

Analysis of evacuation time for New publicly used establishments according to whether safety facilities, etc. are installed

Hong-Sang Lee*, Ha-Sung, Kong**

*Graduate student, Dept. of Fire Safety Engineering, Woosuk Univ, 443 Samnye-ro, Samnye-eup, Wanju-gun, Jeollabuk-do, Korea

**Associate professor, Dept. of Fire Protection and Disaster Prevention, Woosuk Univ, 443, Korea
Corresponding Author E-mail: 119wsu@naver.com**

Abstract

In accordance with the revision of “Special act on the safety control of publicly used establishments”, this study is aim to measure the change in evacuation time due to whether safety facilities, etc. are installed of a room escape cafe business and kids cafe business(hereinafter referred to as “New publicly used establishments”), which were added as new targets of the publicly used business from June 8, 2022. In the case of new publicly used establishments or publicly used establishments whose owners are changed after the revision of the relevant laws, safety facilities, etc. are installed and maintained under the “Special act on the safety control of publicly used establishments”, but in the case of existing businesses that have been operating even before the revision of the law, the business continues without safety facilities, etc. installed because the revised law is not retroactively applied. The purpose of this study is to compare and analyze the change in evacuation time by measuring the evacuation time to operating before the revision of the law to simulate evacuation at existing new publicly used establishments without safety facilities, etc. and measure the evacuation time at new publicly used establishments with safety facilities after the revision of the law

Keywords: *New publicly used establishments, Kids cafe, Room-escape cafe, Evacuation time, Evacuation simulation*

1. Introduction

By the revision of the Enforcement Decree Of The Special Act On The Safety Control Of Publicly Used Establishments, from June 8, 2022, escape room cafes, kids' cafes, and cartoon cafes (hereinafter referred to as "new publicly used establishments") have become subject to public use businesses[1]. In the case of a new type of multi-use business where a new or business owner changes after the revision of related laws, safety facilities are installed, maintained, and safety-managed according to the 「The Special Act On The Safety Control Of Publicly Used Establishments」, however, in reality, the safety management of the existing business place is insufficient to be[2].

Safety facilities refer to firefighting facilities, emergency exits, evacuation routes within the workplace, and

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Corresponding Author: 119wsu@naver.com

Tel: +82-63-290-1686, Fax: +82-63-290-1478

Associate professor, Dept. of Fire Protection and Disaster Prevention, Woosuk Univ, 443, Korea

other safety facilities. By the 「Enforcement Decree Of The Special Act On The Safety Control Of Publicly Used Establishments」 [Attached Table 2] Safety Facility Installation and Maintenance Standards, multi-use establishments include fire extinguishing facilities, emergency bells or automatic fire detection systems, evacuation facilities, firefighting facilities, and emergency exits, etc. should be installed[3]. However, in the case of existing businesses that have continued to operate before the revision of the law, the amended law is not retroactively applied, so the business continues without safety facilities installed sufficiently. In particular, in the event of a disaster such as a fire, it is expected that many difficulties will arise in evacuation as evacuation guidance lights that inform occupants of the direction of evacuation, portable emergency lights that can illuminate the way, and emergency exits that can shorten the evacuation route are not installed.

Kim Min-soo (2019) [4] analyzed the problems of kids' cafe fire safety through analysis of kids' cafe fire accidents and user surveys, and as improvement measures, restricted the number of floors in kids' cafes, used adaptive evacuation equipment, and classified them as firefighting objects. The establishment and the placement of safety managers according to the number of people accommodated were proposed. Moon Ja-young and 1 another person (2014)[5] analyzed the system and related laws for kids' cafe, and then prepared a plan to change the registration method and categorize kids' cafes under the Food Sanitation Act as a system improvement plan for child accidents and prevention in kids' cafes. In addition, they insisted on an overall inspection of the safety management status of related departments. Kim Jeong-soo (2019)[6] conducted a fire simulation and an evacuation simulation for an escape room cafe to determine whether there is an automatic fire detection facility, whether an emergency exit is installed, and the required safety evacuation time (RSET) and allowable safety evacuation time (ASET) according to changes in the composition of non-combustible materials were calculated. Based on these results, it was proposed to secure evacuation safety by installing automatic fire detection equipment and emergency exits, and using non-combustible materials for escape room cafes. Yoon Seon-hwa and five others (2012)[7] conducted an on-site survey of kids cafe safety management and a current status survey of users, and then derived safety management problems and reinforcement measures through safety accident case analysis. As for the problems of safety management, it was pointed out that safety standards and inspection systems were inadequate for amusement equipment not subject to safety inspection, safety management of other amusement facilities was inadequate, management supervision agency's lack of safety management capability and management supervision, and manager's negligence in safety management. In response to this, it was suggested to strengthen safety management of abandoned organizations not subject to safety inspection, prepare management plans for unreported kids cafes, strengthen safety management capabilities and supervision of local governments, and strengthen autonomous safety management of managers. In the case of a preceding study on a new type of multi-use establishment, safety management plans are suggested after analyzing fire safety problems in the relevant industry, or safety management problems and reinforcement measures are derived after conducting on-site safety management status surveys and user surveys, as the predominant research in the field. This study meaningful in that it conducts a comparative analysis of the evacuation situation in case of a fire in a new type of multi-use business that is in operation where retroactive application of safety facilities, etc. is not applied, and the evacuation situation in case of a fire in a new type of multi-use business where safety facilities are installed.

