Task AC unit operating rate prediction in office

Tatsuo Nobe[a,*], Shin-ichi Tanabe[b], Yumie Tomioka[b]

[a]*Department of Architecture, Kogakuin University, Japan;* [b]*Department of Architecture, Waseda University, Japan*

ABSTRACT
The purpose of this paper is to know how the personal air-conditioning system could be used in the office. For this purpose, the investigation of seat occupancy rate was conducted in two actual offices. Whether working persons had sat in their chairs or not was automatically recorded for more than a week using thermal sensors. In these offices, it turned out that many persons had repeated taking and leaving their seats for a short time.

INDEX TERMS
Task/ambient conditioning; Operating rate; Seat occupancy rate

INTRODUCTION

The authors believe the possibility of new development in task/ambient or personal air-conditioning system. These kinds of air-conditioning systems obviously improve working person's thermal environment. By using a task unit, the ambient air-conditioning system can be made simpler and, moreover, its whole energy consumption may become less than the conventional air-conditioning system.

Several reports investigated seat occupancy rate as a research of the free address office (Sunayama *et al.*, 1997; Yamada *et al.*, 1998). However, there was no quantitative analysis about how the task unit could be used in conventional research. Therefore, it was difficult to predict the effect the personal air-conditioning system had on the actual office.

This paper reports the investigation result on seat occupancy rate in an actual office in Japan.

OBJECT

Figure 1 shows investigated offices. In both offices, each working person usually sat at his/her assigned desk and used individual laptop computers. Their personal computers were connected to the LAN network. However, since paperless environment was not realized completely, the working persons occasionally went to the common space where the shared printers and copying machines were installed.

Figure 1 The investigated room (left 2001/right 2002).

INVESTIGATION IN 2001

The investigated office was in a 52-storey office building located in the centre of Tokyo. The

* Corresponding author. E-mail: nobe@cc.kogakuin.ac.jp

investigation was conducted in eight sections where a total of 240 office workers were engaged in various kinds of works. The investigation was carried out from 5 September to 21 November 2001.

The sensing device continuously recorded the seating status of each working person for 1 week. The interval of measurement was 1 min. The authors also carried out a questionnaire survey that asked the types of the work done by all the working persons. The details of this investigation are described elsewhere (Kameda *et al.*, 2002; Nobe *et al.*, 2002a,b; Tomioka *et al.*, 2002).

INVESTIGATION IN 2002

The survey investigation was conducted from 30 November to 26 December 2002 in the office of Kogakuin University located in Tokyo. There were 81 workers who were engaged in clerical work. The method was same as that used in 2001. In addition, the authors counted the number of persons in the room to find out how many people were standing there.

Table1 shows the difference between the investigations in 2001 and 2002.

Table 1 Difference between investigations in2001 and 2002

		2001		2002	
Consultation period		From September 5 to November 21		From November 30 to December 26	
Area		4500 m^2		710.1 m^2	
Subject	Number	240		81	
	Sex	Male	155	Male	43
		Female	21	Female	19
		No answer	64	No answer	19
	Work	Clerical work	45	Clerical work	81
		Technical work	47		
		Business work	82		
		Other	3		
		No answer	63		
	Age	Under 20	1	Under 20	0
		20s	18	20s	10
		30s	60	30s	16
		40s	64	40s	15
		50s	32	50s	11
		Over 60	6	Over 60	10
		No answer	59	No answer	19
Average office hours		From 8:40 to 19:00		From 9:00 to 18:00	

METHODS

A sensor that detects the surface temperature change at the time of seat occupation was installed on the surface of every working person's chair, and a small data logger recorded the measured value. It was confirmed by the preliminary experiment that the optimal sensing position was a point that shifted from the centre of the seat to the left or the right 70 mm, and was further left 70 mm to the front. The sensor was covered with a seat cover of thick cloth so that the working person may not feel discomfort due to the sensor (Figures 2 and 3).

The preliminary experiment showed that the temperature measured by the sensor would change abruptly if a working person sat on the chair.

The authors judged the term when the temperature of the sensor changed more than 0.2°C/min, or changed more than –0.5°C/min and more than 30°C to be the seat occupied (Figure 4).

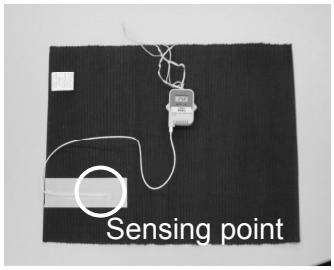

Figure 2 Sensor and seat cover (back).

Figure 3 Measurement condition of chair.

