

Service manner of maintenance management and occupants' satisfaction to indoor environment

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ABSTRACT: The purpose of this study is to see the relation between service level of maintenance management and occupants' satisfaction to their office indoor environment, and indicate service manner of maintenance management to raise occupant satisfaction to IEQ in office. This study uses results from field surveys conducted in two office buildings. We have found that: (1) maintenance service level does not correspond with occupants' satisfaction level. (2) slight difference on physical environmental condition nearby comfort zone did not affect occupant satisfaction greatly. (3) Help desk service provided by maintenance management organization taking care of occupant claims had a very significant correlation with occupants' satisfaction to indoor environment. (4) adaptive opportunity affects to occupants' satisfaction to IEQ psychologically.

Keywords: Office, Maintenance management, Occupants' satisfaction, IEQ

1. INTRODUCTION

As scales of office buildings become larger and high quality of indoor environment is required, a role of maintenance management organization in office buildings becomes more important. People spend more time in their office wherein occupants' comfort and satisfaction to there indoor environment influences their psychological stability and productivity. The maintenance management organization has the duty of delivering good service to their occupants; with this in mind, occupant's satisfaction is directly related to the quality

of service provided by a building's maintenance management organization. Due to these variables, it is necessary to evaluate two factors quantitatively, that is to inquire the relationship between maintenance management service and occupants' satisfaction to their indoor environment. To add to this, we need to grasp factors that affect occupants' comfort and satisfaction to an office's indoor environment. Through this study, we would indicate basic roles of maintenance management in promoting occupants' satisfaction to indoor environment in an office.

2. PREVIOUS RESEARCH AND PURPOSE OF THIS RESEARCH

In previous research(1), we conducted a survey by providing questionnaires for occupants and maintenance managers in seven office buildings in Seoul in order to compare the level of maintenance management service with the level of occupants' satisfaction. Each building's maintenance management service level was defined using the 'Evaluation index of maintenance management service quality', which was created by Takakusagi.

A checklist, 'evaluation index of maintenance management service quality', was developed by Takakusagi Akira in Japan, 2006(2). It is composed of 8 parts, 90 questions. In this tool, all area of maintenance management service is divided in 8 parts. Each part contained following contents; part 1 is insurance of reliability and prevention of failure in building service, part 2 is prevention of deterioration and obsolescence. Part 3 is energy, water resource and waste management, part 4 is improvement and support of indoor thermal comfort, part 5 is improvement and support of indoor air quality and environmental hygiene, part 6 is supervision of maintenance service, part 7 is plan of renovation, part 8 is risk management.

Answers of each question are graded Level 1, Level 2 and Level 3. Level 1 is the highest and Level 3 is the lowest. All parts of this survey were conducted, but part 1, 4 and 5 was only used in this paper because they are related to occupants' satisfaction to their indoor environment. Using the Takakusagi Tool, the answer ratio of level 1 in all answers was calculated.

Occupants' satisfaction is measured using the 5-point Likert-scale and level of occupants' satisfaction is indicated by percentages corresponding to the variables 'very satisfied' and 'satisfied'.

As the result, the level of maintenance service has negative correlation with the level of occupants' satisfaction.

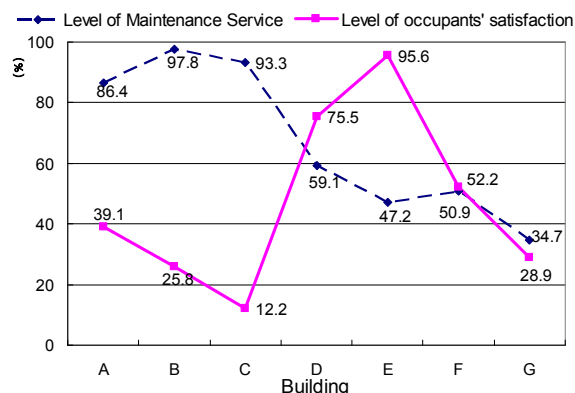


Figure 1: The level of maintenance service and occupants' satisfaction.

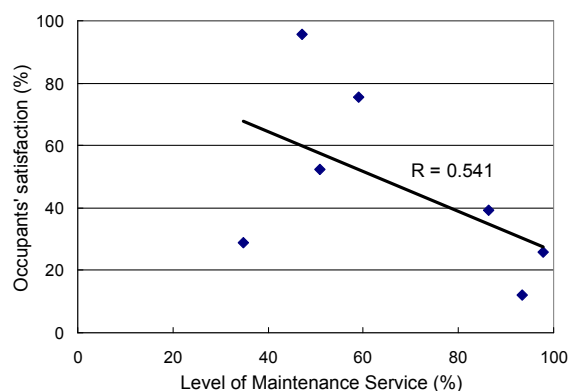


Figure 2: Correlation between the level of maintenance service and occupants' satisfaction.