In this study, among the escape room cafes, kids cafes, and cartoon cafes that have been added to multi-use establishments through the revision of the law, escape room cafes with insufficient installation of safety facilities and many Since children use it, we plan to conduct a study on kids cafes that are expected to have difficulties in evacuation in the event of a disaster such as a fire. This study is to conduct a simulation for the evacuation situation with escape room cafes and kids cafes in Jeollabuk-do, which are not subject to retroactive application as they were in operation before the revision of related laws, conducted a current status survey on

whether safety facilities, etc. were installed, and then modeled escape room cafes and kids cafes, and disasters such as fires occurred. Simulation of the evacuation situation at existing new type of multi-use establishments without safety facilities, etc. that continued operating before the law revision, and evacuation time required for new type of multi-use establishments that newly opened after the law revision and installed safety facilities, etc. and compare and analyze the change in evacuation time accordingly.

2. DISCUSSION

Evacuation simulation is a program that predicts the evacuation time of people in a building in the event of a disaster such as fire. Evacuation simulation programs used for general purposes include Building Exodus, Simulex, EVACNET4, and Pathfinder. In this study, Pathfinder Ver. The 2022.3.1207 program was used.

2.1. Research model

The research model according to the purpose of the study is shown in Fig. 1. First, by reviewing the laws and regulations related to the new multi-use establishment and carrying out fact-finding surveys, problems in evacuation safety of the new multi-use establishment were identified, and then new multi-use establishments without safety facilities and new-type multi-use establishments with safety facilities were identified. An evacuation simulation is to be conducted for an evacuation situation. Through comparison and analysis of evacuation simulation results, it is intended to improve the evacuation safety of new multi-use establishments by presenting improvement plans for related laws and regulations.

The contents set as research problems for the progress of this research model are as follows.

First, is the evacuation safety of the existing new type of multi-use establishments not subject to retroactive application of the law revision sufficient?

Second, is the evacuation safety of the new multi-use establishments installed with safety facilities, etc. applied by the revision of the law sufficient?

Third, what is the difference in evacuation time of new multi-use establishments depending on whether safety facilities are installed?