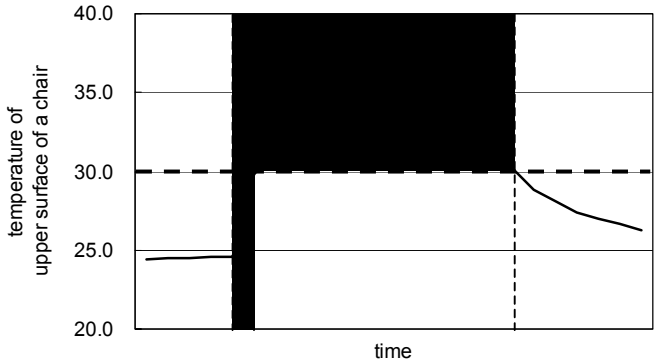

Figure 4 Temperature change of sensor.

RESULTS

Questionnaire Results

In 2001, effective replies were obtained from 182 persons of a total of 240 working persons of the office. The number of subjects who clarified his/her type of work was 174. The questionnaire showed that the working person's job could be classified into three categories: clerical work (25%), technical work (27%) and business work (46%). A total of 88% of the working persons was males. Their age composition was as follows: in their 20s, 10% of the all the persons; 30s, 33%; 40s, 35%; and 50s, 18%.

In 2002, effective questionnaire replies were obtained from 62 persons of a total of 81 working persons of the office. The questionnaire showed that 69% of the working persons were males. Their age composition was as follows: in their 20s, 16% of all the persons; 30s, 26%; 40s, 24%; 50s, 18%; and over 60, 16%.

Seat Occupancy Rate

Figure 5 shows the percentage of seated occupants to all the members who have their own desks in this office. The graph shows the data measured for every minute as average value for 10 min.

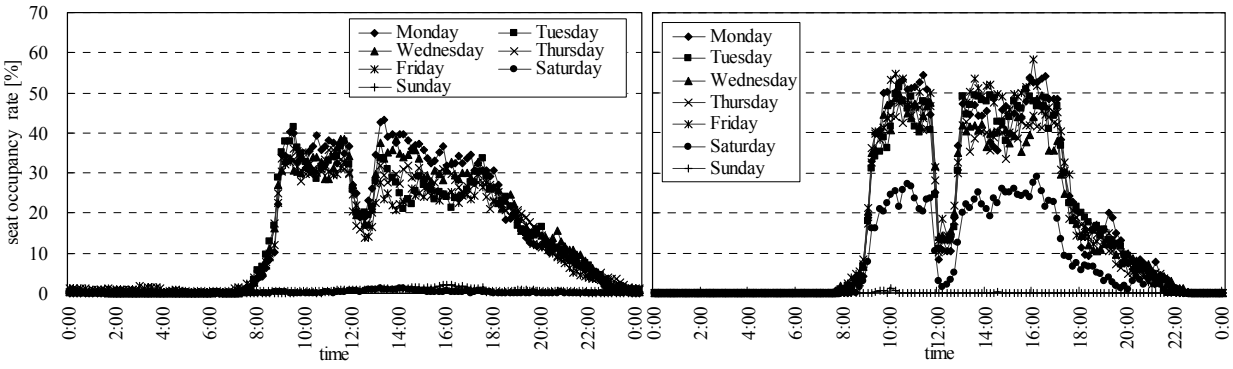

Figure 5 Seat occupancy rate of all the members (left 2001/right 2002).

The average seat occupancy rate in the office hours in a weekday was 29% in the 2001 investigation and 39% in the 2002 investigation. Table 2 shows the average rate by the day of the week.

Table 2 Average seat occupancy rate (%)

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
2001	32	28	30	27	26	0.39	0.87
2002	40	39	37	36	42	19	0.06

In the 2001 investigation, the measured value on holiday and the midnight of weekdays was 2% or less. The seat occupancy rate in weekday opening and overtime work hours showed a similar change and many working persons left their seats during the lunch break. The measured value before noon of weekday had 10% of a difference by the day of the week. This difference was still large in the afternoon, and was 20% or more.

In the 2002 investigation, about 30% of the workers came to the office.

Figure 6 shows the average seat occupancy rate for each type of work during weekday office hours for the attendant only (the outing persons were removed). As well as the peak value, the average seat occupancy rate of the clerical work was higher than technical and business work. It was proved from Figure 6 that the working person was not located at his/her desk most of the time, even if he/she attends office.

