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Thermal and Wind Environment of Korean Traditional House with Korean Hanged Door ~ Field Measurements and Simulation ~

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This paper deals with the field measurements and simulation on thermal and wind environment of traditional houses in Korea. Measurements were carried out on Korean traditional house with a Ondol(stone floor), Maru(Daecheong;wooden floor),Bunhab(hanged door) in summer.

Ondol rooms are recognized that those are suitable room for winter. And the Maru is recognized that it is the suitable space for summer. But according to the result of field measuring, we found Ondol rooms were also comfortable rooms for summer. The opened Ondol room were similar to the Maru's environment. Therefore the most comfortable place is the opened Ondol room because of the temperature of that floor and the wind from the Maru in this survey, we find that the Korean traditional house is comfortable without air conditioners in summer by hanging doors. And when we use air conditioners we waste extra energy. We wonder that we should study from the Korean traditional houses which not waste energy.

Key Words : Ondol, Maru, Bunhap ,Korean traditional houses, thermal and wind environment

1. Introduction

We thought to ideas of the Korean traditional houses that accept various seasons. Korean summer season is very hot and high humidity. Average temperature and humidity of August in Seoul is 25.4°C and 79%. And winter season is very cold. Average temperature of January in Seoul is -3.1°C . Here are stone floor called Ondol room, wooden floor called Maru (Daecheong) and Korean hanged door called Bunhab (hanged door)in the house. Ondol is heating system using heat to occur by cooking. So Ondol room is called space for winter.Maru is opening room made with wood. So Maru called space for summer.

On beginning study, we researched past study about thermal and wind environment of Korean traditional houses. But there

were few documents written about investigation of summer. Therefore we went to Korea to researched thermal and wind environment at the real Korean traditional house in summer. And verify that Ondol rooms and the Maru are appropriate as space of winter or summer.

2. Outline of the measurements

2-1 Measuring period and areas

The measurement was taken place from Sep.3 to 5, 2008 in Yangdong Village, Gyeongju in Korea. This village is location at 36° North/129.25° East and surrounding by mountain(Fig.1). The village has been designated as important cultural properties



Fig.1 Location of Yangdong Village



Pic.1 Landscape of Yangdong Village

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in 1984. There are about 150 houses and lives 740 peoples .The houses built of wood with a tiled roof, thatched roofs in the village(Pic.1).

2-2 Outline of measuring house

The house which we measured is built on the sloping ground. The house is the place of meeting and putting things. The house fronts on the vacant land and there is a house on the opposite side of the house(Pic.2). There are no people living in that house, too. There are two Ondol rooms in the house, located at the east side and in the west side. And the space between two Ondol rooms is the wooden floor. The wooden floor is called Maru or Degchon in Korea. Ondol room's partitions are Korean hanged doors. Korean hanged the doors likes Fusuma of Japan. There are called Bunhab. The details of the house are showed in Fig.2,3.

2-3 Korean hanged door(Bunpab)

Korean door is a fixture used for the partitioning of the Korean traditional houses. It is unique to Korea. Japanese Fusuma is just sliding from side to side. But Korean door opens like a door and also we can be hanged up to the ceiling. By doing so Korean

people can make an individual small room one big large space, as shown in Pic.3. This use of partition adapts each room to various seasons. And Korean people can use it multi-purpose.

When the hanged door is opened in summer, much wind can pass through all rooms. For example from the Ondol room to the Maru or the other Ondol room. It means all rooms which are used different use become same environment and more comfortable by hanging doors.

There are two type of grille in the doors. In Fig.4,5 the upper part and the lower part of grille are loose and the middle part of grille is fine. The parts which are painted are expressed Korean paper in Fig.4. The upper and lower parts of the door are papered from the both sides. The other part is papered from just Ondol room side. So the part of middle plays a role as opening(Pic4,5). The upper and lower parts have an atmosphere layer. An atmospheric layer is effective in raising an insulation effect.

