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An Experimental Study on Control Performance of Radiant Floor Cooling Using Ondol

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ABSTRACT: The objectives of this study are to analyze the application of radiant floor cooling and to evaluate the control methods through experiments when the radiant heating system is used for cooling. Through the experiment analysis the control methods such as on/off control, variable flow control and outdoor reset with indoor temperature feedback control are evaluated and compared.

The cooling curve (reset ratio) is found for radiant cooling, which shows the relation between outside air temperature and supply water temperature. Comparison of cooling methods shows that outdoor reset with indoor temperature feedback control is more appropriate than on/off control and variable flow control with regard to prevention of the condensation and thermal comfort.

Key words: Radiant cooling system(), On/off control(), Variable flow control(), Outdoor reset with indoor temperature feedback control()

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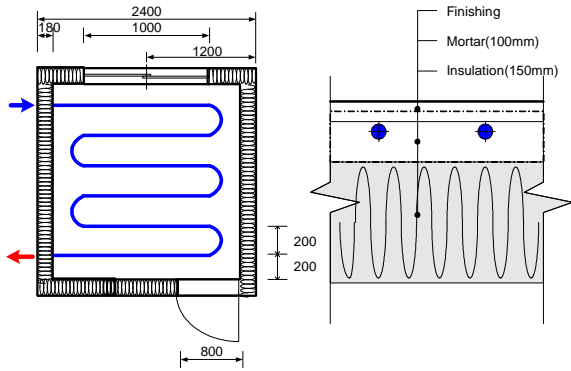


Fig. 1 Plan of test cell and section of floor.

2.2.1

Fig. 2

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2

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32

2.2.2

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4

(test cell) Fig. 1

Fig. 1

2.2

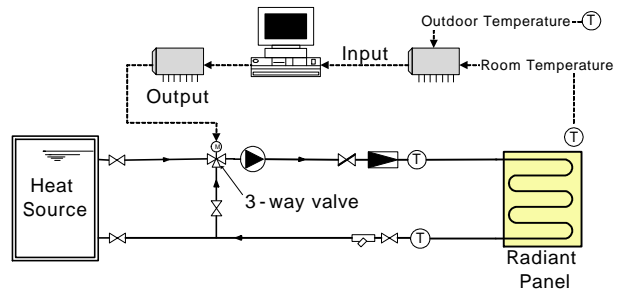


Fig. 3 Schematic diagram of water temperature control.

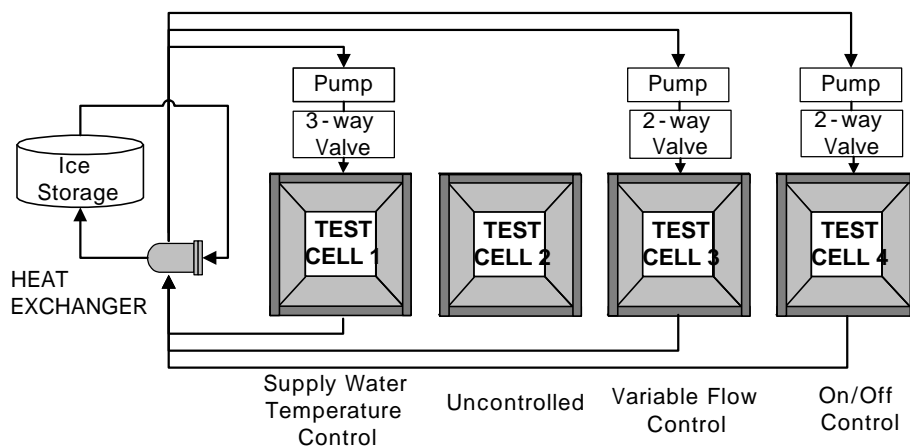


Fig. 2 Diagram of piping system and controls.

