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

## ~comfortability of the riverside houses~

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This paper deals with the field measurements on thermal and air environment of traditional houses which stand the riverside area in Thailand. To know the effect of the river, measurements were carried out in many points in the riverside area. The variation of temperature, humidity, and wind could be seen only in the place which is close to the river. By the comparison of the houses above water and the house on the soil, it was clarified that comfortability of the houses above the water depends on not temperature but wind from the river, by means of SET\*. Especially in the house above water, terrace which faces river is the most comfortable space because of the wind.

*KeyWords* : Field measurement, thermal and air environment, Thai house, vernacular, riverside area

### 1. Introduction

In the world, there are many vernacular houses, which have been developing and adapting themselves to serve natural conditions such as the geography and climate of the area. But there are few scientific demonstrations about the environment of such houses. Traditional houses in Thailand are one of the most typical examples, which exist in tropical area.

The aim of this study is to reveal the comfortability which is caused by the wind from the river of the houses which stand by the riverside or above water, cooling effect of temperature of the houses on the river, and the relationship between the distance from the river and temperatures, humidities, and wind. Measurements were taken place in the house which stands riverside, in those above water, and the house on the soil, in order to compare the environment. And measurements were also carried out in many points from the place just by the river to the place which is little far from the river.

### 2. Outline of the measurements

#### (1) Measuring period and areas

Measurements were taken place from July 31 to Aug. 7, 2004, in LopBuri, Bangkok, and Nonthaburi in Thailand. This period belongs to the rainy season. In Lopburi, measuring period was on July 31 and Aug. 1, while from Aug.2 to 5 in Bangkok, and on Aug.6 and 7 in Nonthaburi.

LopBuri is a rural area, which is 153 km to the north of Bangkok. In this city, measuring house stands just by the river. And temperatures, humidity, and wind are measured in many points in the riverside area. In Bangkok, measurements were carried out in three houses : two above water and one on the soil, in order to know the merit of the house above water. Houses above water have good terraces which face the river, Bangkok Noi Canal. Nonthaburi is to the northeast of Bangkok. In this area, houses are not so crowded as those in Bangkok. The greatest feature of the

measured house is the terrace like a small house above water. In this terrace, comfortable breeze from the river could be felt.

#### (2) Outline of the measuring houses

Block plan of the measuring house in LopBuri is shown in fig.1, while fig.2 plan and section. This house stands just by the river, and houses are not so crowded around this area. The roof was made by zinc and window area is very small, so it expected to be very hot inside the house. In the daytime, every occupant was in the piloti space with doing their housework. Comfortable breeze from the river, or the land could be felt there.

Fig.3, the map of Bangkok Noi area, shows the location of the measuring houses in Bangkok. Chao Praya River is the biggest river in this region, and Bangkok Noi Canal is its branch. Houses stand crowded in this area. Measurements were taken place in three houses : two above water and one on the soil. Fig.4, 5, and 6 are the plans and sections of the three houses. Two houses above water, B1 and B2, have the terraces which face the river, Bangkok Noi Canal. In the B1, the terrace is surrounded with wooden fences, and most of the windows of the living room were closed in measuring time. The greatest feature of the B2 is the big terrace. All of the windows of the living room, which locates next to the terrace, are open in the daytime. So, wind from the river could be felt not only in the terrace but also in the living room. B3 stands on the wet soil. In the daytime, the occupants were in the yard, which has the table and benches.

Details of the house in Nonthaburi are shown in Fig.7. This house has a great terrace that juts out into the river like a floating house. Wind from the river could be felt in the terrace, especially in the terrace that juts out into the river.

#### (3) Measuring points and items

In every house in the three cities, temperatures, humidities, and, wind velocities and directions were measured inside the houses and the piloti space or the terrace, and also room globe temperatures, to compare the comfortability of the each spaces. At many points, temperatures were measured vertically in the living room

