Journal of Sound and Vibration (1997) **205**(4), 481–492

AN INTENSIVE SURVEY ON COMMUNITY RESPONSE TO SONIC ENVIRONMENT IN A RESIDENTIAL–INDUSTRIAL MIXED USE AREA

K. MINOURA, K. HIRAMATSU

Mukogawa Women's University, *Tozakicho* 1-13, *Nishinomiya*, 663 *Japan*

T. MATSUI, K. TAKAGI

Kyoto University, *Kyoto*, 606 *Japan*

AND

K. OI

National Institute for Environmental Studies, *Tsukuba*, 305 *Japan*

(*Received* 3 *March* 1997)

An intensive survey on community response to the sonic environment was conducted in a residential–industrial mixed use area. The size of the study area is comparatively small, about 6 ha. The survey consists of (1) observation of the sonic environment, where the density of observation points is about 7 points/ha, and (2) the investigation of the community response to the sonic environment applying a free response questionnaire method. The results of the survey are summarized as follows. The sonic environment is not homogeneous even in such a small area as investigated here. There are some differences in response to the sonic environment in which respondents live in different social contexts. Responses to questions on the sonic environment depend upon the dominant sounds. Thus, sonic environments observed by researchers and described by respondents cannot be regarded as homogeneous. The fact suggests that the intensive survey is necessary for examining the community response to the sonic environment.

1. INTRODUCTION

The authors consider that the intensive study, which intends to derive general laws from a detailed description of a small number of cases, is significant for the social survey on the community response to the sonic environment, although conventional studies have been carried out using a variety of methods [1]. The results of intensive surveys would be helpful for understanding how people experience their sonic environment, and how the sonic environment acts on people's evaluation of their total living environment.

This paper reports results of an intensive survey and discusses the use of the intensive method for social surveying of the community response to the sonic environment.

2. METHODS

2.1. THE STUDY AREA

The study area is a residential–industrial mixed use area of Sakai city, Osaka, Japan. As shown in Figure 1, the size of the study area is about 200 m from east to west and about 300 m from north to south.

0022–460X/97/340481 + 12 $25.00/0/sv971015

The area is located in the north of Sakai city, about 1 km away from the Sakaihigashi railway station, around which one can find the city hall as well as shops and stores. An elevated motorway and a trunk road with heavy traffic just below the motorway lie to the west of the area, and a trunk road in the east of the area. More than fifty small works, most of which are metal products works, lie scattered throughout the area.

During the past ten years, two large apartment buildings consisting of 210 and 80 comparatively large flats for family use, and 12 small buildings, most of which consist of bedsits for single persons, have been constructed in the area. The residents of this area are classified into three groups according to the type of residence: Group 1 living in detached houses and terrace houses, Group 2 living in large apartment buildings, and Group 3 living in small apartment buildings.

2.2. OBSERVATIONS OF THE SONIC ENVIRONMENT

Observations of the sonic environment were carried out at midpoints between two junctions of roads. The number of observation points was 44, so that the density of observation points was about seven points/ha. Observations were made over three periods: daytime weekday, night-time weekday, and daytime holiday.

Figure 1. Map of the study area.

The items of investigation at each observation point were L_x and L_{Aeq} measured for five minutes by means of a sound level meter (RION NL-14, NL-04), types and properties of the dominant sound sources, distance from the sound source to the observation point, and whether or not road traffic noise was audible.

2.3. FREE RESPONSE SURVEY

A questionnaire survey was carried out. The questionnaire consisted of two sections, as shown in the Appendix. The first section contained questions related to the attributes of the respondents such as age, sex, length of residence, etc. The second section contained three questions for which respondents were requested to describe what they usually felt about (1) their living environment, (2) their sonic environment, and (3) changes in their environment. Answers in this section, not using alternatives, are expected to show matters of particular concern to the respondents as regards their living and sonic environment.

