

Zoning scheme based on stages in evacuation shelters at elementary schools

Yamato Yuya^{1*}, Nguyen Dinh-Thanh² and Shen Zhenjiang³

1. Department of Civil Engineering, National Institute of Technology, Fukui College, Geshi-machi, Sabae, Fukui, JAPAN

2. Department of Engineering Geology, University of Science, Vietnam National University, Ho Chi Minh City, 227 Nguyen Van Cu street, Ward 4, District 5, Ho Chi Minh City, VIETNAM

3. Joint International Laboratory of Spatial Planning and Sustainable Development between Kanazawa University and Fuzhou University in School of Architecture, Fuzhou University Fuzhou, CHINA

*yamato@fukui-nct.ac.jp

Abstract

In Japan, elementary schools are usually designated as evacuation shelters during disasters. Japanese regulations require spatial planning for evacuation shelters. It is important to consider the zoning of spaces according to the stages of shelter life. The purpose of this study is to provide guidelines on the zoning of evacuation spaces, living spaces and educational spaces according to the stage in the evacuation shelter and considering the ease of separation of flow lines, ease of separating the elderly when they are in large numbers and the possibility of insufficient living space.

This study refers to the arrangement of various rooms by building type. Each building type has different characteristics and challenges and linear-shaped building is the simplest choice when considering only flow line planning. However, the building type needs to be selected according to the circumstances of the surrounding environment. When the evacuation space or living space is adjacent to the educational space, the special classroom is best for the evacuation space, as the time spent there is shorter. Such classrooms should be considered to reduce the intersection of the flow lines.

Keywords: Zoning scheme, evacuation shelters, elementary schools, shelter life, building type.

Introduction

Background and Purpose: In Japan, elementary schools are usually designated as evacuation shelters during disasters. Japanese regulations require spatial planning for evacuation shelters. It is important to consider the zoning of spaces according to the stages of shelter life. The guideline for elementary school facilities¹⁹ states that elementary schools play a role as evacuation shelters at the time of disasters such as a great earthquake and that they should be seismically upgraded and coordinated with the local community.

Therefore, it is necessary to consider the use of elementary schools as evacuation shelters. Evacuation shelters must have living spaces for the evacuees (hereinafter, living space), where they can sleep and eat.

In addition, these shelters must have another space (hereinafter, evacuation space) where the evacuees can perform other daily activities. Furthermore, since the primary function of the elementary school is to facilitate educational activities, it is also important to consider the sustainability of this space (hereinafter, educational space) while using the school as an evacuation shelter. In recent years, the consolidation of elementary schools is being carried out in Japan and in some cases, new elementary schools are being built. Thus, it is necessary to show in the construction phase how the rooms can be utilized during an evacuation shelter life. In principle, evacuation shelters are required to be used within one week according to the disaster relief standards⁴.

However, in the case of a great earthquake, evacuation shelters are required to be used for more than one week. In addition, various building types are considered for elementary schools and it is necessary to examine the zoning scheme for each building type. It is necessary to separate the evacuees and children in consideration of the flow line of the school; operation of the evacuation shelter in consideration of the flow line is important³. It is also necessary to manage the evacuation shelters in consideration of the elderly people, as some areas are likely to have many elderly people. Furthermore, it is necessary to show how to respond to the overflow of evacuees in some evacuation shelters with insufficient living space. The aforementioned issues are to be handled differently depending on the building type of the elementary school. The national guidelines⁵ and guidelines of prefectures in Japan on the management of evacuation centers indicate the facilities to be allocated as evacuation spaces and the terms to live there.

However, these do not specify which facilities should be allocated and where they should be located. The purpose of this study is to provide guidelines on the zoning of evacuation spaces, living spaces and educational spaces according to the stage in the evacuation shelter and considering the ease of separation of flow lines, ease of separating the elderly when they are in large numbers and the possibility of insufficient living space. This study refers to the arrangement of various rooms by building type.

Review of Literature

Past studies have employed several approaches in examining evacuation shelters. The following are some of the major approaches found in the existing literature:

* Author for Correspondence

1. Studies that describe the distinction between evacuation spaces and educational spaces²², the use of evacuation spaces and stages of evacuation life¹⁴;
2. Studies that point out the problems of evacuation shelters based on surveys^{8,26};
3. Studies that assess the evacuation spaces and establish their importance^{8,30};
4. Studies that propose methods for reassessing the capacity of evacuation shelters²⁹;
5. Studies that discuss how to calculate the ratio of evacuees according to stage¹³;
6. Studies that examine the sleeping environment in evacuation of shelters²⁵;
7. Studies that discuss the need to reduce the stress of evacuees through appropriate living space arrangements²¹;
8. Studies that examine individual living space based on the congestion in each evacuation shelter^{10,11,29};
9. Studies that examine the capacity of evacuation shelters^{24,28} and the ways in which organizations improve relationships in evacuation shelters²⁷;
10. Studies that describe the importance of educational activities during a disaster^{7,23} and
11. Studies that describe the psychological recovery of children^{1,9}.