2-4 Measurement points

1. Weather on the outside

The following Fig.8 show the measurement points and

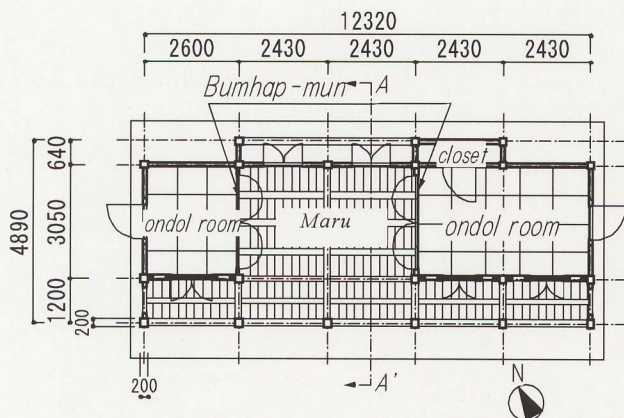


Fig.2 Floor plan

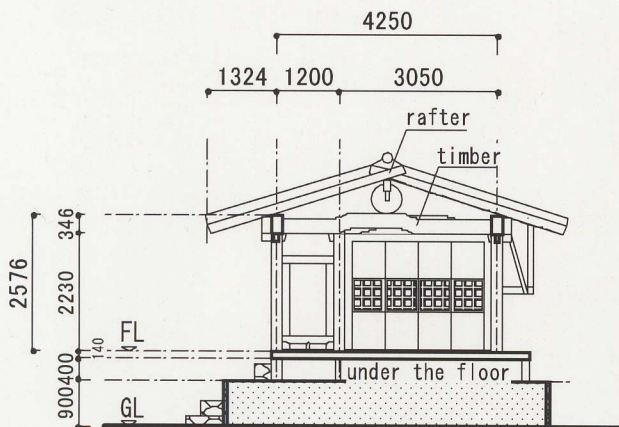


Fig.3 Section A-A'



Pic.2 The measuring house



Pic.3 The Maru and Ondol room

measurement items of the thermal, humidity and wind environment . Three cups type anemometer and Storage meter was set up on the west side of the house. Three cups type anemometer was set up in 5meters on the ground.

2. Horizontal measurement point

The following Fig.6 show the measurement points and measurement items of the thermal, humidity and wind environment in the room. Opened Ondol room is a room in the

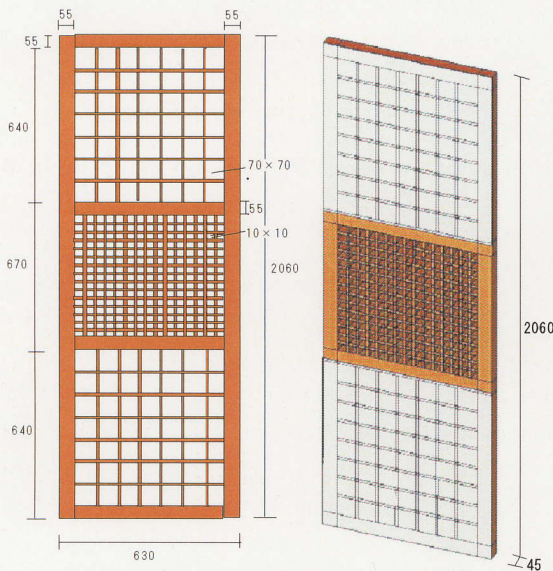


Fig.4 Left: view from the Maru
Right: view from the Ondol room



Pic.4 Ondol room with closed door



Pic.5 Ondol room with opened door

state to open all openings. And, closed Ondol room is a room in the state to shut all openings.

The thermal environment measurement point in five places and the wind environment measurement point in six places were set up in the room.

3. Vertical measurement points

The following Fig.7 show the measurement points and measurement items of the thermal, humidity and wind environment.

Perpendicular distribution of floor level+100mm, +600mm, +1100mm, and +1600mm in four places was taken in each room.

