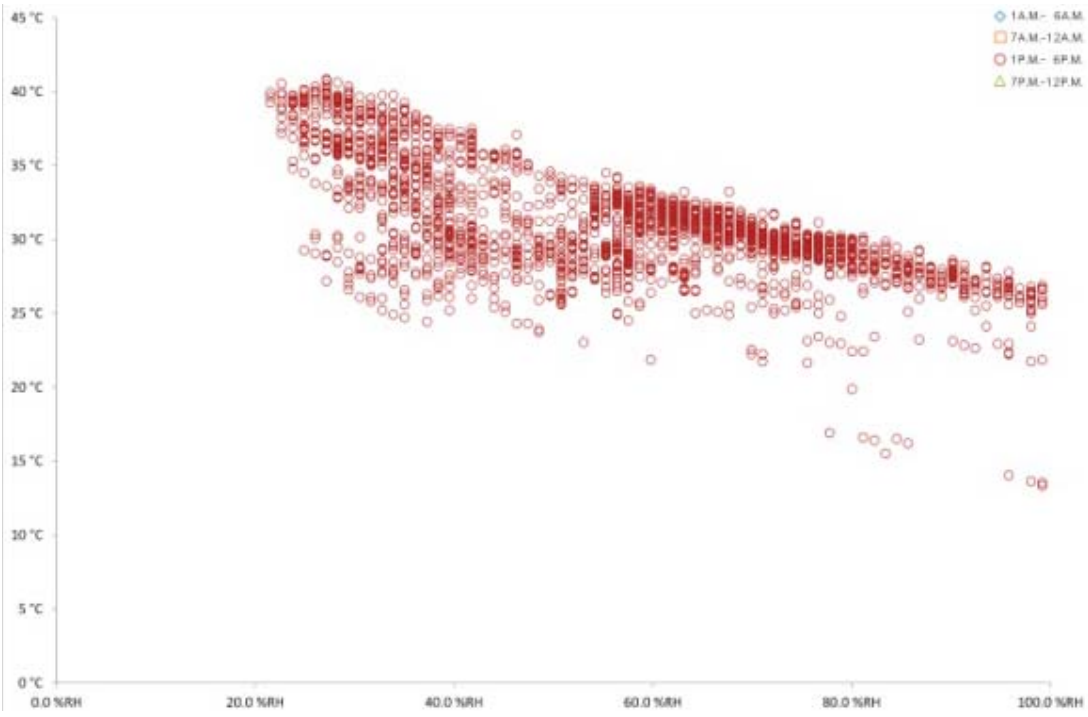
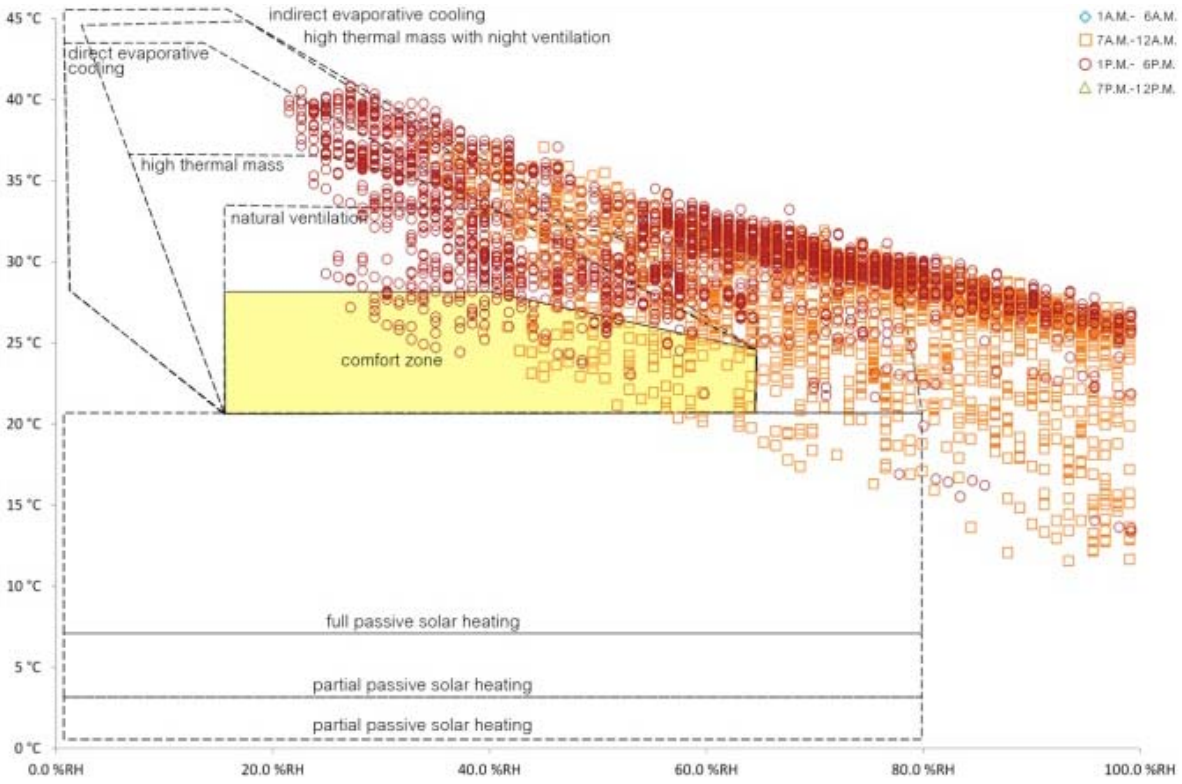