Methodology

The study employed several research methods. It first established the stage of shelter life, ratio of evacuees in the stage of shelter life and the number of rooms, floors and classes required in the elementary school. Further, the researchers outlined the building types commonly used in elementary schools and extracted similar types. The evacuation space, educational space and rooms that should be located were then identified based on the contents. The researchers mentioned the zoning scheme of the evacuation space, living space and educational space according to the stage of life in the evacuation shelter for each building type considering the ease of separation of flow lines, ease of separating the elderly when they are in large numbers and the possibility of insufficient living space.

Planning Assumptions

Stage of shelter life: In Japan, the concept of the stage of living in evacuation shelters differs from municipality to municipality and is not clearly defined. To classify the stage of disaster response from the actual situation of evacuation shelter management during a disaster, this research refers to the actual situation of the Kumamoto earthquake² and the study of evacuation shelters during the Great Hanshin-Awaji Earthquake⁹. The four stages, referring to both the earthquake disasters, are given below:

- **Initial response stage** (disaster occurs over a three-day period): This is the period when the number of evacuees is the highest and the evacuees are most disorganized.
- **Ensuring sheltered-life stage** (from three days until one week after the initial event): The number of evacuees begins to reduce, the whole school is

considered for the operation of the evacuation shelter and the evacuation space is expanded.

- **Emergency response stage** (between one week and one month after the event): Evacuees begin to show their self-reliance, teachers and staff can concentrate on schoolwork and this is time for school education to resume. The school setting is rearranged, evacuation space is reduced and education space is expanded. After resuming the education process, in the initial period, the student activity mainly takes place in the normal classrooms, but as time passes, classes in the special classrooms also start.
- **Recovery stage** (after one month): In this period, the evacuation area is further reduced. Classes in special classrooms and those following the regular curriculum are both conducted.

The layout of the evacuation shelter's evacuation space, living space and educational space is complicated until the emergency response stage. The researchers describe a zoning method for the "initial response stage", "ensuring sheltered-life stage" and "emergency response stage". In the recovery stage, the evacuees' mental support is considered more important than the detailed study of the shelter management plan.

Ratio of evacuees in stage of shelter life: The number of evacuees varies according to the stage in the evacuation shelter. Therefore, the number of evacuees is calculated based on the ratio of evacuees estimated from the establishment of the evacuation shelter. Kimura et al¹³ calculated the formula which is described as follows:

$$y = -0.2302 \ln(x) + 1.184 \quad (6.0-6.4 \text{ JMA scale } 6 \text{ upper}) \quad (1)$$

$$y = -0.232 \ln(x) + 1.1321 \quad (5.5-5.9 \text{ JMA scale } 6 \text{ lower}) \quad (2)$$

$$y = -0.415 \ln(x) + 1.3557 \quad (5.0-5.4 \text{ JMA scale } 5 \text{ upper}) \quad (3)$$

where x S Days and y = Ratio of evacuees.

In this study, we adopted equation (1) which assumes the intensity to be 6 or higher on the JMA seismic intensity scale. This is because it is assumed that people will live in evacuation shelters for a long period of time such as in the cases of the Great Hanshin-Awaji earthquakes and Kumamoto earthquakes in Japan. Ratio of the assumed number of evacuees is shown below. The number of days spent in the evacuation shelter is the number of days in the middle of the days set, since the stage of living in a classified shelter is set to a certain period. Accordingly, the initial response ensuring sheltered-life and emergency response stages are 2 days, 4 days and 18 days respectively and the ratios are shown in table 1.

Number of rooms, floors and classes required in the elementary school: The rooms of the elementary school are listed in the guideline for elementary school facilities and

their items are shown in table 2.

Regarding the number of floors in an elementary school, three or fewer floors are desirable as per the guidelines for elementary school facilities. Therefore, it is appropriate to use a two- or three-story building, since the building area is likely to be larger if it has only one-story. It is desirable to assign the rooms on the first or second floor for regular classrooms for first to third grades in the elementary school (hereinafter, lower grades), first floor for special-need classrooms to minimize the number of stairs and second or third floor for fourth to sixth grades in the elementary school (hereinafter, upper grades).

