

사무소건축의 실내온열환경 평가방법에 대한 연구 A Study on the Evaluation Methods of Indoor Thermal Environment in Office Building

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<Abstract>

1. The objective of this paper is to investigate the indoor environment from the viewpoint of interaction between physical environment and the human responses.
2. A continuous measurement has been carried out for 1 year and distribution of variables have been measured for 1 day.
3. The attitude of workers was investigated by a questionnaire.
4. As the result, average luminance represented more than 800-1800 lx in the office, in contrast with less than 1000 lx in the encourage luminance of an office.
5. There was a significant difference of the occupants' response to the light environment between the neighboring environments.
6. Measured thermal conditions are on the edge of the ASHRAE comfort envelope in summer, and in the neighborhood of the lower dry limit of the envelope in spring.

Key Words : office building, indoor thermal environment, post occupancy evaluation, physical environmental condition

1. Introduction

In the present time we tend to demand comfort and efficiency in the office. In Korea, the working population has increased due to increased financial strength. Under these circumstances, studies regarding the office have been going on for a few years from many points of view. It is also necessary to investigate the occupants' comfort environment for these few years. The previous post

occupancy evaluations cannot clarify the relation between physical environment and human responses from the viewpoint of overall evaluation.

This study reports on the office environment from five points of view : heat, air, lighting, sound and space environment. We will show that people working in the room may be influenced by environmental elements, and we will try to obtain fundamental data to establish indoor environmental planning in an office building.

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2. Method

Table 1 shows a schedule of field surveys. We measured responses of workers and physical environment variables. Measurements were carried out 3 times a day, the morning(9:30), daytime(13:30), evening(16:30). Responsiveness of workers was investigated by a questionnaire. The items of questionnaire were selected from five points of view : psychological responses to heat, air, lighting, sound and space environment.

Table 1. Schedule of investigation

Investigation's number	Measurement-term	Distribution & Questionnaire
1st (January)	2003.01.16-2003.01.18	2003.01.17
2nd (April)	2003.04.11-2003.04.13	2003.04.12
3rd (August)	2003.08.21-2003.08.23	2003.08.22
4th (October)	2003.10.16-2003.10.18	2003.10.17

Table 2 shows measuring instruments of physical environment variables. The following variables were measured : air temperature, humidity, air velocity, surface temperature, globe temperature, illuminance (5 directions), luminance, solid angle projection area factor, noise level.

Table 2. Measuring conditions and instrumentation

Item	Instrument	Position
Thermal environment		10,90,180cm high
air temperature	digital hygro-thermometer thermocouple C-C	
humidity	Assmann's psychrometer	
air velocity	digital anemometer	
thermal radiation	globe thermometer	
Acoustic environment		120cm high
noise level	sound level meter	
Light environment		horizontal
illuminance	illumination photometer	vertical
luminance	luminance meter	4-direction
solid-angle	camera + orthographic	
projection factor	projection fish-eye lens	

Table 3 shows number of valid responses. Questions are 32 items. Table 4 shows question items.

Table 3. Number of valid questionnaires

Investigation's number	A	B	C
1st	16	18	15
2nd	19	20	17
3rd	18	19	17
4th	20	19	17

Notes : A-morning(09:30) B-noon(13:30) C-evening(16:30)

Table 4. Question items

Item
1. Whole body thermal sensation
2. Upper body thermal sensation
3. Lower body thermal sensation
4. Wetness sensation
5. Air movement
6. Smell
7. Dust
8. Cigarette smoke
9. Illumination on de 나
10. Illumination in room
11. Coloring
12. Silence
13. Echo
14. Vibration
15. Extent of room
16. Extent of work space
17. Furniture arrangement
18. Relaxation
19. Order sensation
20. Refinement of room
21. Plenty of space
22. Greenness of indoor
23. Stain
24. Privacy
25. Reassuring
26. Concentration on work
27. Comfort sensation
28. Efficiency of work
29. Indoor-thermal environment
30. Indoor-sound environment
31. Indoor-light environment
32. Synthetic indoor environment

3. Physical environment condition

3.1 Noise level

Figure 1 shows a change of an average level of noise level (Leq). In the office, noise level was about 58dB. Sound environment was improved a little above the normal noise level(50-55dB) of office.

3.2 Horizontal illumination

Figure 2, 3, 4 and 5 show comparison of perceived brightness of illumination between the January, April, August and the October. In the January, April, and October almost all occupants reported "-1" in voting scale, but they reported "0" and "+1" in the August. Lighting environment was improved also in the human perception. Figure 6 show horizontal distribution of illuminance in the office. Average luminance represented 800-1800 lx in the office.