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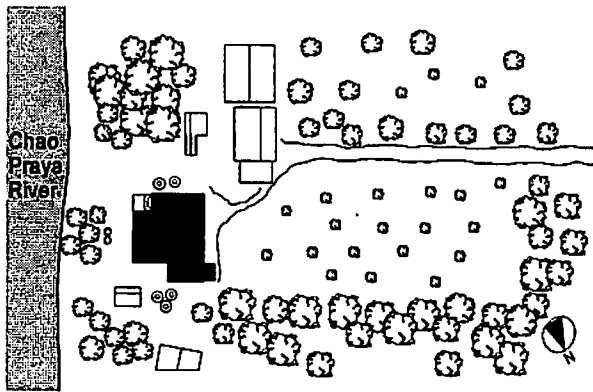
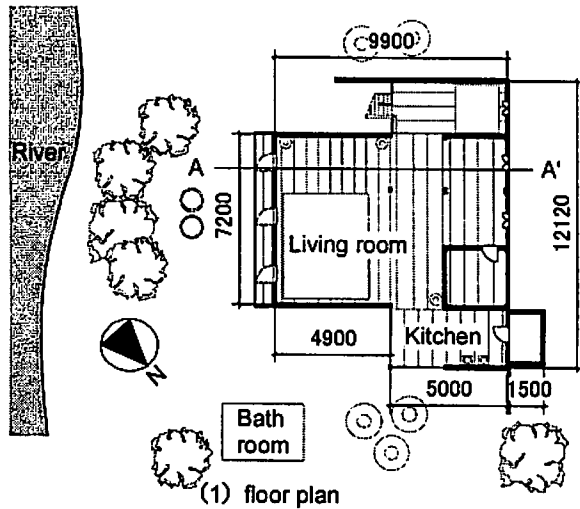
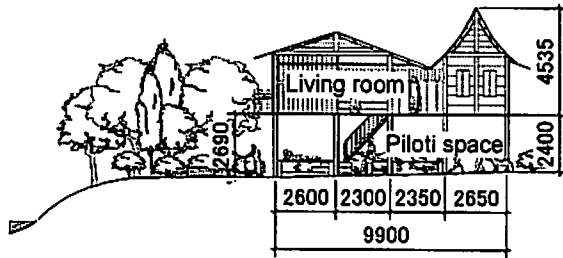


Fig.1 Block plan of a house in LopBuri



(1) floor plan

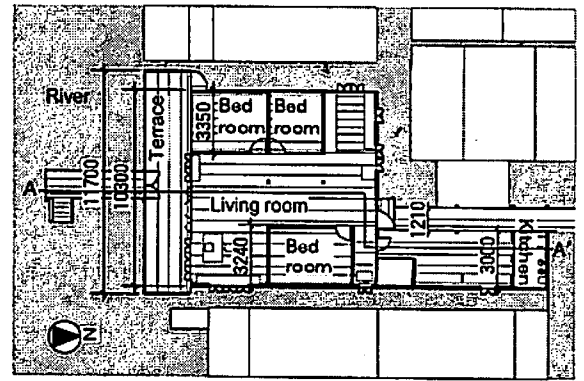


(2) section A-A'

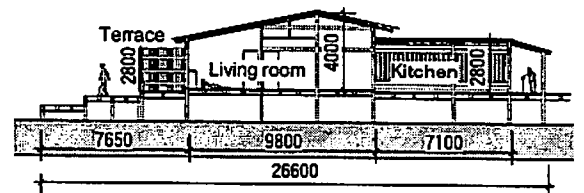
Fig.2 Plan and section of a riverside house in LopBuri



Fig.3 Location of the three houses in Bangkok Noi

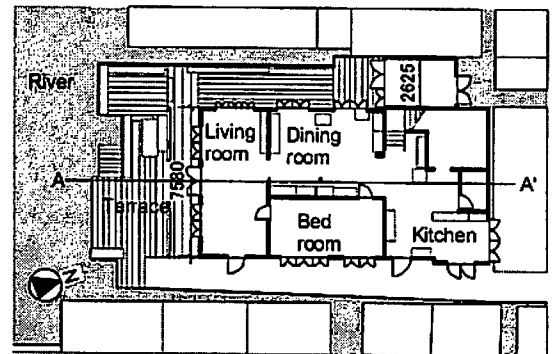


(1) floor plan

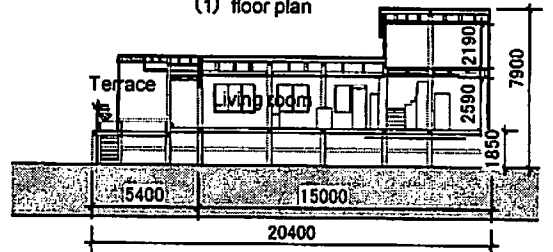


(2) section A-A'

Fig.4 Plan and section of a house above water, B1 in Bangkok Noi area



(1) floor plan



(2) section A-A'

Fig.5 Plan and section of a house above water, B2 in Bangkok Noi area

and the pilot space.

To know the relationship between the distance from the river and the environments, temperatures, humidities, and wind velocities and directions were measured in many points, in LopBuri and Bangkok.

