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Indoor Thermal Environment and Characteristics of Heat Emission with Floor Finishing Material in Ondol (Floor Heating)

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Abstract

The thermal characteristics of floor finishing material are very important factors on the thermal comfort because Koreans are used to seat on the floor in room. In this study, experimental chamber were constructed to evaluate the thermal comfort and characteristic differences in floor finishing material and structure of Ondol system. The results of this study are 1) The factor that influence reaching time to the set temperature of the model room were thickness and thermal conductivity of floor finishing material. 2) Surface temperature for maintaining same indoor air temperature and thermal comfort is different according to thermal conductivity and diffusibility of the floor finishing material 3) In case of the glass plate Ondol system, wooden floor was most close to comfort zone, and in case of the conventional Ondol system, marble was. 4) The factor that the most influence the amount of energy used to reach set temperature was thickness of floor finishing material.

1. Introduction

Floor finishing material of Ondol, korean traditional floor heating system, in very important because of korean life style in house used to seat on the floor.

This research aims to compare and evaluate indoor thermal environment and heat emission characteristics by various floor finishing material widely used in apartment house of korea.

Floor finishing material in Ondol have been changed from a laminated paper lacquered with been oil to an wooden floor. etc.. Table 1 shows the investigation results of floor finishing material of korean housing. In this research, thermal environment and characteristics of heat emission with various floor finishing material in Ondol system was estimated.

2. Experiment Summary

Model room test was conducted under the 12 conditions that include 2 Ondol structure which are conventional hydronic type having heat storage layer and plate glass type having no heat storage layer, and 5 floor finishing material.

Indoor thermal environment and heat emission characteristics are estimated in model room. Table 2 shows experimental conditions.

Experiment was conducted for September 7, 2001 - October 30, 2001 in artificial environmental rooms of hanyang university which can be

Table 1. floor finishing materials used in korean housing.

Unit :Frequency(%)

material / space	PVC sheet	Ethnic custos paper floor	wood	marble /tail	total carpet	part carpet	mat	the others	total
master room	82 (12.5)	496 (75.6)	0 (0.0)	2 (0.3)	0 (0.0)	3 (0.5)	2 (0.3)	47 (7.2)	656 (100)
living room	544 (82.9)	20 (3.0)	14 (2.1)	7 (1.1)	3 (0.5)	51 (7.8)	0 (0.0)	1 (0.2)	656 (100)
kitchen/ dining room	576 (87.7)	11 (1.7)	11 (1.7)	7 (1.1)	0 (0.0)	5 (0.8)	0 (0.0)	2 (0.3)	656 (100)
room1	112 17.1)	228 (34.8)	0 (0.0)	2 (0.3)	0 (0.0)	5 (0.8)	0 (0.0)	46 (7.0)	656 (100)

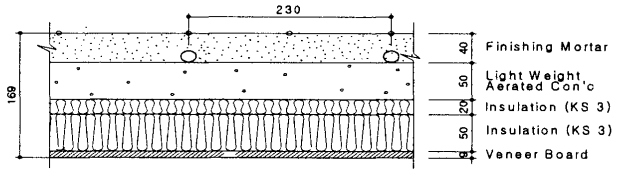
maintained within a temperature range of -5 ~ 35℃ and its size 5 [m] (width)× 5 [m] (depth)× 3 [m] (height). Two experimental model rooms are 1.8 [m] (width)×1.8 [m] (depth)×1.8 [m] (height) in each, and be in the artificial environment test room.

Two model rooms are consisted of equal structure except Ondol floor. Figure 1. shows the section of each Ondol structure of two model rooms.

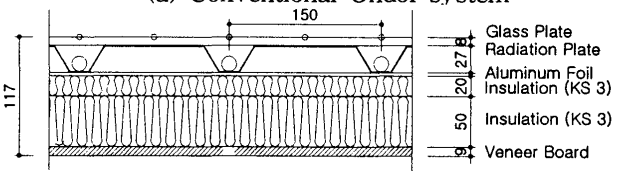
Figure 2. shows plan, heating pipe diagram and measuring points of the experimental model rooms.

Table 2. Measurement conditions

Ondol Type	Floor Finishing Material
Conventional hydronic Ondol System	Wooden floor (8mm)
	Carpet (5mm)
Plate Glass hydronic Ondol System	laminated paper (0.1mm)
	No finishing material (0 mm)
	PVC sheet (1mm)



(a) Conventional Ondol system



(b) Plate glass Ondol system

Fig 1. Cross-sectional view and temperature measuring points of the Ondol system

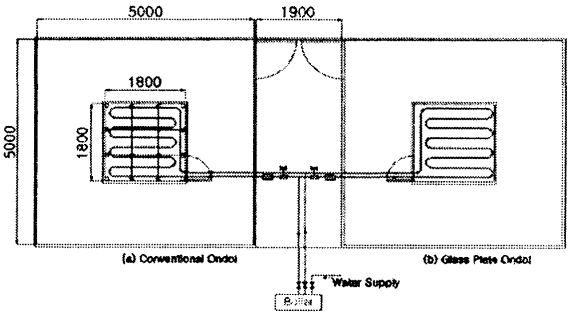


Fig 2. Schematic diagram of hydronic Ondol heating systems and measuring Points

3. Experimental Result

3.1 characteristics of heat emission

Figure 3. and Figure 4. show the transient response of model room temperature of the conventional Ondol having a heat storage layer and of the plate glass Ondol in each, under the schedule of heating for 8 hours and emitting for 16 hours.