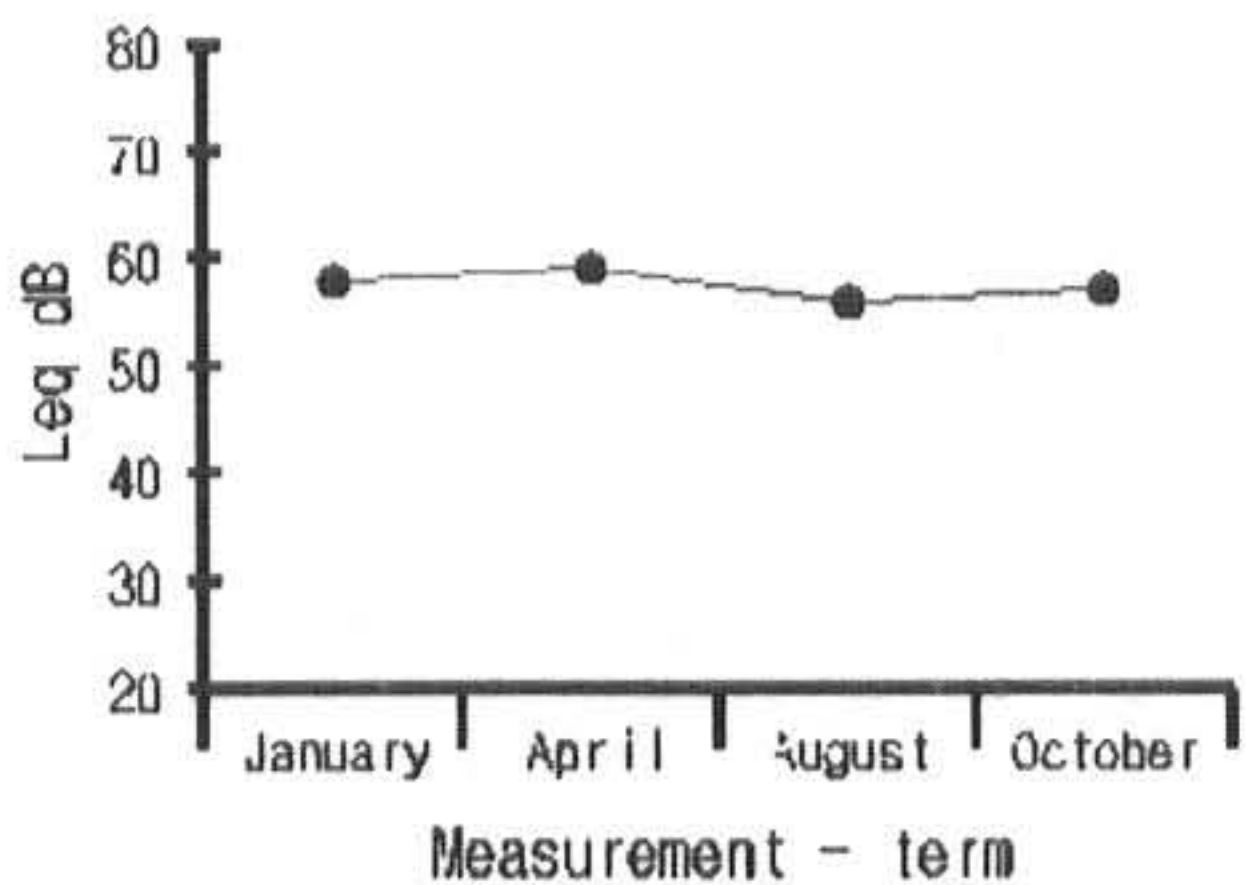


Fig.1 Mean noise level at each measurement period.