Table 2 shows the details of the measuring items.

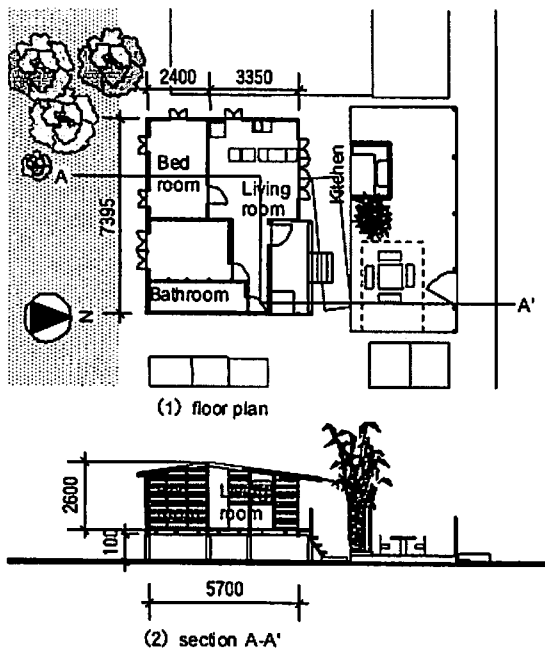


Fig.6 Plan and section of a house on the soil, B3 in Bangkok Noi area

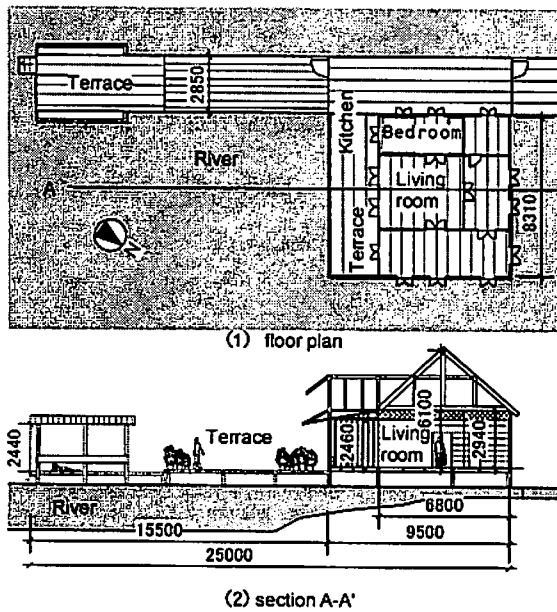


Fig.7 Plan and section of a house above water in Nonthaburi

Table2 Measuring items and instruments

Items	Instruments (maker)
temp	thermic 2300A (eto denki)
humid	thermic 2300A (eto denki)
globe temp	globe thermometer (sibata)
wind velocity and direction	climomaster 6541 (kanomax)
quantity of solar radiation	pyranometer MS-62 (eko instruments)

### 3. Results of the measurements

#### 3-1 Riverside house with the zinc roof (LopBuri)

##### (1) Temperatures in the living room and the piloti space

The house in LopBuri stands just by the river and has zinc roof. Temperatures inside the house and in the piloti space on July 31 are shown in Fig.8. Data were taken continuously until 13:00, Aug.1, but in the nighttime, there are little differences among the all data.

Maximum outside temperature was 33.8°C, at 13:00. Inside temperature was 36.3°C, globe temperature inside of the house was 39.1°C, and temperature in the piloti space was 32.0°C. It can be said that the piloti space was cooled because of the sun shading effect and wind effect from the river and the land, and inside air was heated by the radiation of the zinc roof as shown by the data of globe temperature.

##### (2) Vertical profiles of air temperatures

Fig.9 is vertical profiles of the riverside house with the zinc roof in LopBuri on Aug. 1. At 13:00, temperature at 600mm from FL in the living room was 33.6°C, that in the point near the roof was 4.1°C higher to that at 600m because of the zinc roof. At that time, globe temperature at 600m from FL in the living room hit a maximum value of 39.3°C, outside temperature was 33.8°C. In the piloti space, temperatures are lower than those inside the house, and the wind comes from the river. So every occupants were not inside the house in the daytime.