In reaching time to set temperature, conventional Ondol structure was shorter(average 187 min.) than the plate glass type(average 262 min.) under the condition that floor finishing material are the same.

Reaching time to set temperature by floor finishing material became longer when its thickness became thicker. This result was thought because of the thermal storage effect by a thickness of material.

Reaching time to set temperature in glass Ondol structure became longer in order of no finishing material< laminated paper< PVC sheet< wooden floor< carpet.

And that in conventional Ondol structure became longer in order of no finishing material < laminated paper< PVC sheet< carpet< wooden floor.

Table 3. shows reaching time to set temperature by Ondol structure and by each floor finishing material. after starting hot water supply, transient room temperature was affected by the thickness of floor finishing material in the plate glass Ondol system and in conventional Ondol system.

After the room temperature reached to the set temperature, the width of room temperature change in the plate glass Ondol system was smaller than that in conventional system having a heat storage layer. The cause of this was thought that there was a time leg in heat transfer from the hot water pipe to a room air by the heat storage layer and, by this, heat was supplied excessively to a heat storage layer until room temperature reaches to the set temperature. Suppling energy was estimated by the formula as followed.

Figure 5 shows energy supplied until room temperature reaches to the set temperature in each case of floor finishing material.

$$Q_{in} = \Delta t \times C_p \times M_w \quad (1)$$

Q_{in} : Supplied energy until room temperature reaches to the set temperature[Kcal]

Δt : Average of temperature differences between supply water and return water in hot water pipe[℃]

C_p : Constant pressure specific heat of water [kcal/kg · ℃]

M_w : Floor rates of supply [kg]

Table 3. Results of reaching time to set temperature(21.5℃)

Ondol type / Finishing material	Plate glass ondol [min]	Conventional ondol [min]
No finishing material	160	130
PVC sheet	245	185
Laminated paper	170	140
Wooden floor	295	260
Carpet	440	220
Mean time	**262**	**187**

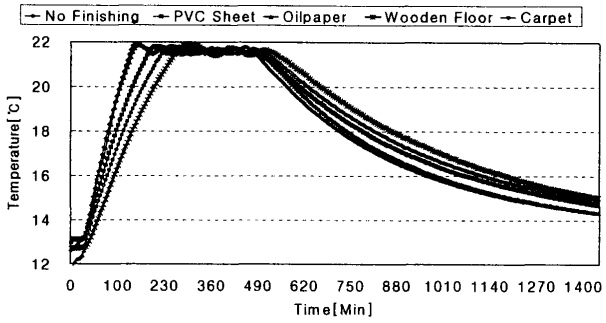


Fig 3. Transient response of room air temperature(Conventional ondol)

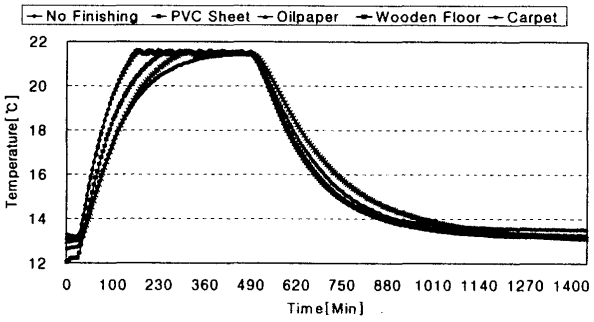


Fig 4. Transient response of room air temperature(Plate glass ondol)

Supplied energy became smaller in order of carpet (2224 Kcal)> marble (2074 Kcal) > wooden floor (1576 Kcal) > PVC sheet (1319 Kcal) > laminated paper (1033 Kcal) > no finishing material (974 Kcal).

3.2 thermal comfort estimated by OT

Figure 6. and Figure 7. show a difference between OOT and OT of each floor finishing material during room temperature was maintained at the set temperature (21.5℃), and Table 4. shows its mean value.

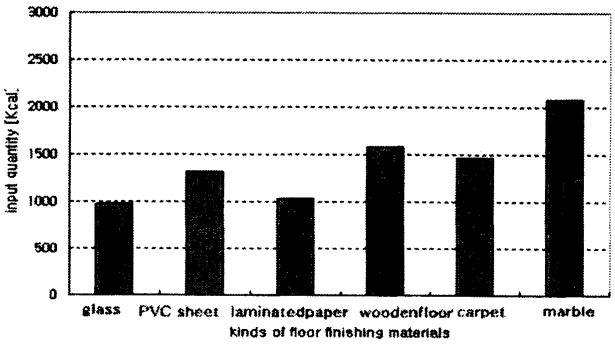
When an OOT-OT difference is near to 0, room temperature is near to the comfort zone.