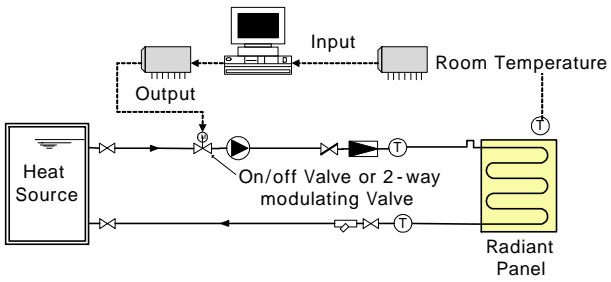


Fig. 4 Schematic diagram of water flow control.

Fig. 3, 4

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가 (on/off)

3.2

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(reset ratio)

3.1

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24

Fig. 6

Fig. 5

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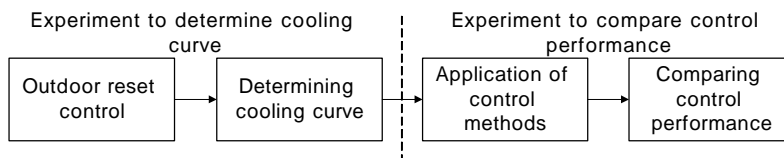


Fig. 5 Outline of experiments.

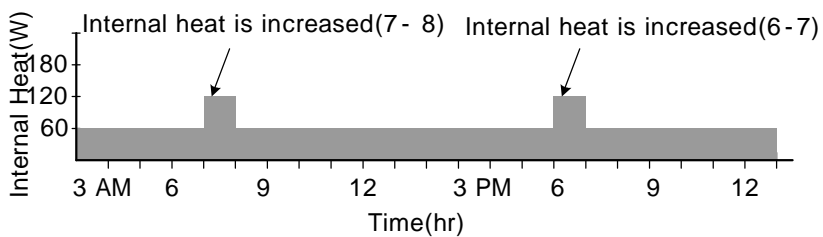


Fig. 6 Schedule of internal heat gain.

1.2 lpm

26

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1.1 m

() Fig. 7(a)

31.1

4.

(2)

15

17

4.1

, Fig. 7(b)

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3

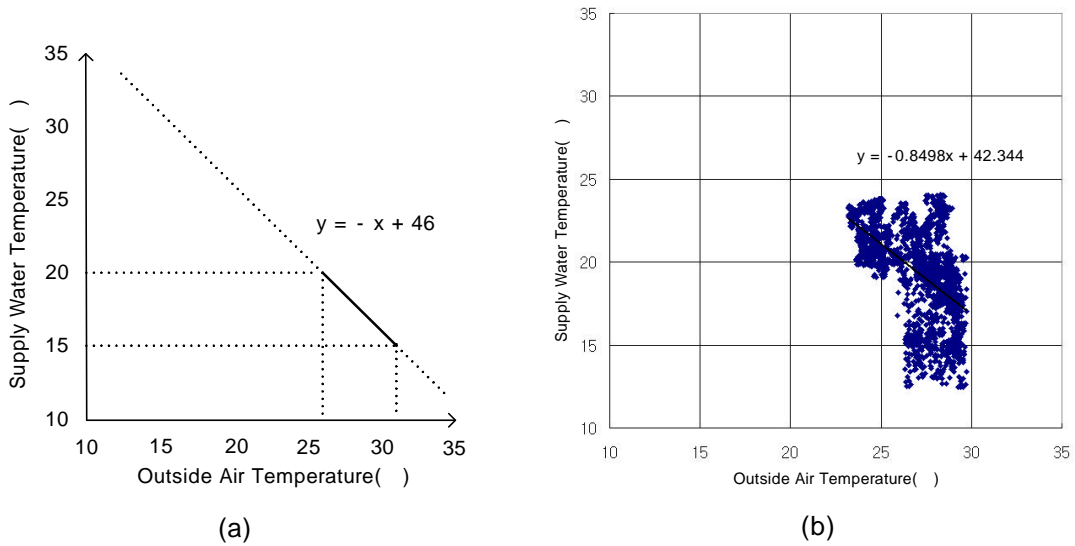


Fig. 7 Relation between outside air temperature and supply water temperature.

