

A Study of the Thermal Environment about Heating System "Ondol" : Modern Living that carries on Korean Traditional Folk House

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A Study of the Thermal Environment about Heating System "Ondol"

-Modern Living that carries on Korean Traditional Folk House-

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This study clarified warm temperature environment about Ondol (stone floor) room and the Maru (Daecheong; wooden floor) in the Korean traditional folk house. Floor surface temperature of Ondol room the fuel hole is maximum temperature 60.4 degree Celsius. Ondol rooms are recognized that those are suitable room for winter. We felt in Ondol room very warmly. This depends on heat transfer and radiant heat. And the Maru is recognized that it is the suitable space for summer. Maru was closed down with a big glass door. Therefore winter cold wind does not enter the room in the daytime. Because the room was warmed by sunlight, it was warm. The main subject followed an effect of the heat storage of Ondol room of the Korean tradition house. It is the conclusion of this study to aim at the future passive construction.

Key Words : Ondol, Maru, Korean folk traditional houses, heating system, thermal environment, heat flux, thermography

1. Introduction

Korea has the culture to take off shoes and to sit on the floor. Ondol is a stone floor room and Maru is a wooden floor room. The Ondol is a heating facility that heats the floor directly. This is wisdom of the ancestor who lives in the severe cold of winter. The thermal environment was clarified in the 46th thesis [A study of the thermal environment about heating system "Ondol" for the Korean traditional house]. The research of the past of the research on Ondol and Maru thermal environment is actually very few.

The present study continuously did the measurement survey of thermal environment in winter. Moreover, it verifies as a numerical value, and Ondol and Maru thermal environments are clarified. The Yangdong village that is the region for the

research is in Kyongju City, and is located in a place away from Seoul to the southeast by about 350 km. The experiment house was in the Yang dong village, and was built about five years ago (Fig1,2).

It is a house of the living of the present age when tradition house is succeeded to style. This house is a single swinging door in the shoji to partition it between Maru and the Ondol in the curved house for the south. And there was sliding door of the clear glass in Maru (Fig3).

2. Study method

It was performed from February 2, 2010 to 4th for the measurement period. The fuel at the time of the experiment is



Fig.1 Location of Yangdong Village(Daum map)



Fig.2 Landscape of Yangdong Village



Fig.3 The measuring house



Fig.4 The fuel hole and fire wood

firewood used routinely. We set fire at 10 kg once a day for approximately one hour from 6:00 p.m. I divided by approximately 2.5 kg into four times (Fig4) .

It is measured the vertical and horizontal temperature, humidity, installed a heat flux meter to measure passage heat capacity. Furthermore, We used the thermography. It analyzed the relative comparison of the temperature by the image processing.

We show the measurement point of the floor surface temperature in figure5. We show a vertical direction measurement point in figure 6.

It is measured at +100mm, +600mm, +1,100mm, +1,600mm, ceiling side -100mm, a ceiling side from floor. The indoor humidity and glove temperature measured it at +600mm from the floor which was a head height and about the same height when a person sat on the floor. The indoor

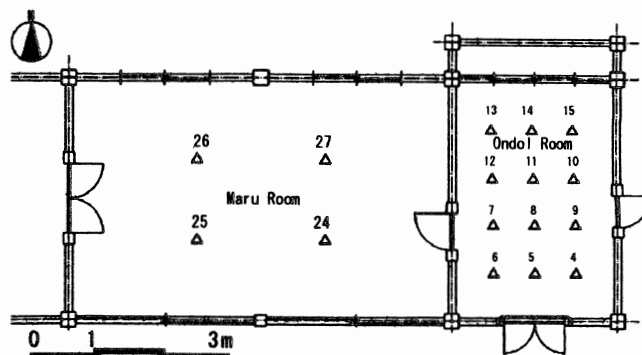


Fig.5 Surface measured

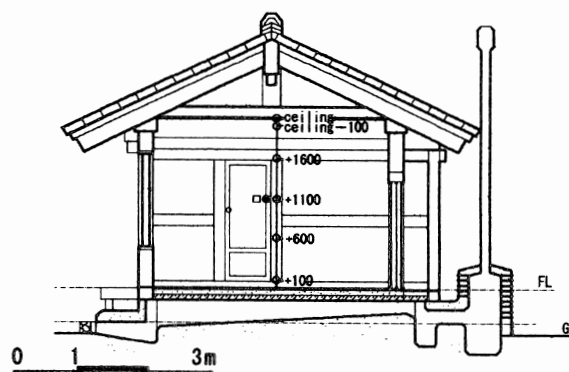


Fig.6 Vertical measured

wall and room outer wall measured it, too. We measured outside temperature, glove temperature, the humidity.