The authors distributed a questionnaire to each household by a leave-and-pick-up method, and requested that the person who most stays at home in the household should answer the questionnaire.

3. RESULTS OF OBSERVATIONS OF THE SONIC ENVIRONMENT

Figure 2 shows the sound level and type of the most dominant sound at each observation point during the daytime on weekdays. Symbols are illustrated at the observation points in the map and the size of the symbol is proportional to the value of the sound level

Figure 2. L_{Aeq} measured and the type of dominant sound observed during the daytime on weekdays. Symbols are illustrated at the observation points in the map and the size of the symbol is proportional to the value of the sound level expressed in L_{Aeq}, which is shown in the symbol.

expressed in L_{Aeq}, which is shown in the symbol. Circles and squares indicate where road traffic noise and noise from works are the dominant sounds, respectively. At the points indicated by triangles, road traffic noise or noise from works is not the dominant sound, but rather some other sound in the vicinity dominates. Sound levels over 70 dB are observed at points near the motorway and around some works.

Figure 3 shows the sound level and type of the most dominant sound during the night-time on weekdays. The sound levels are around 50 dB at most of the observation points where noise from works is dominant in the daytime. At observation points near the motorway, however, sound levels are around 70 dB, which is approximately the same as that during the daytime. The dominant sound source at night-time is road traffic almost throughout the area.

4. RESULTS OF THE FREE RESPONSE SURVEY

4.1. RESPONDENTS

There are 716 households in the area. The number of households and respondents among different groups are tabulated in Table 1.

The attributes of the respondents in Groups 1 and 2 are shown in Table 2. Answers among Group 3 are so few that they have been omitted from the analysis.

The age of respondents in Group 1, with a median of 57 years, is significantly higher than that of Group 2, with a median of 39 years.

Figure 3. L_{Aeq} measured and the type of dominant sound observed during the night-time on weekdays. Symbols are illustrated at the observation points in the map and the size of the symbol is proportional to the value of the sound level expressed in L_{Aeq}, which is shown in the symbol.

TABLE 1

Households and respondents

	Households (A)	Deliveries (B)	Answers (C)	C/B (%)	C/A (%)
All groups	716	333	308	92·5	43·0
Group 1	190	135	121	89·6	63·7
Group 2	280	154	147	95·5	52·5
Group 3	246	44	40	90·9	16·3

The range of 80 percentile of length of residence in the area for respondents in Group 2 is three to six years, because the apartment buildings in which respondents of Group 2 reside were constructed six years before the survey was conducted. The length of residence of 8·8% of the respondents in Group 2 is longer than seven years because the length of residence is related not to the house but the area, and these residents are not newcomers to the area. On the other hand, the median length of residence among Group 1 is 28 years and the range of 80 percentile is seven to 54 years.

A remarkable difference was found in the number of respondents between sexes in Group 2, while the difference was small in Group 1. This is explained by their occupation, that is, most of the male respondents in Group 1 are self-employed (49·0%) or unemployed including retired (26·5%), which means that they spend comparatively long times at their home and its surroundings.

4.2. RESPONSES ON THE LIVING ENVIRONMENT

Question 1 is "Do you think your neighbourhood is comfortable to live in? Please express your ideas freely". By this the authors intend to obtain the respondents' answers about the amenity of the area which may be more or less related to the sonic environment.

4.2.1. *Words used in free responses*

Table 3 shows the words used by more than 10% of respondents in the free responses about the living environment. The words shown here have been arranged as follows: Decomposition of phrases and sentences into single words in Japanese and removal of the meaningless words. Different words obviously expressing the same meaning were clustered so as to be treated as the same word. Also, a word can have different meanings according to context, in which case it is classified into different categories [2].