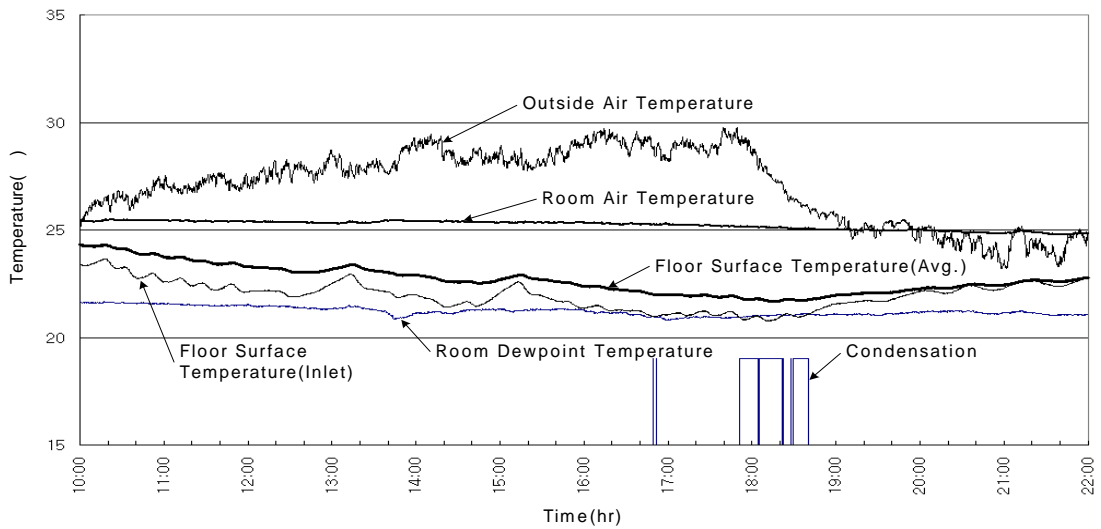


Fig. 8 Profiles of room conditions by radiant cooling.

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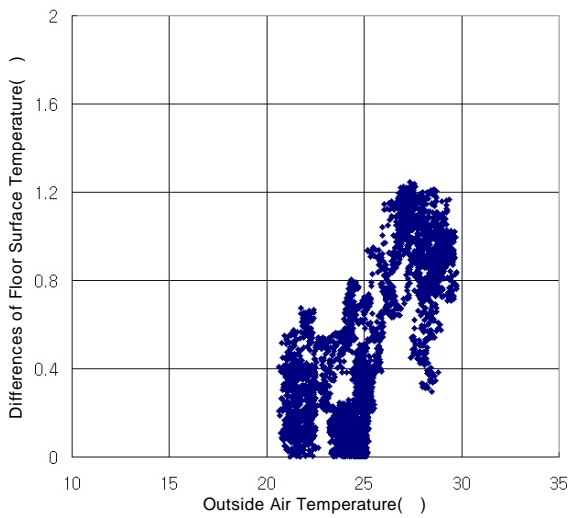


Fig. 9 Difference between average floor surface temperature and floor surface temperature above the supply pipe.

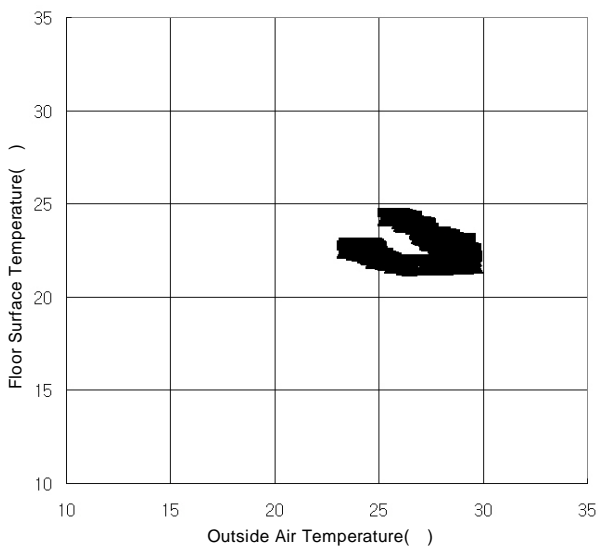


Fig. 10 Relation between outside air temperature and floor surface temperature.