The special classrooms need to be located on the second or third floor of the school considering the flow line of the upper grades.

The common learning rooms such as the audio-visual room and library, which are used often by all grades, should be located on the first or second floor to accommodate the lower grades and the computer rooms, which are heavily used by the upper grades, should be located on the second or third floor. The administrative rooms should be located on the first floor, except for the storage space, since many of these facilities are necessary for the operation of the school.

According to Article 41 of the Enforcement Regulation of the School Education Law, the number of classes in an elementary school should be between 12 and 18. The same number of special classrooms, classrooms for faculty and staff and multipurpose rooms are required between 12 and 18 classes and according to the Kenchikugakutaiki 32 (It is guideline for school design)¹².

Table 1
Ratio of evacuees based on the stage of shelter life

Stage	Number of days	Calculation	Ratio
Initial response stage	2 days	$-0.2302\text{Ln}(2) + 1.184$	102%
Ensuring sheltered-life stage	4 days	$-0.2302\text{Ln}(4) + 1.184$	86%
Emergency response stage	18 days	$-0.2302\text{Ln}(18) + 1.184$	52%

Table 2
Rooms in elementary school

Room classification	Name of facilities	Placement floor	
Normal classroom	Normal classroom	Lower grade	First or second floor
		Upper grade	Second or third floor
	Special-need classroom		First floor
Special classroom	Science room		Second or third floor
	Music room		Second or third floor
	Art room		Second or third floor
	Home economics room		Second or third floor
Common learning rooms	Audio-visual room		First or second floor
	Computer room		Second or third floor
	Library		First or second floor
	Multipurpose classroom		All floors
Administrative rooms	Counseling room		First or second floor
	Broadcasting room		First or second floor
	Teaching materials' storage room		All floors
	Cafeteria		All floors
	School kitchen		First floor
	Principal's room		First floor
	Teacher's room		First floor
	Infirmary		First floor
Office		First floor	

In addition, since there is no significant difference in architectural planning and evacuation shelter management between 12 and 18 classes in terms of classrooms alone and the flow line is not expected to be significantly different, this study adopts 12 classes with two classes per grade. There are two types of corridors, a central corridor and single corridor. This study adopts the single corridor from the viewpoint of lighting.

All classrooms and other rooms may not be available for use as an evacuation shelter in the beginning. However, in this study, all classrooms and rooms were available for use except for the toilet and science room, which are prohibited locations.

Elementary School Building Type: Figure 1 organizes the building types commonly used in elementary schools. The non-migratory type is considered to be linear-shaped, L-shaped and U-shaped and the migratory type is considered to be figure-□-shaped, figure-8-shaped and the bifurcated type. Since the pool can be used to flush the toilets, it should be located as close as possible to the school building and gymnasium as shown in figure 1.

Building Type Extraction: The elementary school building types described earlier are summarized and characterized ahead by extracting one of the most valid types to analyze similar types.

First, we did not group the linear-shaped because there is no other type that is similar to it as the flow line is limited. Next, the L-shaped and U-shaped are similar in shape and their floor area is larger than that of the linear-shaped. Therefore, the types to be extracted are L-shaped and U-shaped, which

have more complicated flow line planning. Among the three migratory types, figure-8-shaped is the most complex in terms of flow line planning and design. However, there are some cases in which the bifurcated-shaped is modified to make figure-□-shaped. Therefore, we extracted the figure-□-shaped in this study. This study, thus, extracted three types: linear-shaped, U-shaped and figure-□-shaped.

In the case of the linear-shaped, the school buildings are arranged in a single horizontal row, making it easy to simplify the flow line planning. Classrooms for the administrative offices and lower grades are located on the first floor, those for common learning on the second or third floor and special classrooms on the second or third floor. Since common learning rooms and special classrooms are larger in floor area than normal classrooms, they can be located at both ends of the school building for more efficient use. Zoning either the east or west side of a normal classroom would simplify the flow line. The corridor to the gymnasium is connected to the normal classroom zone. Since the floor space per floor is smaller than that of the other types, the number of floors may increase.

