公衆衛生院研究報告, 28 巻 1 号, 1979
UDC 614.712:551.556:69.032.22

原　　著

On the Environmental Effects of Changes in Wind Conditions after Construction of Buildings

—Questionnaire Survey among Inhabitants around Buildings—

Koichi IKEDA*1, Susumu YOSHIZAWA*2

(from the Department of Architectural Hygiene and Housing, the Institute of Public Health, Tokyo)

and Masataka NAKANO*3

(from the School of Nursing, Chiba University, Chiba)

K. IKEDA, S. YOSHIZAWA and M. NAKANO *On the environmental effects of changes in wind conditions after construction of buildings—Questionnaire survey among inhabitants around buildings—*. Bull. Inst. Publ. Health, 28(1): 1–11, 1979.—To obtain fundamental data for establishing dose-response relationship on wind environmental changes around tall buildings, we conducted two kinds of questionnaire surveys (A and B).

From survey A, which was conducted among inhabitants who complained that they were suffering from wind environmental changes, we elucidated various facts, such as:

① The buildings causing wind environmental troubles are, in many cases, multi-storied apartment blocks;

② The minimum height of the buildings causing wind environmedtal trouble is three stories;

③ Wind environmental problems affect pedestrians and low buildings in proximity to tall building in various ways.

From survey B, which was conducted among inhabitants selected by a specific sampling method, we found that the incidence rate of wind environmental problems is highest in the zone nearest to the tall buildings, and gradually descreases to zero at a distance of 2 to 4 times the height of the building in question.

1. Introduction.

It has been a long time since the problem of changes in wind environment around tall buildings emerged as a new type of public nuisance in urban areas. Nowadays, it is regarded as necessary to take also this problem into account along with the problems of T.V. wave propagation interference and sunshine-obstruction.

As in other environmental problems, standards should be established to analyse the problem effectively. For this purpose, we have to establish a dose-response relationship in order to prove a "nuisance". The physical characteristics of air flow around tall buildings correspond to "dose", and the effects on people,

*1 池田耕一（国立公衆衛生院建築衛生学部）
*2 吉沢　晋（同上）
*3 中野正孝（千葉大学看護学部）

plants, animals and small structures around them correspond to "response". The psychological effects on people are also taken into account.

Hitherto, research on the "response" has lagged behind that on "dose". Particularly, while some laboratory studies on exposing people to wind stream have been done by Penwarden[1], Hunt[2] and Murakami[3], field survey reports on the effects on inhabitants and their behaviour caused by the wind environmental changes are scarce[4),5)].

In this paper*, we report the results of a field survey aimed at establishing a method of investigation and finding the kinds of troubles that occur and their incidence rates. We believe that our report is a first step in establishing the dose-response relationship in given wind environment conditions.

2. Outline of Surveys

The surveys for this report were of two types (A and B).

2-1 Survey A

In this survey we attempted to find out the various troubles pertaining to changes in the wind environment after the construction of buildings. We conducted the survey among inhabitants who were living in areas where wind environmental troubles existed or had existed and who were complaining that they suffered from these conditions.

We distributed and recovered questionnaire papers in two ways. First, we requested some representatives in organized groups to distribute the questionnaire papers directly to their members and also to their neighbours, and then to recover them on completion. Second, we asked other representatives, whose organizations were not able to distribute the questionnaires, to give us list of addresses of the members who they thought would cooperate.

As this survey was carried out only among the inhabitants who insisted that they were suffering from the wind problems, it can not always be said that the results are universally valid. However, it is useful to find out the kinds of wind environmental problems, because it is thought that the results reveal the nature of problems very clearly.

2-2 Survery B

In our second survey, we attempted to find the rates of incidence of wind environmental problems.

The questionnaire papers were handed directly to the informants by ourselves. They were selected by a specific sampling method.

Generally speaking, problems concerning wind environment are apt to occur in areas where tall buildings are built among low buildings. We consider that there are three such patterns, which are:

(1) a single tall buildings stands among low buildings;

(2) tall buildings stand some distance apart from each other among low buildings;

(3) tall buildings stand close to each other along the main street with low buildings standing behind them.

We decided that we should adopt different survey methods for each type depending on the pattern. As the first stage in this survey, we thought it best to investigate the first pattern, as it is the most basic and the easiest to analyse.

In this case, it is generally known that the problems do not occur uniformly in the whole area but are concentrated in the vicinity of a tall building itself. And the rates of incidence are closely related to the distance from the outside of the building. So we used a specific sampling method taking this factor into accout rather than mere random sampling.

