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► **To cite this version:**

Kanako Ueno, Toshiko Fukuchi, Yuzo Tsuchiya. Revision of standard for sound environment in school buildings published by the Architectural Institute of Japan. Forum Acusticum, Dec 2020, Lyon, France. pp.177-180, <10.48465/fa.2020.0299>. <hal-03235231>

HAL Id: hal-03235231

<https://hal.science/hal-03235231v1>

Submitted on 26 May 2021

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REVISION OF STANDARD FOR SOUND ENVIRONMENT IN SCHOOL BUILDINGS PUBLISHED BY THE ARCHITECTURAL INSTITUTE OF JAPAN

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ABSTRACT

As a standard addressing the acoustic performance of classrooms, AIJ, the Architectural Institute of Japan, published a standard for school buildings in 2008, titled “Academic Standard and Design Guidelines for Sound Environment in School Buildings.” The standard indicates the acoustical performance criteria of ambient noise level, sound insulation performance, and reverberation time. In addition, requirements regarding the operation characteristics of the electro-acoustic system are indicated in the annex. The standard also provides design guidelines to fulfill the acoustical criteria and for the rooms that require special care in terms of acoustics. Twelve years after the first edition was published, the revised edition was published in 2020. In the revised edition, the following additions were made. First, in the annex of the standard part, the recommended values of nursery rooms for preschoolers were added. In the design guideline section, chapters regarding the generally lower acoustic performance of wooden construction and steel-frame construction were added, reflecting the recent trend of school buildings. Furthermore, for children who need special acoustic consideration, the chapters “Learning environment for children requiring special support,” and “Nursery room for preschool children” were added. This paper offers an overview of the revisions to the standard and the guidelines.

1. INTRODUCTION

Acoustical conditions in school buildings are essential for educational activities, and many countries have published the national standards or guidelines. In Japan, the Architectural Institute of Japan (AIJ) published a standard for school buildings in 2008, titled “Academic Standard and Design Guidelines for Sound Environment in School Buildings.” [1, 2]

Since the first edition was issued, the role of the environmental standards of AIJ (AIJES) has been discussed in relation to national laws and regulations and how they are used in practical situations. It was also necessary to reconsider the contents while referring to the recent situation in Japan. Under the conditions mentioned above, a working group in the revised edition was set up in 2016. After working for three and a half years, the

Part I: Environmental Standards for the Sound Environment in School Buildings

1. Purpose
2. Scope of application
3. Normative references
4. Required acoustic condition of rooms
5. Acoustical performance criteria
 - 5.1 Background noise level
 - 5.2 Airborne sound insulation
 - 5.3 Sound insulation for floor impact sound
 - 5.4 Reverberation

Annex A. Operating characteristics of electro-acoustic system

Annex B. Sound environment in nursery facilities *

Part II: Design Guidelines

1. Sound environment in school buildings
 - 1.1 Acoustic problem of school buildings
 - 1.2 Acoustic performance for school buildings
 - 1.3 Sound conditions in schoolrooms
2. Planning of sound environment in school buildings
 - 2.1 Overview
 - 2.2 Acoustical consideration in site planning and room arrangement planning
3. Acoustical performance criteria and design guideline
 - 3.1 Background noise level
 - 3.2 Airborne sound insulation
 - 3.3 Sound insulation for floor impact sound
 - 3.4 Reverberation
 - 3.5 Operating characteristics of electro-acoustic system
4. Design for the rooms that require special acoustic care
 - 4.1 **Wooden construction ***
 - 4.2 **Steel construction ***
 - 4.3 Open-plan type classroom
 - 4.4 Gymnasium
 - 4.5 Rooms for music
5. Design for children who require special acoustic care
 - 5.1 **Learning environment for children requiring special support ***
 - 5.2 Classroom for hearing impaired children
 - 5.3 **Nursery room for preschool children ***

* : sections newly added on the revised edition

Table 1. Table of contents of the revised edition.

revised edition was published in June 2020 [3]. In this paper, an overview of the revisions to the standard and design guidelines is presented.