Since the floor area per floor of the U-shaped is larger than that of the linear-shaped, the flow line is likely to be more complicated. Therefore, the administrative offices and classrooms for the lower grades should be located on the first floor. Common learning rooms for all grades should also be located on the first floor. Special classrooms should be on the second or third floor in consideration of the use of the upper grades. Since the floor area per floor is large, it is necessary to provide multiple entrances. The connection of the corridor to the gymnasium should be to minimize the burden on the children.

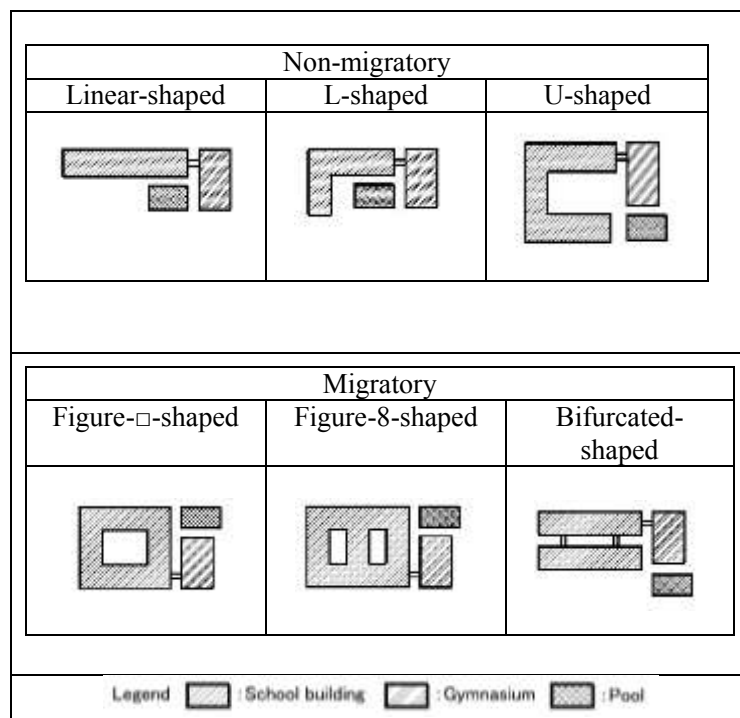


Figure 1: Building type

In the figure-□-shaped, since the floor area per floor is larger than that of the linear-shaped, the flow line is more complicated and therefore, it is necessary to consider the flow line of teachers, children and evacuees. It is considered appropriate to locate the special classrooms on the second or third floor with multiple entrances. The connection to the gymnasium should be arranged in the same way as the U-shaped.

Results and Discussion

Evacuation and educational spaces and the stage of shelter life: Table 3 summarizes the facilities that are listed in the national guidelines⁵ and those that are not listed. More than 50% were listed in the prefectural guidelines (N=23) as facilities that should be allocated in the evacuation centers. It is necessary to set up the evacuation space in one week after the first day of living in the evacuation shelter because a delay in its deployment may interfere with the operation of the shelter. Therefore, it is necessary to open the evacuation space between the initial response stage and ensuring sheltered-life stage and apply the facilities with the highest priority to the initial response stage and other facilities to the ensuring sheltered-life stage. The stage of application is based on the national guidelines and the national guidelines indicate when each facility should be applied.

It describes how it should be applied when the period of opening a shelter is set at one week. However, since this study considers long-term sheltering for more than one month, the content of the national guidelines is read as long-term sheltering. When the national guidelines state that the evacuation spaces should be deployed by the third day, they are of high importance and should be applied to the initial

response stage. Evacuation spaces that are required by the national guidelines to be located between the fourth day and first week are to be applied during the ensuring sheltered-life stage. In addition, it is necessary to allocate the evacuation space during the initial response stage because it otherwise interferes with the operation of the shelter.

However, there may be cases where it is not possible to place them in the ensuring sheltered-life stage and in such cases, the priority is set according to the ratio of the guideline of the prefecture. The location of the evacuation space is determined by referring to the national²⁰ and prefectural guidelines^{6,15,16} (Table 3).

The frequency of use of the classrooms is based on the number of classes that are stated in table 4 of the Enforcement Regulations of the School Education Act (Section 51) and their duration. This research calculates average class hours of each subject from the first to the sixth grade by totaling the classroom to be used for each subject. The educational space is determined from the frequency of use of the classroom.

Additionally, classrooms for home economics, music and art are assumed to be held as special classrooms. Classrooms for the subjects of life studies or for the period of integrated study and special activities are not targeted because they differ depending on the content of the class. Classrooms that can conduct classes similar to a normal classroom, such as a learning room or special support school, are treated as normal classrooms. Upon class resumption, it is necessary to preferentially conduct classes for normal classroom subjects with a large number of classes such as national languages and mathematics.