In this report, hypothesizing that the incidence rates of wind environmental problems are highest in the close vicinity of a tall building and decrease gradually with distance to almost zero at a certain distance away, we divided the circumference of the tall building, as shown in Fig. 2, into 144 blocks. These were partitioned by 16 axes and 9 belt-like zones with widths of half the height of the building. We distributed one questionnaire

* Some part of this report was already presented in Japanese Journal of Public Health Vol. 25 No. 10 and Proceedings of 49th Technical Meeting of Kantoh Branch of Architectural Institute of Japan.

in each block.

3. Survey Period

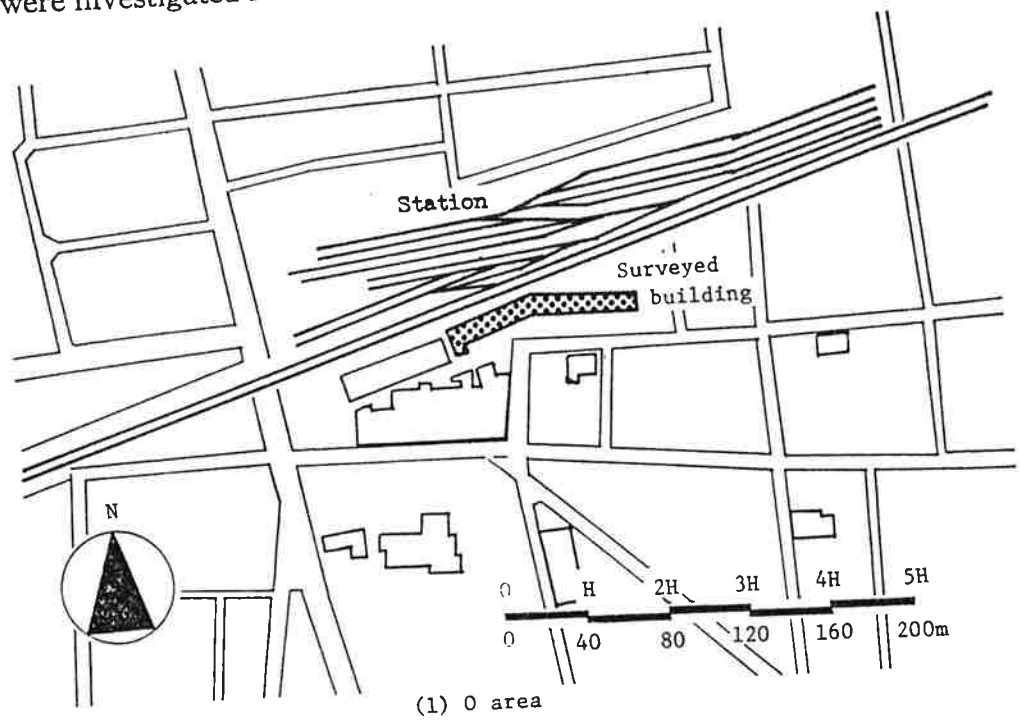
Survey A was carried out for 2 months from the end of April to the end of June 1977. Survey B was carried out for 15 days from 10th to 25th March 1978.

4. Survey Area

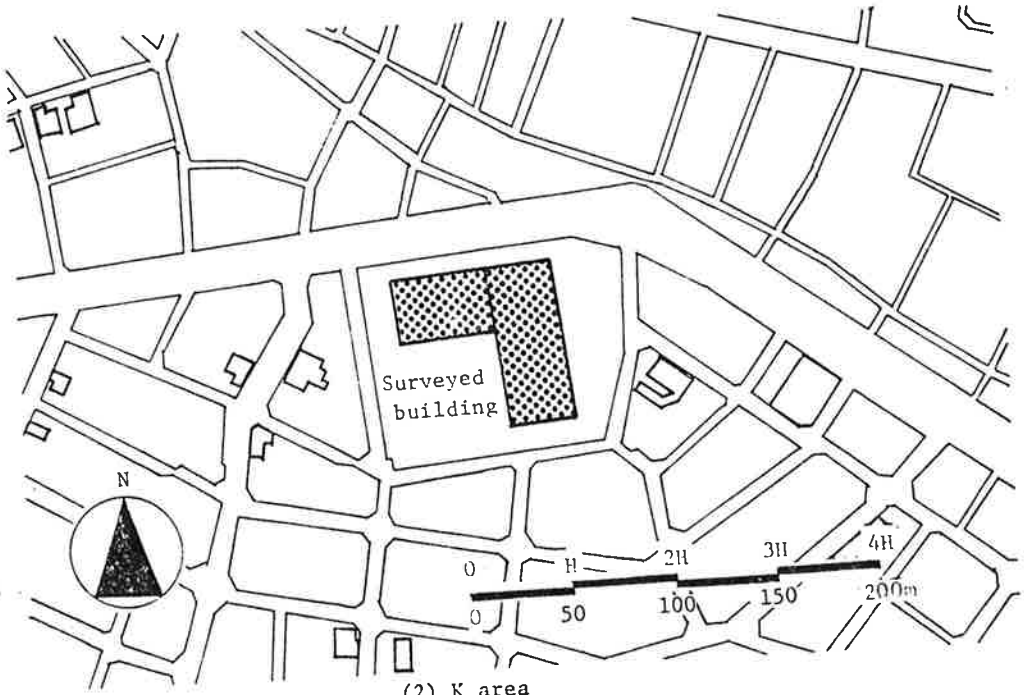
102 areas were investigated in survey A (See Table 1). They are located all over the Tokyo metropolitan area. However we failed to recover any questionnaire papers from eleven areas, although we distributed them by mail. Thus, our study was limited to 91 areas.

