Fundamental investigation of easy to talk at multigroup communication space

Y. Hiraguri[1], M. Ueda[2], K. Kawai[3] and T. Yano[3]

[1] Department of Civil Engineering and Architecture, Tokuyama College of Technology, Gakuen-dai, Shunan, Yamaguchi 745-8585, JAPAN, hiraguri@tokuyama.ac.jp

[2] Aviation Environment Research Center (AERC), 1-6-5 Haneda airport, Ohta-ku, Tokyo 144-0041, JAPAN, m-ueda@aeif.or.jp

[3] Graduate School of Science and Technology, Kumamoto University, Kurokami 2-39-1, Chuo-ku, Kumamoto 860-8555, JAPAN, kkawai@kumamoto-u.ac.jp, yano@gpo.kumamoto-u.ac.jp

ABSTRACT

It is often the case that the spaces where multigroup has conversation individually such as restaurants, tearoom or hotel lobby, have long reverberation time and high noise level because of the architectural characteristics. In general, people feel noisy or difficult to talk in such space. On the other hand, the spaces with less reverberation and low noise level are not preferred as the communication space, because someone's own voice can easily transfer to other communication group. There is opposite evaluation about easy to talk at multigroup communication space. In order to find out a solution of sound environmental problem about easy to talk at multigroup communication space, measurements of sound environments and questionnaire survey were conducted at a restaurant in Kumamoto University. As the results, a unique relationship between the RASTI and the evaluation of easy to talk was indicated.

INTRODUCTION

Achieving a good acoustical design at the space where multigroup has conversation individually such as restaurant, teahouse and hotel lobby is difficult. In a case of large room volume or a lot of unabsorbed interior materials, the room has too much reverberation. Sometimes serious flaws are pointed out by the users or the customers, with some saying it is "Noisy," "In order to less speech intelligibility, it is not easy to talk" or "When I'm there for quite a while, I get a headache." On the other hand, a conversation from another group of customers (for example business meeting or talk about their serious problem) is clearly audible to us in a case of quiet acoustic environment with no reverberation in the room. At the time, our group's voice of conversation also propagates enough to the other group. There is opposite evaluation about easy to talk at multigroup communication space. Therefore, it is difficult to achieve a balance of establishing clear speech communication and ensuring speech privacy.

Astolfi *et al.* evaluated the quality of speech communication in four pizzeria-restaurants by means of questionnaire and measurements (Astolfi & Filippi 2004). They evaluated a spatial distribution of Speech Intelligibility Index, SII (ANSI S3.5/1997) with taking into account the sound reverberation, seating density and the type of customers. As the results, they proposed that SII values should be greater than 0.45 at the customers own table, for fair speech intelligibility (ISO 9921:2003), but lower than 0.20 in correspondence to the neighbouring tables, for good privacy.

In order to find out a solution of sound environmental problem about easy to talk at multigroup communication space, acoustic measurements and questionnaire survey were conducted at FORICO, a restaurant in Kumamoto University. In this research, reverberation time and Rapid Speech Transmission Index, RASTI (Houtgast & Steeneken 1984), which is generally used for designing a room acoustic are measured to evaluate the easy of talk at multigroup communication space.

ACOUSTIC MEASUREMENT AND QUESTIONNAIRE SURVEY

The acoustic characteristics (the reverberation time and the RASTI) were measured in area 1 build up with 1-A, 1-B, 1-C and 1-D, area 2 and area 3 illustrated in Fig. 1. This restaurant is constructed with reinforced concrete walls, glass windows and rock wool ceiling board (Fig. 2). At first, the reverberation time were measured with no customer according to the interrupted noise method using two loudspeakers (YAMAHA SMR 400). The number of receiving points is 8, 5 and 5 points in the area 1, 2 and 3, respectively. The representative reverberation time at each area is the averaged value of all the data in the set.