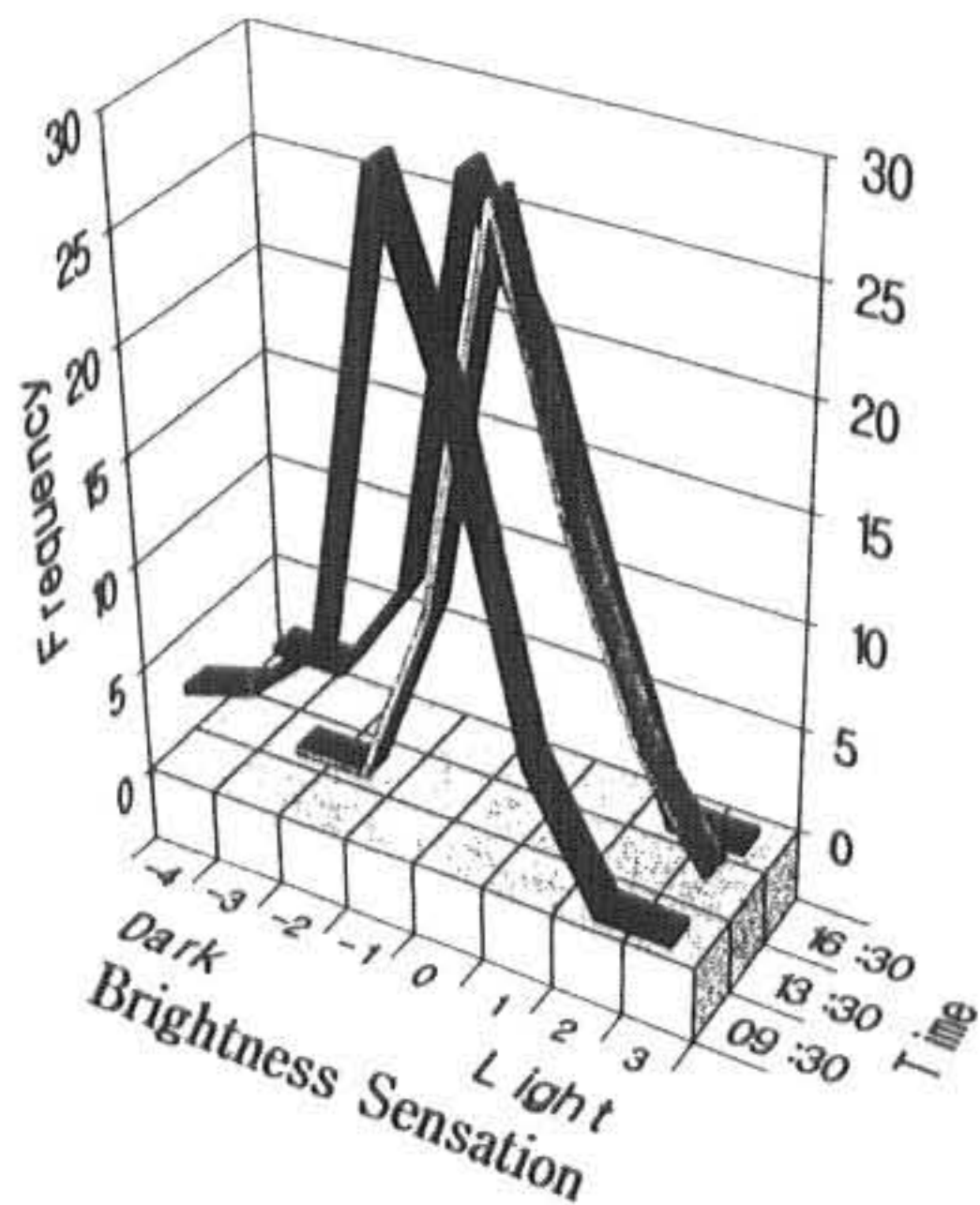


Fig.2 Voting number of brightness sensation(January).

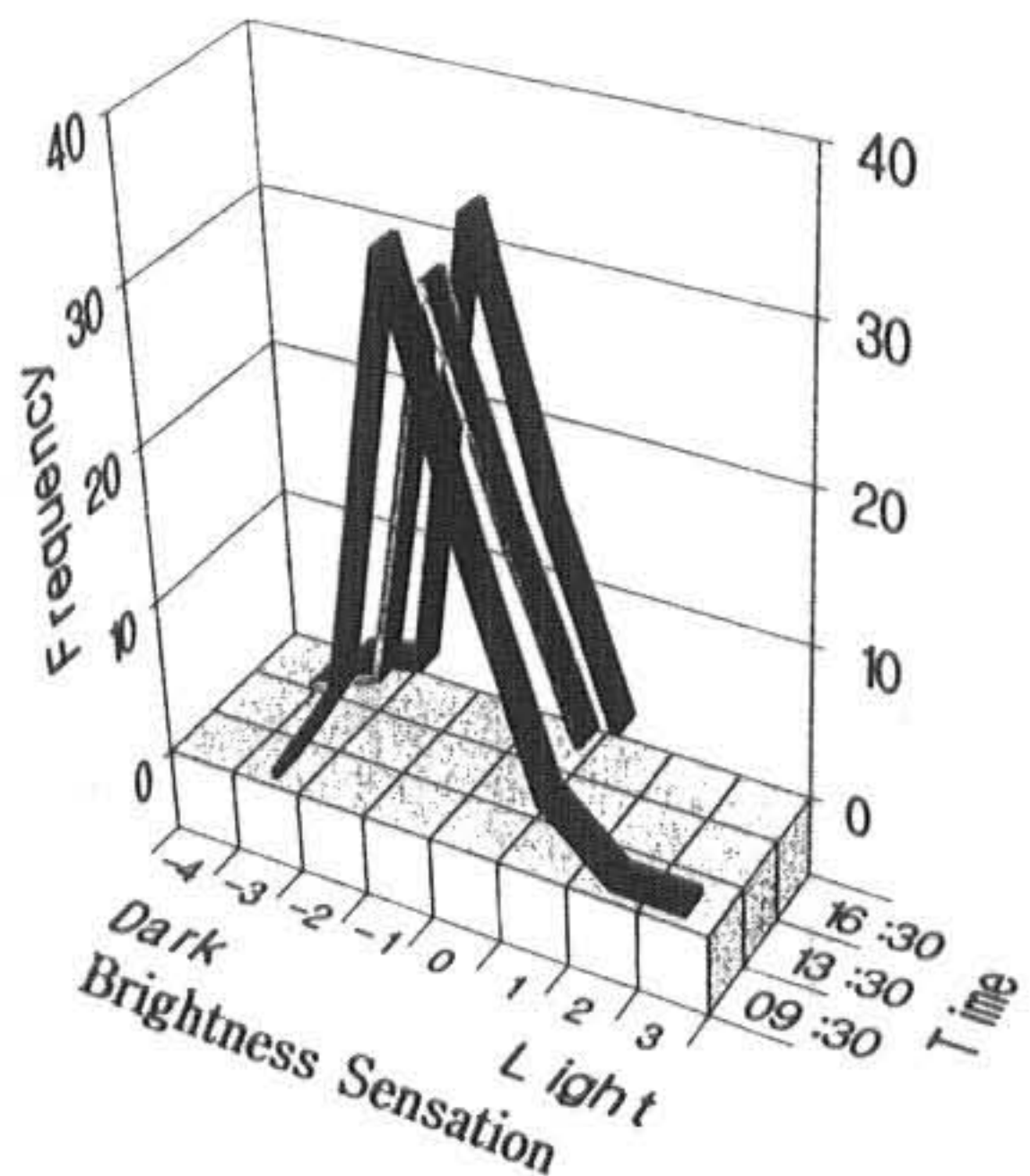


Fig.3 Voting number of brightness sensation(April).