2. OVERVIEW OF THE REVISED PUBLICATION

2.1 Structure of the original version

The original standard published in 2008 consists of two parts: Part I indicates standards and Part II shows design guidelines.

In Part I, the purpose is stated to indicate the recommended values of acoustic performance to maintain the indoor sound environment of school buildings from the viewpoint of functionality, health, comfort, and welfare. The scope of application is the rooms in elementary schools (age 7 to 12), junior high schools (age 13 to 15), and senior high schools (age 16 to 18). The acoustic criteria are indicated for background noise level in rooms, airborne sound insulation and floor impact sound insulation between rooms, and reverberation in rooms. In addition, the operation characteristics of the electroacoustic system are indicated in the annex. To determine the acoustical performance criteria of schoolrooms, activities in the rooms, sound generation by the class activity, required background noise level, and required reverberation were supposed as shown in Table 2. The rooms were categorized by four ranks of activity noise, three ranks of required background noise level, and three ranks of required reverberation. [2]

Part II, Design Guidelines, describes acoustic problems that occur frequently in school facilities, acoustic performances that should be taken into consideration, and acoustic checkpoints at the locational planning stage of buildings and rooms. Moreover, explanations of the recommended values of the acoustic performances shown in Part I and design guidelines for achieving the recommended values are summarized.

Furthermore, acoustic design methods and design examples are presented for open-plan classrooms, gymnasiums, music-related rooms, and classrooms for hearing-impaired children, which are particularly prone to acoustic problems.

2.2 Outline of the revision

The revision of the standard was carried out as a minor revision process of AIJES. That is, the overall configuration and the recommended values of acoustic performance shown in the first edition did not change.

The table of contents is shown in Table 1, in which the new chapters are indicated by bold fonts with asterisks. In the revised edition, the following additions were made. First, the rooms for children requiring special support were added to the table of schoolrooms for categorization. In addition, as Annex B of Part I, recommended values of nursery rooms for preschoolers were added. For Part II, chapters about the generally lower acoustic performance of wooden construction and steel-frame construction were added, reflecting the recent trend of school buildings in Japan. In addition, the chapters “Learning environment for children requiring special support” and “Nursery room for preschool children” were added.

3. ADDITION MADE IN THE STANDARD

3.1 Rooms for children requiring special support

In Japan, the number of children with disabilities and children enrolled in regular classes requiring special educational support is increasing. According to a survey by the Ministry of Education, Culture, Sports, Science and Technology of Japan on the targets of special needs education, the percentage of children receiving special needs education in elementary and junior high schools is

Room / Space	Activities	Activity noise* ¹	Generation of floor impact sound* ²	Required background noise level* ³	Required reverberation* ⁴
<i>Classroom</i>	<i>Class</i>	<i>Middle-1</i>	-	<i>B</i>	<i>Moderate</i>
<i>Classroom for hearing impaired students</i>	<i>Listening/speaking training</i>	<i>Middle-1</i>	-	<i>A</i>	<i>Short</i>
Classroom for children requiring special support	Class and activities	Middle-1	-	B	Short
Relax room for children requiring special support	Taking a rest	High	-	A	Short
Nursery room* ⁵	Singing, talking, playing, eating	Middle-2	○	B	Short
	Sleeping, taking a rest	Low		A	Short
Playroom* ⁵	Playing the instrument, gymnastic exercises, playing	Middle-2	○	B	Short

*¹ Activity noise are categorized in four steps of Low, Middle-1, Middle-2, and High.

*² ○, ⊙: rooms where the floor impact that disturbs the class situated below is supposed to be generated in class activities.

○: light and heavy impact source, ⊙: mainly heavy impact source.

*³ Required background noise level are categorized in three steps of A: 35 dB, B: 40 dB, and C: 45 dB.

*⁴ Required reverberation are categorized in three steps of Short, Moderate, and Long.

*⁵ Rooms defined in Annex B

Table 2. Classification of schoolrooms that are newly added in the revised edition.

