A Study of Thermal Comfort of Local Houses in Urban Areas: Ramdaeng Songkhla Province

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Abstract

The article tries to demonstrate thermal comfort among local houses using natural ventilation. The study's main objective is to study the physical architectural characteristics and to assess living comfort in local houses. The researchers explored two distinctive architectural dwellings in Ramdaeng Community, Singhanakorn District, Songkhla Province. According to its geography, the community is located in the South of Thailand. From the site survey, local knowledge and wisdom are applied and adapted according to local culture and environment. Building methods and building technology are transferred among local people in the Songkhla Lake Basin area. Furthermore, they tended to apply local materials in their local architecture. Questionnaire and field research were the main key processes. 200 samples were used in the questionnaire. It was found that Thai people's thermal comfort relates to natural ventilation. In other words, thermal comfort is the operative temperature that people feel comfortable. The average temperature for the thermal comfort is 28.0–30.2 °C when comparing to operating temperature. The results from the study show that Thai people were comfortable with temperature calculated by ASHRAE 55. Moreover, thermal comfort for Thai people seems to be higher than standard by 2.0–4.2 °C. When comparing with Busch study, it stated that Thais are within the maximum range of comfort conditions using natural ventilation of Busch by 0.8 to 1 °C. Referring to the study, both local construction technology and materials affected temperature and the ventilation system in vernacular houses. Also, Thai people can adapt themselves with the temperature as well.

Keywords: thermal comfort, vernacular architecture

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Introduction

Vernacular houses in Southern Thailand were designed to be compatible with local climate. Based on the study, it showed that most of local knowledge was derived from the adaptation among local people. Since building technique was inherited from generation to generation, the unique local architectural pattern could conform to local environment and climate. These elements, which include a well-ventilated floor plan, linked terrace, proper building materials, eaves, housing alignment, and position of doors and windows, all benefit to resident's thermal comfort. They can be counted as housing elements in a tropical area.

At present, a large number of local people prefer to choose European architectural patterns over the local one. With that reason, Southern Thai vernacular architecture seems to be disappearing in our perception. In addition, increasing construction material cost, social value, growing population number, and higher land prices, all affect the change in architectural pattern. Somehow, those buildings seem to be inappropriate with the local climate in tropical areas. Since Thailand is located in tropical areas, a modern architecture pattern is not appropriate with local climate. It is because heat cannot ventilate properly. This will result in higher temperature in the house. Finally, the owner has no choice but to install air conditioning, which leads to higher energy consumption continuously.

The researchers are interested in studying thermal comfort in vernacular residences in Songkhla and Trang Provinces. The local resident's thermal comfort was highlighted as main importance. It was believed that this would lead to the management of design guidelines that can apply vernacular architecture with modern architecture. The researchers supposed that the result of the research would lead to the thermal comfort of the residents when living in the local environment. Moreover, it may be able to reduce energy consumption in the future.

Objective

To study physical and architectural condition of vernacular houses that affect

to thermal comfort and to evaluate thermal comfort in vernacular houses

Scope of the Study

The research and data collecting area was in Singhanakorn District, Songkhla Province. The local architectural pattern in this area is remarkable. With that reason, the researchers had selected two vernacular houses. The study was accomplished using questionnaire together with field research at the same time. 200 samples were used in the questionnaire.

Research Methodology

First step: Primary data collection

Studying the primary data about the physical condition of Southern vernacular houses and its thermal comfort

Studying the related documents and research

Second step: Field study data collection

Surveying and gathering information from two vernacular houses located in Singhanakorn District, Songkhla Province by sketching and recording useful data. Surveying and collecting data about thermal comfort of residents in vernacular houses by using questionnaire and analyzing the data from 200 samples (local people and students from the Faculty of Architecture, RMUTSV) together with local weather. Recording data by using data logger, which was installed one meter above the ground, together with filling in the questionnaire.

Third step: Data analysis and drawing conclusion

Concluding thermal comfort data by analyzing from correlation and predicted mean vote: PMV from ASHRAE's seven scales (American Society of Heating, Refrigerating and Air-conditioning Engineer, Inc., 1987) and the Three–point McIntyre scale.