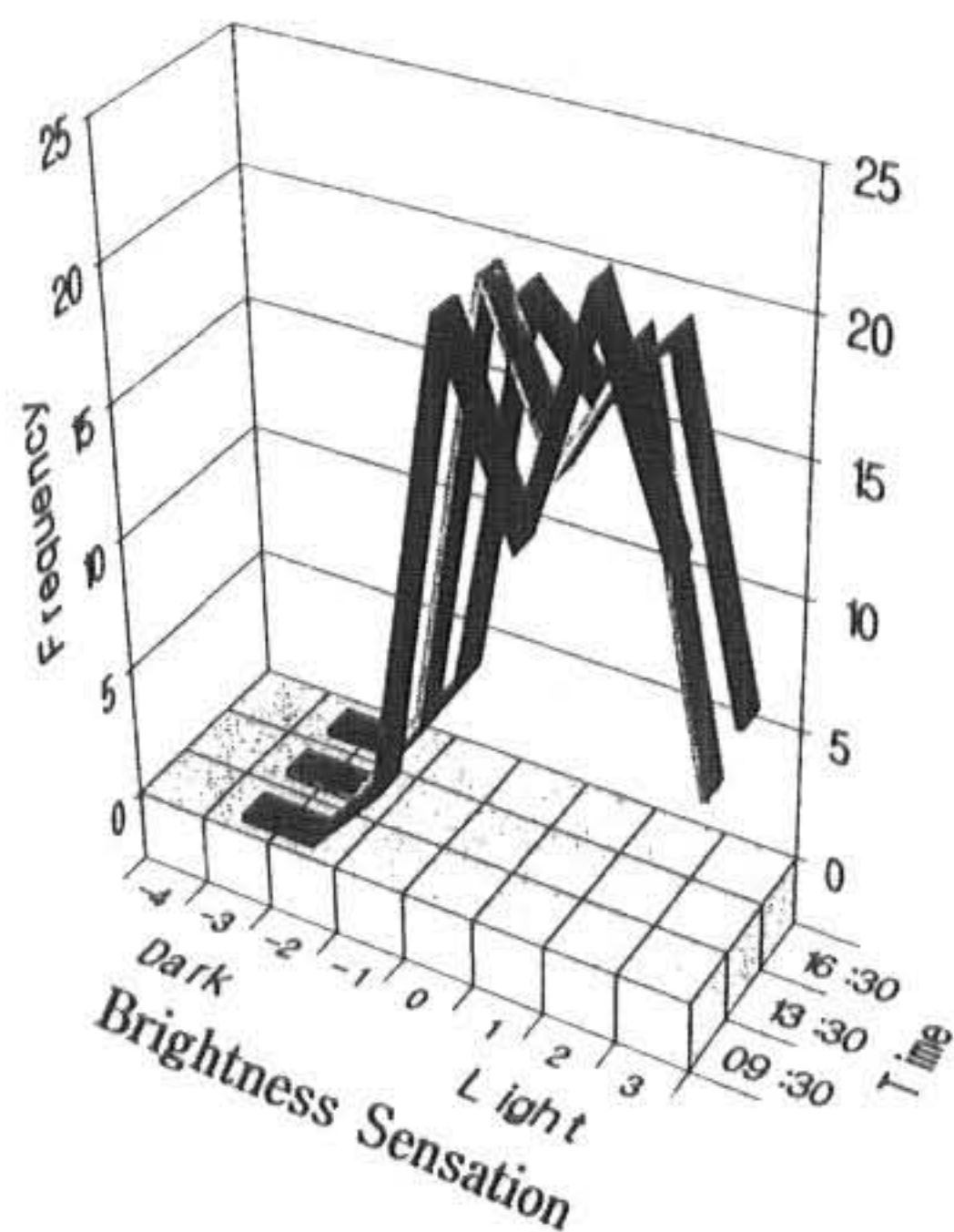


Fig.4 Voting number of brightness sensation(August).