TABLE 2

Attributes of respondents

	Group 1	Group 2
Age	Median 57 yrs.	Median 39 yrs.
Length of residence†	Median 28 yrs. 10% = 7, 90% = 54	Median 6 yrs. 10% = 3, 90% = 6
Sex	Male 40·5%, female 58·7%, no answer 0·8%	Male 13·6%, female 86·4%
Occupation	Self-employed 29·8% Housewives 27·3% Salaried workers 19·0% Unemployed‡ 12·4%	Housewives 40·1% Salaried workers 32·7% Part-time workers 17·0%

† 10% and 90% show 10 and 90 percentiles, respectively.
‡ including retired.

TABLE 3

Words used in free responses about the living environment

Rank	Word used	Rate (%)	Rank	Word used	Rate (%)
1	Convenient	43·7	11	Good	17·0
2	Comfortable	39·0	12	Bad	13·7
3	Transportation	28·0	13	Children	12·3
4	Neighbourhood	27·0	14	Environment	12·0
5	Many	26·7	15	Motorway	11·3
6	Shopping	24·0	15	Noise	11·3
7	Works	23·7	17	Uncomfortable	10·7
8	Nearby	20·7	18	Automobiles	10·3
9	Air	19·3	19	Supermarket	10·0
10	Station	17·3	19	Few	10·0

Description rates are shown in the table, expressed in percentage of users of the word to all respondents.

The word "comfortable" is used by 39·0% of respondents. On the other hand, the word "uncomfortable" is used by 10·7%.

The rates of the words used to describe the convenience in everyday life are high, such as "convenient", "transportation", "shopping", "nearby", "station", etc. Judging from the contexts in which the words are used, these words are used in relation to the affirmative evaluation, "comfortable", of the living environment.

Words concerning the uncomfortableness of the environment are also used by many respondents, such as "works", "air", "motorway", "noise", "automobiles", etc. This result suggests that the reason why some respondents find their living environment uncomfortable is for the most part the noise and/or air pollution caused by the works and/or the motorway.

Tables 4 and 5 show words used by more than 10% of the respondents in Groups 1 and 2, respectively, in the free responses about the living environment.

That Table 5 contains more words than Table 4 is a reflection of the fact that the sentences written by the respondents in Group 2 are longer than those in Group 1, which suggests the respondents in Group 2 have a higher writing ability. The words with a high description rate are common in Tables 3, 4 and 5.

4.2.2. *Subject matters of free responses*

Table 6 shows subject matters described by more than 10% of the respondents in the free responses about the living environment. It would be safe to say that the respondents regard these subject matters at least as important elements of their living environment. The description rates shown in the table are expressed in percentage of respondents who described the subject matter to respondents who described one or more subject matters. The subject matters "transportation", "shopping" and "public facilities", which relate to the convenience of everyday life, are described by many respondents. This suggests that respondents regard the convenience of everyday life as the most important element of the living environment. By comparing Group 1 with Group 2, it is seen that the respondents of Group 2 regard convenience as more important.

The subject matter "sounds" is described by 26·0% of the respondents. Among the respondents who describe this subject matter 47·1% describe sounds from works, and 38·6% describe sounds from the motorway and trunk road. The respondents in Group 1 describe the subject matter "sounds" the second most frequently, at the rate of 28·4%,

TABLE 4

Words used by respondents in Group 1 *in free responses about the living environment and their description rates*

Rank	Word used	Rate (%)	Rank	Word used	Rate (%)
1	Comfortable	36·2	9	Nearby	15·5
2	Convenient	34·5	10	Air	13·8
3	Transportation	20·7	11	Bad	12·1
4	Many	19·0	11	Neighbours	12·1
4	Good	19·0	11	Motorway	12·1
6	Neighbourhood	18·1	14	Sound	10·3
6	Works	18·1	14	Lives	10·3
8	Shopping	16·4	14	People	10·3

TABLE 5

Words used by respondents in Group 2 *in free responses about the living environment and their description rates*