Climate of Thailand

Thailand is located in the tropical area between latitute 6o N to 20 o N. Weather in Thailand can be classified into three different seasons. However, the temperature in the South of Thailand changes slightly throughout the year about 24.0-33.0 oC. The average relative humidity is about 45-95 percent (Meteorological Development Office, 2003).

Thermal comfort

Thermal comfort for residents in the tropical area like Thailand may be different from other parts of the world. The thermal comfort standard of ASHREA 55 (ASHRAE,1992) identified that the highest thermal comfort is 26 oC and 20 oC for the wet bulb. However, it was found in several researches that thermal comfort for people in different parts of the world should be different based on their local climate. In other words, thermal comfort for people living in the tropical area tends to be higher than those living in the temperate zone since they have to adjust themselves with various weather and climate.

Referring to Busch (Givoni, B., 1998), it can be concluded that thermal comfort of white-collar workers in Thailand is 28 oC while it is 31 oC for blue collar workers. According to Kwok (Kwok, 1998), he had conducted a survey with 3,544 students and teachers. The research presented that students, who study in the natural ventilator, can endure temperature from 22.0 oC to 29.5 oC.

The survey on thermal comfort

The research project had done the survey aiming at studying thermal comfort for the Southern Thai people living in vernacular houses. The researchers chose to study in Singhanakorn District, Songkhla Province, during April 24th–25th, 2017. The research mainly derived its information from former residents and students. The research used the 2nd story of a vernacular house as a resting area. The site assessment was composed of questionnaire and measure surrounded environment in the vernacular house. The site assessment had collected information from those who stayed in the house for more than half an hour.

Research tool

a) Questionnaire

The Questionnaire could be divided into two main parts. The first part was basic information about the interviewees, like age, gender, and costume. The second part was about thermal comfort during the interview as well as surrounded environment in the vernacular house.

Table 1 Rating scale of the thermal sensation used in the comfort survey

Numeric scale	ASHRAE sensation scale	Thermal acceptability		
		Temperature	Air movement	Humidity
+3	Hot		Too high	Too high
+2	Warm		High	High
+1	Slightly warm	Truly accept	Slightly high	Slightly high
0	Neutral	Accept	Neutral	Neutral
−1	Slightly cool	Not accept	Slightly low	Slightly low
−2	Cool		low	low
−3	Cold		Too low	Too low

Source: ASHRAE (1992)

a) Indoor climate measuring instruments

Portable meters were used to measure thermal conditions while filling in the questionnaire. Those measurements included dry-bulb temperature and relative humidity of a room, temperature, and air velocity. According to the meter specifications, accuracy of measurement was $\pm 0.3^{\circ}C$ for the air temperature, $\pm 3\%$ for the relative humidity and air velocity, and $\pm 0.2^{\circ}C$ for the globe temperature. The results of these measurements were used: $\pm 0.3^{\circ}C$ for the air temperature, $\pm 3\%$ for the relative humidity and air velocity, and $\pm 0.2^{\circ}C$ for the globe temperature.

The results from site survey and data analysis

The surveyed vernacular houses in Rumdang Community, Singhanakorn District, Songkhla Province were Southern Thai

vernacular houses. The Southern vernacular houses are able to show local knowledge and ability in adapting themselves with local way of life and climate. The vernacular houses were built using local materials and building technique and technology of people living around the Songkhla Lake Basin. The characteristics of Southern Thai vernacular houses included high space under a house, gable roof, and using dried palm tree leaves or clay roof tile. The main structure of the house made of palm tree or hardwood. The house would face both directions—water way and road. There was a small terrace in front of the house as a resting area.

Figure 1: Ms. Ubon Boonrat's vernacular house, Rumdang Community, Singhanakorn District, Songkhla Province. Source: Satinee Wattanakit (2560)

Figure 2: Mr. Pian Madue's vernacular house, Rumdang Community, Singhanakorn District, Songkhla Province. Source: Satinee Wattanakit (2560)