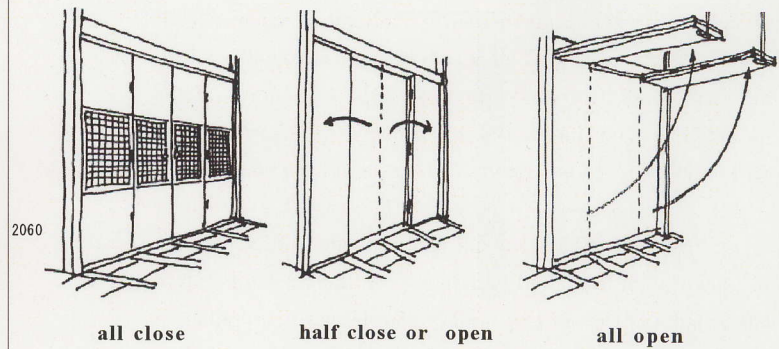


Fig.5 Bunhab close and open

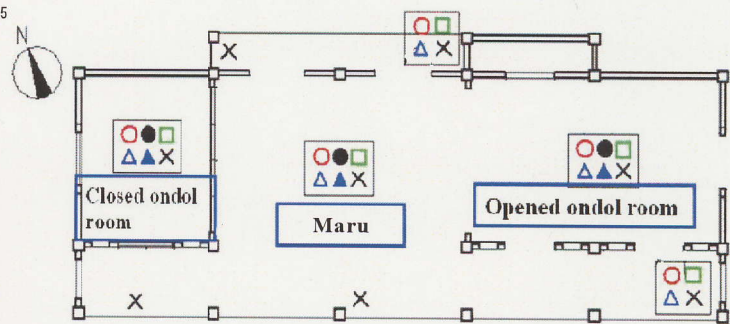


Fig.6 Horizontal plan

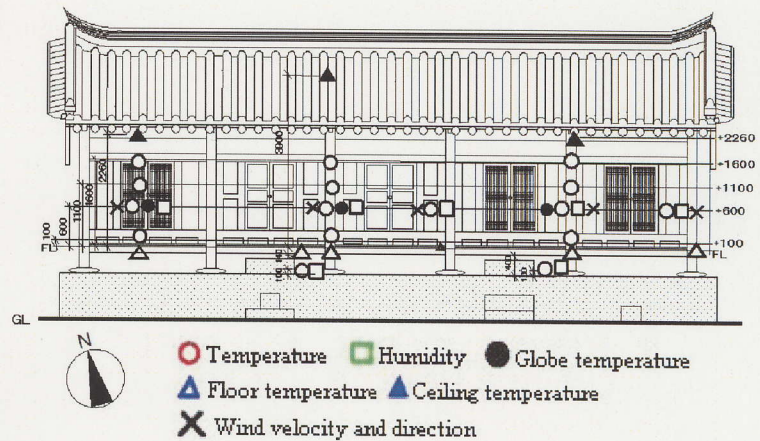
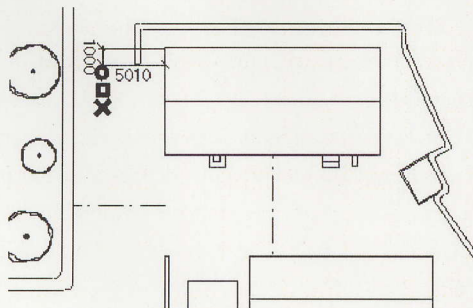


Fig.7 Vertical plan and elevation



○ Temperature □ Humidity X Wind velocity and direction

Fig.8 Measurement points of the outside

In the below the floor level of the Maru, the temperature and humidity was measured.

