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## Field Measurements on Thermal and Air Environment of Traditional Houses in Thailand

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This paper deals with the field measurements on thermal and air environment of traditional houses in Thailand. It has been said that such houses are comfortable in Thai, hot and humid climate. But the proof about that has not been done enough. To prove the merit of the houses with elevated floors, the measurements were taken place in two cites: Ayutthaya and Lampang. Houses under investigation in Ayutthaya stand by the river and a house under investigation in Lampang stands in a farm village. Based on results, effects of shade in the piloti space were clarified. In a river side area, cooling effects by breeze also revealed by means of ET\*s.

**KeyWords :** *field measurement, thermal and air environment, Thai house, vernacular*

### 1.Introduction

In the world, there are many vernacular houses, have been developing and adapting themselves to serve natural conditions such as the geography and climate of the area. But there are few scientific proofs about the environment of such houses. A traditional house in Thailand is one of the most typical examples, that exists in tropical area.

To prove thermal and air environment of traditional houses in Thailand, scientifically, measurements on thermal and air environment of the houses were carried out in Ayutthaya and Lampang. Fig.1 shows the location of the two cites. Measured houses in Ayutthaya stand on the riverside, while one in Lampang countryside. By this survey, the merit of the floors being high and the differences in result between riverside and countryside are clarified.

### 2. Outline of Measurements

#### (1) Measuring Period and Areas

Measurements were carried out from Aug.3 to 5, 2003 in Ayutthaya, and from Aug. 6 to 8 in Lampang. Ayutthaya is located at about 0m from sea level, in latitude of 13°73'N, a longitude of 100°56'E, and Lampang is located at about 1200m from sea level, with latitude of 18°25'N, a longitude of 99°51'E.<sup>1)</sup> (Fig.1) Ayutthaya is located 80km north to Bangkok, the capital of Thailand, and the main terrain is like a large sandbank, surrounded by Chao Phraya river. Measured houses stand by the river. On the other hand, Lampang is located at high altitude, highland. A measured house stands in a farm village.

#### (2) Outline of Investigated houses

Arrangement plan, floor plan and section of the houses under investigation in Ayutthaya are shown in Figs. 2 and 3. The pictures of the houses are shown in Fig.4.

Floor heights of one house are 2.2m and 1.8m respectively from the ground.

In Ayutthaya, occupants spend most of the time in the daytime in the living room or the entrance terrace. In the nighttime, they sleep in the bed room or the living room.

Figs.5~8 are the details of a house in Lampang. Floor height of the house is 2.2m. In Lampang, occupants spend most of the daytime in the piloti space. In the night, they sleep in the bed room or the living room. In the piloti space, there was a great bench, on which neighbors were sitting. Piloti space was used as a store, laundry, garage, and so on. (Fig.8)

Ratios of the areas of windows to the wall are 21% in Ayutthaya and 7% in Lampang respectively. Those are very small compared to the averaged value 30%<sup>2)</sup> in Japan.

And in both cases, floors have small clearance because of rough construction.

#### (3) Measuring points, items and methods

Environmental surveys were taken place by measuring of air temperatures, wall surface temperatures, humidities, globe temperatures, wind velocities and wind directions, in the living room, the piloti space and the entrance terrace.



Fig.1. Location of Ayutthaya and Lampang

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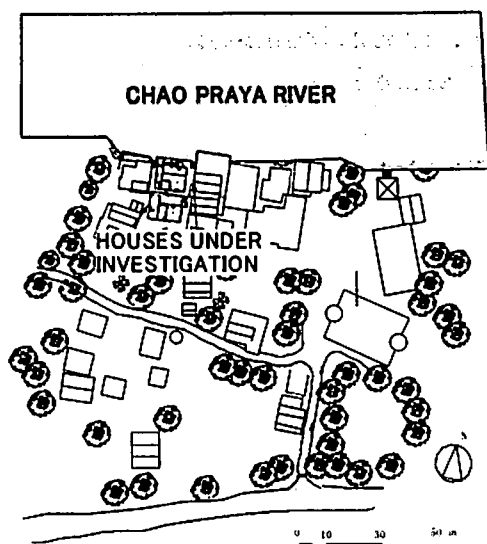