5.0% (486,387 students, as of May 2019). This number includes students enrolled in special needs schools and special needs classes, and those enrolled in regular classes and receiving special support. In addition, the percentage of children with developmental disabilities (LD, ADHD, high-functioning autism, etc.) enrolled in regular classes was approximately 6.5% (2012 survey results). Recently, there has been increasing awareness of the need to set the environment based on the sensory characteristics of children with developmental disabilities. In other countries, there are cases where recommended conditions have been added to the guidelines in recent years [4-5].

Based on the abovementioned situation, two rooms of “Classroom for children requiring special support” and “Relax room for children requiring special support” were newly set in room classification. By referring to the survey results indicating the actual situation of special needs education and the guidelines published in the other countries, the sound environment characteristics of the two rooms were set, as shown in Table 2. “Classroom” and “Classroom for hearing impaired students” that were indicated in the first edition are shown in italics for reference.

3.2 Nursery rooms for preschoolers

The target facilities for the first edition were elementary school, junior high school, and senior high school, and they did not include childcare facilities for preschoolers. There have been many cases where acoustic consideration is insufficient in the design of nursery rooms, and problems with poor sound environments have been pointed out in recent years. Moreover, WHO has mentioned that infants in the developmental stage of language and hearing are susceptible to interference from ambient noise and reverberation, and the importance of indicators such as background noise and reverberation is being recognized in Japan. Therefore, referring to the guidelines in other countries, the revised version shows "Sound environment in nursery facilities" as Annex B, which targets nursery schools, kindergartens, certified children's institutes, after-school day-care facilities, etc.

Two categories of nursery room and playroom were acoustically characterized, as shown in Table 2. In Annex B, the recommended values of background noise level and reverberation time are shown for the three-room category. In addition, the importance of the following four points were indicated: (1) ensuring conversation clarity and reducing noise, (2) conserving a quiet environment, (3) planning considering the noise propagation inside and outside the nursery school, and (4) countermeasures against floor impact noise and floor vibration.

4. ADDITION MADE IN DESIGN GUIDELINES

4.1 Design for the rooms that require special acoustic care

In addition to the open-plan classrooms, gymnasiums, and music-related rooms shown in the first edition, acoustic precautions for wooden and steel structures, which have been increasing in recent years, are summarized. The sound insulation performance and floor impact sound insulation performance of wooden and steel constructions are different from those of conventional reinforced concrete construction. To obtain sufficient acoustic performance, it is necessary to know the precautions peculiar to wooden and steel structures. Therefore, the measurement results in the laboratory and the actual building are shown, and the points to be noted regarding ensuring the acoustic performance are described. In the design guidelines, many diagrams were presented to convey the main points to the designer. Figure 1 shows examples of the diagrams.

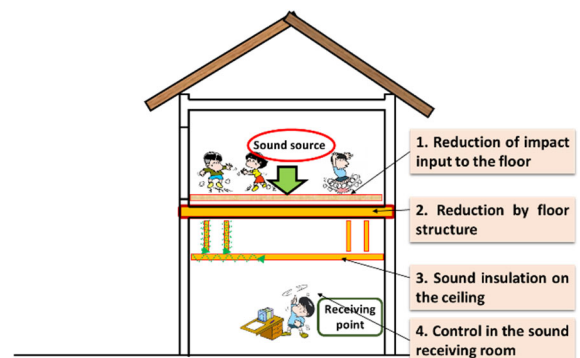


Figure 1. Measures against floor impact noise in wooden school buildings.

Acoustic criteria	Recommended value	note
Background noise	35 40	Quiet condition is especially required (for rest) Quiet condition is desirable (for class and activities)
Airborne sound insulation performance	45 / 50 / 60 40 / 45 / 55	Source room : Middle-1 / Middle-2 / High ^{*1} (for rest) Source room : Middle-1 / Middle-2 / High ^{*1} (for class and activities)
Floor impact sound insulation performance	50 55/45/40	Source room : I ^{*1} * ² (for rest) Source room : I / II / III ^{*1} (for class and activities)
Reverberation time [s], ($\bar{\alpha}$)	0.5, (0.25)	Reverberation category : Short (200 m ³)

*1 Middle-1, Middle-2, and High show the category of noise level generated in the room. I, II, and III show the category of floor impact generation.