In survey B, we selected two areas—called O and K respectively. These areas have one tall buildings among low ones, and in selecting them we used air photographs of Tokyo.

Area O is an urban district spread around



(1) O area



(2) K area

Fig. 1. Object area of survey B.

Table 1. Number of Areas and Recovery Ratio of Survey A in Each Administrative Division of Tokyo

Administrative division	Area	Number of questionnaire		Recovery ratio
		distributed	recovered	
Chiyoda Ward	3	8	3	38%
Chuoh	3(1)	9	4	44
Minato	4	23	22	96
Shinjuku	3	24	6	25
Bunkyo	2(1)	6	3	50
Shinagawa	19	83	53	64
Meguro	25	106	98	93
Ohta	6	56	17	30
Setagaya	10	41	24	59
Shibuya	6(1)	28	7	25
Nakano	2(1)	6	1	17
Suginami	5(2)	15	9	60
Toshima	2(1)	8	1	13
Kita	2	10	3	30
Nerima	3	60	10	17
Adachi	1	3	1	33
Chofu City	1	3	1	33
Musashino	5(4)	15	1	7
Total	102(11)	504	264	52

Numbers enclosed in brackets show the number of areas where we failed in recovering the questionnaire form although we conducted the survey by mail

O-station (Fig. 1). The building surveyed is an apartment block of 11 stories high (H= 40 m, where H is height of the building) standing in front of the station, and its whole configuration looks like a large fence.

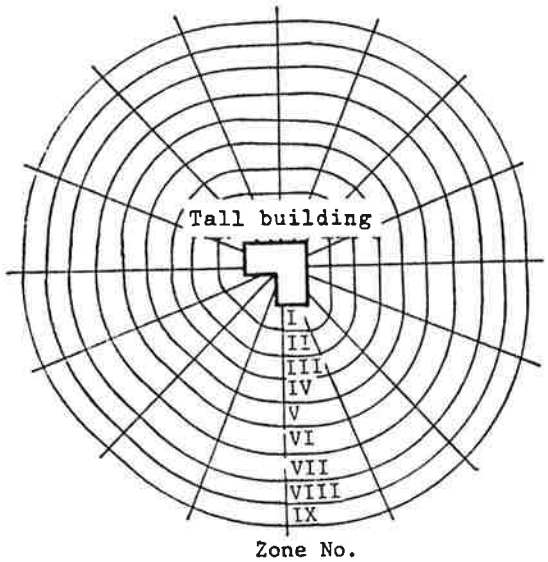


Fig. 2. Sampling blocks used in survey B describing a parameter of distance from the outside of the tall building.

Area K is a comparatively old residential district. The surveyed building is a municipal apartment block of 14 stories high (H=50 m).

The reason we selected these two areas is that they satisfy the previously mentioned conditions. There was no citizen movement against the wind problems in these areas. This is the most important difference between survey A and B.

5. Informants

We chose housewives as informants for the surveys.

6. Questionnaire Form

The questionnaire used in this survey consisted of three main parts. In the first part, we asked about the informants themselves; for example, their age, occupation, housing conditions, etc. Then in the second part, we inquired how the wind environmental problems affected them. Finally, we asked them how

they reacted against these conditions. For each of the questions, informants were requested to add freely what they thought about the question.

7. Results of Surveys

7-1 Recovery Ratio of Questionnaire

As shown in Table 1, the number of questionnaires distributed in survey A was 504, and the number recovered was 264, thus the recovery ratio was 52%.

In the case of survey B, as we previously mentioned, the number of questionnaire distributed was 288 (144 in each), and the number recovered amounted to 223 (92 in O area and 131 in K area), the recovery ratio being 77% (64% in O area and 92% in K area).