Fig.2. Arrangement plan of houses in Ayutthaya

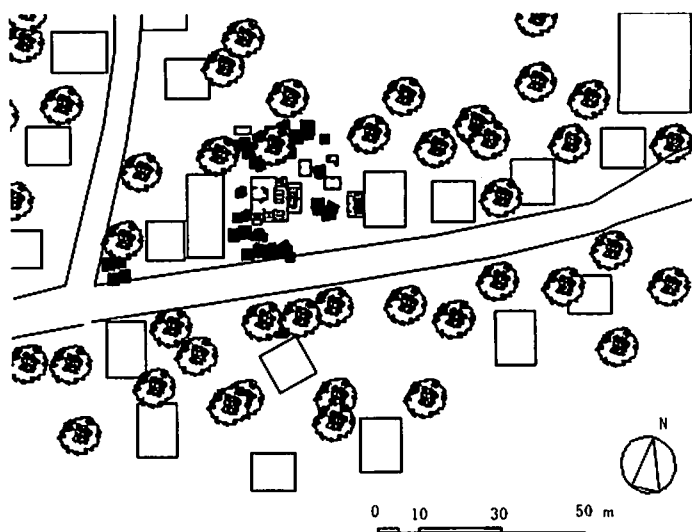


Fig.5. Arrangement plan of a house in Lampang

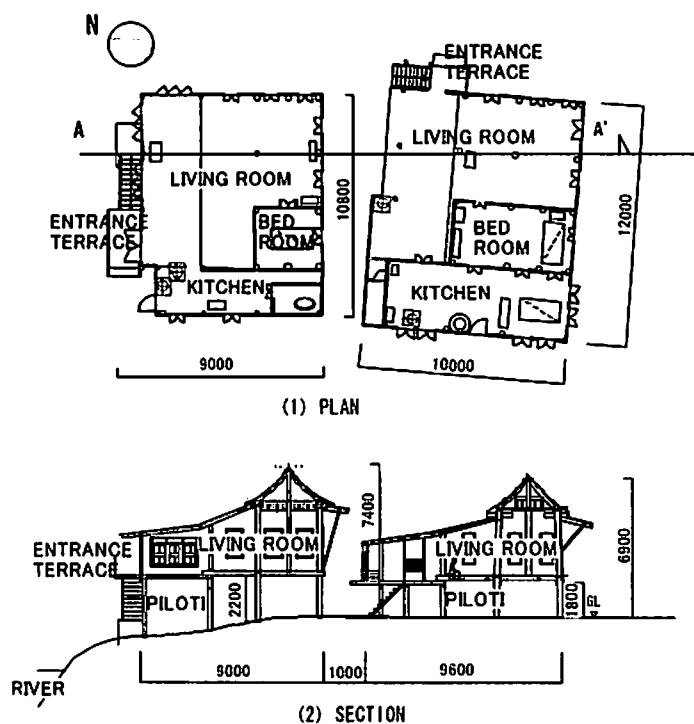


Fig.3. Plan and section of houses in Ayutthaya

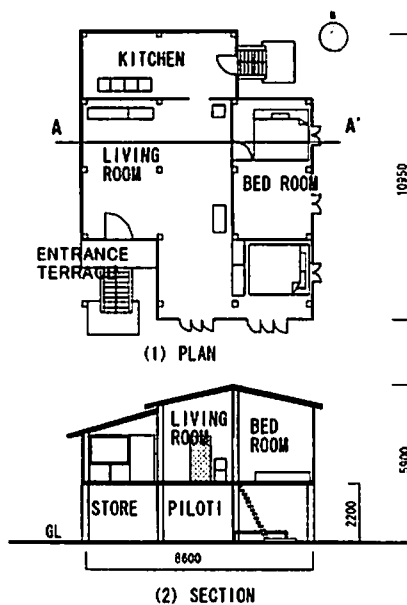


Fig.6. Plan and section of a house in Lampang



Fig.4. Houses under investigation in Ayutthaya



Fig.7. A house under investigation in Lampang



Fig.8. Piloti space of a house in Lampang

Table 1. The measuring items and methods

Items		Used devices(maker)	Method
Outside	Temp.	Thermo Recorder, 35251-21(ETO DENKD)	15 minutes time step for automatic measurement
	Humid.	Thermo Recorder, SK-200TH(SATO KEIRYOKU)	
	Quantity of solar radiation	Pyranometer, MS-62 (EKO INSTRUMENTS)	
	Wind velocity	Velometer, 6004(KANOMAX)	manual measurement, 2 hours time step from 9:00 to 17:00 <sup>A)</sup>
	Wind direction	Smoke Tube, 501(GASTEC)	1 hour time step from 11:00 to 17:00 <sup>A)</sup>
Inside and underneath	Temp.	Thermo Recorder, 35251-21(ETO DENKD)	15 minutes time step for automatic measurement
	Temp. of wall	Thermo Recorder, SK-200TH(SATO KEIRYOKU)	
	Humid.	Thermo Recorder, SK-200TH(SATO KEIRYOKU)	
	Globe temp.	Globe Thermometer (SIBATA)	
	Wind velocity	Velometer, 6004 (KANOMAX)	2 hours time step for manual measurement from 9:00 to 17:00 <sup>A)</sup>
	Wind direction	Smoke Tube, 501 (GASTEC)	1 hour time step for manual measurement from 11:00 to 17:00 <sup>A)</sup>

A) means the case of Ayutthaya, L) means the case of Lampang

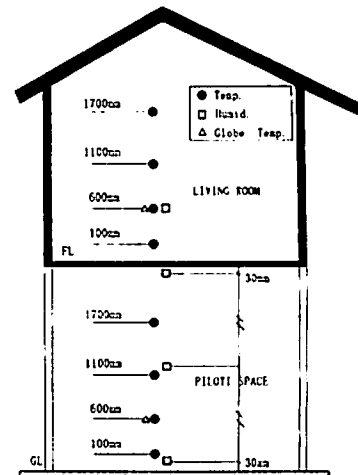