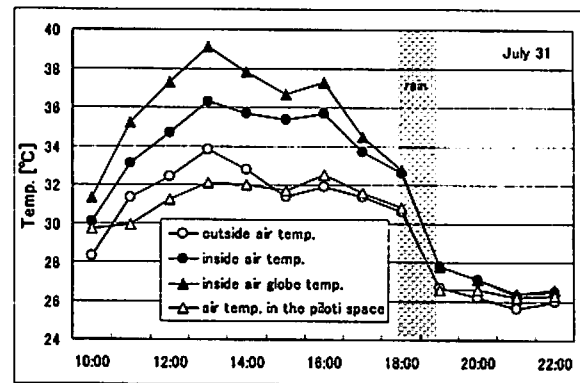


Fig.8 Relationship between the Temperatures and Humidities and the distance from the river in LopBuri

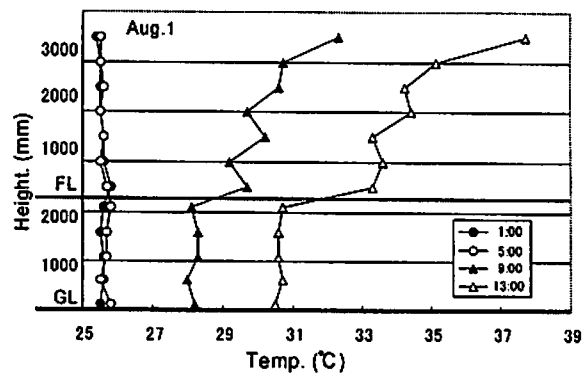


Fig.9 Vertical profiles of temperatures of house in LopBuri

**(3) Wind in the piloti space and the inside of the house of the riverside house**

Fig.10 shows wind velocities and directions in the piloti space and the inside of the house of the riverside house in LopBuri at 13:00 on Aug.1. Reference wind speed was measured at the height of 5.5m from the ground, while others 1.3m. In the living room, only one door of the three which faces the river was open.

In the piloti space, wind velocities were 0.8 ~ 0.9 m/s, almost the half value of the reference, higher than those inside. And wind rose shows that the wind comes from both the river and the land, there where occupants spend most of the daytime.

**(4) Relationship between the distance from the river and Temperatures and Humidities**

Fig.11 shows the relationship between the distance from the river and the temperatures and humidities at 13:00 and 1:00 on Aug.1. At 13:00, at 0m points from the river, temperature is about 31.2°C, 2.8°C lower than other points.

Relative humidity is 66%, about 10% lower than other points. At 1:00, there are almost no differences among the every point, both temperatures and humidities. It can be said that in the daytime, temperatures are lower and humidities are higher just by the river than other points, but this feature could be seen until the 10m points from the river, and in the nighttime, both of those values are almost same.

**(5) Relationship between the distance from the river and wind**

Fig.12 is the relationship between the distance from the river and wind velocities and directions at 17:00 on July 31 and 9:00 and 13:00 on Aug.1. Wind velocity at just by the river is very high, at 17:00 and 9:00. It can be said that wind comes from both the river and the land.

**3-2 Comparison between the houses above water and the house on the soil (Bangkok Noi area)**

**(1) Temperatures in the living room and the bed room of the houses above water and the house on the soil**

Temperatures of the houses in Bangkok Noi area from Aug. 2 to 4 are shown in fig.13. The upper graph shows the data in the living room, while the other terrace. Big differences are not seen among the three houses in both spaces. It was raining from 15:00 to 17:00 on Aug.3, at that time outside air temperature was cooled to 25.3°C, humidity was high, about 90%. It was expected that the air temperatures in the houses above water were lower than those in the house on the soil because of the moisture cooling effect, but the effect didn't occur because of this humid climate condition. Temperatures were about 30~32°C in every house in the daytime.

**(2) Wind in the terrace and the inside of the house above river**

Fig.14 shows the wind velocities and directions of the terrace and the inside of the house B2 above water in Bangkok Noi area at 9:00 on Aug.3. Every reference data was measured at the terrace of the house B1, and the height from the FL was 4m. Measuring points were 0.6m from the FL inside of the house, while others 1.8m from the GL of FL.

Wind comes from the river at every measuring point. Especially, at the big terrace which faces the river and the

living room next to the terrace, wind velocities are very high, about 1m/s, almost the value of 70% compared to the reference. River breeze were easily caught at this terrace