Table 3
Evacuation spaces and the stage of application

Evacuation space	Rooms	Priority	Stage of application
Headquarters	Audio-visual room, meeting room	—	Initial response stage
Storage place for food and goods	-		
Nursing room	Normal classroom		
Distribution place for food and goods	-		
Bulletin board	-		
Reception	-		
Telephone	-		
Community room	Library	High	Ensuring sheltered-life stage
Dressing room	Normal classroom		
Nursing room	Infirmery/First-aid room		
Cooking room	School kitchen		
Counseling room	Counseling room		
Study and playroom	Normal classroom		
Welfare evacuation room	Janitor’s room		
Isolation room	Normal classroom, special classroom	Low	

However, it is necessary in some cases to conduct classes in subjects with a lesser burden on the mental state of students.

Educational activities should not be resumed immediately after the opening of an evacuation shelter, but only after the shelter is settled and the children are able to go to school. Therefore, the educational space is applicable during the emergency response stage. The resumption of education differs according to the scale of the disaster. In this study based on the great earthquake, education was resumed about two weeks after the disaster.

The researchers investigated the timing of resumption of elementary schools and the number of students attending classes after resumption in municipalities with more than 2,001 evacuees. The earliest resumption of education at an elementary school was on April 26, 2016. The resumption of education in evacuation shelters after the Great Hanshin-Awaji Earthquake is also valid as most of them resumed after about 10 days⁹.

When resuming educational activities, it is necessary to prioritize those subjects that require many hours of instruction in normal classrooms such as Japanese language and mathematics. Table 4 shows the educational spaces to be allocated. Since more classes are held in normal classrooms than in special classrooms, the former should be prioritized as educational spaces.

Zoning according to the stage of shelter life by building type: First, we organize a zoning scheme for each stage of shelter life. Second, each building type is analyzed. Third, zoning methods for the evacuation space, living space and educational space are described according to the stage of shelter life.

We also describe the ease of separation of flow lines for each building type, ease of separating the elderly from the rest of the population and the case of insufficient living space. Section 3 defines the stage of living in the evacuation shelter, ratio of evacuees, rooms in elementary school and building types (linear-shaped, U-shaped and figure-□-shaped) in the zoning process. Section 4 describes the evacuation space, educational space and applicable stage in the evacuation shelter.

Figure 2, figure 3 and figure 4 show the zoning scheme for each building type according to the three evacuation stages: the initial response stage, ensuring sheltered-life stage and emergency response stage. Here, the ratio of living space occupancy defined in this study is based on the use of about 80% of the normal classrooms in the initial response stage. The division of space for children and evacuees at the stairs or entrance is considered appropriate.

Therefore, the staircase is not an independent type, but located adjacent to a normal classroom or special classroom. Floor area and room areas of each building type are fixed.