Fig.9. Section of the measuring points

The outside air temperatures, humidities, quantities of solar radiation, wind velocities and wind directions were also measured. Measuring items and methods are shown in Table 1.

Particularly, in the living room and the piloti space, air temperatures, humidities and globe temperatures were measured precisely based on ISO7726.<sup>3)</sup> (fig.9)

### 3. Results of the Measurements

#### (1) Air temperature

Air temperatures measured at each room in Ayutthaya on Aug.3 and 4 are shown in fig.10. Those in Lampang on Aug. 7 and 8 are shown in fig. 11.

In both cases, air temperatures in the living room and the bed room are almost the same. Those in the piloti space are always lower than those in the two, or three points.

In Ayutthaya, outside air temperatures in the daytime reached at about 35°C, because direct sunlight hit the sensor part of thermoelement. So outside air temperatures are regarded as those in piloti space, because these two temperatures are almost the same. Temperature differences between the terrace and the inside of the house are about 2°C in Ayutthaya and 4°C in Lampang respectively in the daytime, and 1°C in Ayutthaya and 0.5°C in Lampang in the nighttime. In both cases, air temperatures in the piloti space are lower than in the inside of a house, especially in the daytime. The temperature differences between the inside of a house and the piloti space are larger in Lampang, than in Ayutthaya. In Ayutthaya, room air would be cooled by the wind from the river.