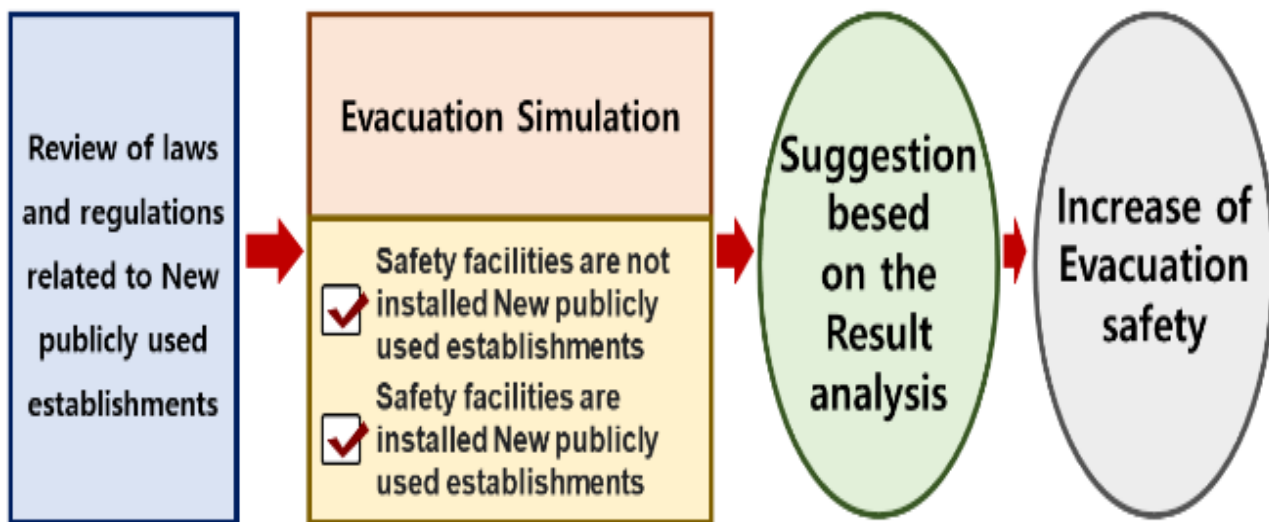


Figure 1. Research Model

2.2. Facility overview

2.2.1 Overview of target facilities for modeling

The escape room cafe set as the subject of evacuation simulation is located on the 4th floor of a building with 1 basement floor and 6 floors above the ground. The business area is 526.47 m² and consists of 5 themes to enjoy escape room games. It has a structure in which small rooms that can be moved whenever a quiz is taken in a large room are divided into four or five by theme. In addition to the room where guests enter for the escape room game, it is composed of a storage room, a counter for information on the escape room game and bill payment.

Kids Café is located on the 1st basement floor of a building with 1 basement floor and 6 floors above ground. The business area is 1,617.03 m² and consists of a ball pool, cypress tree playroom, trampoline zone, kitchen play zone, cafeteria, slide and jungle gym. The floor plan of the escape room cafe and kids cafe is shown in Fig. 2.