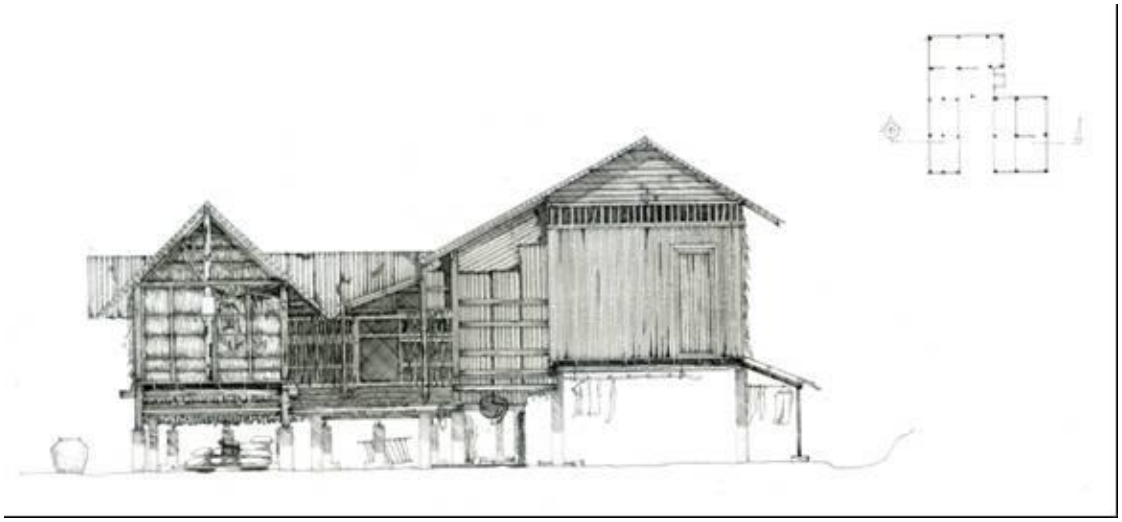

Figure 3: Ms. Ubon Boonrat's vernacular house, Rumdang Community, Singhanakorn District, Songkhla Province. Source: Perapat Puangpee (2555)

Figure 4: Mr. Pian Madue's vernacular house, Rumdang Community, Singhanakorn District, Songkhla Province. Source: Ekachai Kuinkumsan (2555)

It can be observed that the vernacular house seems to be more compatible with local geography and tropical climate. In other words, vernacular architecture has high potential in ventilating system, housing direction, openings, and material. All of the elements result in heat transfer and ventilation system, which lead to the thermal comfort for the residents.

Survey samples

According to the survey, 200 total samples were compiled from 120 local people that acclimatized to hot and humid climate.

Table 2 Summarizes subject information that extracted from sample data

Information		Male	Female	Total
Age (year)	<20	0	0	0
	21-25	49	30	79
	26-30	10	10	20
	31-35	13	11	24
	36-40	8	31	39
	>40	8	30	38
	Total	**88**	**112**	**200**
Clothing insulation (clo)	Mean	0.45	0.47	0.46
	Standard deviation	0.18	0.15	0.17
	Maximum	0.92	0.94	0.94
	Minimum	0.14	0.23	0.14

Source: Satinee Wattanakit (2560)

Clothing insulation

The inventory data of clothing garments was collected from subjects and used to estimate the clothing insulation, which was based on garment values published in ANSI/ASHRAE 55-1992. The estimation results are summarized in the lower part of Table 1. It could be observed that the mean values of clothing insulation were 0.45 clo for the males and slightly lower at a value of 0.47 clo for the females.

Indoor climate and comfort

The thermal environmental conditions were measured during the comfort survey. The measurements included dry-bulb temperature (t_a) and relative humidity (RH) of the room air, dew-point temperature (t_{dp}), and globe temperature (t_g). The air movement surrounding subjects could not be directly measured. To assess thermal comfort of the subjects according to ASHRAE standard 55, the PMV/PPD indices were calculated using Fanger's model. (Fanger, P.O, 1970) This survey focused on relaxed activities. The metabolic rate was 1.2 meters or 69.8 W / m^2.