As shown in Figure 2, when the level of maintenance service goes up or becomes high, then the more occupants' satisfaction goes down or becomes low. Note that building B and C which has the highest level of maintenance service has the lowest level of occupants' satisfaction, while building E which has the lowest level of maintenance service (disregarding data taken from building G) has the highest level of occupants' satisfaction. (Figure 1)

Finding out the reason why this result happened is the purpose of this research.

3. METHOD

To find out the reason why negative correlation was showed between service level of maintenance management and occupants' satisfaction, we chose two

buildings for case study. They are building B which showed high service level and low occupants satisfaction, and building E which showed low service level and high occupants' satisfaction.

3.1. Survey for occupants in office buildings

Surveys of occupants in these office buildings were conducted to evaluate occupants' satisfaction and other factors to their indoor environment. The contents of the questionnaire for occupants consist of three fields: thermal comfort, indoor air quality and help desk service set up by maintenance management organization which deals with occupants' claims. Questions of satisfaction are answered within a 5-Likert-scale and thermal sensation was evaluated by the ASHRAE 7-point thermal sensation scale.

The survey was conducted from the 4th of October to the 12th of the same month, year 2007. Occupants in this set were taken from the three floors in which measurement of physical environment condition was carried.

3.2. Measurement of physical environmental condition

Temperature and CO₂ level were measured in three respective floors of both B and E office buildings. Air temperature and relative humidity were measured at 110cm high from the floor with HOBO, RH-temperature data logger, during 7 days from October 4th to 12th in 2007 while CO₂ level was measured in two stairways in both office buildings within the same day.

4. RESULTS

4.1. Characteristics of investigated buildings

Information of two office buildings was showed in Table 1. Building B has large scale, and E has a smaller scale.

4.2. Occupants' satisfaction in three fields

272 respondents were answered to questionnaire from three floors each of buildings B and E. Respondents' characteristics were shown in Table2.

Table 1: Outline of two buildings

Building	B	E
Type	Office	Office
Floor[m ²]	141,551	6,113
The number of floors	38F, B6F	6F, B3F
Completion year	1999	2001
Type of management	directly /outsourcing	outsourcing

Table 2: Characteristics of respondents

		B (N=191)		E (N=71)	
		N	%	N	%
gender	male	115	60.2	62	87.3
	female	76	39.8	9	12.7
	sum	191	100	71	100
age	20s	71	37.2	10	14.3
	30s	83	43.5	46	65.7
	40s	28	14.7	14	20
	upper 50	7	3.7	0	0
	avg.	33.3		34.9	
	sum	189	99	70	98.6
worked career	less than 1 year	43	22.5	21	29.6
	1 ~ 3 years	75	39.3	43	60.6
	more than 3years	67	35.1	3	4.2
	sum	185	96.9	67	94.4

Because building b is larger than building E, the number of respondents in building B is more than building E.

Occupants' satisfaction to office B and E was compared in three fields – thermal environment, indoor air quality and help desk service. No significant difference between two buildings was founded in thermal environment and indoor air quality, but significant difference was founded in satisfaction of help desk service.

4.3. Physical environment

■ Thermal environment

Average outdoor temperature of 18.4°C and a humidity of 50.9% were recorded within the seven day measurement period. Comparison of the ASHRAE comfort zone

was made in order to measure the thermal condition between office building B and E during the seven days (Figure 3).

Results indicate that the thermal condition in office B which operates HVAC system during all four seasons is within the ASHRAE comfort zone. However, half of thermal condition in office E which only operates HFCU during summer and winter is outside of the of ASHRAE comfort zone. Comparison on ASHRAE chart shows that office E had high indoor air temperature than office B.

However, like mentioned above, there was no significant difference between two offices' occupants'

■ Indoor air quality

CO₂ level measured in two respective floors of both buildings B and E during a one day period, resulted in an average of 519ppm in office B and 697ppm in office E. This means that Office B had good indoor air quality than office E. In occupant response of

air freshness, some about 60% of occupants surveyed say 'slightly impure' in both office B and E.