Vertical profiles of temperatures in Ayutthaya are shown in fig.12. The upper graph is from 9:00 am on Aug.3 to 7:00 am on Aug.4, and the lower graph is from 9:00 am

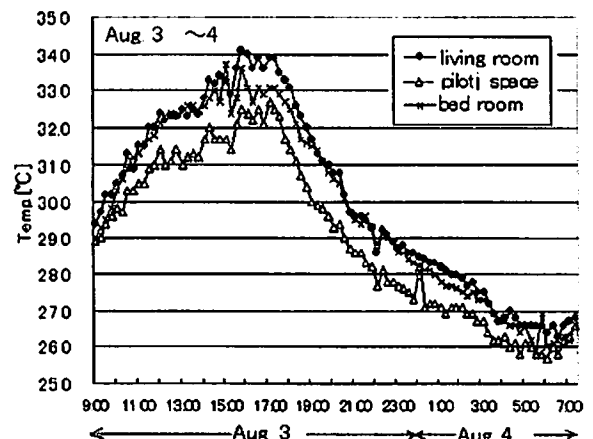


Fig.10. Temperatures of the each room of a house in Ayutthaya

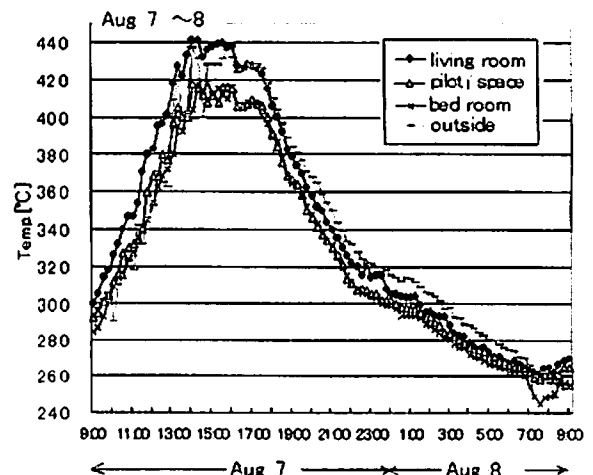


Fig.11. Temperatures of the each room of a house in Lampang

to 9:00 am on Aug.5. On Aug. 3, it was fine. But on Aug.4, it was almost cloudy and a heavy rainfall from 11:00 am to 1:00 pm. It can be said that air temperatures are high at the higher points, from the upper graph. The reasons are following. Specific gravity of high-temperature air is light. And, air in the piloti space is cooled by solar shading effect. Temperature differences are large especially in the daytime, between the higher points and the lower points. But in the lower graph, air temperatures are low at the higher points. Because room air was cooled by the rain.

### b) Humidity

Vertical profiles of absolute humidities in Ayutthaya are shown in fig.13. From fig.13, it can be said that humidities near the ground are very high, compared to that at the higher points which are far from the ground. This is the nature of humidity. Humidity differences between the two points are larger in the lower graph, compared the upper graph of fig.13. For example, the difference is 0.000106kg/kg at 13:00 on Aug.3, and 0.000721 kg/kg at the same time on Aug.4. On Aug.4 from 11:00am to 1:00 pm, shown in the lower graph, it was raining. So it can be said that a rainfall makes the humidity differences larger.

### c) Wind velocity and Wind direction

Mean wind velocities and directions in Ayutthaya are shown in fig.14. This is one example of data at 9:00am on Aug.3. Fig. 15 shows as fig.14, but in Lampang. This is at 4:00pm on Aug. 8. In both cases, similar data were obtained at each time, so the other data skipped in this paper.

In both cases, surely outside wind velocities are the largest in the four points, living room, piloti space, entrance terrace and outside.

In Ayutthaya, that in the entrance terrace are the largest in the three points except for outside. As this house stands by the river, and wind blows from the river. Wind velocities at the terrace are comparative high, a comfortable breeze could be felt in the entrance terrace. Occupants sometimes sit on the chair in the terrace. This phenomena is the feature of the houses in Ayutthaya, which stands by the river.

In Lampang, wind velocities in the entrance terrace are not the largest but that in the piloti space are the largest.

But in both cases, wind velocities were measured by using the only one anemometer, the data could not be measured simultaneously. Data of the four points can't be compared with accuracy.

Air flow from the piloti space to the room was also observed by smoke, in both cases. Low-temperature air in the piloti space came to the inside of a house through a lot of small clearance of floor boards. Then indoor air would be well ventilated. The air flow makes people in houses feel comfortable.