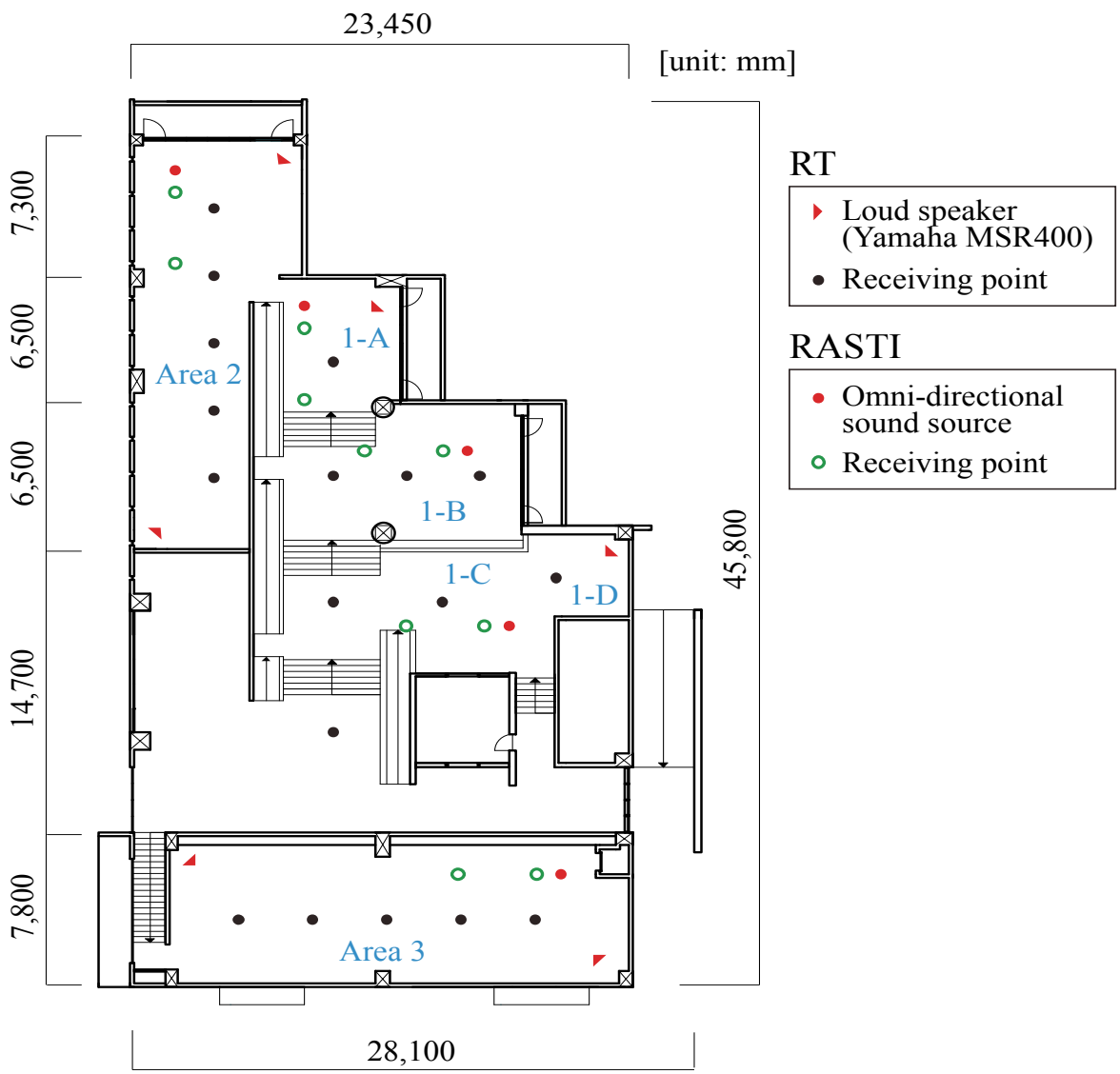

Fig. 1 Floor plan and measuring points.

Fig. 2 Conditions inside the FORICO, left: view from area 1-A to area 3, middle: view of area 1-C and 1-D, right: area 2.

The measurements of impulse response for calculating the RASTI were carried out in the area 1-A, 1-B, 1-C, 2 and 3 according to maximum length sequence method using an omni-directional loudspeaker. The distances from sound source to receiver are one meter on the assumption that the speech intelligibility in own talking group and five meter on the assumption that the speech intelligibility from other talking group (Fig. 1). The receiving points are located 1.2 meter from the floor.

The questionnaire survey was conducted with 493 customers (377 male and 116 female) from April to May 2012. The questionnaire consists of five categories: (i) individual attribution, (ii) usage frequency, (iii) area where respondents take a seat during the period of survey, (iv) impressions of the sound environment at table and (v) free description about the sound environment in the FORICO. The Category (iv) consists of four questions: a) Reverberation, b) Noisiness, c) Ease of talking and d) Volume of BGM, and the responses to the questionnaire items are made on a five point ordinal scale ranging from “Not at all” (code 1) to “Extremely” (code 5) as shown in Table 1.