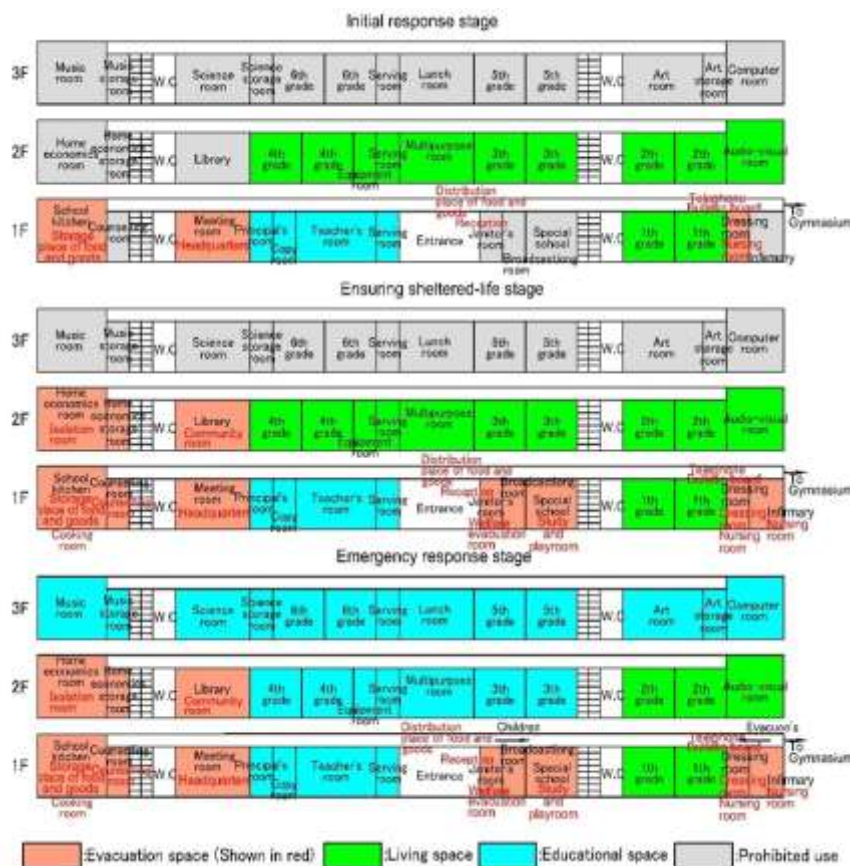


Figure 2: Zoning of linear-shaped

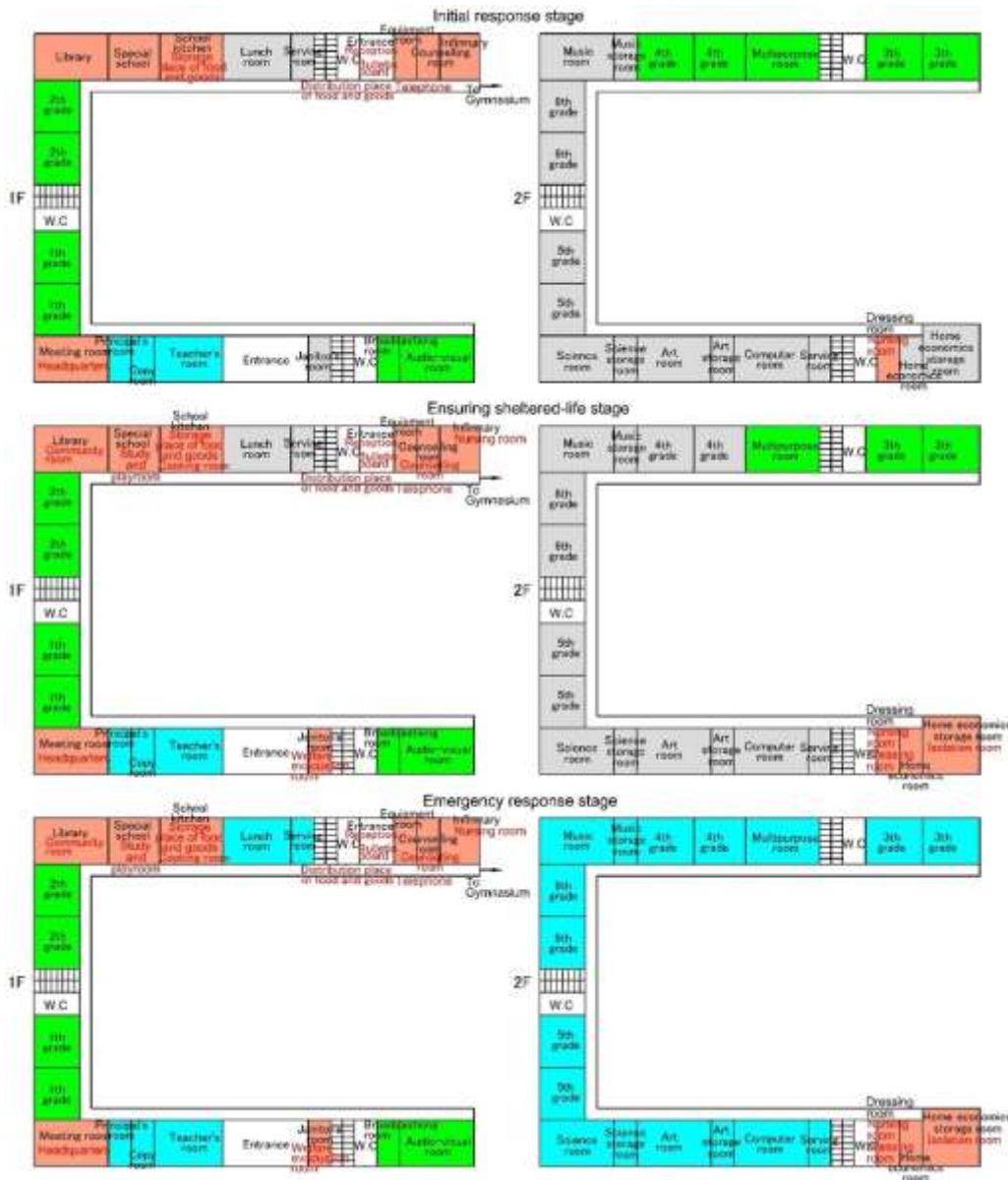


Figure 3: Zoning of U-shaped

Table 4
Educational spaces to be allocated and the stage of application

Rooms	Number of class hours	Stage of application
Normal classroom	586.8	Emergency response stage
Art room	59.7	
Music room	59.7	
Home economics room	19.2	