3. Results of the measurements

3-1 Outside environment

During the measurement, air temperature was recorded from 24.0°C to 28.0°C in daytime and maximum temperature was recorded 28.6°C, 14:00 Sep.3,2008. Average temperature of air temperature during the measurement was recorded 20.6°C. And September average temperature of Yangdong Village was recorded

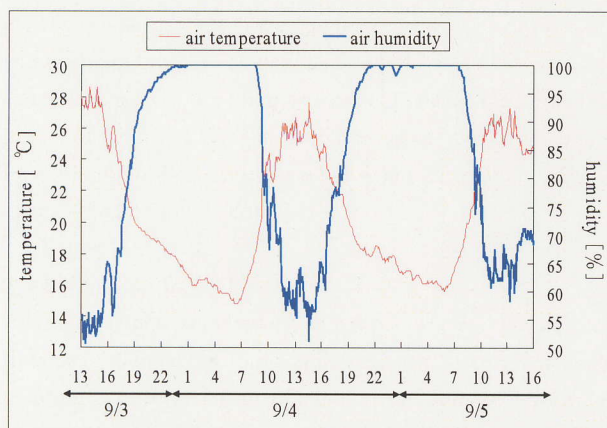


Fig.9 Air temperature and humidity, Sep.3 to 5, 2008

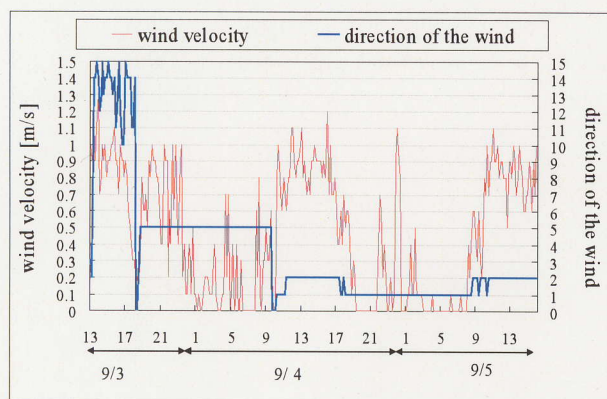


Fig10 Outside wind environment, Sep.3 to 5, 2008

20.9°C and average of maximum temperature was recorded 25.1°C in 1971~1990. Maximum temperature of the measurement period was higher than September average of maximum temperature. Fig.9 shows air temperature and humidity during the measurement.

Fig.10 shows the wind velocity and the direction of the wind during the measurement. Maximum wind velocity was recorded 1.3(m/s). It was blowing from southwest, south-southwest to northeast, north-northeast in the daytime.

3-2 Thermal environment

At first, we focus on the result for the floor temperature of the house. Under the floor of the Ondol room is surrounded by earth, so the temperature of the Ondol floor is affected by that of earth. Compared with the temperature of the Maru, the temperature of the Ondol floor is low from about 1°C to 3°C in the daytime. Fig.11 shows the temperature of the floor and air temperature, Sep.4,2008.

Daytime, the temperature of the house's floor was getting high as air temperature was getting high. But the growing of temperature of Ondol room's floor was lower than that of the Maru's floor because of the Ondol's structure built of earth. The

