Actual Condition Survey and Evaluation on Acoustic Environment of Open Type Classroom

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Abstract

An acoustic environment of open type elementary school has often been reported about sound problems to be solved. Noting such a situation, we have been studying on actual condition of these type schools, such as acoustic characteristics of classroom, sound transmission between classrooms and user's consciousness about acoustic environment. As a series of our studies, we grasped acoustic problems quantitatively both in building conditions and consciousness of children and teachers. Besides, we could acquire the knowledge of improving sound insulation.

1. Introduction

In the past, one classroom was generally consisted of about 60 students in our country, and the most of classrooms were planed as the closed type (side corridor type). Recently, 40 students classroom becomes to be usual, and unique planning classroom is increasing by request of educational qualities. It is considered that open type classroom is one of planning techniques, and this tendency must become stronger in Japan. It is supposed that this open type planning most possibly causes the various troubles [1]. The present report concerns the results of field measurements and scale model experiment on sound insulation between classrooms, and summary of questionnaire investigation on consciousness of children and teachers.

2. The outline of the open type classroom

Fig. 1 shows the arrangements of the open type classrooms that were chosen as the field measurements [2]. As may be seen from Fig. 1, securing of sound insulation is very difficult. Table 1 shows the interior finishing of each classroom. As shown Table 1, most of interiors were finished with reflection materials without ceiling and floor. It is supposed that the specifications as described above are often usual in our country.

Table 1: The outline of the classroom interior specifications.

Table 2: The measured value of reverberation time

Fig. 2 shows the reverberation time of the open and closed type classroom and of the comparison between the open type classroom and its open space. As well known, the reverberation time of the closed type is dominated those classroom's own interior specifications. On the other side, it of the open type is affected by the interior specifications of the open space. As shown Fig. 2, the average value of reverberation time of the open type is about 0.7 sec., which is a little longer than it of the closed type.
4. The measured value of STI

Fig. 3 shows the dispersion of the measured value of STI at each open type classroom. From Fig. 3, the range of STI shows 0.65 - 0.75 on the whole, and standard deviation is small.

5. Sound insulation performance between the classrooms

Fig. 4 shows the difference of SPL (Sound Pressure Level) between classrooms comparing the open type with the closed type. The measured value of the closed type is about D35. On the other hand, it of the open type is about D15. Among the open types, School-B has the best performance for its sidewalls between classrooms. Sound insulation of School-A2 is under D15, which is caused by room arranging in a series through the open space and by the reflective floor. Noting to the sound insulation between classroom and corridor at the closed type, the measured value is about D15, which is similar to the performance between the open type classrooms.

6. Sound attenuation property of classroom area

Fig. 5 shows the contour of the sound attenuation property at classroom area in 500Hz, which was measured by setting up the nondirectional speaker at the center of sound source room. From these contour maps, the attenuation amount, from sound source room to its next room, is 14 - 16 dB in the worst case (School-A2), and is 22 - 24 dB in the best case (School-B).

7. Sound propagation during class hours

Fig. 6 shows sound propagation during class hours from a classroom to its next. The time rate beyond 45dBA is 74% as shown this figure. It can think that above sound environment most possibly raises various problems on learning without a proper countermeasure [3].

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**Fig. 2**: The measured value of reverberation time of the classroom without students.

**Fig. 3**: The measured value of STI.

**Fig. 4**: Comparison of sound insulation between the classrooms.

**Fig. 5**: The contour map of the SPL attenuation property (500Hz).
8. Scale model simulation on sound propagation

On the effect of the classroom arrangement and the sound absorption to the attenuation between classrooms, we made the experiment by the 1:10 scale model of classroom [4], [5]. The experimental conditions were the following.

1. Absorbing ceiling only
2. In addition to (1), Absorbing floor
3. In addition to (2), putting sidewall at a divider between classrooms
4. In addition to (3), absorbing walls in the open space
5. In addition to (4), putting absorbed edges around the opening of classroom

First, we made the model with 4 parallel-arranged rooms like Fig. 7 (I type), which based on the arrangement of School-B. Fig. 8 shows the difference of SPL between classrooms in Fig. 7. From this figure, the difference of SPL is D-15 in the worst case (case (1)), and is D-25 in the best case (case (5)). Fig. 9 shows the comparison of sound contour map between (1) and (5).

Next, we made the model with 3 oblique arranged rooms like Fig. 10 (II type). Fig. 11 shows the difference of SPL between classrooms in Fig. 10. From this figure, the difference of SPL is about D-35 in the best case. Fig. 12 shows the comparison of sound contour map between (1) and (5).
9. An example of improved plan

Photo 1 shows an example of improving the performance of sound insulation between classrooms using continuous sliding doors. As shown in Fig. 13, the difference of SPL between classrooms is about D-30 when the doors of both rooms were closed.

Fig. 13: Difference of SPL (Open type classroom with sliding doors).

1) Whole door closed. 2) Whole door opened.

Photo 1: The classroom with continuous sliding doors

10. Questionnaire investigation on user’s consciousness

Fig. 14 shows an example of the questionnaire investigation result about the sound environment for the teachers and students who moved from the closed type to the open type [6]. From this figure, it can be observed that they were sensitive about the noise from the neighboring classroom. And we see that such tendency is not very much change over several years.

1) Can you hear the sound from your next classroom?

2) Does the sound of the next classroom disturb your learning?

Fig. 14: Questionnaire investigation on user’s consciousness.

11. Conclusions

1) Acoustic characteristics such as reverberation time of classroom are often influenced by that of open space.
2) At the open type classrooms shown in this paper, the measurement results of STI are almost satisfactory.
3) It is cleared that the sound insulation performance between open type classrooms is considerably lower than that of the closed type. So that, it may be in danger of incurring sound problems without delicate usage.
4) The noise from the neighboring classroom tends to disturb children’s focus attention on learning.
5) The tendency described in 4) is confirmed through questionnaire investigation.
6) To improve sound environment of classrooms, on the sides of school planning, absorbing treatment and arrangement of classrooms are important factors, and at the same time, the particular device on usage is indispensable [6].

Hereafter, it is hoped to investigate continuously on the sound environment of classrooms.

12. References