The area of the normal classrooms shall be 63 m²¹⁷ and the special classrooms shall be twice as large as the normal classrooms. After considering the area of the rooms and required number of rooms, the number of floors is set as follows: the third floor in the linear-shaped, second floor in the U-shaped and second floor in the figure-□-shaped. The U-shaped and figure-□-shaped have two entrances because of the large floor area in one floor. In addition, a reception

desk, telephone and bulletin board are set around the entrance to the evacuation area.

Zoning scheme for each stage of shelter life

(i) Initial response stage: The evacuation spaces are the minimum necessity for the operation of an evacuation shelter including administrative offices, food and supplies storage.



Figure 4: Zoning of figure-□-shaped

Therefore, it is necessary to prepare the structure of the evacuation shelter and prohibit the use of the evacuation spaces at this stage because of the burden of moving the evacuees when the rooms in the evacuation spaces are used as living spaces. The normal classrooms for the lower grades are located on the first floor and it is desirable to prioritize the living space for the elderly people considering the burden on them.

(ii) Ensuring sheltered-life stage: In preparation for the resumption of education, high-priority normal classrooms in the educational spaces should not be used at this stage and should be prohibited as much as possible. In addition, Sakata et al²⁶ stated that when operating the evacuation shelter, it is desirable to use the first floor as an evacuation or living space except for the rooms used by faculty and staff, such as the staff room and Principal's office.

Further, special classrooms are often located in a corner and it is necessary to consider whether the rooms will be used as

an evacuation space or educational space at the time of planning. According to the case of lack of living space in the ensuring sheltered-life stage, the accommodation of evacuees should be considered by making it the living space rather than less important rooms. When there is insufficient living space even after these responses, the individuals' living area needs to be reduced.

(iii) Emergency response stage: The zoning of the evacuation space and living space should not be adjacent to the educational space. This is to avoid the intersection of the evacuees' and childrens' flow lines. In addition, the connection between the evacuation space and the education space should be kept to a minimum. It is desirable to reduce only the living space since reducing the evacuation space at this stage may cause dissatisfaction among the evacuees. The gymnasium is the most frequented area in the living space and has the greatest impact on the flow line.

Therefore, when the boundary between the gymnasium and

school building is an educational space, it is necessary to consider partitioning the space to separate the entrances. Lower grade classrooms may be used as living spaces. For this reason, it is appropriate to consolidate the upper grade classrooms and use the vacant classrooms, multipurpose rooms, audio-visual rooms and other rooms where classes can be held as study rooms for the lower grades. As an example, the first grade students should be taught in the audio-visual room and other grades should be taught with two classes in a single classroom.

Analysis by building type

(i) Linear-shaped: As shown in figure 2, the educational spaces are located in the center of the first and second floors and the living spaces and evacuation spaces are located on the east and west sides of the building, making zoning possible. The second floor is adjacent to the evacuation space and educational space for the emergency response stage. An evacuation space is like a living space where the evacuees stay, though it is not a room. Therefore, even if it is not possible to physically separate them by stairs or other means, the impact is considered to be relatively small. However, it is desirable to prevent evacuees from gathering as much as possible when they are adjacent to the educational space. For example, rooms where the evacuees do not stay long such as nursery and changing rooms should be adjacent to the art rooms. It is necessary to reduce the intersection of flow lines between the evacuation spaces and special classrooms where students spend only a short period of time.

Next, we will discuss what should be done when there are a large number of elderly people. The number of normal classrooms on the first floor of the school is not as large in the linear-shaped and the burden of going up and down the stairs is likely to be greater. The first-year normal classrooms and clerk's office will be used as living spaces for the elderly and when there is still a shortage of space, the normal classrooms on the second floor will be used. Alternatively, it is preferable to turn the study and playroom into a special classroom on the second floor and use the special needs classrooms as living spaces for the elderly.

Now, we will discuss what needs to be done when there is a lack of living space. A normal classroom on the second floor

that is relatively close to the living space will be used initially. When this is insufficient, the special classrooms on the second floor can be used. The use of these rooms can be continued even when the stage of shelter life changes.