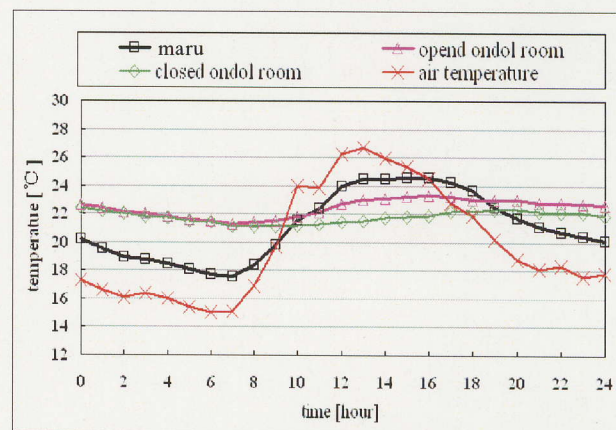


Fig.11 The temperature of the floor, Sep.4, 2008

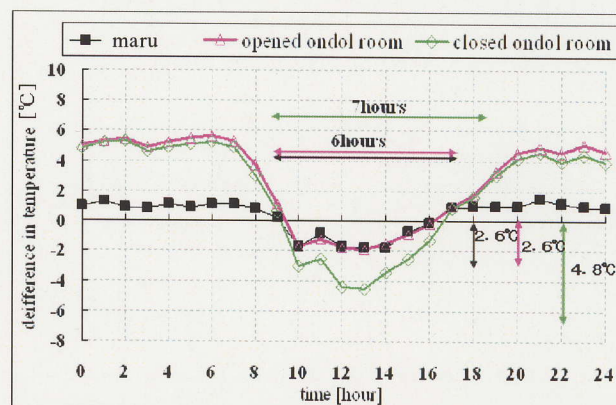


Fig.12 The difference in temperature at the height of 600mm of standard for air temperature, Sep.4, 2008

temperature of the Maru's floor rose from 19.8°C to 24.9°C in the daytime. The temperature of the closed Ondol room's floor rose from 21.1°C to 22.3°C in the daytime. And the temperature of the opened Ondol room's floor rose from 21.5°C to 23.4°C in the daytime. We felt the floor of the Ondol room be cool when we sat on the floor. Next, we mention the result of the temperature at the height of 600mm because Korean people live on the floor.

Fig.12 is the graph of the difference in temperature at the height of 600mm of standard for air temperature, Sep.4, 2008. Daytime, all temperature at the height of 600mm were recorded under air temperature from 2.6°C to 4.8°C. Such this characteristic was showed in the other heights.

3-3 Wind environment

To know wind environment in this house especially how much influence are there by opening and closing doors, we measured direction of wind and wind velocity in 8 points.

Fig.13 shows wind velocity of 8 points. Porch is almost outside space that has wood floor and a roof. The number is the percentage that is standard for outside average wind velocity of each average wind velocity.

The ratio of porch4, 97% is highest of all. Because the wind gathers to the Daecheong from various direction and wind to pass by is concentrated in the porch4. Wind velocity of the Maru and opened Ondol room shows in Fig.14,15. Much wind from south west pass by the Maru. The ratio of opened Ondol room is lowest of all. All of Wind direction of opened Ondol room pass by X direction. It means that much wind go through between opened Ondol room and the Maru.

3-4 Evaluation by SET*

SET* is new standard effect temperature and means comfortable of thermal environment in buildings. SET* is calculated by using thermal residence of cloth, metabolism rate, MRT and temperature, humidity, and wind velocity. MRT was calculated by using globe temperature. Thermal residence of cloth is estimated as 0.68(clo) and metabolism rate is used 1.0(Met). SET* is defined as comfortable between 22.2°C and 25.°C. Table1 shows the basic data for calculation of each space this time. Wind

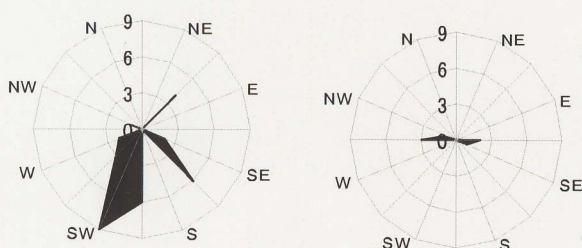


Fig.13 Wind direction of each points

velocity of each space were calculated by the average and the maximum wind velocity. The calculated result of SET* are shown in Fig.16.

The SET* of the closed Ondol room was defined as little cool, little uncomfortable and comfortable. Because Bunhab, windows of closed Ondol room were closed, it didn't blow in the room. The SET* used the average wind velocity of the Maru and opened Ondol room was defined as the comfortable. So the most comfortable spaces are the Maru and opened Ondol room.

4. An analysis with simulation

4-1 Purpose

This time, it is a purpose to grasp the whole flow with the investigation of the actual measurement and the analysis of the simulation. And, it is verified about the validity of the Bunhab by the actual measurement by giving the analysis which the condition of the Bunhab which couldn't do it is changed from.