As shown in Fig. 3, the recovery ratios of the zones located near the building are comparatively low. One of the reasons for this fact is that the zones nearest to the building are smaller, so the number of inhabitants is less. Especially in O area, we can see this tendency very clearly. Another reason for the low recovery ratio of O area is that few people live in the zones nearest to the building because there is an open space in front of the station.

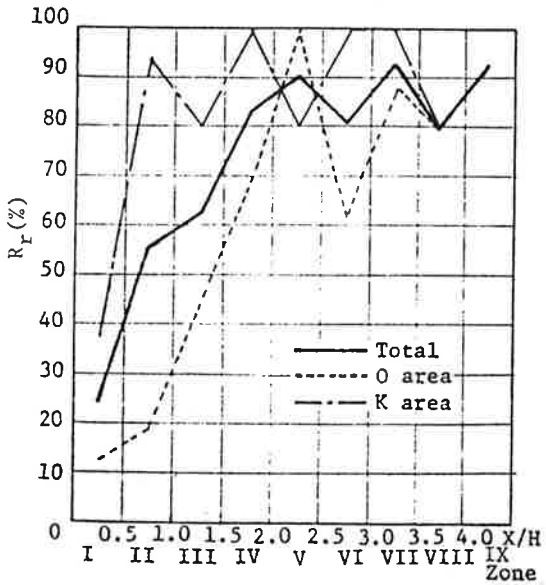


Fig. 3. Recovery ratio of survey B according to the different zones.

X: distance from the building
H: height of the tall building
R_r: recovery ratio

7-2 Details about the Informants and their Houses

Although we did not study in detail the informants and their housing conditions, we could roughly sum up as follows. Most of the informants of survey A and B were housewives in their forties, and were either without occupation or self-employed. Most of their houses were independent wooden houses of 2 stories. 80% of all informants lived in their own houses.

7-3 Features of the Buildings Causing the Wind Environmental Problms

We show the results of the survey of the features of the buildings causing the wind environmental troubles in Tables 2 to 4.

60% of them are multi-storied apartment blocks, and 25% are office buildings. One of the reasons why the ratio of multi-storied apartment blocks is so high is that such buildings are likely to be built in residential areas where there are many houses.

Their minimum height is three stories, and the oldest building causing wind environmental problems, in this survey, was built in 1963.

7-4 Degree of Seriousness of Wind Environmental Problems

As shown in Table 5, the wind environmental trouble was thought to be a most serious problem in survey A. As this survey was conducted among the inhabitants complaining that they were suffering from it, this is understandable.

On the contrary, in the case of survey B, it is rated only the inconvenience of fifth

Table 2. Buildings Causing Wind Environmental Problems (Survey A)

Kinds of buildings	Number	Ratio
Multi-storied apartment block	54	59%
School	1	1
Office building	23	24
Hospital	2	2
Department store	2	2
Other answer	4	4
No answer	5	6
Total	91	100

Table 3. Number of Stories of Buildings Causing Wind Environmental Problems (Survey A)

Number of stories	Number of case	Ratio
1	0	0%
2	0	0
3	2	2
4	5	6
5	6	7
6	8	9
7	12	13
8	4	4
9	4	4
10	3	3
11	12	13
12	9	10
13	6	7
14	4	4
15	1	1
25	1	1
26	1	1
36	1	1
52	1	1
No answer	12	13
Total	91	100

Table 4. Year of Construction of Buildings Causing the Wind Environmental Problems (Survey A)

Year	Number of case	Ratio
1963	1	1%
64	0	0
65	2	2
66	0	0
67	3	3
68	0	0
69	3	3
1970	6	7
71	6	7
72	8	9
73	10	11
74	8	9
75	7	8
76	5	6
77	3	3
No answer	29	32
Total	91	100

importance in O and fourth in K.

7-5 Wind Environmental Effects on Pedestrians

(1) Survey A

We chose four problems which we thought pedestrians suffered from, namely:

(a) interference with walking,
(b) damage to umbrellas,
(c) disturbance of hair and clothes,
(d) exposure to dust.

For each of them, many informants responded that they suffered.

As for other problems which were not listed in the questionnaire, there are several, for example, "having one's hat blown blown off, or other things they are carrying being blown away", "fear of being hit by wind projected objects" and so on.

(2) Survey B

In Fig. 4, we show the rates of informants who answered that they had suffered from the various wind effects caused by the building when they were walking near it.

In survey B, the incidence rates (or the percentage of person who suffered as a ratio of all informants) of each wind environmental trouble are 48-54%.