Table 1 Questionnaire items about impression of sound environment

	Code				
	1	2	3	4	5
a) Reverberation	Not at all reverberate	Slightly reverberate	Moderately reverberate	Very reverberate	Extremely reverberate
b) Noisiness	Not at all noisy	Slightly noisy	Moderately noisy	Very noisy	Extremely noisy
c) Ease of talking	Not at all matter	Slightly no matter	Moderately difficult to understand	Very difficult to understand	Extremely difficult to understand
d) Volume of BGM	Not at all noisy	Slightly noisy	Moderately noisy	Very noisy	Extremely noisy

RESULTS OF ACOUSTIC MEASUREMENT

Figure 3 illustrates the average values of reverberation time at 1/3 octave band, the center frequency is from 50 Hz to 10 kHz, of each measurement area. The reverberation time at 1 kHz is about 2.8 seconds, 1.8 seconds and 2.6 seconds at the area 1, 2 and 3, respectively. While there is no customer but few measurers during the measurements, whole area in the FORICO has too much reverberation equivalent of the optimum reverberation time in a church. The result of measuring the RASTI will hereinafter be described with the results of questionnaire survey.

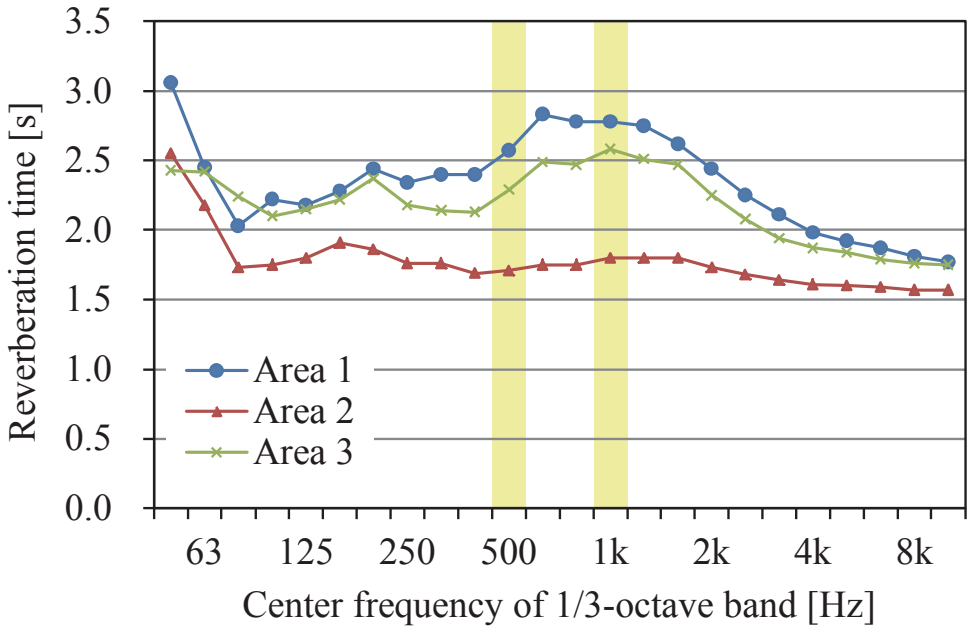

Fig. 3 Average of Reverberation time of each measurement area.

RESULTS OF QUESTIONNAIRE SURVEY

The results of four questionnaire items (reverberation, noisiness, ease of talking and volume of BGM) about the sound environment in the FORICO are illustrated in Figure 4. The summation of the ratio who responded “moderately,” “very” or “extremely” reverberate (from the code 3 to 5) are about 73 percent of all respondents. The 62 percent of all respondents were answered as “moderately,” “very” or “extremely” noisy. Moreover, almost 33 percent of all respondents feel “moderately,” “very” or “extremely” difficult to understand the partner’s talking. Judging replies such as these, the customers may dissatisfy to the acoustic characteristics of the FORICO. However, the true rate of the difficult to talking is higher than it, because all customers do not talk with their partners. In addition, many respondents also answered “noisy,” “much reverberate” or “difficult to talk” at the free description section. Another hand, the volume of BGM is of relevance for almost customer.