### 4. Thermal comfortability ET\*

To evaluate the thermal comfortability of the traditional houses in Thailand, ET\*s were calculated. Air temperatures, humidities and mean radiant temperatures (MRTs), are based on the result of the measurements. But globe temperatures are regarded as MRTs. MRTs can be

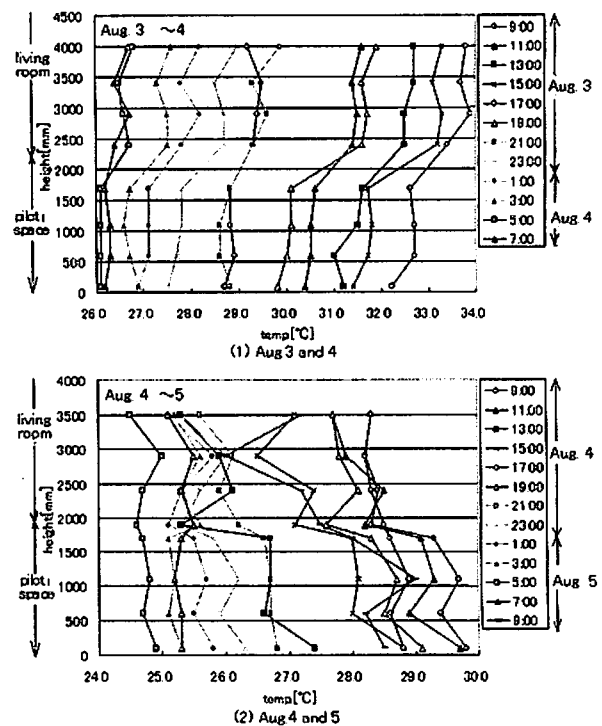


Fig.12. Vertical profiles of temperatures of houses in Ayutthaya

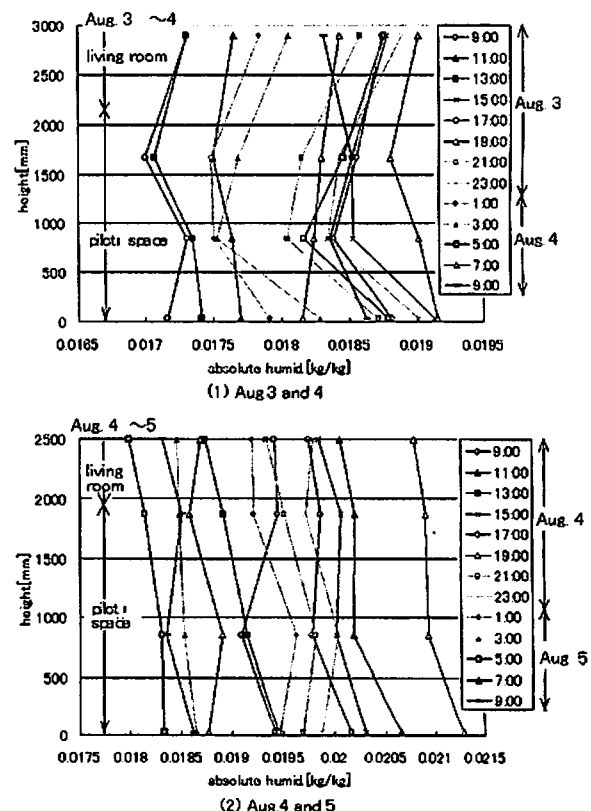


Fig.13. Vertical profiles of absolute humidities of houses in Ayutthaya

calculated by the following numerical formula.

$$t_r = t_g + 2.37\sqrt{v}(t_g - t_a) \quad (1)^{3)}$$

$t_r$ : MRT[°C],  $t_g$ : globe temp [°C],  
 $t_a$ : air temperature[°C],  $v$ : wind velocity [m/s]

Globe temperatures and air temperatures are almost the same and wind velocities are very small. So MRTs and globe temperatures are also almost the same. Wind velocities are regarded as 0m/s. Because the wind velocities were almost 0m/s in the measurements.

Thermal resistances is estimated as 0.6clo, as a typical values of summer clothes, and metabolism rate is used 1.1Met, condition of sitting or very light work.