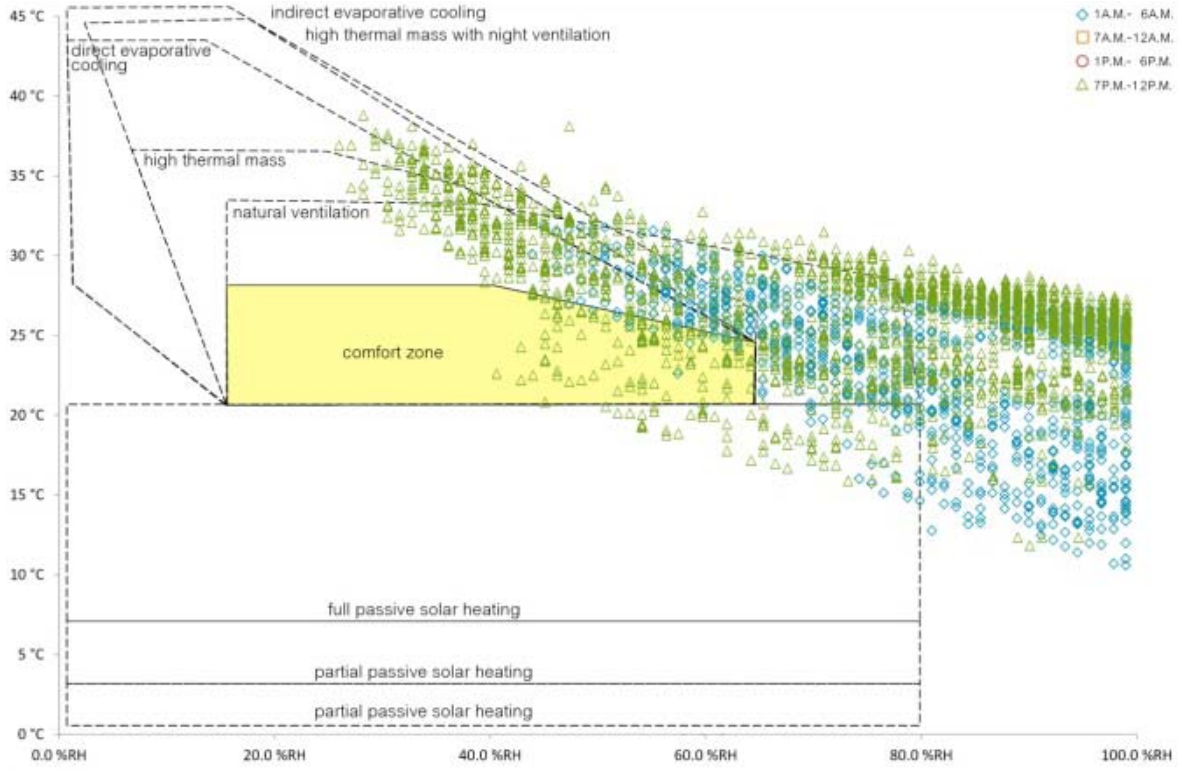