Comparing the results by area, the rates of O area are higher than those of K area except for one trouble, "exposure to dust". But even in this case, the rate of those answering "often happens" in O area is greater than that in K area. It is conceived that these results are brought about by the fact that the informants of O area had more chances to go to the neighborhood of the building because this building stands near the station.

7-6 The Effects on the Houses and Residential Environment

(1) Survey A

As with the effects on pedestrians, we chose nine effects on the houses and residential environment, namely:

Table 5. Degree of Seriousness of Wind Environmental Problems as Compaired with other Environmental Problems—Results of the Question, "Choose the Problem You are Facing among the Following Items"

Items	Numbers (Ratios) of informants who chose the item			
	Survey A	Survey B		
		O area	K area	Total
Sunshine-obstruction	88(33%)	27(29%)	40(31%)	67(30%)
T.V. wave propagation interference	87(33%)	13(14%)	45(34%)	58(26%)
Nearby noise and vibration	38(14%)	13(14%)	18(14%)	31(14%)
Traffic noise and vibration	85(32%)	26(28%)	25(19%)	51(23%)
Disposal of waste	14(5%)	7(8%)	3(2%)	10(5%)
Bad smell	21(8%)	7(8%)	8(6%)	15(7%)
Wind environmental problem	109(43%)	12(13%)	29(22%)	41(18%)
Air pollution	50(19%)	7(8%)	6(5%)	13(6%)
Lack of privacy	23(13%)	4(4%)	6(5%)	10(5%)
Other problem	10(4%)	4(4%)	4(3%)	8(4%)
No answer	29(11%)	24(26%)	34(26%)	58(26%)
Total	564(213%)	144(156%)	218(166%)	362(162%)

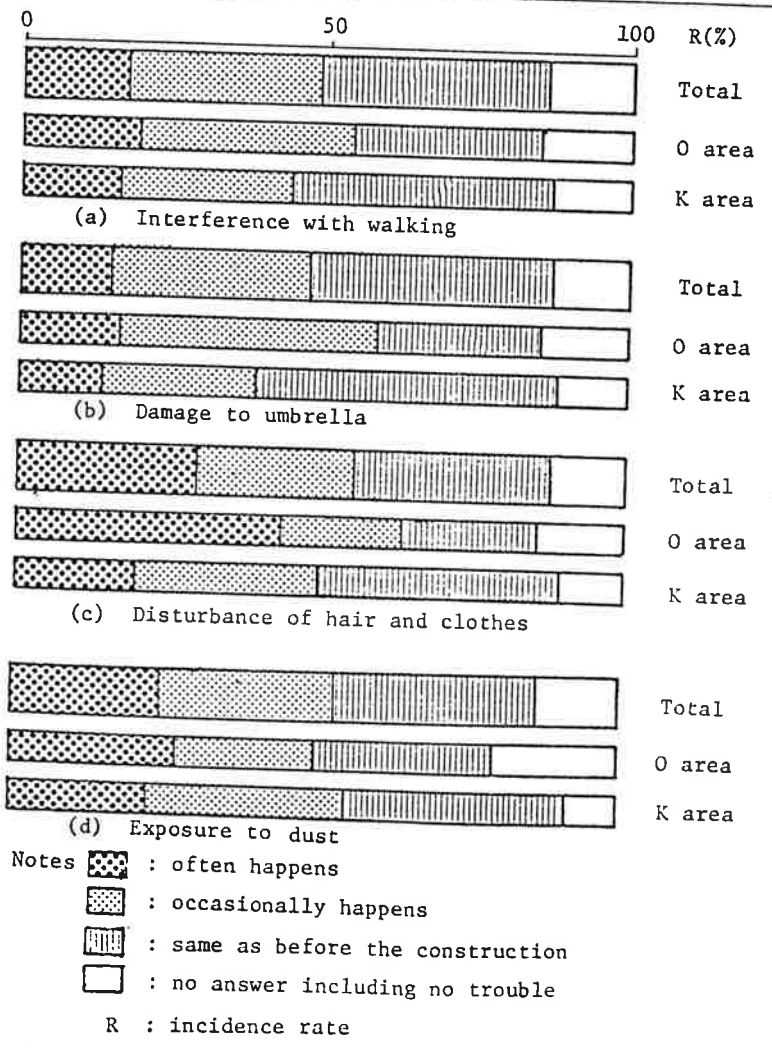


Fig. 4. Results of survey B on the effects of wind environmental trouble to pedestrians.