Rank	Word used	Rate (%)	Rank	Word used	Rate (%)
1	Convenient	54·8	13	Environment	15·8
2	Comfortable	41·1	14	Bad	15·1
3	Transportation	34·9	15	Noise	13·7
4	Many	31·5	16	Automobiles	13·0
5	Shopping	30·1	17	Supermarket	12·3
6	Neighbourhood	29·5	18	Motorway	11·6
7	Station	26·7	18	Few	11·6
7	Nearby	26·7	20	Uncomfortable	11·0
9	Works	26·0	21	Feels	10·3
10	Air	25·3	21	Public office	10·3
11	Children	20·5	21	Not very good	10·3
12	Good	18·5	21	Nature	10·3

which is as high as that of "shopping". On the other hand, Group 2 respondents describe "sounds" the fourth most frequently, at the rate of 25·2%, which is half of that of "shopping". These results show that respondents in Group 1 are comparatively concerned about the sonic environment as an element of the living environment.

TABLE 6

Subject matters of free responses about the living environment and their description rates

	Description rate (%)			
Subject matter	All groups	Group 1	Group 2	Classification
Transportation	49·8	36·8	61·2	Convenience
Shopping	42·4	28·4	50·4	Convenience
Sounds	26·0	28·4	25·2	Environment
Air quality	25·7	18·9	31·7	Environment
Public facilities	14·9	8·4	20·9	Convenience
Nature related	14·5	13·7	16·5	Environment
Human relations	10·0	20·0	4·3	Communal environment

TABLE 7

Words used in free responses about the sonic environment and their description rates

Rank	Word used	Rate (%)	Rank	Word used	Rate (%)
1	Works	49·2	12	Opens/closes	14·9
2	Noisy	39·3	12	Doesn't bother	14·9
3	Motorway	37·3	12	Windows	14·9
4	Automobiles	30·0	15	Daytime	14·2
5	Neighbourhood	29·7	16	Audible	13·5
6	Noise	24·4	17	Apartment houses	13·2
6	Night-time	24·4	18	Runs	12·2
8	Gets on one's nerves	19·8	19	Motorcycles	11·2
9	Many	18·5	19	Road	11·2
10	Boso-zoku (motorcycle gangs)	16·5	21	Upstairs	10·2
11	Quiet	16·2			

The subject matter "air quality", which is also an important element of the environment, is described by as many respondents as "sounds". The description rate of Group 2 for this subject matter is the third highest and higher than that for "sounds", suggesting that respondents in Group 2 pay more attention to this subject matter than those in Group 1 do.

The description rates of Group 1 for the subject matter "human relations", 20%, which is strongly related to neighbours, is remarkably higher than that of Group 2, 4·3%. Many of the respondents in Group 1 respondents describing this subject matter admire their neighbours, writing a sentence such as "this area is comfortable to live in because of good neighbours". This result suggests that Group 1 consider their neighbours as a more important element of the living environment than Group 2 respondents. This is because there is a rural style to the relationship among the residents, except those living in apartment houses, who are mostly newcomers to the area and have an urban life style that includes more independent living.

4.3. RESPONSES ON THE SONIC ENVIRONMENT

Respondents were asked in Question 2 about the sonic environment as follows; "Please describe freely what you feel about 'sounds' at your house or in your neighbourhood".

When a respondent described the sonic environment in the answer to Question 1, it is very likely that he or she presumably omitted it in his or her answer to Question 2. Thus,

TABLE 8

Words used by respondents in Group 1 *in free responses about the sonic environment and their description rates*

Rank	Word used	Rate (%)	Rank	Word used	Rate (%)
1	Works	40·2	8	Quiet	18·8
2	Motorway	37·6	9	Many	17·1
3	Noisy	34·2	10	Audible	13·7
4	Automobiles	27·4	11	Gets on one's nerves	11·1
5	Night-time	20·5	11	Daytime	11·1
6	Neighbourhood	19·7	13	Has got used to	10·3
6	Noise	19·7			

TABLE 9

Words used by respondents in Group 2 in free responses about the sonic environment and their description rates