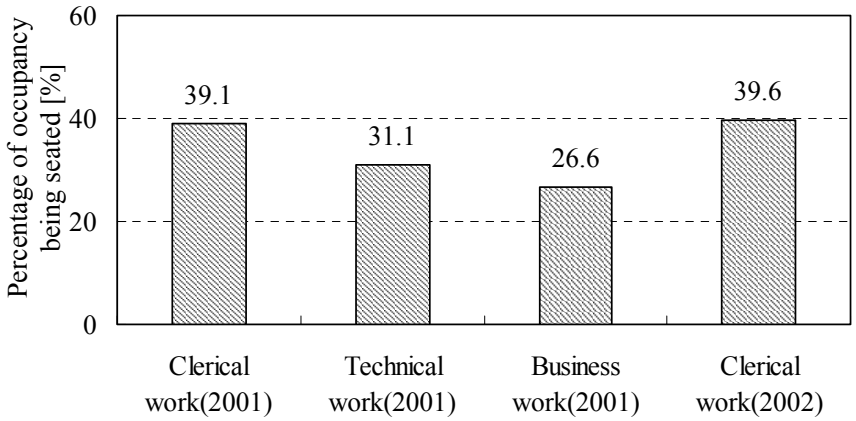

Figure 6 Average seat occupancy rate during weekday office hours for the attendant only.

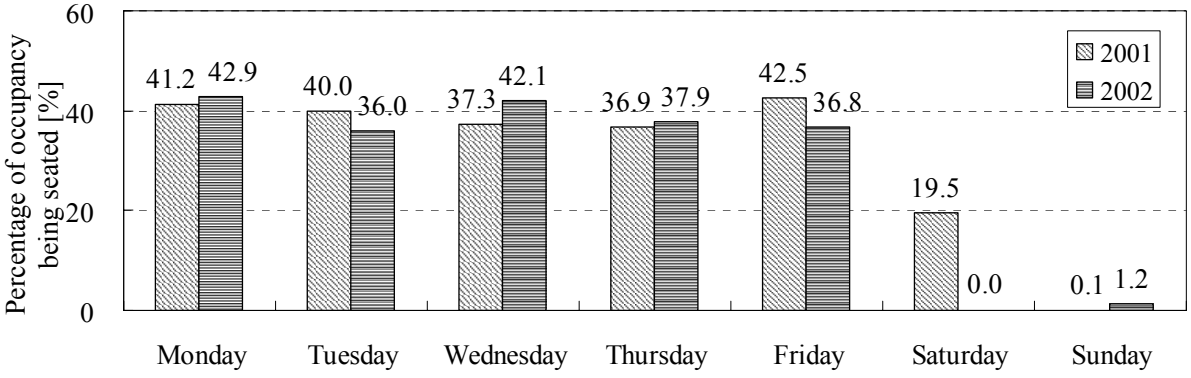

Figure 7. Average seat occupancy rate during office hours for the attendant only. (Clerical workers)

Figure 7 shows clerical worker's average seat occupancy rate during office hours. It contains only attendants except for the outing persons. On weekdays, regardless of the day of the week, the clerical worker's seat occupancy rate was about the same.

Seating Duration Time

Figures 8 and 9 show the average frequency distribution of a working person's seating duration time. The frequency was converted per day. It was observed that the working person tended to leave his/her seat again within the short period, even if he/she once sat in his/her seat. This tendency was observed regardless of the types of work.

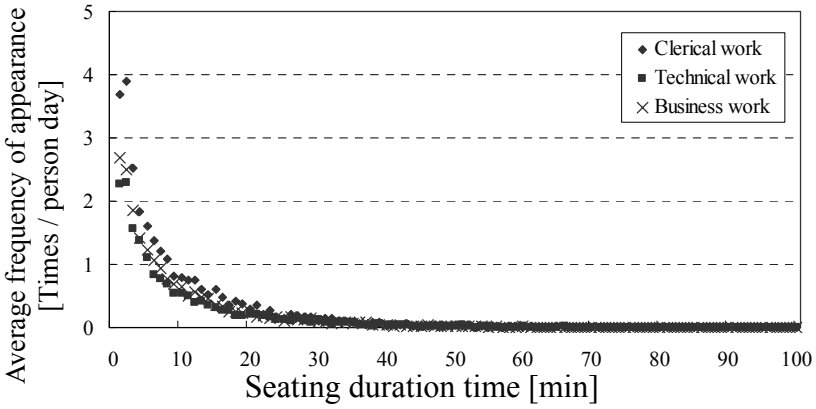

Figure 8 Frequency distribution of seating duration time (2001).

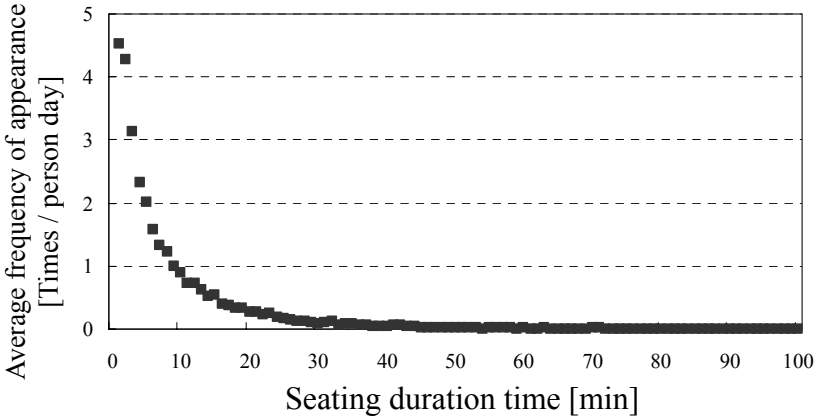

Figure 9 Frequency distribution of seating duration time (2002).