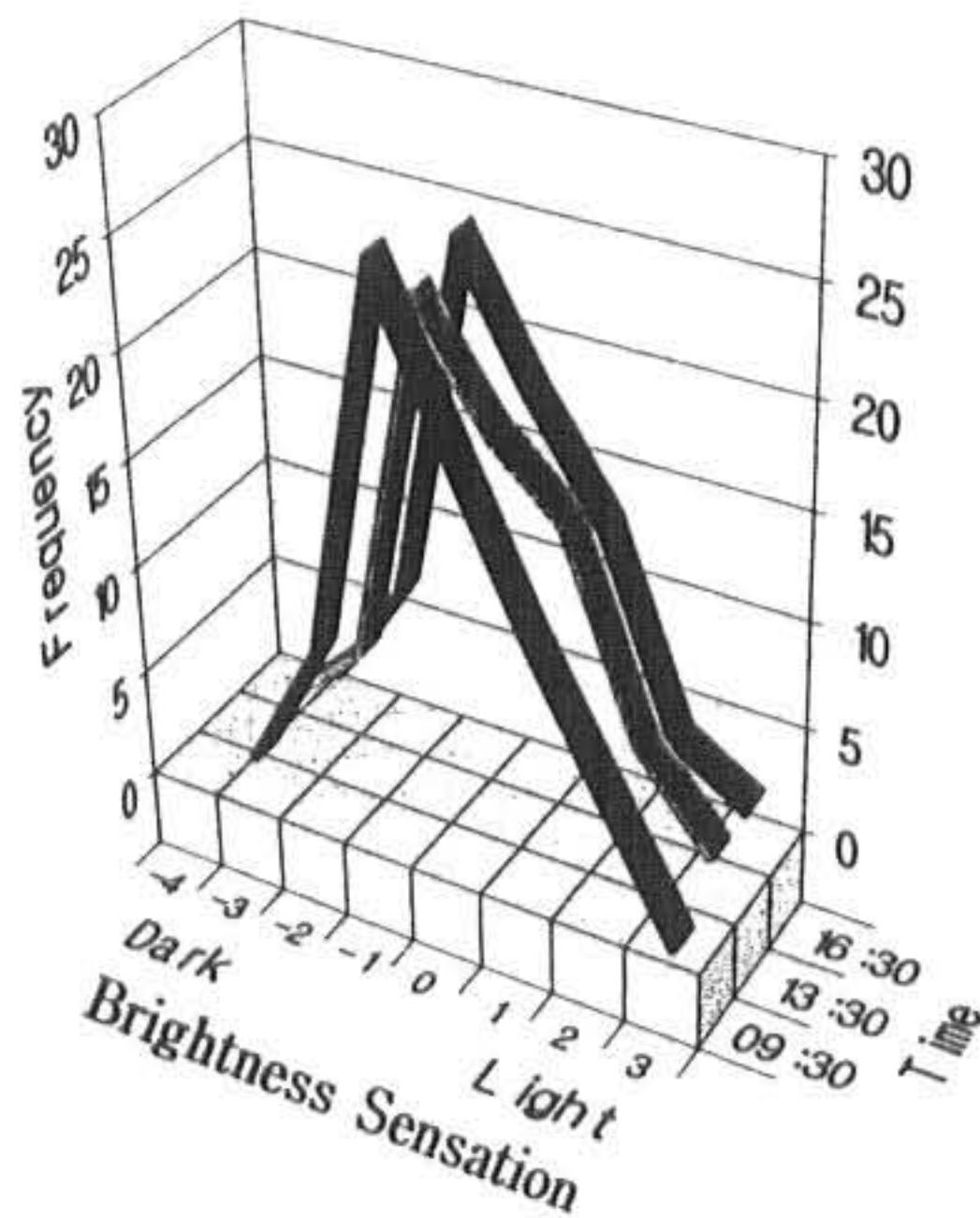


Fig.5 Voting number of brightness sensation(October).

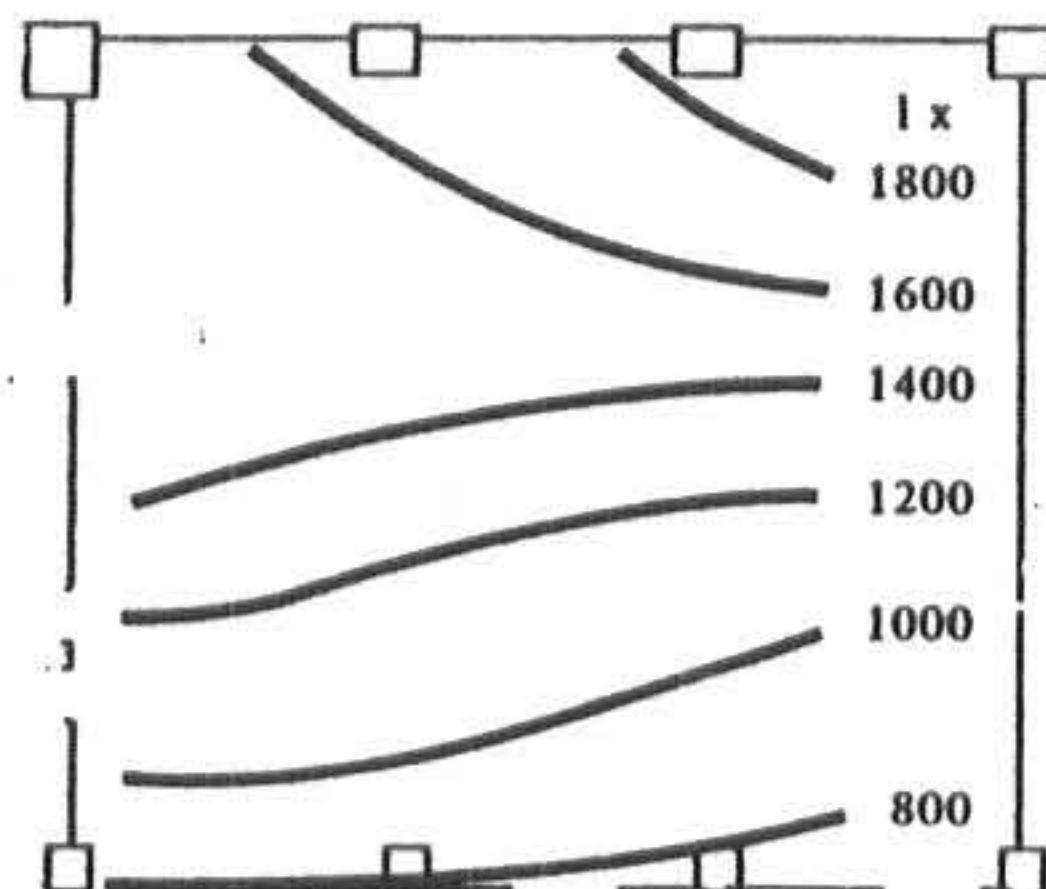


Fig.6 Horizontal distribution of illuminance on the desk.