4-2 Method

This time, we research the flow of the indoor wind of the building by using simulation software of "STREAM for Windows Ver.7". We verify the flowing of the wind which is the Ondol room and Maru by this software. On that occasion, we compare the condition of the opening in 2 patterns.

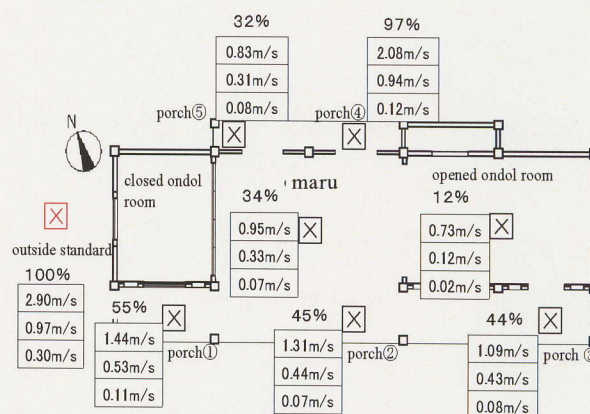


Fig.14 4th Sep. 16:00~16:19

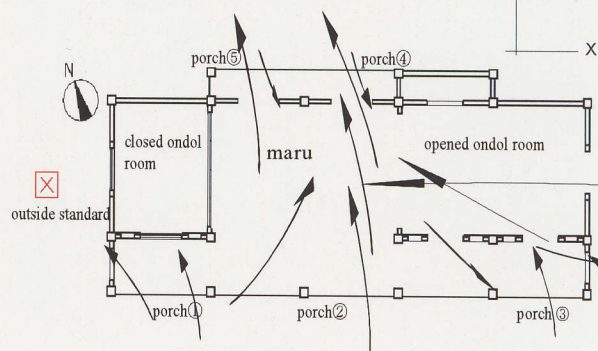


Fig.15 The main direction of the wind

1. A condition is same at the time of the measurement.
2. A condition that half of the fusumas were opened.

We check the validity of the Korean Fusuma(Bunhab) by the above analysis. And, a wind direction uses the southwest which was the most abundant with observation. As for the model of the residence, it is simplified a measurement house and did minute



Pic.6 Measurement machinery set a velocity and a direction of wind

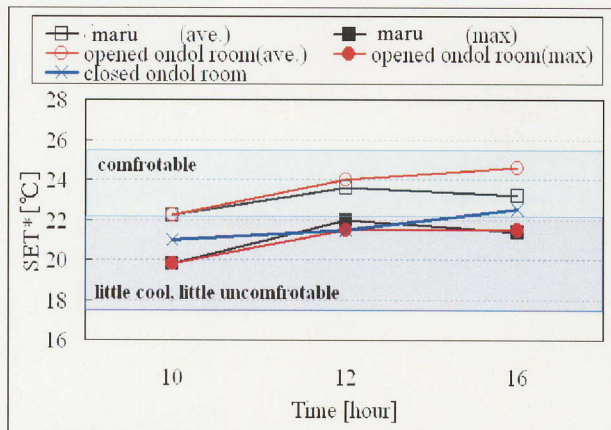


Fig.16 SET* of the house, Sep.4, 2008

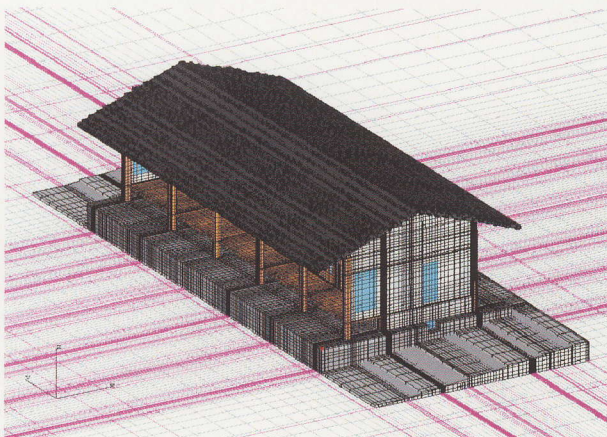


Fig.17 the model figure of the residence used with simulation

mesh division(fig.17).