Day (1P.M.-6P.M.)

Fig. 4 The relationship between temperature and relative humidity value of each time



Day (7A.M.-6 P.M.)



Night (7P.M.-6 A.M.)

Fig. 5 The relationship between temperature and relative humidity value in thermal comfort chart

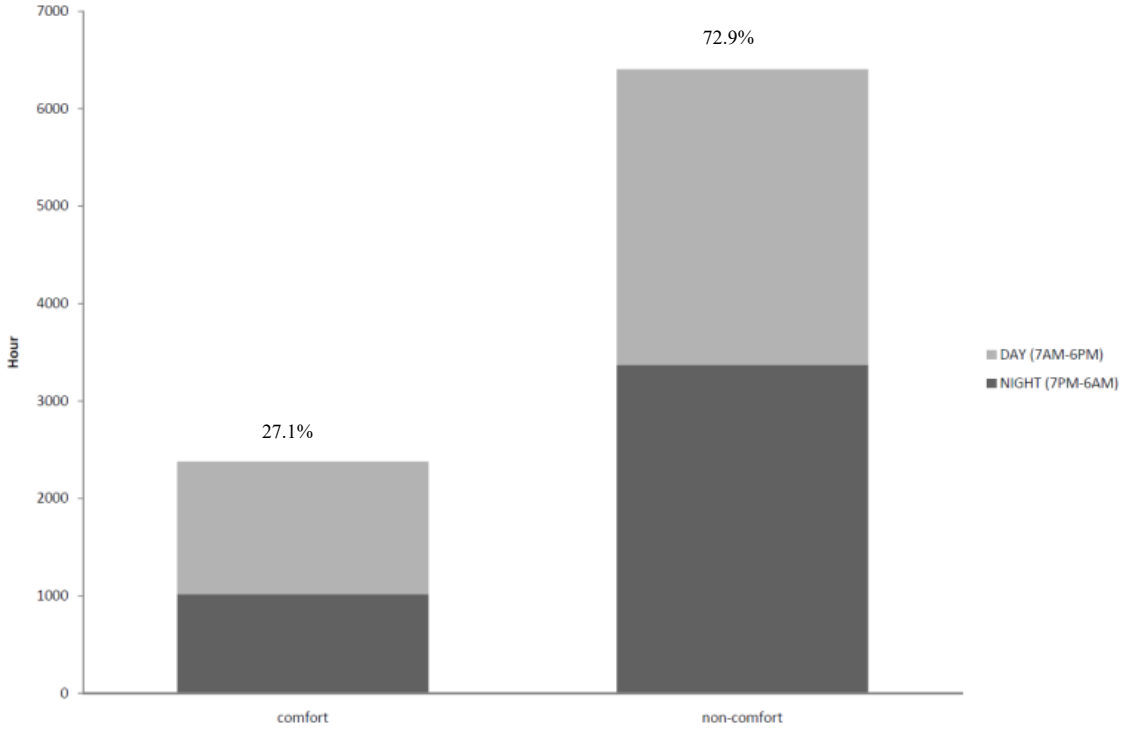


Fig. 6 Comfort and non-comfort hours of the year

V. Conclusion

The results of field study indicated that 27.1 percent of the relationship between temperature and relative humidity values of each hour of the year encounters with the comfort condition, while the non-comfort condition rises to 72.9 percent (Fig. 6). This would mean that the area of the case study, Landscape Studio needs to find the solution to decrease humidity indoor air before the renovation. The solution for solving humidity problem can be divided into two ways which are raising ventilation and enhancing indoor temperature. These would use both active and passive strategies, such as using fan, exploring daylight to enhance temperature, designing stack effect.

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