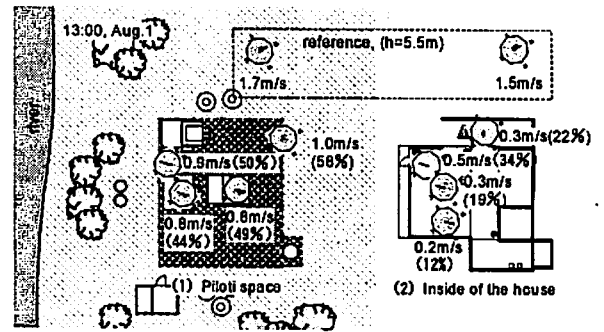


Fig.10 Wind velocities and directions of a house in LopBuri

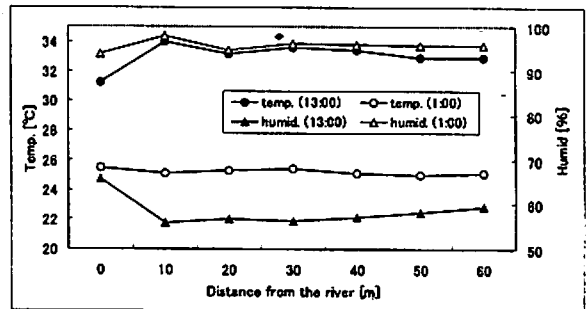


Fig.11 Relationship between the Temperatures and Humidities and the distance from the river in LopBuri

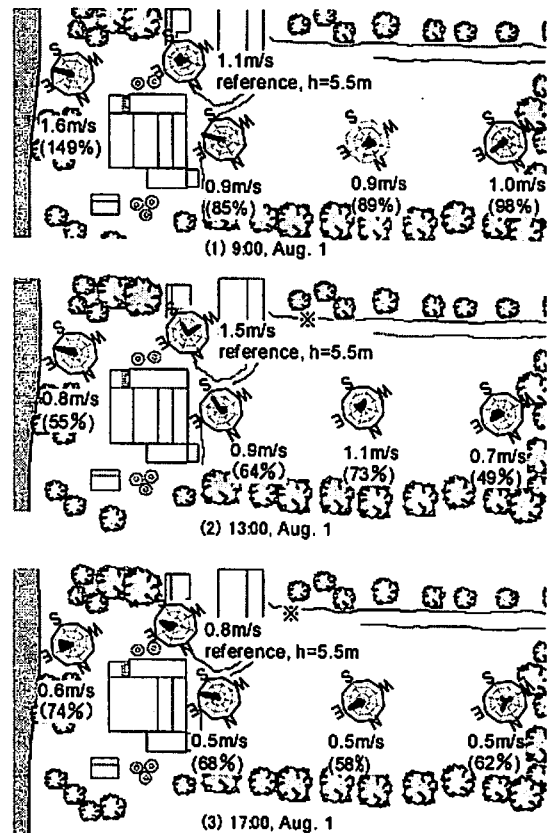


Fig.12 Relationship between the wind velocities and directions and the distance from the river in LopBuri

without fences, and same as in the living room because every windows were open at the daytime.

(3) Thermal comfortability SET\*

Table 2 is the data to calculate SET\*s in the living room and the terrace, while calculated values of SET\*s fig.15. Thermal residence of cloth is estimated as 0.6clo, typical value of summer clothes, and metabolism rate is used 1.1 Met, condition of sitting or very light work. Comfortable SET\*s range from 22°C to 22.5°C.

In both spaces, houses above water, B1 and B2 are better than B3 on thermal viewpoint, because of not the temperatures but wind velocities. For example, in the living room, SET\* was 26.6°C in the house B2 above water, while 31.1°C in the house B3 on the soil, and the wind velocity was 1.2m/s in B2, while 0.2 m/s in B3. It can be said that the thermal comfortability depend on not the cooling effect by water under the floor but that by wind from the river. Addition to that, SET\*s of B2 are better than those of B1 for higher wind velocities. B2 has no fence at the terrace like B1, so it's easy to catch the wind from the river, in the terrace as much as the living room.

(4) Relationship between the distance from the river and Temperatures and Humidities

Temperatures and humidities are shown in fig.16 with the function of distance from the river. The negative value of the distance means measuring points in the street above water. Measurements were carried out at many points vertically to the river. There are no correlations between the distance and both temperatures and humidities.