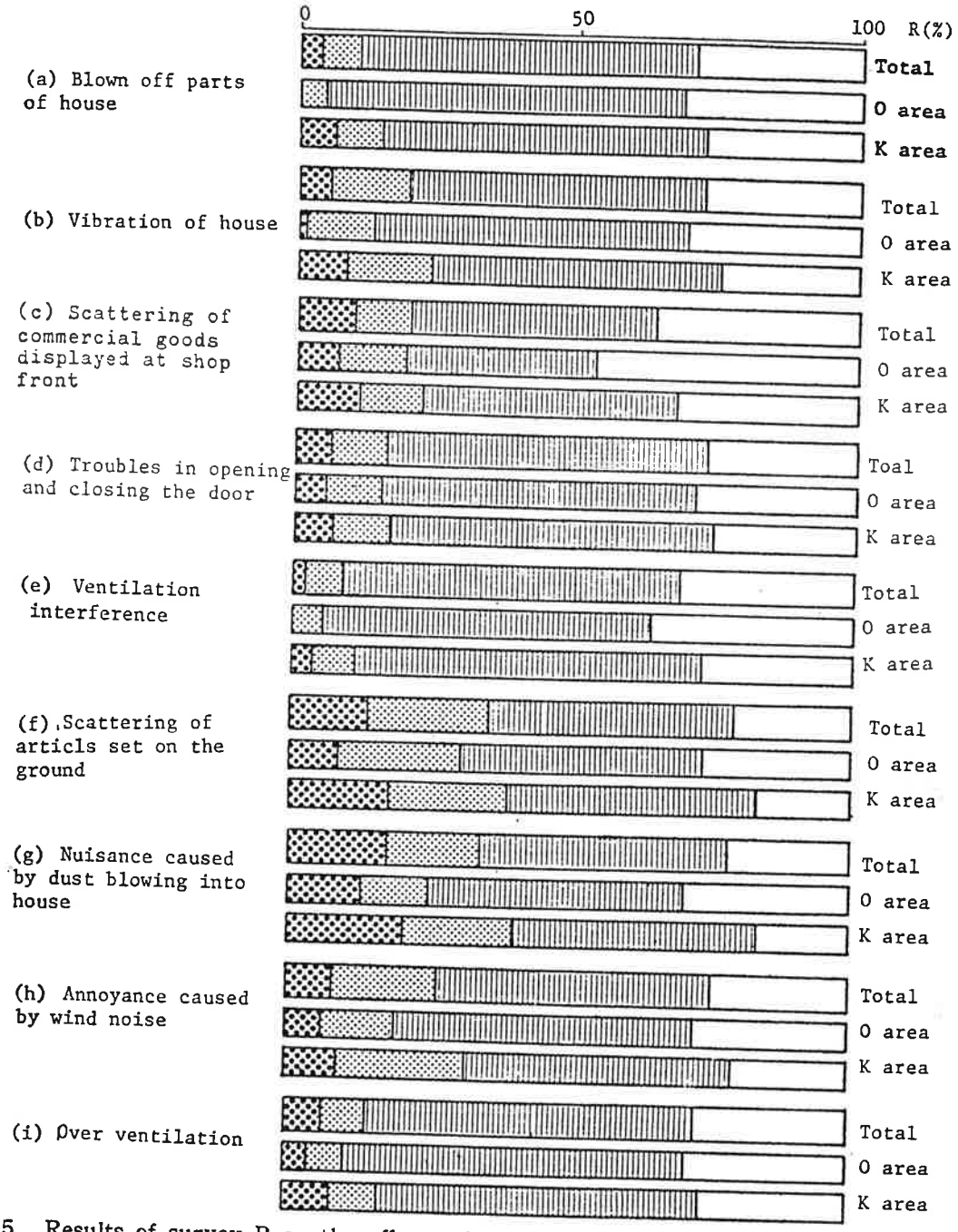


Fig. 5. Results of survey B on the effects of wind environmental trouble on houses and the residential environment. (Notes are the same as Fig. 4.)

(a) blown off parts of house,
(b) vibration of house,
(c) scattering of commercial goods displayed at shop front,
(d) tronbles in opening and closing the door,
(e) ventilation interference,
(f) scattering of articles set on the ground,
(g) nuisance caused by dust blowing into house,
(h) annoyance caused by wind noise,
(i) over ventilation.

For each of them, many informants replied that they suffered.