Table 3 The statistics related to thermal comfort

Statistical parameter	Air temperature (°C)	Relative humidity (%)	Dew point temperature (°C)	Operative temperature (°C)	Mean radiant temperature (°C)	Air Velocity (m/s)	Comfort indices	
							PMV	PPD
Mean	29.40	70.56	24.50	29.66	29.91	0.89	0.62	19.49
S.D.	2.06	12.18	0.56	2.37	2.88	0.16	0.70	22.60
Max	33.44	83.60	25.68	33.85	34.36	1.35	2.95	82.00
Min	27.00	52.41	23.40	26.71	26.40	0.56	-0.35	0.05

Source: Satinee Wattanakit (2560)

Table 4 Statistical summary of the thermal comfort indices

Statistical parameter	Actual mean vote	Acceptability	
		Temperature	Air movement
Mean	0.33	0.30	0.37
S.D.	0.51	0.57	0.48
Max	1	1.00	1.00
Min	-1	-1.00	0.00

Source: Satinee Wattanakit (2560)

Actual Mean Vote: AMV

The comfort of the respondents was assessed on the scale as shown in Table 1. The results from the questionnaire survey were shown in Table 3.

Table 3 shows that the AMV index value has an average of 0.33, indicating that it is neutral. The standard deviation of AMV index value was 0.51 with maximum value of +1, which was "slightly warm," and the lowest value was -1, which was "cold."

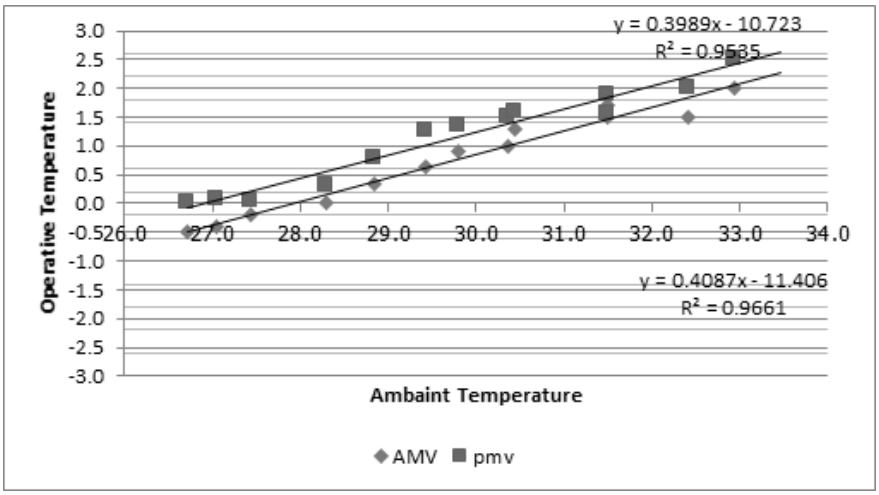

Figure 5: Operative temperature related to indoor temperature

Source: Satinee Wattanakit (2560)

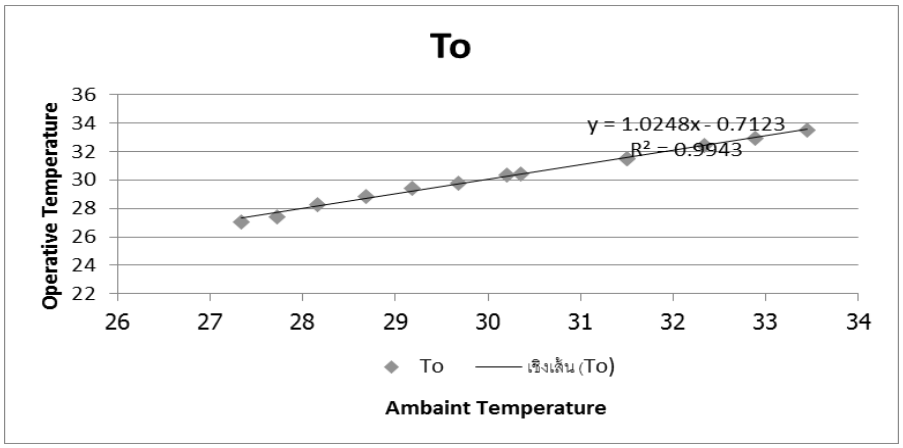

Figure 6: AMV and PMV calculations related to operative temperature

Source: Satinee Wattanakit (2560)

In a step of the subjective thermal sensation analysis, the mean actual sensation votes for each half-degree operative temperature were plotted as illustrated in Figure 5. It is obvious that the linear regression technique can be applied well to fit the plot. The fitted equation was AMV = 0.408 t_o – 11.406.

By using regression equation, the corresponding operative temperature for thermal neutral temperature (t_n), without hot or cold, was between 28.0-30.2 °C. However, the regressed PMV model that predicted the operative temperature value was between 27.0-29.2 °C. It was lower than the observation by 1.2 °C.