Rank	Word used	Rate (%)	Rank	Word used	Rate (%)
1	Works	56·2	15	Upstairs	19·9
2	Noisy	43·2	16	Daytime	16·4
3	Motorway	41·8	16	Road	16·4
4	Neighbourhood	37·7	18	Runs	15·8
5	Automobiles	33·6	19	Quiet	15·1
6	Noise	30·8	20	People	14·4
7	Night-time	27·4	20	Audible	14·4
8	Gets on one's nerves	26·7	22	Reverberates	13·7
9	Windows	25·3	22	Children	13·7
10	Opens/closes	24·7	24	Motorcycles	12·3
11	Apartment houses	23·3	25	Small	11·6
12	Many	21·2	26	Midnight	11·0
12	Boso-zoku (motorcycle gangs)	21·2	27	Downstairs	10·3
14	Doesn't bother	20·5			

the part of the answers to Question 1 relating to the sonic environment have been added to the answers to Question 2 in the following analysis.

4.3.1. *Words used in free responses*

Table 7 shows words used by more than 10% of respondents in the free responses concerning the sonic environment. Tables 8 and 9 show words used by more than 10% of respondents in Groups 1 and 2, respectively, in the free responses on the sonic environment.

The highest description rate is found for the word "works" which is described by about half of the respondents, the third highest for "motorway" and the fourth for "automobiles". This shows that works and road traffic are regarded as two major sound sources by the respondents.

Many of them describe "Boso-zoku", which are motorcycle gangs made up of mostly male teenagers who ride modified bikes as loudly as possible at night in and around cities.

The word "upstairs" shows sounds from upper or neighbour flats, which is a characteristic sound source in apartment houses. This word is used by about 20% of Group 2, and thus sound from other flats is the third main sound for Group 2.

The words "open/closes" and "windows", which are used by about 25% of Group 2 and used in sentences such as "so noisy as not to open the window" or "quiet when closing

TABLE 10

Sound sources described in free responses about the sonic environment and their description rates

	Description rate (%)		
Sound source	All groups	Group 1	Group 2
Road traffic sounds	63·7	58·3	68·3
Sounds from works	60·9	56·5	64·0
Sounds from other flats	22·8	2·8	38·1
Neighbourhood sounds	8·9	11·1	6·5