The wind which went from the southwest gets in from the opened the south side of the Maru, and that most flows out from the opening on the east of the north side for the Maru. The sediment place of the wind is made in the part at the west side of the Maru, and it flows out from the opening on the west of the north side of the Maru little by little. Though wind was sometimes blowing in the circle from the various directions during the actual measurement, it can be predicted that this is because the wind which hit a wall is causing a war way from the simulation. And, when two ways are compared, when it is completely opened, the wind flows in about 0.7(m/s) in the whole of the Ondol room(fig.18). While when it is half opened, the wind flows in about 0.5 (m/s) in the whole of the Ondol room(fig.19). It was proved by this that it had ventilation performance by hanging doors(Bunhab).

5. Conclusions

Ondol rooms are recognized that those are suitable room for

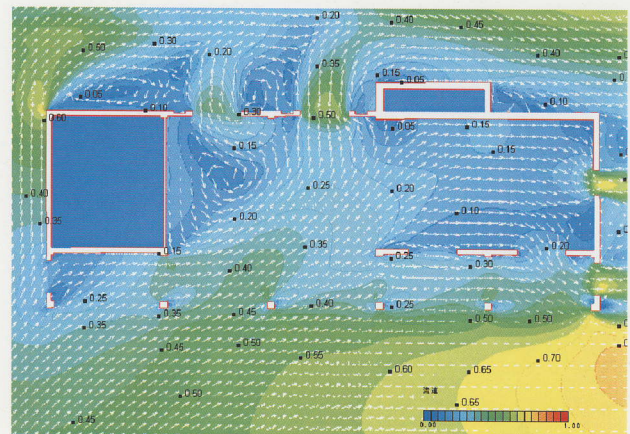


Fig.18 The flow of the wind in the actual measurement

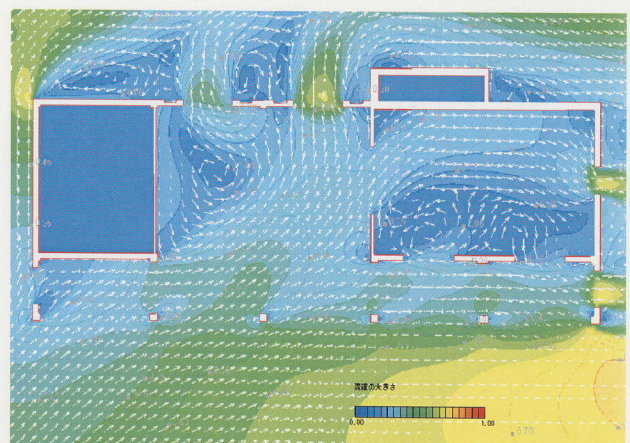


Fig.19 The flow of the wind on the condition that it was narrowed opening

winter. And the Maru is recognized that it is the suitable space for summer. But according to the result of field measuring, we found Ondol rooms were also comfortable rooms for summer. The opened Ondol room were similar to the Maru's environment.

1. In thermal environment of the closed Ondol room, temperature at all heights were about 2°C lower than that of other points in the daytime.

2. The temperature of Ondol room's floor is from about 1°C to 3°C lower than that of the wooden floor in daytime. So we felt the Ondol's floor cool when we sat on the floor.

3. Because under the floor of Ondol rooms are built of earth, the homoiothermal temperature of earth effects in the temperature

of Ondol room's floor. The temperature of earth is about 15°C, fixed temperature, for years.

4. Then in wind environment, it was blowing from the Maru to the opened Ondol room by hanging doors. In the opened Ondol room, the wind from west-northwest was blowing to east-south-east.