4.4. Help desk service to deal with occupant claims

The help desk service is under the maintenance organization and has purpose to address occupant claims. In the event that occupant discomfort happens, the occupant makes a request at the building's help desk to settle their claim. Result from the survey shows occupants in office E take a more proactive role in using the help desk than occupants in office B. (Fig. 4a). The survey also shows that among occupants that make use of the help desk service, occupants from building E gave a better evaluation than those from building B (Fig. 4b). These results mean that when occupants more use help desk to settle their complain to indoor environment more positively evaluated help desk service than when occupants didn't it.

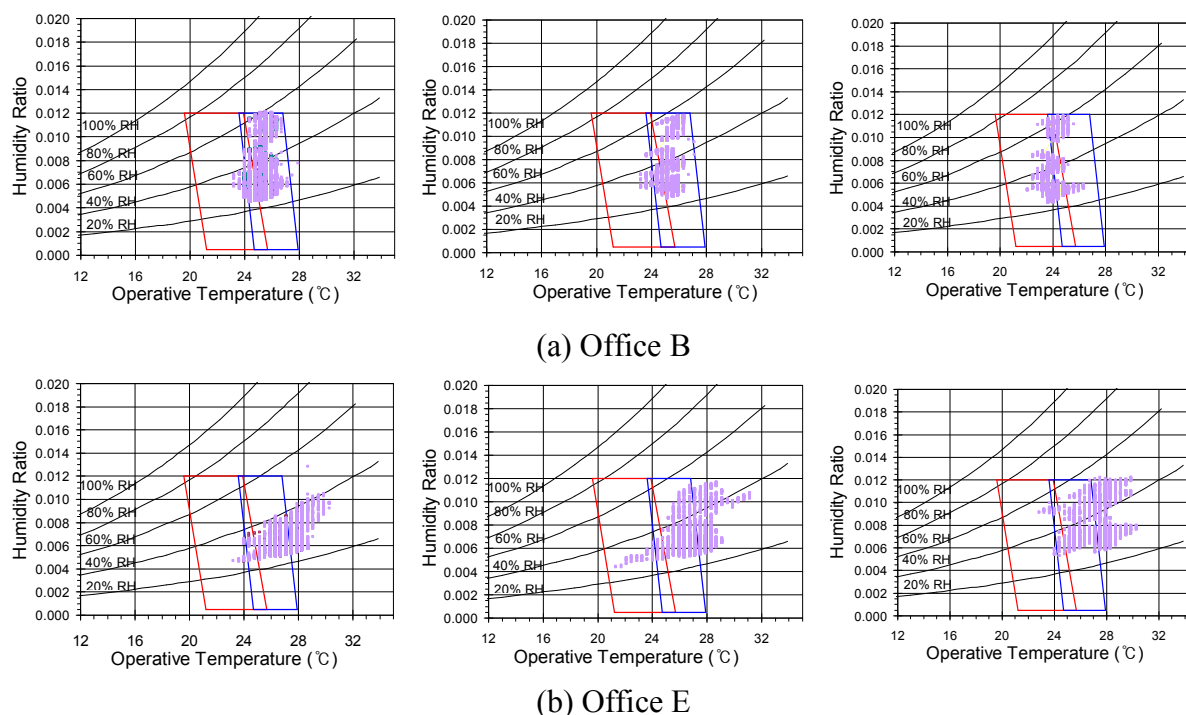


Figure 3: Thermal condition on ASHRAE comfort zone.