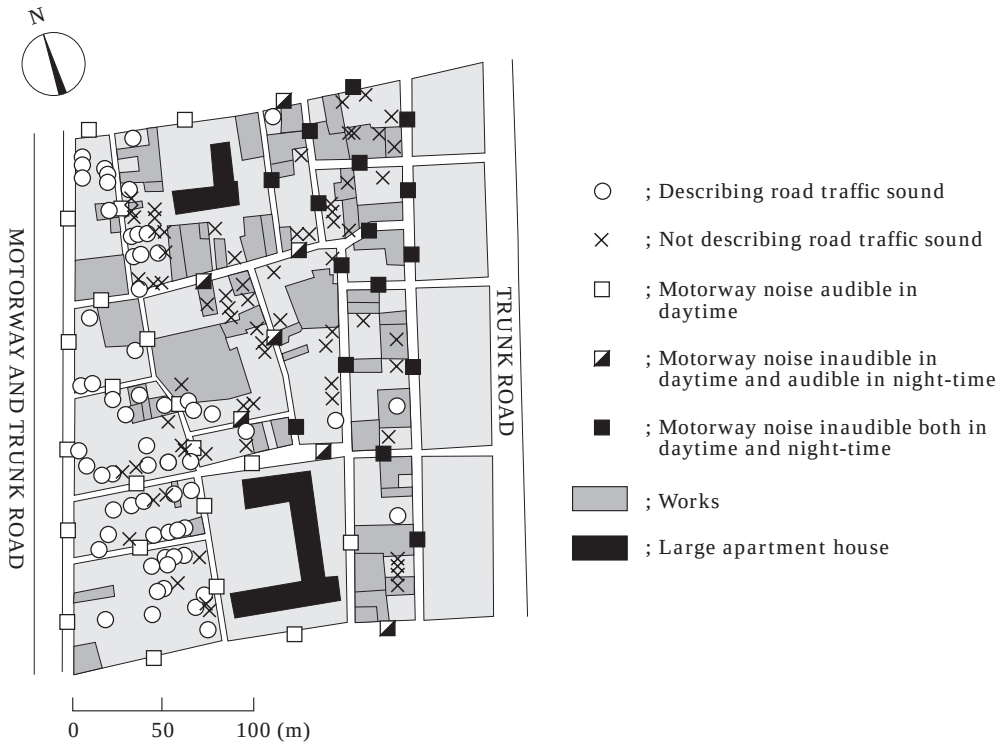

Figure 4. Locations of residences of respondents describing or not describing road traffic sounds.

the window'', show that windows play an important role when residents hear from neighbourhood sounds in their houses, especially for residents of apartment houses.

Of the words which are evaluations of the sonic environment, the word ''noisy'' is used by about 40% of the respondents and ''gets on one's nerves'' is used by about 20%. These words are used by more respondents in Group 2 than Group 1. On the other hand, the words ''quiet'' and ''doesn't bother'' are also used by about 15% of respondents.

4.3.2. *Sound sources described in free responses*

Table 10 shows sound sources described in free responses on the sonic environment. The word ''noise'' is not used as a name of a sound in the table, because answers describing the sound given by the respondents do not always imply a negative evaluation.

The description rates shown in the table are expressed in percentage of respondents who described the sound source to respondents who described one or more sound sources. Both ''road traffic sounds'' and ''sounds from works'' are described by more than 60% of respondents.

Figure 4 shows the locations of residences of respondents in Group 1 describing or not describing road traffic sounds. More respondents describing road traffic sounds live within 100 m of the motorway, and their distribution agrees well with the area in which the motorway noise is audible during the daytime on weekdays. Many of the respondents more than 50 m away from the motorway describe ''doesn't bother'' or ''has got used to'' etc.

Figure 5 shows the locations of residences of respondents in Group 1 describing or not describing the sounds from works. Many respondents describing these sounds live in places where these sounds are dominant during the daytime on weekdays.

Although many respondents who mention the sounds from works describe annoyance with those, 15% say that they are not bothered by them or have become used to the sounds from works. A few respondents affirmatively describe the sounds from works as ''sounds of vigour'' or ''sounds showing that people are working eagerly'' and so on. Respondents who are managers of works say that they do not mind the sounds of neighbours' works because they are afraid that the noise they make may bother their neighbours.

''Sounds from other flats'' are characteristic of apartment houses. Many respondents describing this sort of sound source mention sounds of children running or jumping, or those of dropping or dragging something on the floor in upper or neighbouring flats, particularly during night-time.

It is suggested in free answers that a resident living in an apartment house can be a marker of noise as well as an annoyee by noise. For example, some respondents describe that they have been warned against their children's making noise. Some also describe their attention to not making noise in their everyday life, such as telling their children not to make noise, or being cautious not to make noise when bathing or washing late at night. Some respondents say that noisiness can be alleviated by good relations with noisy neighbours.

5. CONCLUSIONS

The results of the present intensive survey are summarized as follows.