*2 Avoid placing rooms containing heavy impact sources, indicated by II and III, upstairs.

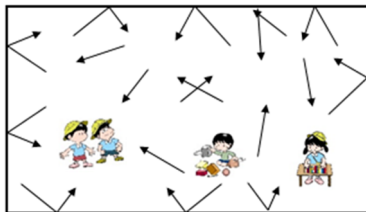
Table 3. Recommendation value for the learning environment for children requiring special support.

Acoustic criteria	Recommended value	note
Background noise	35 40	Quiet condition is especially required (for afternoon nap and rest) Quiet condition is desirable (for activities)
Airborne sound insulation performance	50 45	Source room : Middle-2 ^{*1} (for afternoon nap and rest) Source room : Middle-2 ^{*1} (for class and activities)
Floor impact sound insulation performance	45	Source room : II ^{*2}
Reverberation time [s], ($\bar{\alpha}$)	0.4, (0.25) 0.5, (0.25) 0.7, (0.25)	Nursery room (for one class, 125 m ³) Nursery room (for multiple classes, 250 m ³) Playroom (600 m ³)

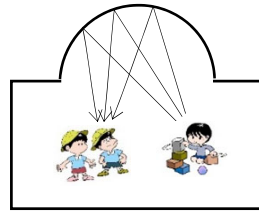
*1 Middle-2 shows the category of noise level generated in the room.

*2 II shows the category of floor impact generation for light and heavy impact.

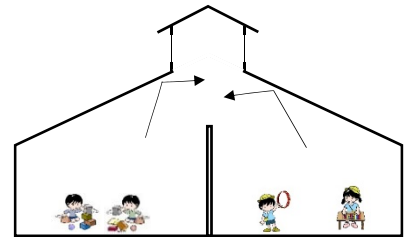
Table 4. Recommendation value for nursery room for preschool children.



Playroom (200 m², CH=7 m) with no sound absorption materials. The reverberation time is close to 3 seconds and it is difficult to make conversation.



A ceiling with a vault shape. Both the concentration of sound due to the concave surface and the increase in reverberation due to the high ceiling occur.



Opening the upper part of the partition wall so that the windows on the high ceiling can be seen from both sides. The sounds of each other are interfering.

Figure 2. Examples of an actual sound problem in nursery rooms.

4.2 Design for children who require special acoustic care

As shown in Sections 3.1 and 3.2, rooms for children requiring special support and nursery rooms for preschoolers have been newly added to the target rooms. Tables 3 to 4 show the recommended values of the acoustic performance of each space. These values are set in consideration of the characteristics of each space. Regarding the criteria of the background noise, the recommended values for the rooms for rest are lower than those of the standard classroom. Regarding the room reverberation, the average sound absorption coefficient $\bar{\alpha}$ is set at 0.25, which is higher than that of the standard classroom (0.2), and the reverberation time was calculated and indicated for each room volume.

In the section on learning environments for children requiring special support, we explained the characteristics of children that need consideration regarding the sound environment and the acoustic requirements of special support classrooms. In addition, we introduced the importance of sound absorption in the work space, the need and examples of a relaxing space, sound absorption in stair and corridors, and sound absorption treatments that can be introduced at the operation stage.

Regarding nursery facilities, we presented the importance of sound environment, typical sound sources in nursery rooms, and acoustical requirements for nursery spaces. In addition, acoustic problems caused by insufficient sound absorption, insufficient sound insulation, and acoustically unfavorable room shapes were illustrated for the designer as shown in Fig. 2. Moreover, we explained the facility layout plan to prevent the transmission of sound to the neighborhood and the measures to be taken when the nursery facility is located in a noisy environment.

ACKNOWLEDGEMENT

The standard and guidelines were drafted by the following members of the working group: Toshiko Fukuchi (chief editor), Kanako Ueno (organizer), Yuzo Tsuchiya (organizer), Satoshi Inoue, Masaya Uchida, Keiji Kawai, Toru Kawarazuka, Tetsuya Sakuma, Atsuo Hiramitsu, Motoki Yairi, Mitsutoshi Watanabe, and Isao Masuda (illustrator).

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