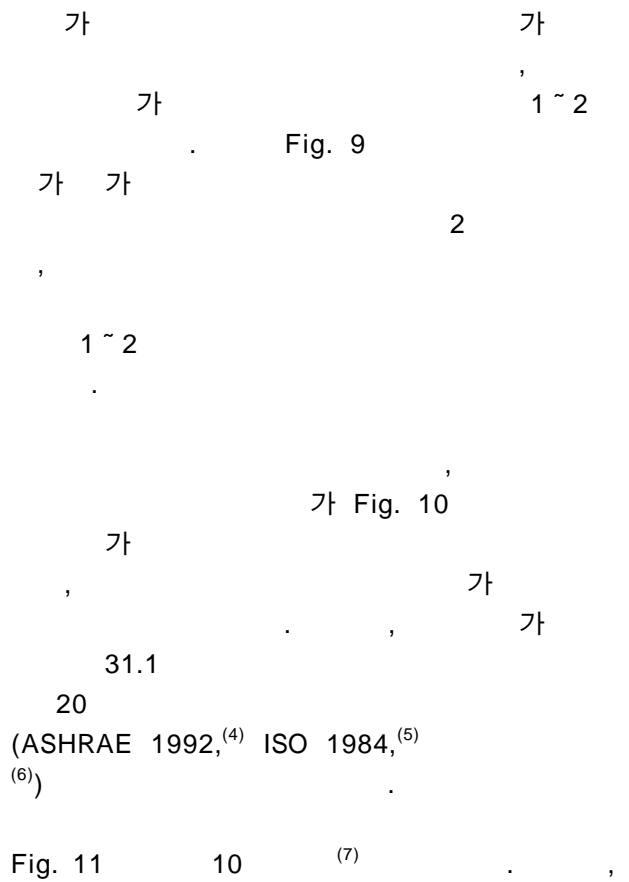


Fig. 11

Fig. 11 Differences between floor surface temperature and wall surface temperature.

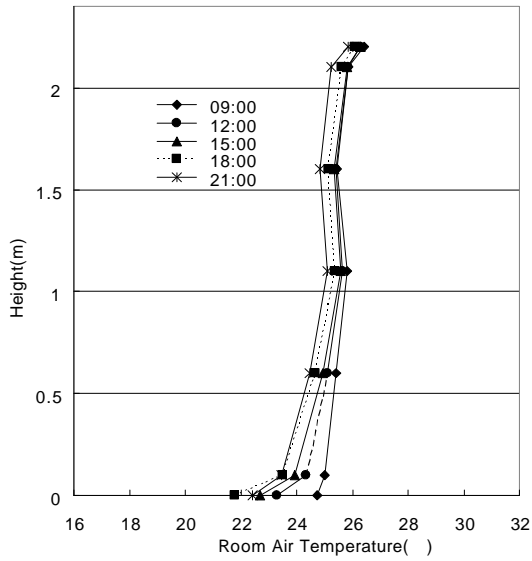


Fig. 12 Profiles of vertical air temperature.