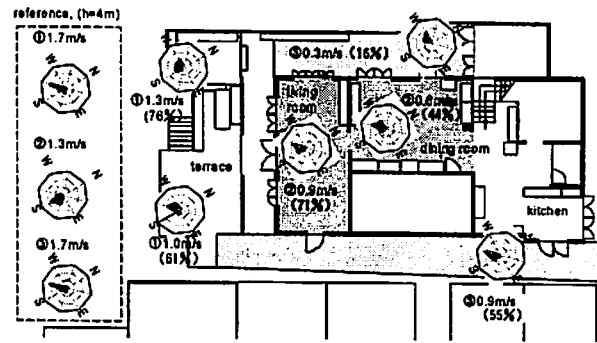


Fig.14 Wind velocities and directions of a house B2 above water in Bangkok Noi area

Table2 Data to calculate SET\* of the three houses in Bangkok Noi area

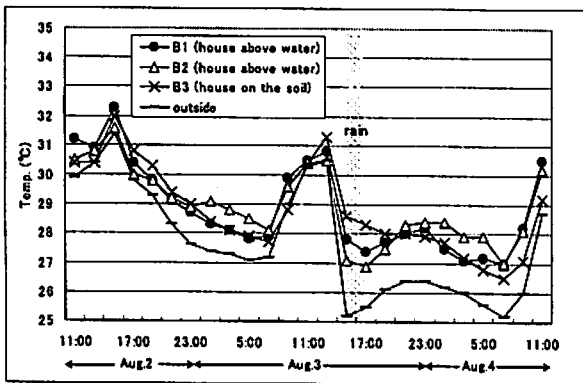
	Temp[°C]			MRT[°C]			Humid[%]			Wind Velocity[m/s]		
	17:00	9:00	13:00	17:00	9:00	13:00	17:00	9:00	13:00	17:00	9:00	13:00
B1	30.4	28.9	30.8	31.4	31.8	32.6	61.3	63.7	60.5	0.5	0.5	0.5
B2	30.0	29.8	30.5	30.6	30.9	31.9	64.1	65.0	62.6	0.9	1.0	1.2
B3	30.9	29.8	31.3	30.8	30.1	31.9	69.1	68.4	69.7	0.2	0.1	0.2

(1) living room

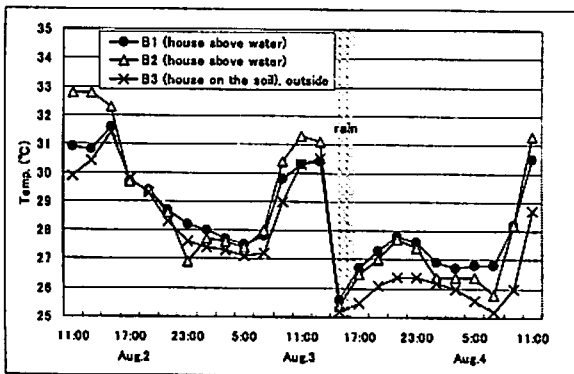
	Temp[°C]			MRT[°C]			Humid[%]			Wind Velocity[m/s]		
	17:00	9:00	13:00	17:00	9:00	13:00	17:00	9:00	13:00	17:00	9:00	13:00
B1	29.7	29.7	30.4	29.7	29.8	30.4	64.3	64.2	62.6	0.5	0.6	1.0
B2	29.7	29.7	31.1	29.7	30.4	31.1	64.7	61.7	59.7	2.3	1.3	2.5
B3	29.8	29.8	30.5	29.8	29.0	30.5	63.7	69.3	62.9	0.3	0.2	0.4

(2) terrace

※ means house on the soil (B3), the others mean house above water (B1, B2).



(1) Living room



(2) Terrace

Fig.13 Temperatures of the three houses in Bangkok Noi area

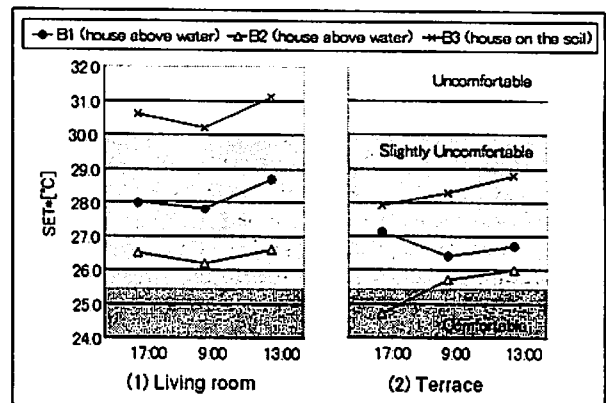


Fig.15 SET\* of the three houses in Bangkok Noi area

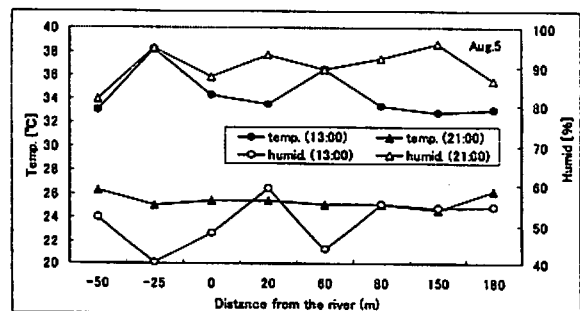


Fig.16 Relationship between the Temp.s and Humid.s and the distance from the river in Bangkok Noi area

