

ANALYZING THERMAL ENVIRONMENT EFFICIENCY OF RAISED-FLOOR ONDOL WITH VENTILATION

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ABSTRACT

A floor heating, so called 'Ondol', is widely used in Korea, and it has been known that Ondol provides good thermal environment. [1] However, the impact sound through floor is great and ventilation rate depends on infiltration in rooms where the Ondol is applied.[2] It is reported that impact sound is reduced on raised-floor Ondol system.[3]

This study aims at analyzing thermal environment efficiency of raised-floor Ondol with ventilation system which is an alternative plan about Ondol with insufficient ventilation. The study is performed at a residential house located on Yang-Pyoung, Kyoung-gi do in Korea. A size of sample house is 4.45m (L) x 3.35m (D) x 2.85 (H). Experimentation compared factors of thermal environment of each case; Ondol-heating only (Case A), introduction of outdoor-air (Case B), using raised-floor Ondol with ventilation system. Case A was the highest in every factor of thermal environment, and then case C, case B was. The case C is likely to effectively contribute to keep required indoor environment with better indoor air quality.

KEYWORDS

Ondol, Good thermal environment, Impact sound, Ventilation

INTRODUCTION

Ondol is a heating method that has been used traditionally in Korea. Radiant heating is adapted to Ondol and it is considered to provide good thermal environment in space.

However, the impact sound through floor is great and ventilation rate depends on infiltration in rooms where the Ondol is applied. It was reported that the impact sound reduced When the Ondol panel was installed keeping away from the slab within distance. This new system is so called 'raised-floor Ondol' This study aims at proposing appropriate alternatives for ventilation rates that satisfy Korean guidelines with less thermal energy consumption in the space where the raised-floor Ondol was used.

Field measurements were performed in an actual house where the raised-floor Ondol was installed. Three ventilation methods were applied to the Ondol to examine the impact of ventilation on indoor thermal environment

METHOD

The house used for field measurements was in Yang-pyoung, Korea. Figure.1, shows the plan of the house.

The room used for measurement is also shown in the figure.

The dimension of the room was 4.45m (L) by 3.35m (D) by 2.85m (H). The window was facing directly south.

As the structure of the Ondol is described in Figure. 2, insulation layer was installed on the top of the slab. Ondol panel was installed right above the insulation layer keeping 8cm of distance.

A duct system was installed in the cavity to provide outdoor air that can be used for ventilation.

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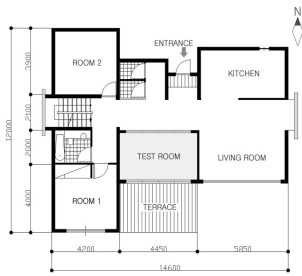


Figure 1. Floor plan of the test room

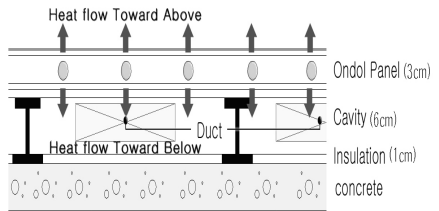


Figure 2. Details of the Ondol penal board

The diameter of the pipe embedded in the Ondol panel was 1.5cm and the pitch between each pipe was 20cm. How water was supplied through the pipe to heat the Ondol panel. The layout of pipe is shown in Figure. 3.

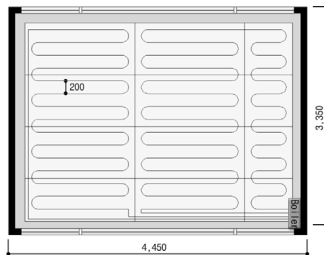


Figure 3. Arrangement of pipes.

The indoor thermal environment caused by the raised-floor Ondol was evaluated for three cases: Case A, B, C. The 'Case A' was that the Ondol panel was heated and no ventilation was provided. In this case, only ventilation source was infiltration. 'Case B' was that ventilation was supplied using outdoor air directly. 'Case C' was that ventilation was provided using the duct in the cavity between Ondol panel and slab structure. The supply temperature of hot water that moves through the pipe was set to be 60°C. The flow rate of hot water was 3.80 /min. The hot waster was provided by a boiler and it was controlled according to the on/off basis. It was turned on for one hour and turned off for next one hour. Ventilation rate was available only when boiler was on and hot water was supplied to the Ondol panel. For these conditions, data monitoring were performed and the monitoring interval was 5 minutes.

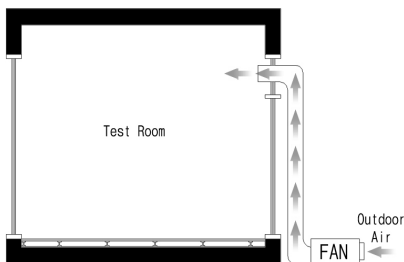


Figure 4. Case B, The pathways of ventilated air

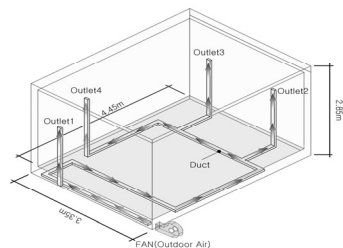


Figure 5. Case C, The pathways of ventilated air

For the case B and C, the pathways of ventilated air are shown in Figure.4, Figure.5.