1.3 , Fig. 12 1.9 (mean absolute error, MAE)가 (0.1 m) 3 (ASHRAE 1992, ISO 1984)

4.2

(offset)

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Table 1 Comparison of on/off bang-bang control, variable flow control, and outdoor reset with indoor temperature feedback control

Control		On/off	Variable flow	Outdoor reset with indoor temperature feedback
Room Temp. ()	Avg.	25.64	24.19	26.09
	STDEV	0.60	0.71	0.77
	Max.	26.82	25.90	27.77
	Min.	24.72	22.67	24.66
Floor Surface Temp. ()	Avg.	22.73	20.83	22.92
	STDEV	1.18	0.37	0.95
	Max.	25.28	21.73	24.52
	Min.	20.01	19.89	20.93
MAE (Room Temp.-Setpoint)	Avg.	0.61	1.81	0.65
	Internal heat	0.34	1.33	0.86
	Non-heat	0.64	1.86	0.63
MAE (Room Temp.-Average)	Average	0.53	0.57	0.65
	Internal heat	0.50	0.64	0.82
	Non-heat	0.53	0.56	0.64
Condensation (hour : minute)		12 : 32	1 : 10	0 : 00

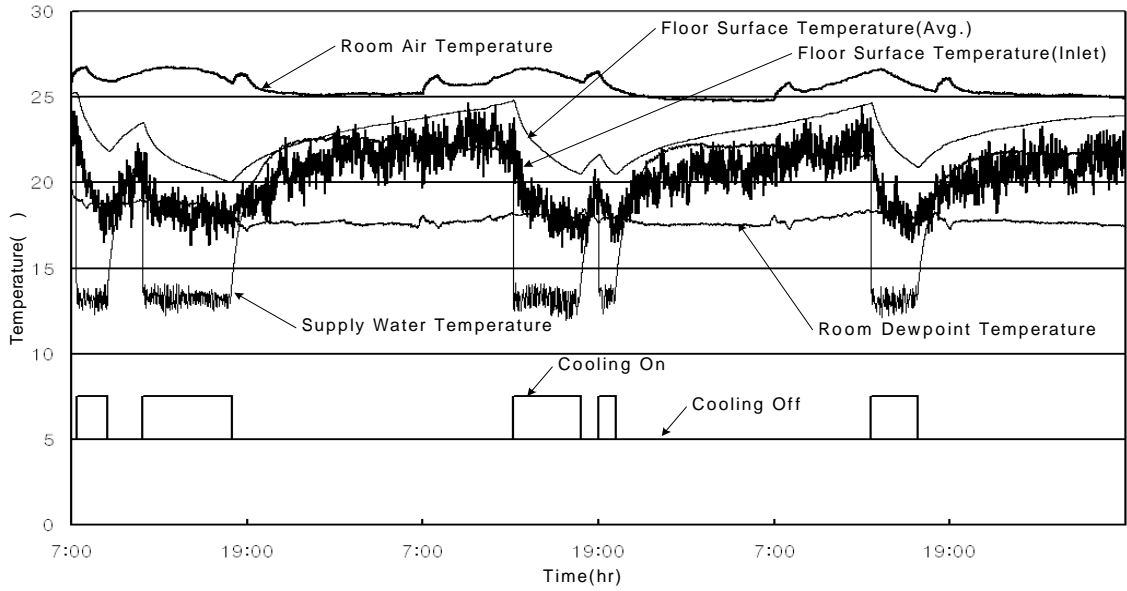


Fig. 13 Profiles of temperatures and flow for on/off control.