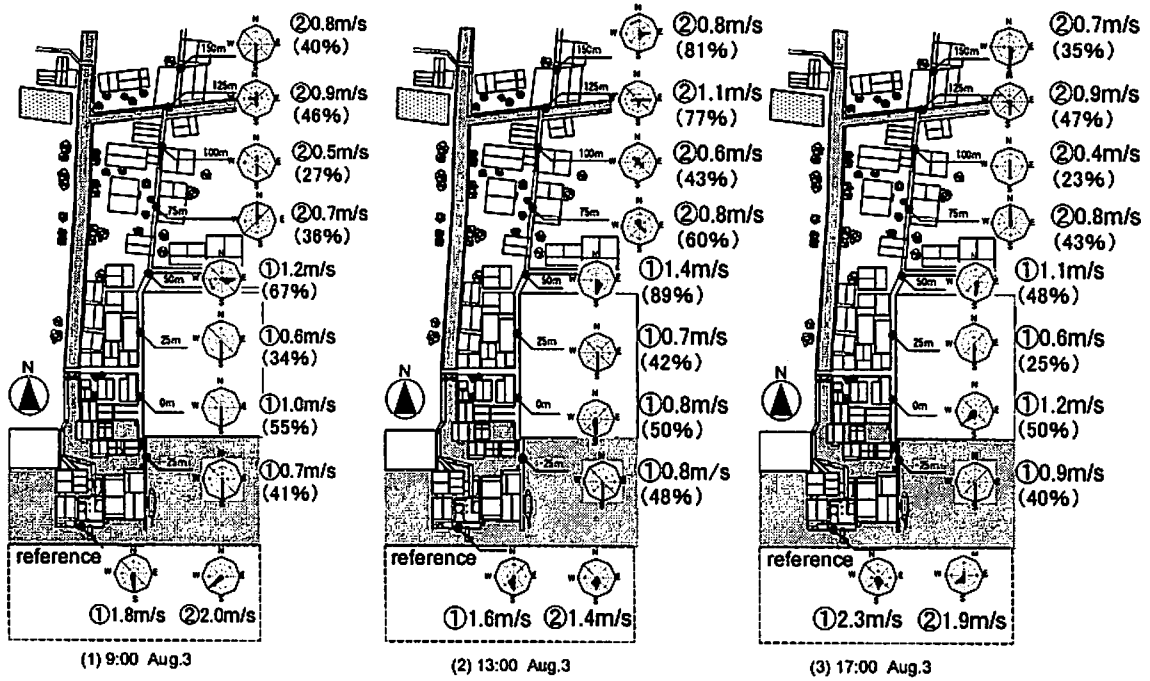


Fig. 17 Relationship between the wind velocities and directions and the distance from the river in Bangkok Noi area

(5) Relationship between the distance from the river and wind

Fig. 17 shows the relationship between the distance from the river and wind. The negative value of the distance means that measuring points in the street above water. The lower graph is the relationship between the distance and the ratio of the wind velocities to the standard. At the riverside points, from -25m, to 50m, from the river, it can be said that wind comes from the river, by the wind roses. There are no correlations between the distance and wind velocities. But, at the 50m point from the river, the wind velocities were high, because of the wind from the eastern street.

3-3 A house with a great terrace above water (Nonthaburi)

(1) Wind velocities and directions

Wind velocities and directions are shown in Fig. 18. Those data were measured three times, at 9:00, 13:00, and 17:00, on Aug. 7. Reference values were measured at the height of 4m at the terrace. Every door except that in the bed room was open. Wind velocities were comparatively high at the terrace, semi-outdoor space, especially the terrace that juts out into the river, it was 0.7 ~ 1.3m/s, 45 ~ 50 % to the references. Inside the house, wind velocities were low, about 0.2m/s, and the wind comes from the river through the doors which face the river.

(2) Thermal comfortability SET\*

Table 3 shows the data to calculate SET\*s, while fig. 19 result of SET\*s. Data of the terrace were measured at the terrace that juts out into the river. SET\*s in the terrace, which belong to the slightly uncomfortable zone, is the best place of all. This thermal comfortability at the terrace mainly depends on not the temperatures but the wind. Bed room was the most uncomfortable place, because windows were closed and wind velocities were low.