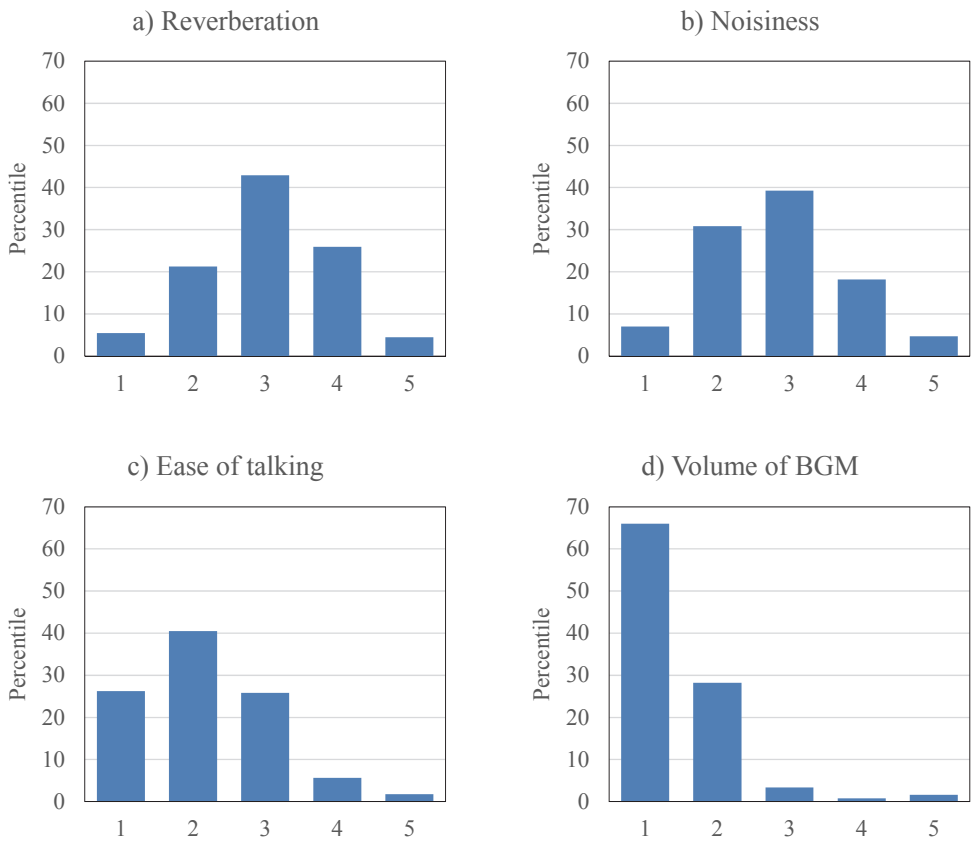

Fig. 4 Responses to question about the sound environment in FORICO. The value on the horizontal axis means the code of evaluation in table 1.

RELATIONSHIP BETWEEN RASTI AND EASY TO TALK

Figure 5 illustrates the relationship between the reverberation time of 500 Hz and 2 kHz and RASTI at 1 and 5 meter distance from sound source. Only the relationship between the RT_{500Hz} and $RASTI_{1m}$ has correlation. Since the each room is connected spatially as a coupled room it would appear that the reverberation time becomes longer.

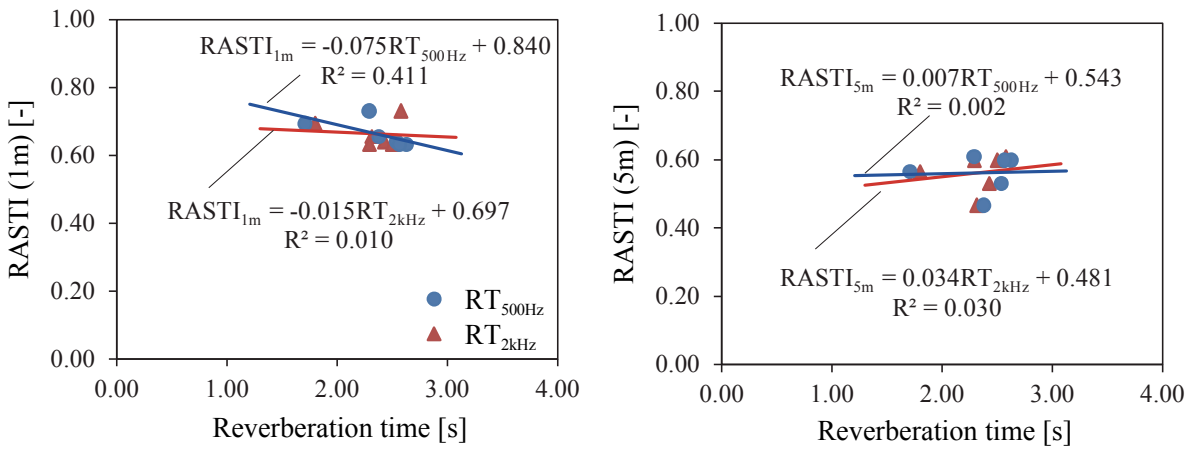

Fig. 5 Relationship between reverberation time at 500 Hz and 2 kHz and RASTI observed 1 and 5 meter distance from sound source. The blue line and plots means the reverberation time at 500 Hz, and the red line and plots means those at 2 kHz.