3. Surface temperature of the floor

The average of the outside temperature is -2.6°C . The highest temperature is 3.3°C at 16:00 on the afternoon of February 2 and minimum temperature is -6.7°C at 6:00 on the morning of February 3 (Fig.7) . As for the wave pattern, Maru room is similar in comparison with outside temperature but Ondol room is reverse. In other words, Maru room is affected by the outside temperature. However, Ondol room goes up when outside temperature downs, and down when up.

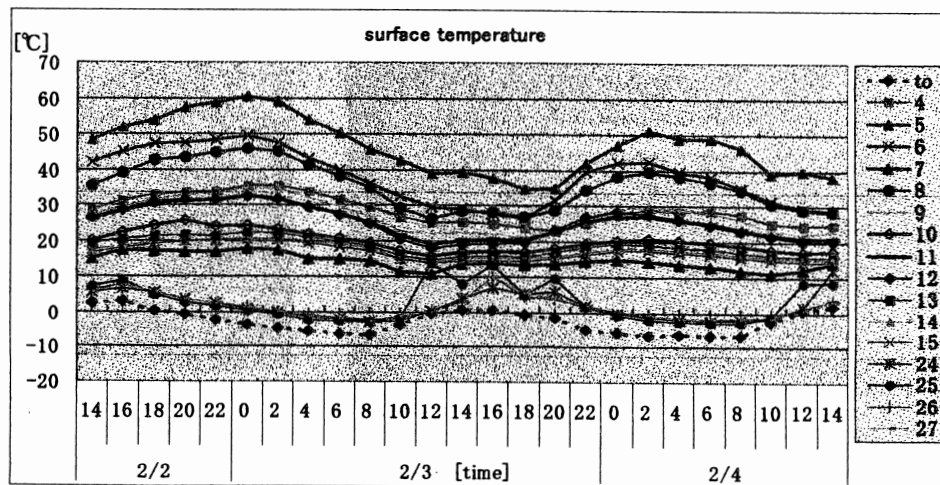


Fig.7 Floor surface temperature

As for the one-day temperature change, Ondol room begins to fire at 18:00, and surface temperature gradually rises. 0:00 and 2:00 becomes the peak, and the temperature falls slowly. The backing away of the temperature stops in afternoon 12 and is stable until 18:00. This has effect of the heat storage of the building by the sunlight of this time.

The 12point sees three lumps when I watch a graph. It is average of 40 °C, 30 °C, 20 °C and there is considerably the difference of the surface temperature in the same room. The figure 7 expressed average of the surface temperature. 5 points of near centers of the fuel hole are the highest. It is an average of 49.1 °C. 15 points that is near to the lowest chimney is the lowest. It is an average of 16.2 °C.

There is difference of temperature so much in a same narrow room. It seems as if the North Pole and the Equator exist. The best surface temperature of point 5 records 60.4 °C at 0:00 of February 2. Outside temperature is -3.7 °C this time. In addition, outside temperature is -6.5 °C on February 3, and the surface temperature is 51.1 °C. Maru room considerably has lower surface temperature than Ondol room. If outside temperature falls, the surface temperature of Maru room falls. It goes up from 10:00, but only point 25 suddenly goes up. It becomes the peak at 16:00 and lowers slowly.

4. Vertical temperature

As for the wave pattern, Maru room is similar in comparison with outside temperature but Ondol room is reverse. In other words, Maru room is affected by the outside temperature(Fig.8). However, Ondol room goes up when outside temperature downs, and down when up. This resembles a change of the floor surface temperature. 0:00 and 2:00 becomes the peak, and the temperature falls slowly. Temperature suddenly down 8:00 a.m. and goes up from 10:00.