ET\*s in each room in Ayutthaya on Aug.3 and 4 is shown in fig.16. Fig.17 shows as fig.16, but in Lampang,

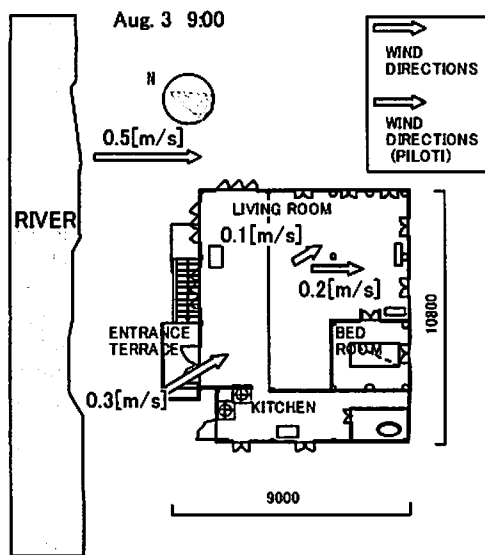


Fig.14. Wind directions of a house in Ayutthaya

Aug.8 16:00

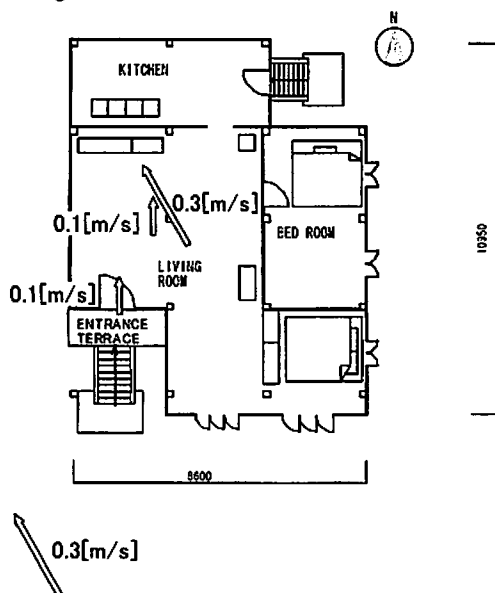


Fig.15. Wind directions of a house in Lampang

on Aug. 7 and 8.

In fig.16, ET\*s in the living room and that in the bed room are almost the same, and that in the piloti space are the lowest of the three points, living room, piloti space, and bed room through 24 hours. Differences of ET\*s between piloti space and room are 1.5°C in the daytime, 0.5~1°C in the nighttime and almost 0 °C in the morning. This changing of ET\*s is similar to that of air temperatures.

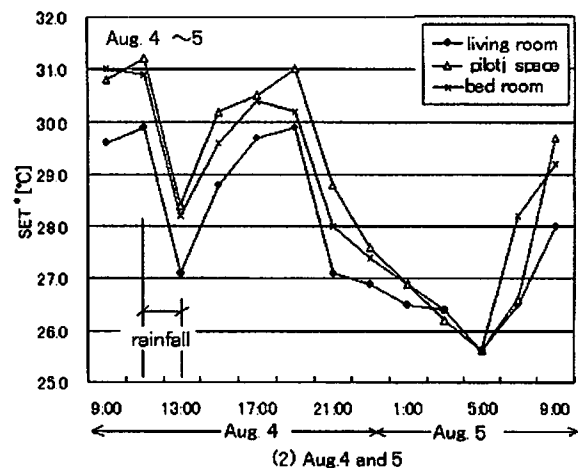
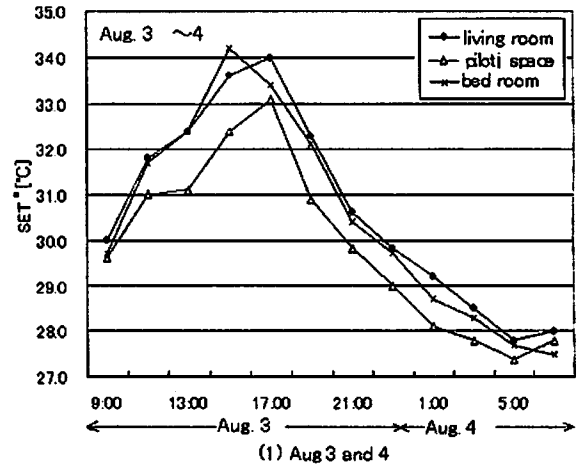