In the case of the emergency response stage in which normal classrooms or special classrooms are used as living spaces, it is possible to combine normal classrooms with double-entry classrooms when dealing with educational spaces and reduce the size of individual living space when dealing with evacuation spaces. When a special classroom is used as an evacuation space or living space, the home economics room, which has fewer class hours, is considered appropriate. The home economics room can also be used as a cafeteria or kitchen and is a special classroom with a high degree of applicability as an evacuation space or living space.

(ii) U-shaped: As shown in figure 3, the U-shaped is considered to have special classrooms and common learning rooms at the corners of the school building. In the emergency response stage, the evacuation space and educational space are adjacent to each other, but it is necessary to separate the two spaces as much as possible so that there is no intersection between the flow line of the children and evacuees.

When there are many elderly people, floor movement is long, but movement of stairs to go up and down is small. Therefore, the burden on the elderly people is considered small. Due to the large floor area, many of the lower grade classrooms are located on the first floor and can be used as living spaces for the elderly. In addition, the community room is located on the first floor where the elderly can easily gather.

We will now discuss what needs to be done in case of insufficient living space. Many of the special classrooms in this plan are located in the corners. This may lead to the intersection of traffic lines and burden of moving from the living spaces to the distribution places for food and goods and the entrances and exits. When the living space is insufficient even for the sheltered-life stage or emergency response stage, it is desirable to start using the normal classrooms on the second floor from the north side to the south as living spaces.

Table 5
Zoning scheme by building type

Building type	Non-migratory		Migratory
	Linear-shaped	U-shaped	Figure-□-shaped
Ease of flow line planning	○	△	×
Dealing with a large number of elderly people	×	○	○
Dealing with insufficient living space	○	×	△

(iii) Figure-□-shaped: As shown in figure 4, one of the advantages of this migratory type is that there is a high degree of freedom of movement within the floor. However, it is necessary to clearly divide the area by stairs as the flow line is more complicated than that of the non-migratory types. The second floor should be used as an educational space. It is necessary to arrange the evacuation space to minimize the movement of the evacuees and children.

What should be done when there are many elderly people? Owing to the large floor area of this plan, it would be possible to place the living space and evacuation space for the elderly on the first floor as in the case of the U-shaped.

What should be done if there is a lack of living space? Since the living spaces on the first floor are concentrated on the east side, it is considered appropriate to use the east side of the school building as the living space separated by the north-south stairs. Compared to the U-shaped, it is less likely to move to the necessary evacuation space due to its migratory nature. However, since the floor area is large, the flow lines are likely to intersect more often.

Organizing zoning scheme by building type: Table 5 organizes the ease of zoning in terms of the ease of flow line separation, ease of separating the elderly when they are in large numbers and the case of insufficient living space. Since each building type has different characteristics and issues, it is considered that the linear-shaped is the simplest when considering only flow line planning; however, it is necessary to select a building type according to the situation of the surrounding environment. When the ratio of elderly people is high, it is assumed that the population is highly depopulated. Therefore, it is preferable to choose a U-shaped or figure-□-shaped, which allows planning keeping the elderly in mind. It is desirable to use a linear-shaped because of the expected lack of living space in urban areas and the fact that the population is not aging in urban areas.

In preparing the operation plan of the evacuation shelter, it is desirable to keep the movement of evacuees to a minimum to avoid burdening them and not to change the location of the facility once fixed. Further, when the stage of life in the shelter changes, the rooms that are to be used in the next stage should not be used; this is to sustain the smooth layout of the rooms.

Conclusion

This study describes a zoning scheme for each building type according to the stage of shelter life focusing on the separation of the flow lines of the evacuees and children, separation of the elderly when they are in large numbers and insufficient living spaces. Since each building type has different characteristics and challenges, it is considered that the linear-shaped is the simplest when considering only flow line planning, but it is mentioned that the building type needs to be selected according to the circumstances of the surrounding environment. When the evacuation space or living space is adjacent to the educational space, special

classrooms where less classroom hours are spent, should be turned into evacuation spaces.

This is to reduce the intersection of the flow lines. Furthermore, separation of each space by physical objects such as stairs and entrances will facilitate the zoning process.

In the future, we would like to study the location of regional community centers and the method of converting a public space into a housing facility, since an elementary school is an educational facility and it would be difficult to manage the school activities if it is used as an evacuation shelter for a long period of time.

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