The ventilation rate was controlled by a controller and equal control setting point was used for both case B and C. The air velocity at diffuser and ventilation rate for the case C is shown in Table.1. In this case, the air change rate was 0.71 ACH.

Table 1. Property of each diffuser

| | Ventilation by the system | | | |
|--------------------------------------|---------------------------|------------|------------|------------|
| | diffuser 1 | diffuser 2 | diffuser 3 | diffuser 4 |
| Dimension (m ²) | 0.001 | 0.0055 | 0.0055 | 0.0045 |
| Max velocity (m/s) | 3.8 | 0.7 | 0.6 | 0.7 |
| Air flow rate (m ³ /h) | 8.21 | 8.32 | 7.13 | 6.80 |

RESULT

When only the raised -floor Ondol was heated with no ventilation except infiltration (Case A), the indoor temperature ranged from 18.93°C to 22.57°C. The mean temperature was 20.54°C.

Globe temperature varied from 19.26°C to 23.45°C which was a little greater than the indoor temperature due to the direct influence of radiant heat from heated on panel on the floor.

The floor surface temperature of Ondol panel was between 32.91°C and 44.14°C. Figure. 6, shows the temperature variation for the case A. When the raised-floor Ondol was heated and outdoor air was directly supplied to the room (Case B), the outdoor air temperature ranged from -2.86°C to 4.88°C.

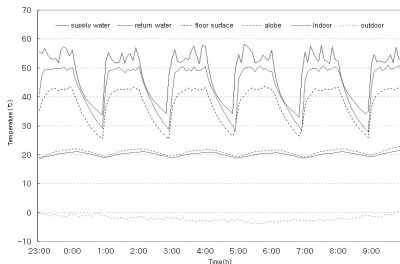


Figure 6. The temperature variation for the case A

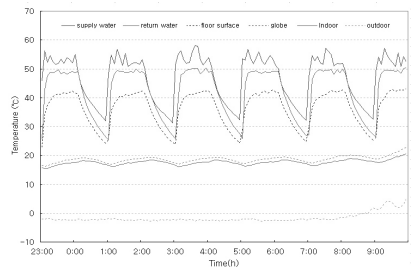


Figure 7. The temperature variation for the case

The indoor temperature ranged from 15.45°C to 20.66°C, which was lower than those of ‘case A’ by 3.48°C and 2.31°C. Globe temperature varied from 16.15°C to 22.83°C, which indicated that the direct influence of radiation from floor surface was mitigated by the direct supply of outdoor air. The floor surface temperature of Ondol panel ranged from 34.32°C to 42.99°C. Figure. 7 shows the temperature variation for the case B. When the raised-floor Ondol was heated and ventilation was provided using the duct in the cavity (Case C), the indoor air temperature ranged from 18.62°C to 21.58°C, which might satisfy the thermal comfortable range. Globe temperature varied from 19.01°C to 22.88°C, which shows greater value for the lower limit compared with the case B. The floor surface temperature of Ondol panel ranged from 35.32°C to 43.76°C, which was slightly higher than that of the ‘case B’ . Figure. 8 shows the temperature variation for the case C. Figure. 9 shows the temperature variation at diffusers. When mean outdoor temperature was 1.96°C, the mean supply air temperature the four

diffusers were 12.11°C, 16.12°C, 18.45°C, and 18.26°C respectively.

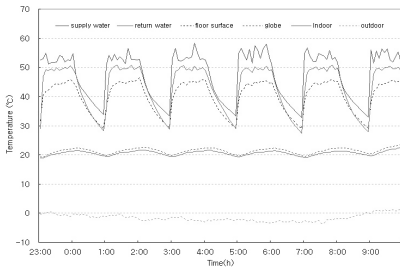


Figure 8. The temperature variation for the case C

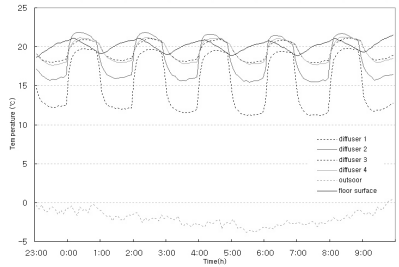


Figure 9. Case C, The temperature variation at diffusers

CONCLUSION

For the case A, thermal environment factor showed greater values compared with the other two cases. However, the ventilation was achieved only by infiltration. So, it was unlikely that the required ventilation rate by Korean guideline was obtained. This is consistent with other studies [4].

For the 'case B' and 'case C' that satisfied the required ventilation rate, the indoor temperature for the case C was greater than that under 'case B' by 2.21°C

It appears that the heat flows toward the cavity space contributed to heating the induced air into the cavity while it moved through the duct.

When case C is compared with case A, the required ventilation rate was obtained and indoor thermal environment factor did not show significant difference.

Hence, the case C is likely to effectively contribute to keep required indoor environment with better indoor air quality.

In summary, the raised-floor Ondol system that can utilize ventilation with less energy can be considered to be an appropriate alternative for the typical Ondol in space where ventilation rates depend on infiltration only.

ACKNOWLEDGEMENTS

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