There were some slopes of related field between PMV and operative temperature; the PMV model predicted thermal sensation. The respondents were lower than the reality of both cold and hot.

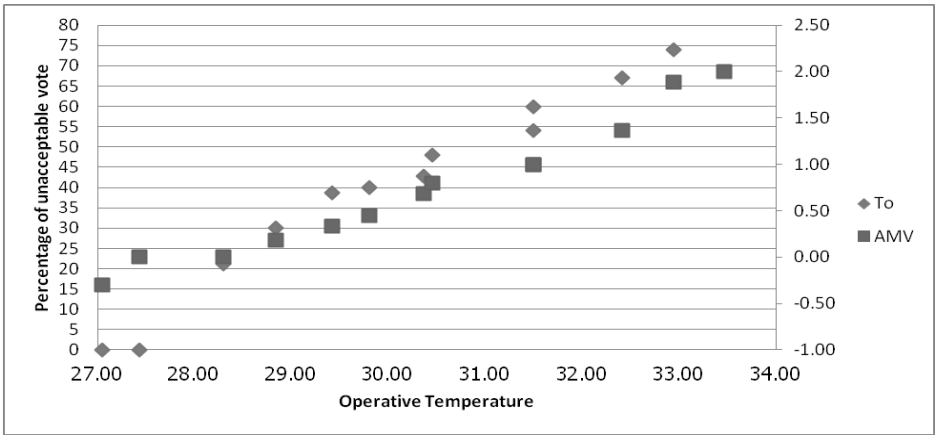

Figure 7 AMV acceptability calculated with operative temperature

Source: Satinee Wattanakit (2560)

In Figure 7, it showed that the AMV values with operative temperature that respondents did not accepted temperature values were higher than ASHRAE standard 55 at operating temperature exceeding 31 °C, not acceptable more than 50 percent.

Discussions

According to the study, it can be discussed that operative temperature for

Thai people stays around 28.0–30.2 °C and relative humidity is about 70.56%. When comparing to ASHRAE 55's standard, the researchers stated that operative temperature among samples tends to be 2.0-4.2 °C, higher than standard level. Somehow, the result seemed to be different when comparing with Busch (Busch, 1990). The researchers presented that the highest operative temperature among samples staying in the natural ventilation atmosphere was lower that Busch research by 0.8-1.0 °C. The average Clo Value for both women and men was around 0.46, and the average wind speed was at 0.89 m/s. Referring to the number, the acceptable wind speed was somewhat slightly high. It was presented that the pattern of Southern vernacular architecture was in concordance with local climate and benefited to the thermal comfort of the residents.

It was found from the research that relative humidity and wind speed all affected operative temperature. Referring to the study, the South of Thailand has hot and tropical climate all year round. The wind flow helps reducing temperature and easing the sticky or uncomfortable feeling in the humid weather. This factor relates to the elements of vernacular architecture and influences the operative temperature. Vernacular houses, as a result, have long and wide awning. The selection of natural materials helps reducing heat accumulation as well. In addition, the design of bright, spacious, and airy house favors the natural ventilation system in the house.

However, there were some other physical environment and related factors that became the limitation of the study, such as sample size, age, and case studies. It can be said that these limitations also affected the strength of evidences of the research.

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References

American Society of Heating Refrigerating and Air-conditioning Engineer, Inc., (1987). **ASHRAE Handbook Fundamentals, Physiological Principles and Thermal Comfort**.

A.G Kwok. (**1998).Thermal comfort in tropical schools** ASHRAE Transactions., 104. pp. 1031-1047

ASHRAE. (1992). **Thermal environmental condition for human occupancy.** ANSI/ASHRAE standard 55.

Busch, J. (1990).Thermal responses to the Thai office environment**. ASHRAE Transactions** 96(1) :859-872

Fanger, P.O. (1970). **Thermal Comfort Analysis and Applications in Environmental Engineering**, Technical University of Denmark, Laboratory of Heating and Air Conditioning.

Givoni, B. (1998). **Climate considerations in building and urban design**. New York: Van Nostrand Reinhold

Meteorological Development Office. (2003) **Bangkok Weather Information**. Cluster Information Services Meteorological Development Office.