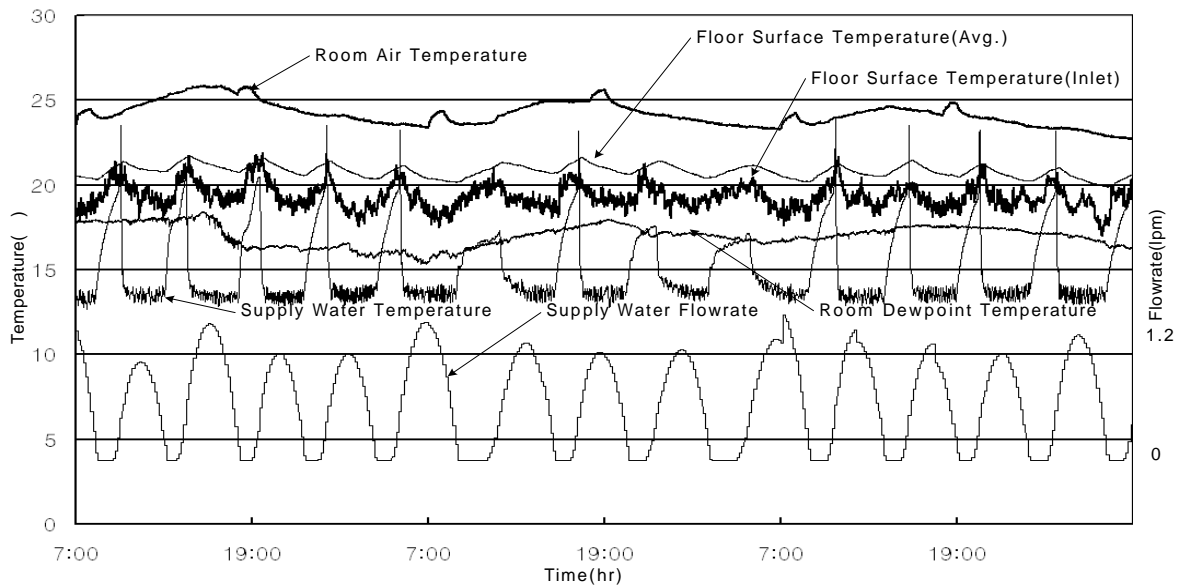


Fig. 14 Profiles of temperatures and flowrate for variable flow control.

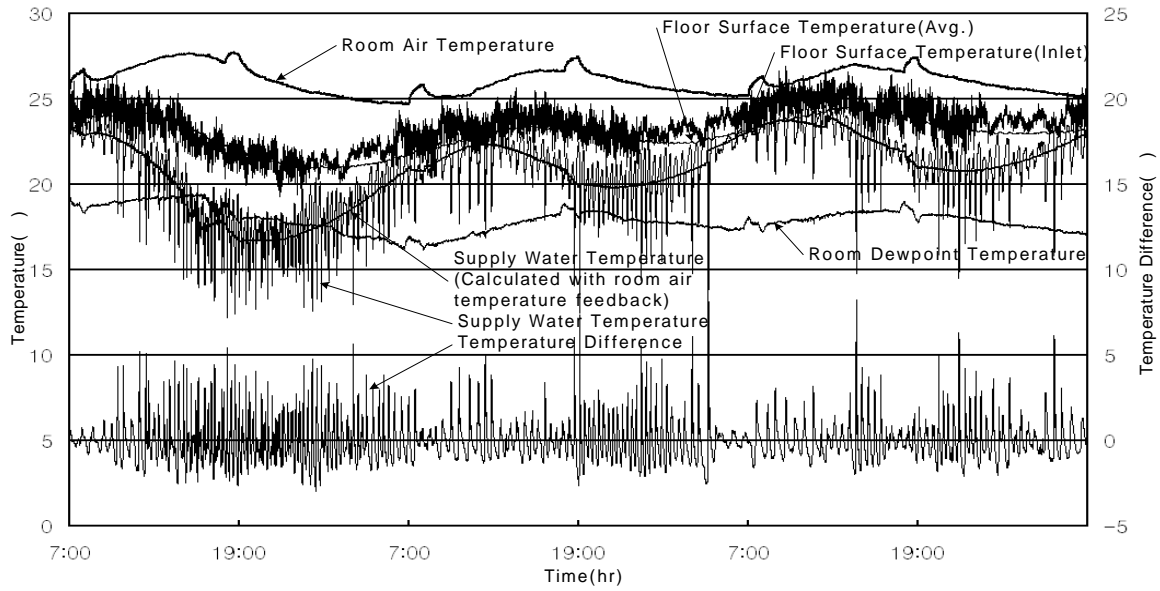


Fig. 15 Profiles of temperatures for outdoor reset with indoor temperature feedback control.

4.2.2

(linear type)

Fig. 13

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4.2.4

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Fig. 15

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4.2.3

Fig. 14

(stem)

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(1)

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