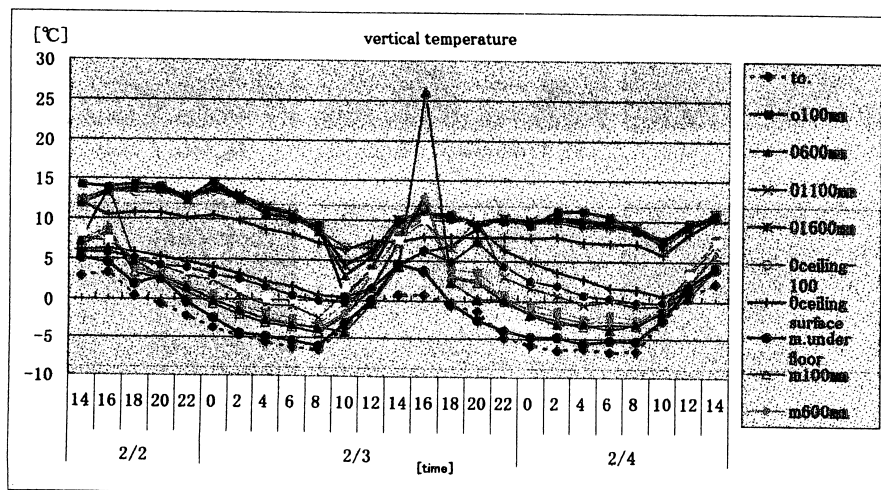


Fig.8 Vertical temperature

The 15point sees two lumps when we watch a graph. There is Ondol room in the range of 10°C to 15°C.

There is Maru room in the range of 10°C to 15°C. Ondol room is stable without being affected with a change of the outside temperature. It is a peak at 26 °C at 14:00, 20.1 °C at 15:00 and, 22.2°C at 16:30 in the case of Maru room. These exceed 20 °C for daytime one hour 30 minutes. This is the thing that is higher than Ondol room. Maru room makes an indoor environment better by sunlight without heating.

5. Surface temperature of the wall

There is a considerable difference in the surface of a wall temperature of the south side of Ondol room(Fig.9). If there is not sunlight, the outside wall is the same as outside temperature.

When there is sunlight, it becomes the high temperature. Temperature rises to 10 suddenly in the morning and becomes 20 °C from 12:00 to 14:00. The inside wall is stable in the range of 5°C to 15°C.

There is a considerable difference in the surface of a wall temperature of the north side of Ondol room. The outside wall is the same as outside temperature. The inside wall is stable

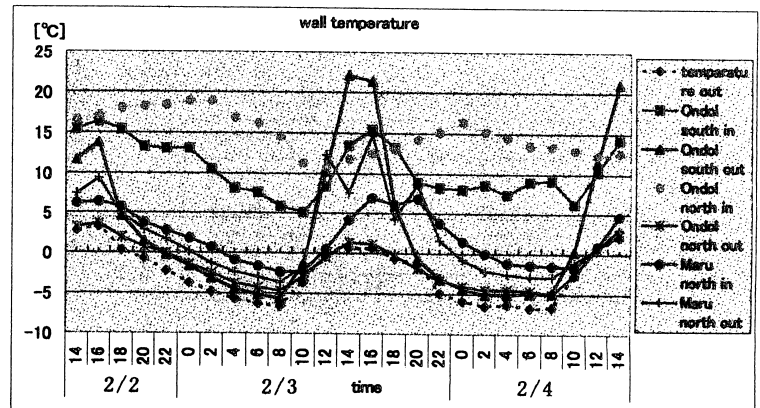


Fig.9 Wall surface temperature

in the range of 11°C to 19°C. It is surprised that it was the highest place in a wall. This is the characteristic of the Ondol room system. The north side surface of a wall temperature of Maru room rises from 10:00 a.m. Temperature falls slowly from 21:00.

6. Heat flux

It measured 4 places of heat flux in an Ondol room(Fig.10,11). No.1 is a Aremoku(warm place), No.4 is a Woogmoku(cold place).

It is quantity of heat flux by each position from table 1. The average ,No.1 is 172.89W/ m², No.2 is

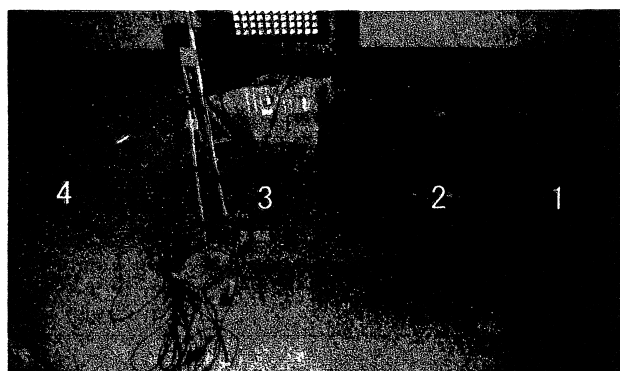


Fig.10 Heat flux point

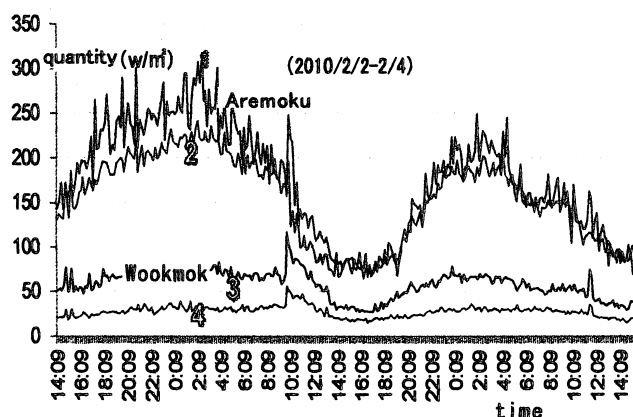


Fig.11 Quantity of heat flux by each position

Table.1 Quantity of heat flux on the Ondol room

	max	min	average
1	318.08	66	172.89
2	247.83	64	157.93
3	55.83	15	27.79
4	116.7	26.67	58.8