5. According to the measured date, we think that it is very comfortable room for staying in the closed Ondol room in summer. But the wind wasn't blowing because of doors and windows closed.

6. The SET* by the average velocity of the opened Ondol room were 22.2°C, 24.0°C, 24.6°C at 10:00, 12:00, 16:00.

7. The SET* by the average velocity of the Maru were 22.2°C, 23.6°C, 23.2°C at 10:00, 12:00, 16:00.

8. The calculated result of SET* by the average velocity of the opened Ondol room and Maru were defined as comfortable between 22.2°C and 25.6°C.

9. The calculated result of SET* of the closed Ondol room were defined as little cool, little uncomfortable at 10:00, 12:00. The SET* of 10:00, 12:00 were 21.0°C and 21.5°C. The SET* of the opened Ondol room were 22.2°C and 24.0°C at 10:00, 12:00. It isn't easy to stay in the closed Ondol room long time.

Therefore the most comfortable place is the opened Ondol room because of the temperature of that floor and the wind from the Maru. In this survey, we find that the Korean traditional house is comfortable without air conditioners in summer by hanging doors (Bunhab). And it adapts its room. Nowadays, air conditioners are necessary for us. And when we use air conditioners we waste extra energy. We wonder that we should study from the Korean traditional houses which not waste energy.

Table1 Data to calculate SET*

	Temp.			MRT			Humidity			Wind velocity		
	[°C]			[°C]			[%]			[m/s]		
	10:00	12:00	16:00	10:00	12:00	16:00	10:00	12:00	16:00	10:00	12:00	16:00
daecheong	22.3	24.5	24.4	23.4	26.2	25.3	82.1	66.1	69.3	0.20	0.32	0.32
opened ondol room	22.3	24.4	24.3	23.1	25.2	24.8	78.3	65.8	69.1	0.18	0.20	0.12
closed ondol room	21.0	21.8	23.2	21.2	21.4	22.1	76.6	77.2	73.2	0.03	0.03	0.03

means calculated MRT by max wind velocity
means max wind velocity

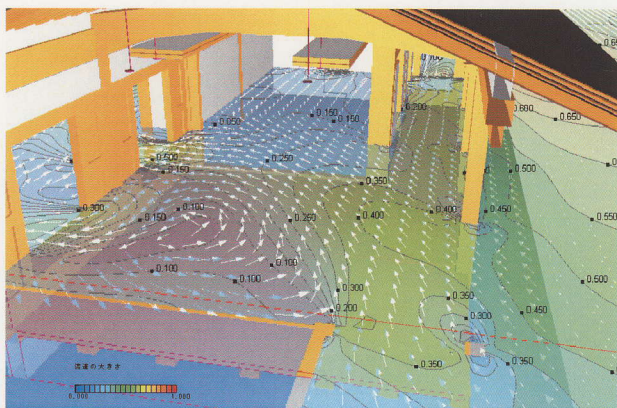


Fig.20 A velocity and a direction of wind simulation

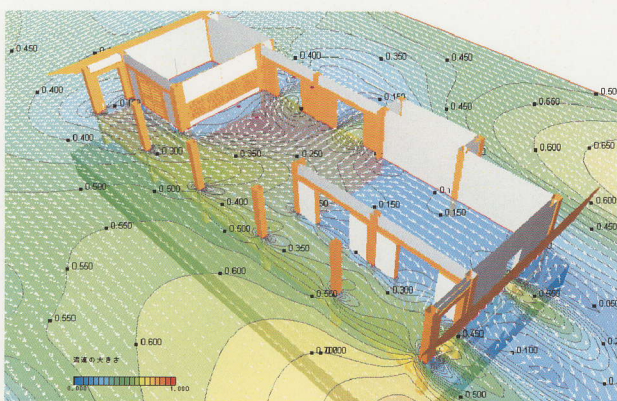


Fig.21 Isometric of the flow wind simulation

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