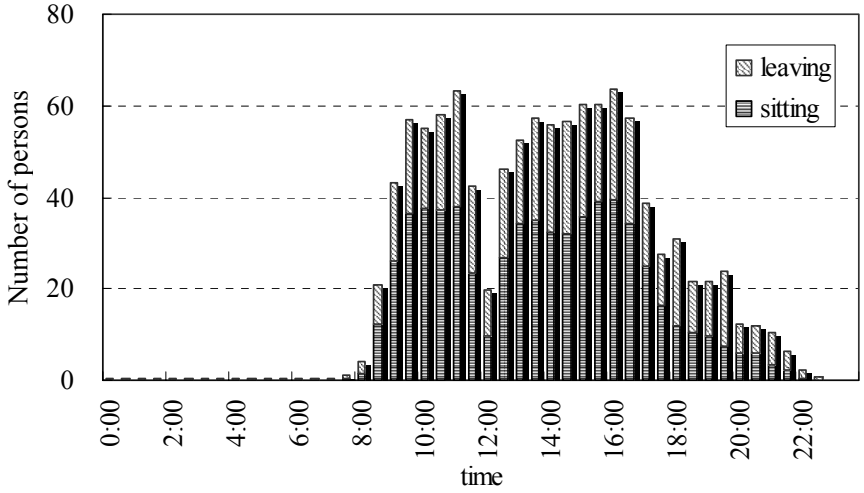

Figure 10 Number of persons that sitting and leaving their seats.

Behaviour of Person in Office

Figure 10 shows the number of persons who were sitting and leaving their seats in the office. This is an average value in weekdays. The latter shows the number of persons who left their

seats but remaining in the room. It is calculated by subtracting the number of sitting persons from the number of existing persons in the room. It was measured with the passing counter installed at the entrance of the room.

CONCLUSIONS

When a designer or an engineer designs a task/ambient air-conditioning system, he usually pays attention only to the environment of the task area. But, according to the result of these actual investigations, it became clear that office workers were taking and leaving their seats frequently. Therefore, the environment of ambient area is also important.

On the other hand, if a point of view is changed, adaptive model (de Dear, 1997) and pleasantness theory (Kuno, 1995) can be applied effectively by cooperation of task and ambient environment.

These investigations were carried out only in Japan. Therefore, it is not clear whether the working styles of other countries are the same as Japan.

ACNOWLEDGEMENTS

The authors would like to express sincere gratitude to Mr Sueng-jae Lee, Mr Kenji Kameda, Mr Yasushi Nishitani and Mr Hiroyasu Sumiya for their cooperation on this study.

REFERENCES

de Dear, R. (1997). Developing an Adaptive Model of Comfort and Preference Final Report, ASHRAE, RP-884.

Kameda, K. *et al.* (2002). Research on task/ambient conditioning system (Part 1). Summary of measurement of the seat occupancy situation in office. *Summaries of Technical Papers of Annual Meeting of AIJ*, E-2, pp. 1053–1054 (in Japanese).

Kuno, S. (1995). Comfort and pleasantness. *Proceedings of Pan Pacific Symposium on Building and Urban Environmental Conditioning in Asia*, Vol. 2, pp. 383–392.

Nobe, T. *et al.* (2002a). Investigation of seat occupancy rate in office. *Proceedings of Roomvent2002*, pp. 289–292.

Nobe, T. *et al.* (2002b). Research on the database of how to use office. Part 1: Investigation of work situation. *Technical Papers of Annual Meeting of the Society of Heating, Air-Conditioning and Sanitary Engineers of Japan*, Vol. 3, pp. 1673–1676 (in Japanese).

Sunayama, Y. *et al.* (1997). The study of efficient use of a research office in a national university. Part 3: Method for surveillance of attendance rate in a research office. *Summaries of Technical Papers of Annual Meeting of AIJ*, E-1, pp. 497–498 (in Japanese).

Tomioka, Y. *et al.* (2002). Research on task/ambient conditioning system (Part 2). Analysis of the seat occupancy situation in office. *Summaries of Technical Papers of Annual Meeting of AIJ*, E-2, pp. 1055–1056 (in Japanese).

Yamada, T. *et al.* (1998). A study of the territoriality in office spaces. Part 6: User's behavior and image in a free-address office. *Summaries of Technical Papers of Annual Meeting of AIJ*, E-1, pp. 661–662 (in Japanese).