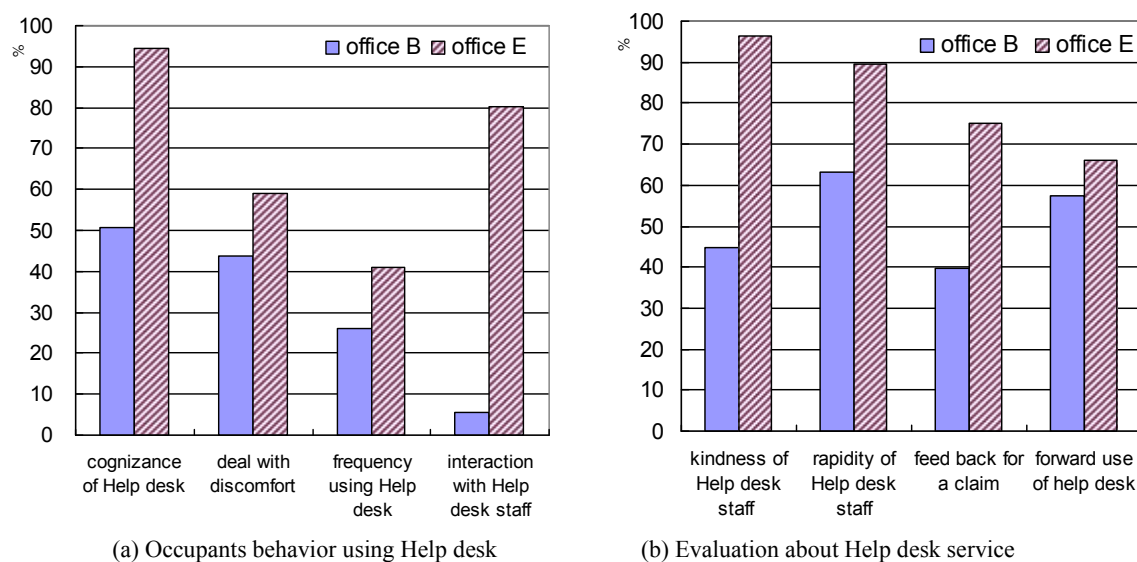


Figure 4: Comparison of evaluation using Help desk in office B and E.

Table 3: The correlation between evaluation of Help desk and satisfaction to indoor environment

Variables of evaluation for Help desk service	Satisfaction of thermal environment	Satisfaction of air quality
Recognition of Help desk	.247**	.304**
Means cope with discomfort	.217**	.248**
Experience of Help desk	.126*	.158*
Kindness of Help desk staff	.196	.200
Rapidity of Help desk service	.346**	.270*
Feedback about handling occupant claims	-.022	-.019
Interaction with Help desk staff	-.012	.097
Satisfaction of Help desk service	.398**	.367**

* p<.05 ** p<.01 *** p<.001

Table 3 illustrates the relationship between the evaluation of help desk service and the occupant satisfaction of thermal environment and indoor air quality. Occupants who more recognize the use of help desks, actively cope with their discomfort and had experience using help desk were more satisfied with the thermal environment and air quality.

Also, when Help desk staffs resolve their complaints fast, occupant satisfaction becomes higher and satisfaction of help desk service has positive effect with the satisfaction rating for thermal environment and air quality. However, it is not significant in kindness of staff, feedback about result of handling claims and interaction with staff.

Variables for evaluation of help desk service classified into two factors – positiveness of occupants and positiveness of help desk service. Among 7 variables, it can be founded that which factors affect occupants' satisfaction by multiple regression analysis. Table 3 and 4 show that means cope with discomfort(2) and rapidity of help desk service(5) affect occupant satisfaction of thermal environment and recognition of help desk service(1) and means cope with discomfort(2) influence occupant satisfaction of indoor air quality.

Simple regression analysis shows a single dependent variable - satisfaction of thermal environment or indoor air quality - was affected by one independent variable – satisfaction of help desk service. (Table 6 and 7)

Table 4 : Effect help desk service on occupant satisfaction of thermal environment

Independent variables	*	Coefficient of non standardization		Coefficient of standardization	t	Significant probability	Tolerance limit	VIF
		B	Standard deviation	Beta				
Positiveness of occupants	1	.289	.174	.204	1.658	.102	.659	1.517
	2	.272	.118	.259	2.301	.024	.786	1.272
	3	-.314	.263	-.136	-1.196	.236	.770	1.298
Positiveness of help desk service	4	.022	.139	.025	.160	.873	.416	2.403
	5	.291	.122	.332	2.385	.020	.516	1.939
	6	-.031	.188	-.019	-.162	.872	.743	1.346
	7	-.236	.120	-.269	-1.964	.054	.531	1.883

$R^2=.321$ $F=4.601$ $p=.000$

- * 1. Recognition of Help desk
 2. Means cope with discomfort
 3. Experience of Help desk
 4. Kindness of Help desk staff
 5. Rapidity of Help desk service
 6. Feedback about handling occupant claims
 7. Interaction with Help desk staff

Table 5 : Effect help desk service on occupant satisfaction of indoor air quality

Independent variables		Coefficient of non standardization		Coefficient of standardization	t	Significant probability	Tolerance limit	VIF
		B	Standard deviation	Beta				
Positiveness of occupants	1	.370	.173	.270	2.139	.036	.659	1.517
	2	.327	.118	.322	2.787	.007	.786	1.272
	3	-.495	.261	-.222	-1.899	.062	.770	1.298
Positiveness of help desk service	4	.004	.138	.004	.027	.978	.416	2.403
	5	.131	.121	.154	1.080	.284	.516	1.939
	6	-.144	.187	-.091	-.767	.446	.743	1.346
	7	-.023	.119	-.027	-.193	.847	.531	1.883