In order to observe the effect of the acoustic characteristics to the impression about sound environment, the relationship between the four kind of responses to sound environment (summation of the ratio who responded “very” or “extremely” to all respondents) and acoustic characteristics (reverberation time at 500 Hz and RASTI at 1 and 5 meter distance from sound source) illustrate in Fig. 6. The red solid lines mean the single regression line. As the results, following knowledge was obtained:

- The rate of responding higher reverberation tends to increase as the reverberation time becomes longer. Similarly, when the RASTI value becomes smaller (the speech intelligibility decreases), the customers become feeling reverberant as common knowledge.
- Concerning the ease of talking, it is correlated to the RASTI at the 5 meter distance from sound source, while the other acoustic characteristics have no correlation. In general, the speech intelligibility becomes better as the RASTI value becomes higher, however, the opposite tendency that the speech intelligibility has gotten worse was observed in this survey. It is a unique aspect in the multigroup communication space.

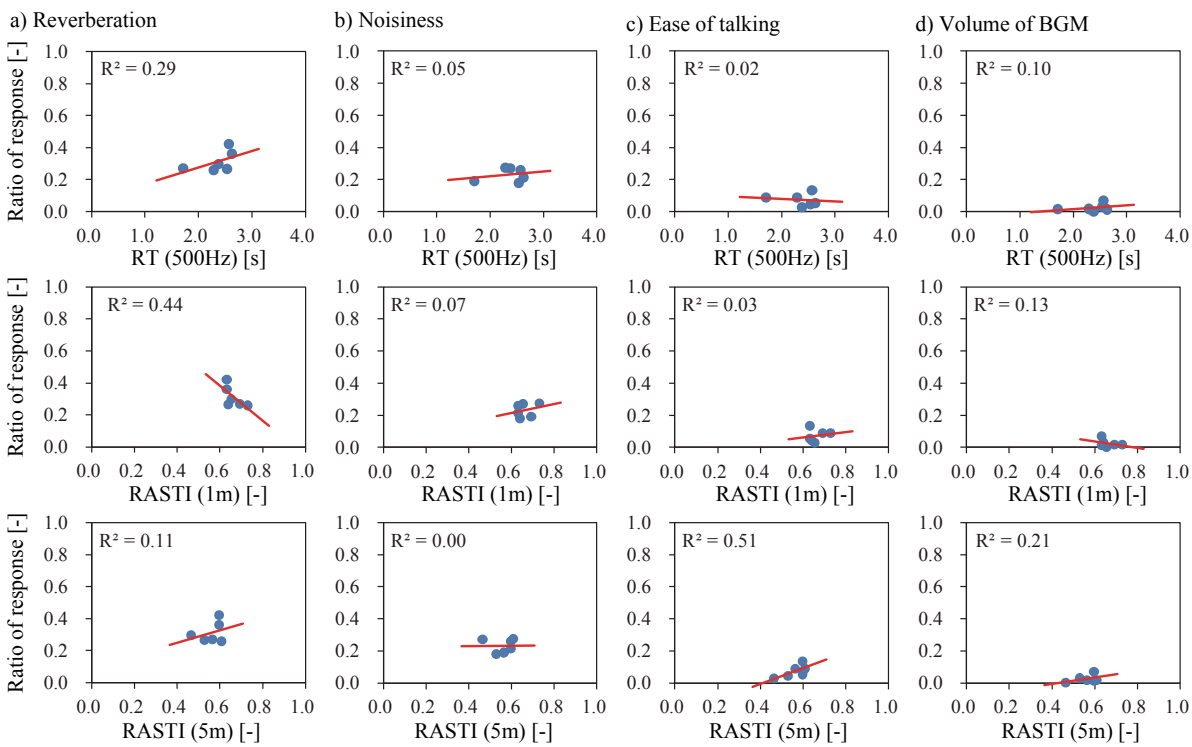

Fig. 5 Relationship between the impressions about sound environment and the acoustic characteristics. The red lines mean the single regression line and the values of R^2 mean the determination coefficient by single regression analysis.

CONCLUSIONS

In order to find out a solution of sound environmental problem about easy to talk at multigroup communication space, reverberation time and RASTI were measured and the questionnaire survey were conducted to evaluate the easy of talk at multigroup communication space. As the result, the unique aspect in the multigroup

communication space was obtained at the relationship between impression about the ease of talking and the RASTI at 5 meter from the sound source.

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