Asked to add some other troubles which were not listed in the questionnaire, informants raised such troubles as "the currents in fans and chimneys were regurgitated", "noises were carried in by the wind", "the electric wires were broken off". In addition to these

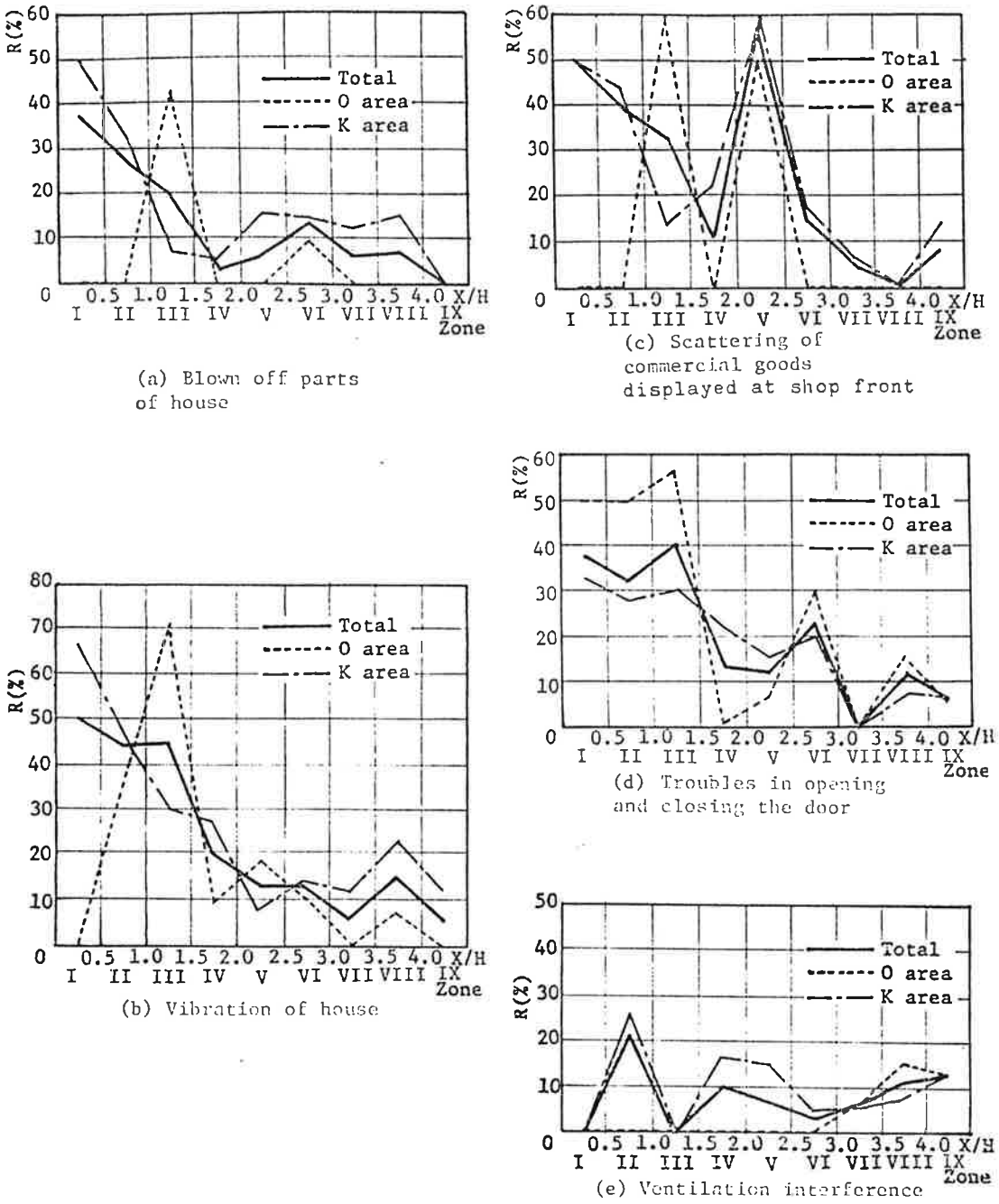


Fig. 6(a)-(e). Results of survey B according to the different zones.

physical troubles, there were replies complaining of psychological troubles, "vague feeling of danger".