1. The sonic environment cannot be regarded as homogeneous even in such a small area as investigated here.

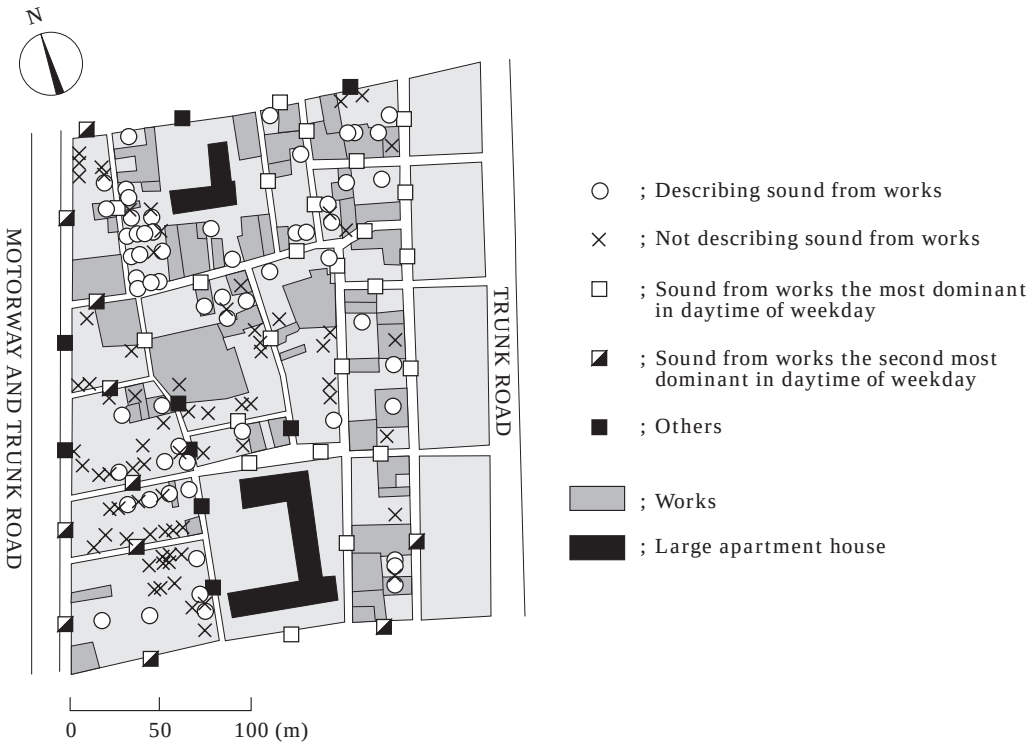

Figure 5. Locations of residences of respondents describing or not describing sounds from works.

2. There are some differences in responses to the sonic environment that are related to the respondents' living in different social contexts.

3. The response to the sonic environment depends upon the dominant sounds.

In the conventional extensive survey in Japan, a study area is sometimes divided into grids of 500 m × 500 m for which administrative information is filed. Each grid is then treated as a unit of the study area in order to assume an average community response to the sonic environment. This concept of survey means that the sonic environment is taken as being homogeneous in each grid.

The results of the present study, however, show that the sonic environment observed by researchers and described by respondents cannot be regarded as homogeneous even in such a small area as the present study area. In such an area, therefore, it would be meaningless to suppose an average community response to the sonic environment. Thus the intensive survey is necessary for studying the community response to the sonic environment.

ACKNOWLEDGMENTS

The authors express their sincere appreciation to the respondents for their co-operation in this survey.

REFERENCES

1. K. Minoura and K. Hiramatsu 1997 *Journal of Sound and Vibration* (this volume). On the significance of an intensive survey in relation to community response to noise.
2. S. Suga, K. Oi, Y. Kondoh and S. Miyamoto 1994 *Proceedings of Inter-Noise*'94, 1169–1172. Study on annoyance and trouble caused by pollution in a residential area in a megalopolis by analyzing free response data.

APPENDIX: CONTENTS OF QUESTIONNAIRE

A. Questions about attributes of respondents: 1. age; 2. sex; 3. number of family members; 4. length of residence in the area; 5. type of residence; 6. occupation; 7. place of work; 8. time leaving the neighbourhood in daytime.

B. Questions to be answered freely: 1. ''Do you think your neighbourhood is comfortable to live in? Please express your ideas freely''; 2. ''Please write your idea about 'sounds' at your house or in your neighbourhood freely''; 3. ''Please write freely what you find has changed in relation to the environment of your neighbourhood in recent years. If you are a newcomer, please write what you find has changed since you moved to this area''.