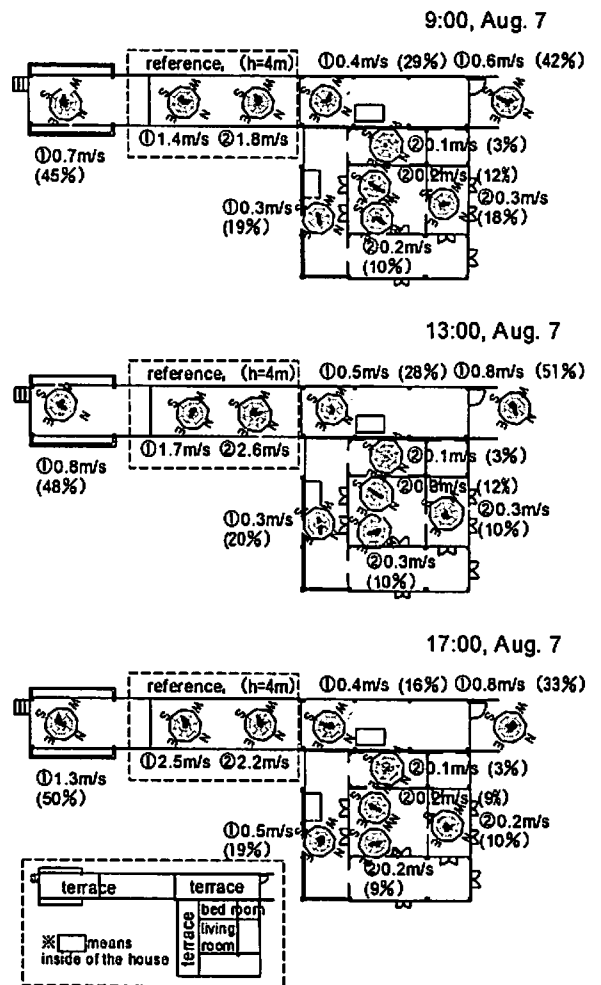


Fig. 18 Wind velocities and directions of a house in Nonthaburi

**4. Conclusions**

In the house with the zinc roof, it hit a maximum value of 39.3°C inside the house, as 30.5°C in the piloti space, at 13:00 in the daytime, for the radiation of the zinc roof makes room air warmer. So every occupant was in the piloti space in the daytime. In the riverside house, comfortable breeze, could be felt from both river and land there. But in the nighttime, there were almost no differences between the temperatures in the piloti space and those inside the house. In the riverside area, it was revealed that variations of temperatures, humidities, and wind could be seen between the border of the river and 10m from the river, especially in the daytime. Temperatures are about 2.8°C lower, humidities are about 10% higher, and wind are stronger, and the wind comes from the river.

By the comparison of the houses above water and a house on the soil, there was no differences about temperatures, and those of comfortabilty was caused by the values of wind velocities which come from the river. In the living room, SET\* was 26.6°C in the house B2 above water, while 31.1°C in the house B3 on the soil, and the wind velocity was 1.2m/s in B2, while 0.2 m/s in B3.

Terrace above water was the most comfortable place, for the wind from the river. SET\* was 29.2°C in the terrace, while 30.8°C in the living room, and the wind velocity was 1.3m/s in the terrace, while 0.1 m/s in the living room.

**Table3 Data to calculate SET\* of a house in Nonthaburi**

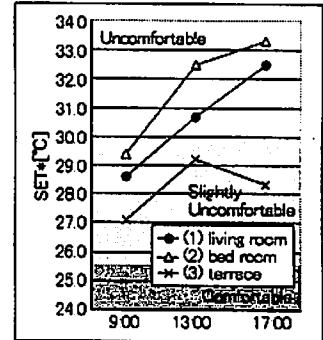
	Temp[°C]			MRT[°C]			Humid[%]			Wind Velocity(m/s)		
	9:00	13:00	17:00	9:00	13:00	17:00	9:00	13:00	17:00	9:00	13:00	17:00
(1)	28.5	32.4	33.2	28.1	33.3	33.8	74.0	58.8	57.8	0.2	0.3	0.2
(2)	28.0	31.8	32.7	28.5	32.2	33.2	75.2	60.5	58.3	0.1	0.1	0.1
(3)	30.1	33.7	33.5	30.1	33.7	33.5	66.7	52.6	52.6	0.7	0.8	1.3

※ (1): living room, (2): bed room, (3): terrace

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**Fig.19 SET\*s of a house in Nonthaburi**