157.93W/m², No.3 is 27.79W/m², No.4 becomes 58.8W/m². The third and the fourth reverse when they watch figure 11 from this result. As for the reason, the traces of the wind under the third floor are clogged up. And, a hot wind does not introduce it into No. 4 directly, and it is thought to have turned around by the side. We compared the minimum with the maximum of the quantity of heat flux. Maximum of Aremoku is about 318W/m² and minimum is about 66W/m².

Maximum of Wookmok is about 247W/m² and minimum is about 64W/m². There is a difference of approximately 3 times in the mean of both positions. In other words,

energy to convey of the heat from a fuel hole to a chimney decreases to a one-third.

7. Thermography

Fig.12 is likely to have taken the hot floor (Aremoku) surface at about 3:00 p.m. when the floor surface temperature of the Korean stove is low. Fig.13 uses thermography and is the relative figure which we compared of the temperature by the image processing in the situation of photograph 10. Surface temperature of the centers is 37.1 °C and surface temperature of the walls is 15.1 °C. Even if the surface temperature of the floor is at lowest time, the surface becomes hot and understands that there is it of a day.

Fig14 is a photograph of the windows of the east sides of Ondol room. Temperature of the Shoji is 12.7 °C. Fig15 is Thermography of Fig14. Fig16 is a photograph of the 9-point at about 5:00 p.m. The floor surface is 16.9°C. Fig17 is Thermography of Fig16 and is blue.

8. Indoor climate and SET*.

The figure is the graphic which expressed indoor temperature of Ondol room and Maru room. Outside temperature does not exceed 5 °C by this actual survey, it was the cold period. Temperature of Ondol room changes between 10°C to 15°C. Effective heating is always carried out in the room of Ondol room(Fig.19).

We understand that time kept constant temperature exists. But, Maru room is not kept constant temperature. The way of the change resembles a change of the outside temperature.

Maru room goes up to nearly 15°C over 16:00 from 14:00

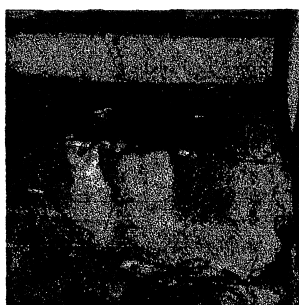


Fig.12 Hot Ondol room

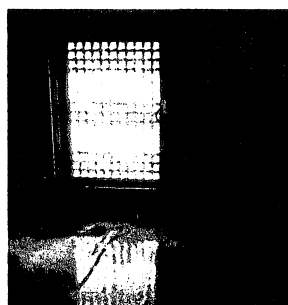


Fig.14 Window of Ondol room

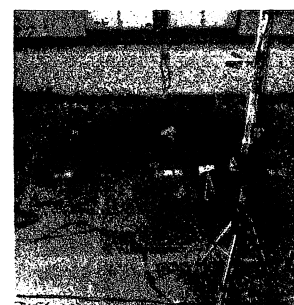


Fig.16 Cold Ondol room

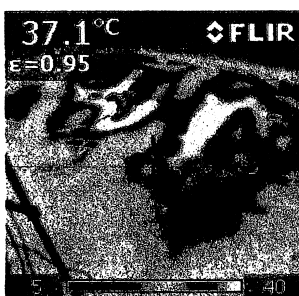


Fig.13 Thermography of Fig.10

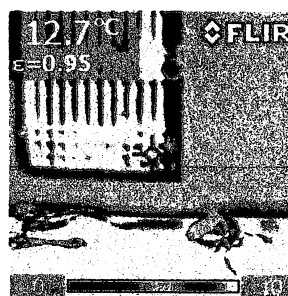


Fig.15 Thermography of Fig.12

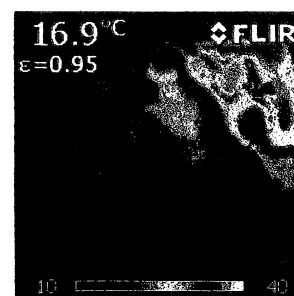


Fig.17 Thermography of Fig.14

of February 3. It is thought that the room was warmed under the influence of sunlight as for this the room. The outside humidity is 65% from 20%. Humidity of Ondol room is not a change of approximately around 20%. It becomes the low value and near straight line at graph. The humidity of Maru room resembles a change of the outside humidity. It is a change of 40% from 20%. The glove temperature does all a change same as each temperature (Fig.18).