As shown in Table 4. a difference between OOT and OT in case of the plate glass Ondol system became larger in order of wooden floor< marble< PVC sheet< laminated paper< carpet< no finishing material. In case of the conventional Ondol system, a difference between OOT and OT became larger in order of marble< no finishing material< carpet< laminated paper< wooden floor< PVC sheet.

3.3 Thermal comfort estimated by PMV

Figure 8 and Figure 9 show a transient PMV in case of the plate glass Ondol system and in case of the conventional Ondol system in each. PMV in the conventional system, in general, was nearer to the thermal comfort zone than it in the plate glass system.

Fig 5. Supplied energy until room temperature reaches to the set temperature (plate glass Ondol)



In case of the conventional type, PMV was near to the comfort zone in order of marble> no floor finishing material> laminated paper > PVC sheet> wooden floor> carpet .

In case of the plate glass type, PMV was near to the comport zone in order of wooden floor> marble> PVC sheet> laminated paper> carpet> no floor finishing material.

Table 4. mean value of difference between OOT and OT during room temperature is maintained of set temperature

Ondol system / Floor finishing material	Plate glass ondol [℃]	Conventional ondol [℃]
No finishing material	3.70	2.00
PVC sheet	2.41	2.19
Laminated paper	2.52	2.12
Wooden floor	2.30	2.19
Carpet	2.60	2.10
Marble	2.36	1.67

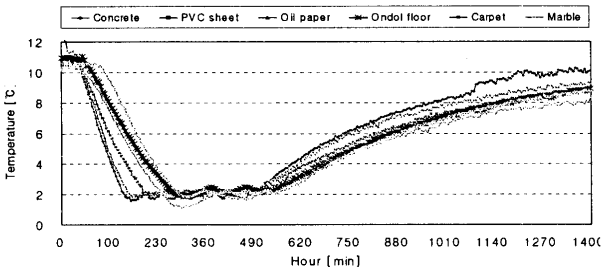
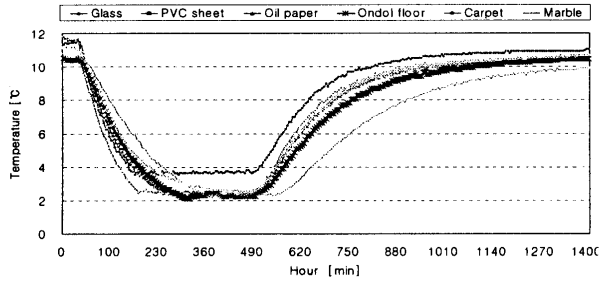


Figure 6. Transient response of OOT-OT (Cnoventional Ondol)



Picture 7. Transient response of OOT-OT (glass Ondol)

4. Conclusion

Indoor thermal environment and heat emission characteristics by floor finishing material in the conventional Ondol system and in the plate glass Ondol system were estimated by model room experiment.

1) Reaching time to the set temperature is affected by the heat storage layer and the thickness of floor finishing material. In case of the plate glass Ondol system, reaching time to the set temperature became longer in order of, no finishing material < laminated paper < PVC sheet< wooden floor< marble< carpet, and in case of the conventional system, it became in order of no finishing material < laminated paper< PVC sheet <carpet< marble< wooden floor.

2) PMV, in the plate glass system, became nearer to the comport zone in order of wooden floor> marble> PVC sheet> laminated paper> carpet> no finishing material, and in the conventional system, in order of marble> no finishing material> laminated paper> PVC sheet> wooden floor> carpet.

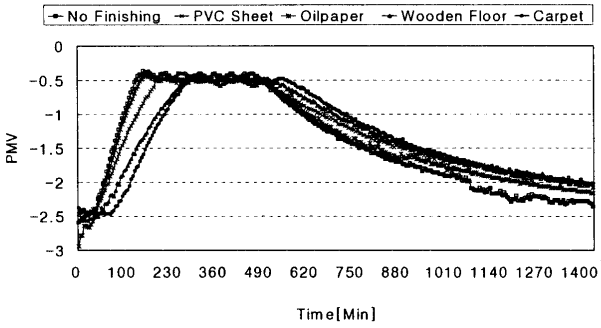


Fig 8. Transient response of PMV (Conventional Ondol)

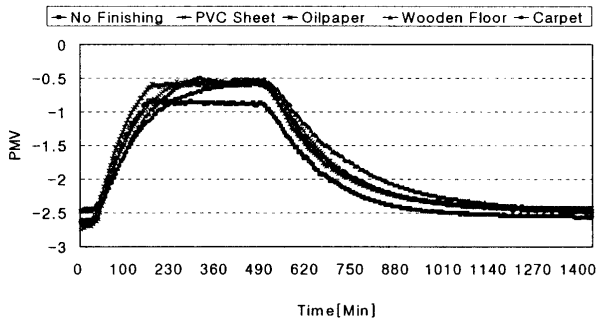


Fig 9. Transient response of PMV (Plate Glass Ondol)

Reference

1. S. H. Park, 2001, "Development of the Access Floor Ondol Using Plate Glass", Proceeding of The Architectural Institute of Korea Vol. 21, No. 2