$R^2=.321$ $F=4.601$ $p=.000$

- * 1. Recognition of Help desk
 2. Means cope with discomfort
 3. Experience of Help desk
 4. Kindness of Help desk staff
 5. Rapidity of Help desk service
 6. Feedback about handling occupant claims
 7. Interaction with Help desk staff

Table 6 : Effect help desk service satisfaction on thermal satisfaction

Independent factor	Coefficient of non standardization		Coefficient of standardization	t	Significant probability	R^2 (significant level)
	B	Standard deviation	Beta			
H.D. service satisfaction	.380	.102	.389	3.731	.000	.151 (.000)
Constant	1.755	.377		4.660	.000	

Table 7 : Effect help desk service satisfaction on indoor air quality satisfaction

Independent factor	Coefficient of non standardization		Coefficient of standardization	t	Significant probability	R^2 (significant level)
	B	Standard deviation	Beta			
H.D. service satisfaction	.344	.099	.367	3.479	.001	.134 (.001)
Constant	1.698	.366		4.646	.000	

4.5 Occupants' adaptive opportunities

Windows, thermal device and blinds are major means by which occupants control the indoor environment in a building. Occupants in office B cannot control window and thermostat but can control the blinds, while at the same time, it is possible to control all three factors in office E. The number of controlling three factors per day was taken from the answers in the questionnaire filled out by the occupants. However, in both office B and E, they hardly control these factors even if they can. Occupants in building E open windows with an average of 0.7 times in a day.

5. CONCLUSION

In our previous research, we analyzed the relation between the level of the maintenance management service and occupants' satisfaction to indoor environment in office buildings, and in this research, we figured out how did these three factors - physical environmental conditions, adaptive opportunity and help desk service - affect occupant satisfaction.

In order to ensure whether the level of maintenance management service corresponds with occupants' satisfaction level, we evaluated maintenance service using the Takakusagi tool and investigated occupants' satisfaction by conducting questionnaires in seven (7) office buildings. Result of a throughout analysis concludes that maintenance service level is not directly proportional to correspond with occupants' satisfaction level. To investigate the possible reasons why this happened and in order to find out factors that influence occupants'

satisfaction, we picked out two buildings among seven surveyed buildings. The first building is office building B wherein maintenance service level is high, but occupants' satisfaction level is low. The second building is office building E wherein maintenance service level is low, but occupants' satisfaction level is high. Three factors were hypothesized to derive these results, these are: physical indoor environment, occupants' adaptive opportunity, and maintenance management help desk service.

The key conclusions drawn from this research are as follows:

- 1) Maintenance service level has an opposite result with an occupant's satisfaction level; as maintenance service level becomes high, occupants' satisfaction level becomes lower.
- 2) Thermal environmental condition of Office B is covered inside the ASHRAE thermal comfort zone while half the part of thermal environmental condition in Office E is not covered inside the thermal comfort zone. The study also shows that the concentration of CO₂ is higher in Office E than Office B. Although this is the case, occupants in both offices have equal level of satisfaction in regards to their indoor environment, despite the fact that office E has low levels of physical environmental condition as well as it shows discomfort to thermal sensation. This means that occupant's satisfaction is not greatly affected by slight differences on physical environmental conditions involving the occupant's comfort zones.
- 3) Maintenance management organization's help desks that take occupants' claims or

complaints, has a direct and significant relation with an occupant's satisfaction to their indoor environment. When occupants use help desks actively, this has a positive effect to an occupant's indoor environment satisfaction. Since occupants in large office buildings cannot directly control their physical environment, they make use of help desk service as their means of control.

4) A comparison of adaptive behavior in two offices may not be significant, however it is to be noted that occupants' relative satisfaction of Office E is higher than Office B. In this case we can assume that adaptive opportunities affect the psychology of an occupants; level of satisfaction.

These results show that not only physical environment condition but other factors are involved in dealing with the occupants' relative level of satisfaction, though physical environment condition is not comprised in perfectly comfort range. Large office buildings cannot offer adaptive opportunity such as opening windows and controlling temperature to occupants, however, as an alternative adaptive opportunity, occupants can make use of the help desk service.

Finally, positive activities of help desk service (maintenance management organization) like fast handling of complaints and kindness shows by the help desk staff, affects occupants' satisfaction level. Furthermore it was observed that the more occupants use the help desk service, the more their satisfaction level goes up.

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