However, glove temperature rises by thermal when only Maru room catches the sunlight. It becomes the "very cold" range as Ondol room and Maru room for SET. It may be said that the room temperature is not comfortable at all.

But, in the case of Ondol room, it became the comfortable

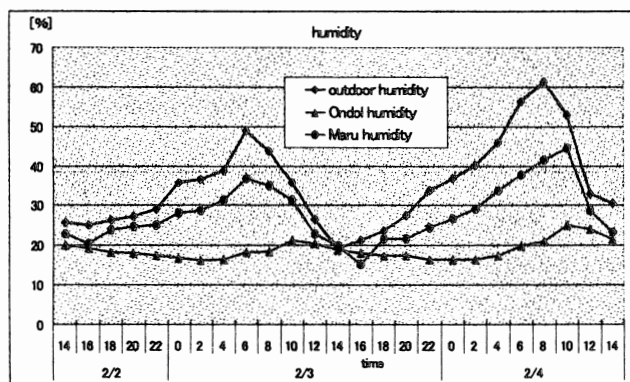


Fig.18 Humidity of Ondol, Maru room

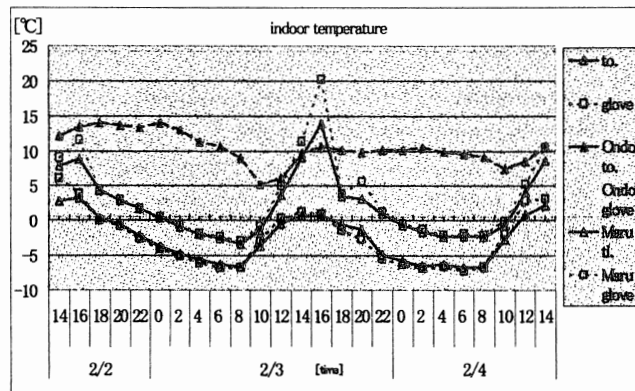


Fig.19 Indoor temperature and SET* calculation result (2010)

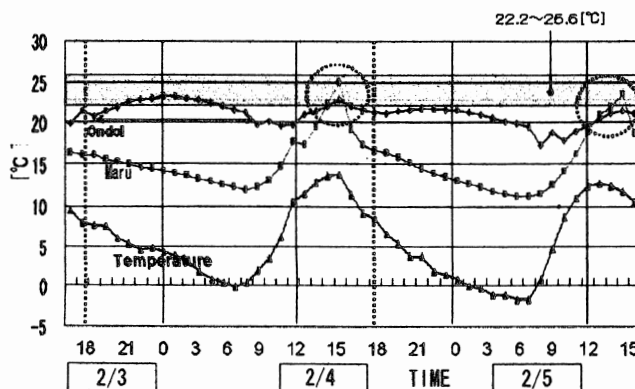


Fig.20 Indoor temperature and SET* calculation result (2009)

range in the last time (Fig.20). Outside temperature lowers 5°C - 7°C, but Ondol room and Maru room become low at temperature same than the last time, too.

However, in the case of Ondol room, it was not comfortable this time in the range of the SET*. Because floor surface temperature was high, it was not so cold. Ondol room was not used for a long time in comparison with the last year. In this, the Shoji of the door of the Ondol room was considerably torn. Furthermore, the thing that became considerably low opened a door frequently at 8:00 a.m.

9. Conclusions

This article clarified warm temperature environment about Ondol room and the Maru in the Korean traditional folk house. Floor surface temperature right above the fuel hole is maximum temperature 60.4°C, minimum temperature 11 °C according to the point.

The difference becomes approximately 50 °C. There was no great difference in all points between the vertical direction temperature of Ondol room. I felt that I was in Ondol room very warmly. This depends on heat transfer and radiant heat. This is because the foot that air warms directly. The one that is high in floor surface temperature feels warmth for the person. Indoor temperature is the same case, but feels Ondol room to be warm than Maru room.

Maru room was closed down with a big glass door. Therefore winter cold wind does not enter the room in the daytime. Because the room was warmed by sunlight, it was warm. However, the comfort like Ondol room is not felt. We felt that I was slightly chilly. The main subject followed an effect of the heat storage of Ondol room of the Korean tradition house. It is the conclusion of this study to aim at the future passive construction.

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