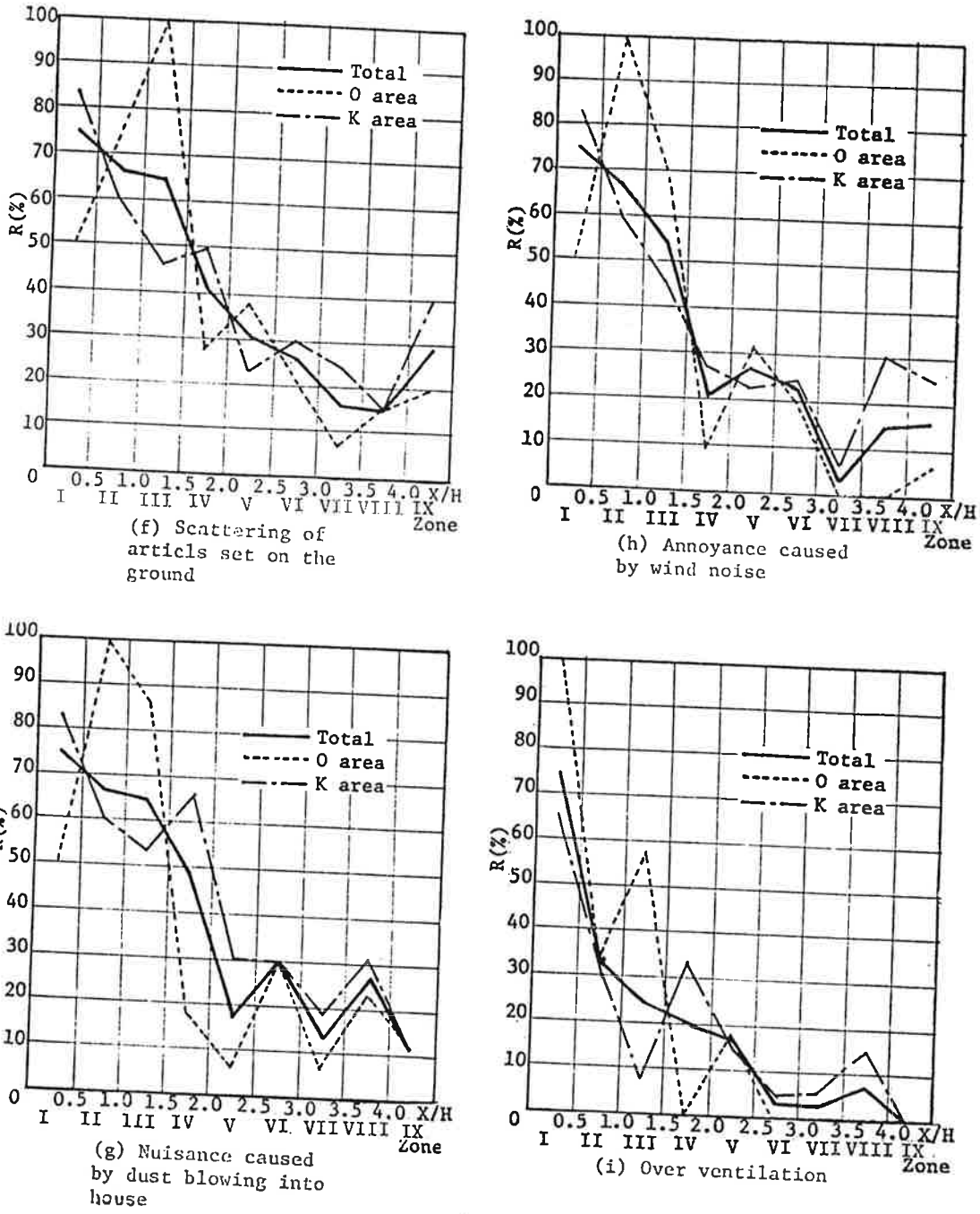
(2) Survey B

① Trouble, "blown off parts of house"

We show in Fig. 5 the results of the survey B on the wind environmental effects on the houses around the tall building. We also show in Fig. 6 the results according to zones.

Incidence rates of this effect is 5% in O area, 15% in K area and 10% in total. These are considerably low compared with the effects on pedestrians.

Looking at the variance of incidence rates, R, according to different Zones, R in O area reaches its peak at X/H=1.0 to 1.5 (where H is the height of the building), and is negligible in other zones as shown in Fig. 6. On the contrary, in K area, R shows its peak at X/H=0.0 to 0.5 (the nearest zone) and decreases gradually as X/H increases, which we expected in our hypothesis. One of the reasons



(f) Scattering of articls set on the ground

(h) Annoyance caused by wind noise

(g) Nuisance caused by dust blowing into house

(i) Over ventilation

Fig. 6(f)–(i). Results of survey B according to the different zones.

that R in O area did not go as we expected is that there were few houses near the tall building in this area.

② Other problems

We can see that R of the other problems are higher than that of "blown off parts of the house", and that the trends of R show a descending line except for one case, "ventilation inteference". In general R retains a high level within $X/H=0$ to $X/H=2.0$ or 4.0.

One of the reasons why R of the problem, "ventilation interference" did not show a high level is that this trouble is seldom considered at present in Japan as one of the wind environemntal problem.

As for other problems which were not listed in the questionnaire, informants added such problems as, "oil was blown off from chimney" in O area, and "annoyed by the noise of the wind beating the electric poles" in K area.