3.3 Thermal environment

Figure 7,8 and 9 show thermal conditions in the office. Humidity in April was low, and humidity was less than 30% in the morning. Thermal conditions were in the neighborhood of the lower dry limit of the ASHRAE comfort envelope(ASHRAE,1989). In the office the measured thermal conditions were on the edge of the ASHRAE comfort envelope in summer, and they were in the intermediate zone of summer and winter envelope in winter. Thermal conditions were warmer in the investigated office than the other general office building.

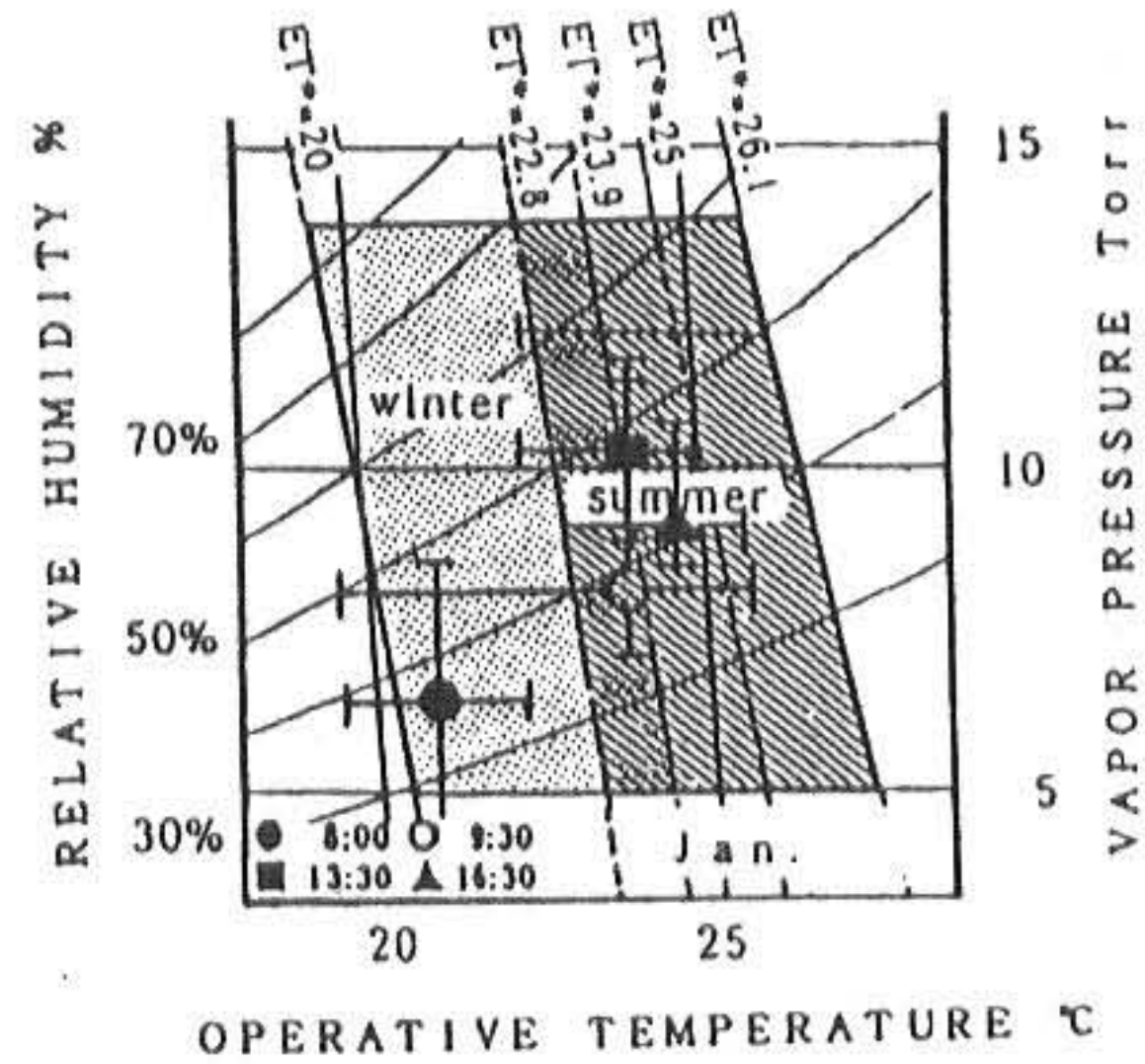


Fig.9 Thermal condition on psychrometric chart(January).