Fig.16. ET\*s of houses in Ayutthaya

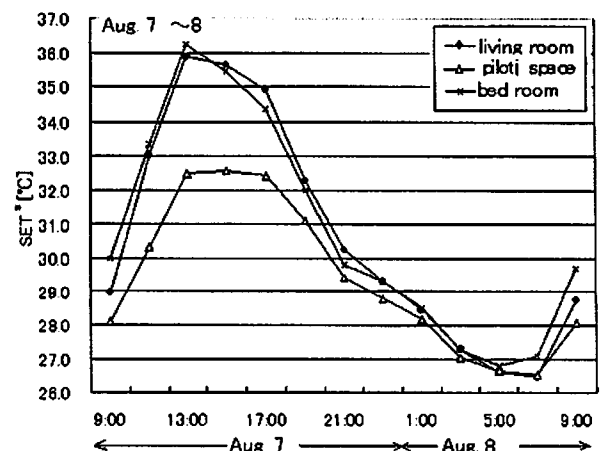


Fig.17. ET\*s of a house in Lampang

Piloti space is the most comfortable place especially in the daytime. In the nighttime and the morning, it's not so uncomfortable in the living room and the bed room, compared to the daytime. But it's not a big problem because there are few occupants in houses in the daytime, for work or school.

The upper graph in fig.16, ET\*s in the piloti space are the highest of the three points. The biggest reason for this is the increase of humidity especially in the piloti space, caused by the rain from 11:00 am to 1:00 pm. ET\*s of every points are low around 1:00 pm. And indoor air was cooled by the rain.

From fig.16, it can be said that the piloti space is the most comfortable place especially in the daytime in a sunny day, but the living room is the most comfortable place in a rainy day.

In fig.17, ET\*s in the living room and that of the bed room are almost the same and that of the piloti space is the lowest of the three points. Temperature differences between the piloti space and the inside of a house are 3°C in the daytime, 0.5°C in the nighttime. The main reason for this is the room air temperatures are much higher than those in the piloti space especially in the daytime. In Lampang, in the daytime, it's very uncomfortable inside of a house and no one is in the house. In the daytime, everyone spend in the piloti space sitting on the bench, sleeping on the hammock, and so on.

From the upper graph in fig.16, and fig.17, differences of ET\*s between the piloti space and the inside of the houses, in the daytime, is larger in Lampang. In Ayutthaya, room air temperature may be cooled by moisture cooling effect caused by the river.

ET\*s in the living room and that in the bed room are almost the same. But we feel more comfortable in the living room than in the bed room, especially in Ayutthaya. This comfortability in the living room would be caused by the wind. This value of ET\*s is caused by the inaccuracy of the value of wind velocity. So, next time, it's necessary for us to get the accurate data of wind velocity. The accurate data of ET\*s will be lead.

## 5. Conclusions

In general, it's more comfortable in the piloti space than inside of a house, especially in the daytime, according to the value of ET\*s. Air in the piloti space is cooled by solar shading effect. And air flow from the piloti space to the inside of a house through small clearance of floor boards, was observed by smoke. So, people, occupants and their neighbors were sitting on the bench in the piloti space. But on a rainy day or after a rainfall, it's more comfortable inside of a house than in the piloti space, because of the increase of humidity in the piloti space. In case of riverside houses, the entrance terrace is thought to be comfortable space by breeze from the river.

Measurements on thermal and air environment of the traditional houses in Thailand will be carried out again. Next time we will measure the wind velocity using the anemometers of the same number as measuring points to evaluate the wind velocity with accuracy. And the houses have many small clearance on floor boards, sometimes on wall. So badness of the ventilation performance should be proved by measuring amount of ventilation.

## Acknowledgments

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