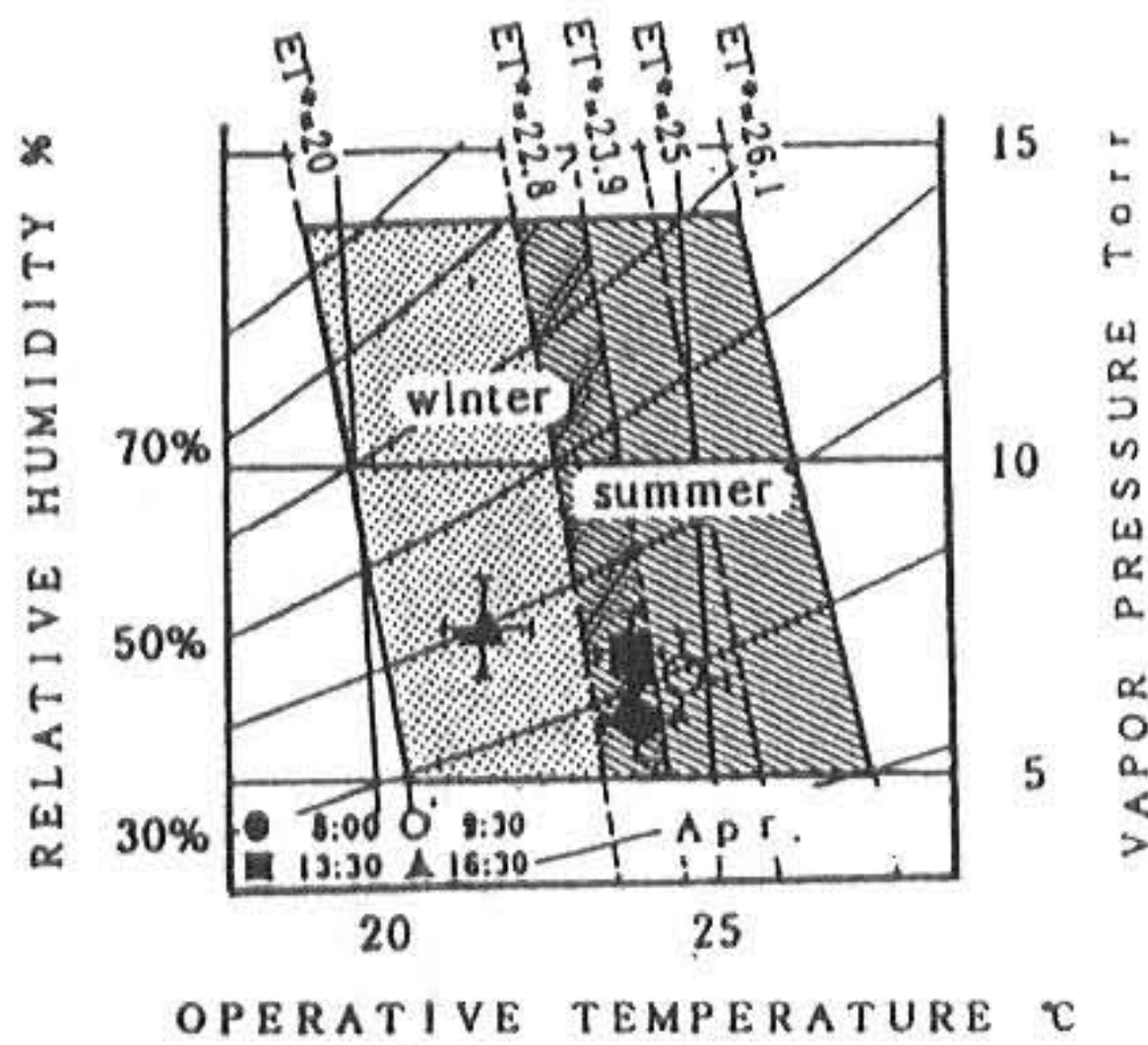


Fig.7 Thermal condition on psychrometric chart(April).

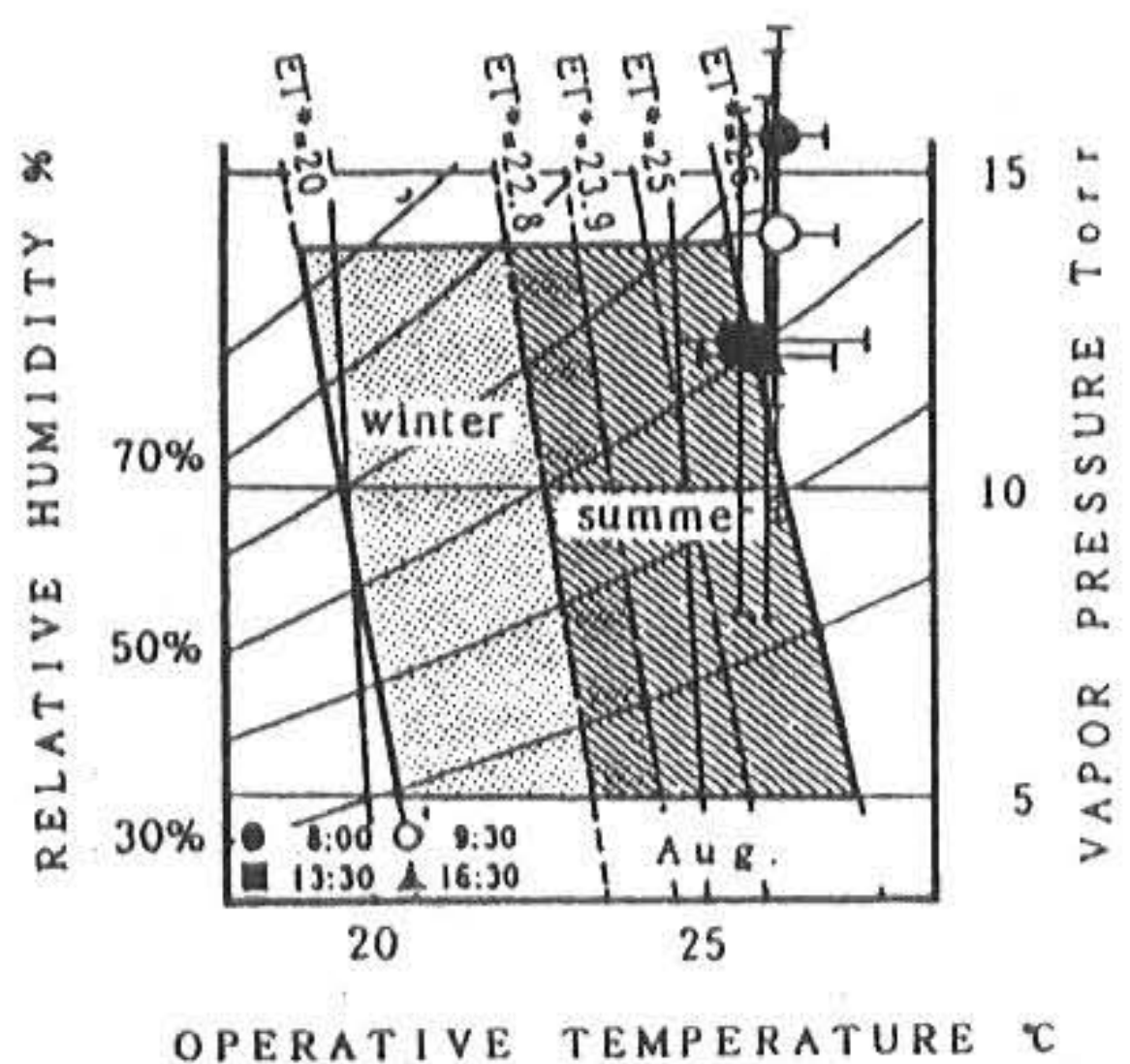


Fig.8 Thermal condition on psychrometric chart(August).

4. Occupants' evaluation

In order to classify occupants' evaluation on each survey, Cluster analysis (Euclid distance, Ward method) was carried out. Daytime data were analyzed because of its stability. The 32 items of the occupants' evaluation were used for the analysis. From the analyzed result, the occupants' evaluation was classified into the office around rescaled distance cluster combine of 25. The occupants' evaluation on the indoor environment were a little changed by the time of the year. The occupants' evaluation was also classified into the office section and the other section around rescaled distance cluster combine of 12 in the neighboring offices in building. However, the occupants' evaluation in the office was classified into the office and the neighboring office around rescaled distance cluster combine of 3. A difference between occupants' evaluations in the office section and the neighboring office section in the office became clear in comparison to the office. Consequently, in the office compared with a neighboring office, a difference has been affected by types of work in the occupants' evaluation.

In order to verify the difference of the occupants' evaluation for each survey, we conducted *t*-test. It is as follows a result of *t*-test. Difference in occupants' evaluation

between first and the other surveys were observed for many items in the office section. The occupants' evaluation have changed remarkably over the almost all items before and after moving into the office. But there was no difference in the occupants' evaluation of thermal sensation, wetness sensation and cigarette smoking effect. Though there was no difference between the both offices in thermal sensation votes, a difference in satisfaction of an indoor thermal environment was observed. In results of *t*-test, there was significant difference in thermal sensation votes in the office. Especially in the fourth survey there was notable difference.

In the neighboring office section, difference of the occupants' evaluation on moving into the office was not remarkable. There was notable difference in the occupants' evaluation of the following items : sensation of air movement, dust, illumination on a desk and a room, coloring, spaciousness of room and working space, order of room, plenty of space, comfort sensation and satisfaction of air, lighting and overall evaluation. The following occupants' evaluation were consistent : sensation of cigarette smoking, silence, echo, vibration, privacy, reassuring, concentration on work and satisfaction of indoor sound environment.

5. Conclusions

The objective of this paper is to investigate the indoor environment from the viewpoint of interaction between physical environment and the human responses. For the purpose of it has been carried out on the office environment from five points of view : heat, air, lighting, sound and space environment. The following results were obtained in this study.

(1) Noise level was less than 60 dB in the office but more than 60 dB in the neighboring environment. It was improved a little above the encourage noise level (50 dB to 55 dB) of an office. However, noise

level sometimes reached up to more than 65 dB.

- (2) Average luminance represented 800-1800 lx in the office, in contrast with less than 1000 lx in the encourage luminance of an office. There was a significant difference between the occupants' response to light environment between the neighboring environments.
- (3) Measured thermal conditions are on the edge of the ASHRAE comfort envelope in summer, and in the neighborhood of the lower dry limit of the envelope in spring. Thermal conditions in winter stand in the intermediate zone of summer and winter comfort envelope.

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