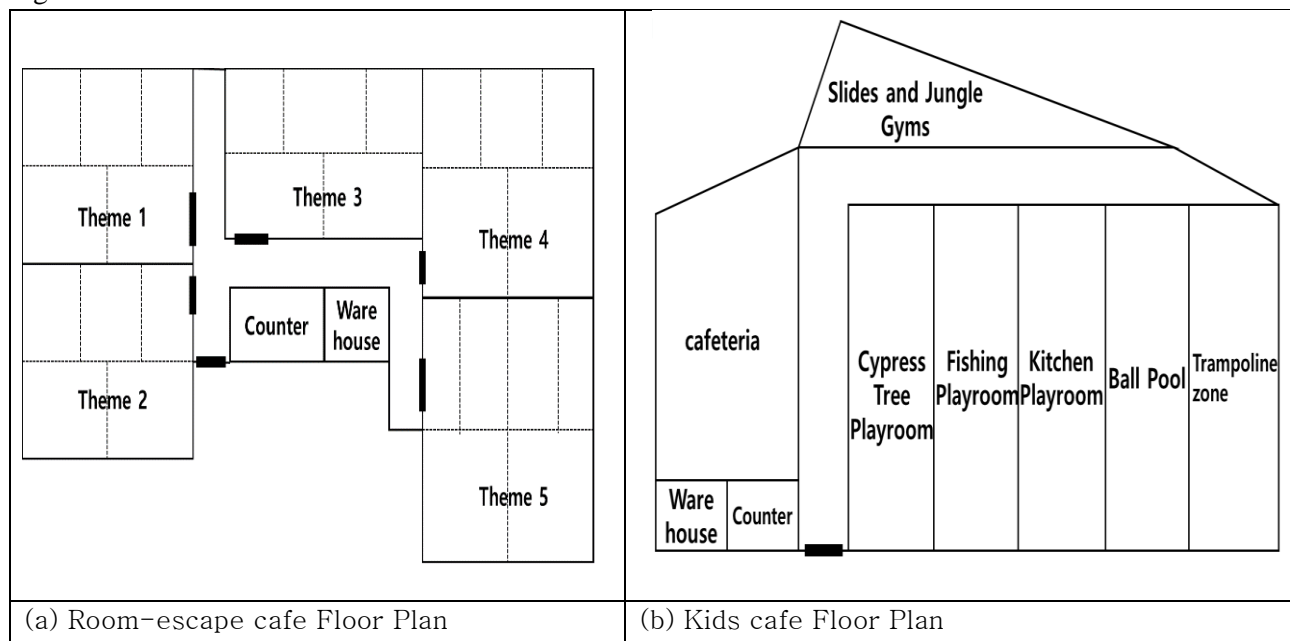


Figure 2. Room-escape cafe, Kids cafe Floor Plan

2.2.2 Installation status of safety facilities in an escape room cafe and kids cafe in 00 area

The installation status of safety facilities in an escape room cafe and kids cafe in 00 area is as Table. 1. In the case of an escape room cafe, in most cases, safety facilities, etc. are not properly installed because the installation of safety facilities damages the interior installed for the guest's immersion in the escape room game, and the installation of the evacuation guidance light gives hints to solving the problem of the escape room game. In the case of kids cafes, there were many cases where safety facilities were installed in kids cafes installed in large buildings, but in the case of kids cafes installed in small buildings, there were kids cafes that operated without safety facilities.

Table 1. Installation status of safety facilities in an escape room cafe and kids cafe in 00 area

No	Cafe name	Business category	Installation of safety facilities, etc.
1	○○ Escape Jeonju Branch	Escape room cafe	×
2	○○ Parker ET	Escape room cafe	×
3	○○ Escape Jeonju Branch	Escape room cafe	×
4	○○ Lim Escape room cafe	Escape room cafe	×
5	○○Turkey Jeongosa Branch	Escape room cafe	×
6	○○ Deu Escape room cafe	Escape room cafe	×
7	○○ Parker escape room	Escape room cafe	×
8	○○ Parker 2nd branch adventure	Escape room cafe	×
9	Flower garden of ○○ in Jeonju	Escape room cafe	×
10	○○ Tang slime cafe	Kids cafe	×
11	○○ Kids cafe Seojeonju branch	Kids cafe	○
12	○○ Kids club	Kids cafe	×
13	○○King Jeonju Hyoja branch	Kids cafe	○
14	○○Ney Land	Kids cafe	○
15	○○'S kids play	Kids cafe	×
16	○○ Us Jeonju Hyoja branch Sangsang Nori	Kids cafe	○

2.3 Input variables and values

2.3.1 Placement of room occupants

The occupant placement for the simulation analysis was set as having 6 guests in each large room with 5 themes and 1 employee at the counter, considering that the capacity of escape room cafes ranges from 2 to 6, and a total of 31 is set as the number of personnel occupying the facility[8]. In the case of the kids café, the criteria for calculating the number of occupants among the fire and evacuation simulation scenario writing criteria in Annex 1 of 「Methods and standards for performance-oriented design of firefighting facilities, etc.」 were applied. Considering that the Kids Café is located in the basement and that it was licensed as a general restaurant, 577 people were calculated based on 2.8m²/person, which is the standard for calculating the capacity of the basement sales area among commercial uses.

In the case of an escape room cafe, considering that the main age group is in their 20s and 30s, out of 30 customers, 15 males and 15 females are respectively in the room, and one employee is set to be in their 30s. Table 2 shows the number of occupants of escape room cafes by age and gender[9].

Table 2. Number of occupants of escape room cafes by age and gender

Category	20s		30s		Total
	M	F	M	F	
Employee			1		1
Customer	8	7	7	8	30

In the case of Kids Café, out of an average of 8.0 employees, 2.4 full-time employees and 5.6 contract/daily employees were considered. Two full-time employees were set as 1 male and 1 female in their 30s, and 6 daily employees were set as 3 males and 3 females in their 20s. Referring to the results of previous studies that analyzed the usage characteristics of kids' cafes, it was set to be used by children and guardians together, and 285 children and 284 parents entered. In the case of parents, a total of 64 were set for males with 5 in their 20s, 48 in their 30s, and 11 in their 40s, and 220 females with 17 in their 20s, 165 in their 30s, and 38 in their 40s. In the case of children, 86 were aged 1 to 3, 148 were aged 4 to 6, and 51 were aged 7 to 9[10]. Table 3 shows the number of occupants of kids' cafes by age and gender.

Table 3. Number of occupants of kids' cafes by age and gender

Category	1-3 years old	4-6 years old	7-9 years old	20s		30s		40s		Total
				M	F	M	F	M	F	
Employee				3	3	1	1			8
Parents				5	17	48	165	11	38	284
Child	86	148	51							285

2.3.2 Physical characteristics of occupants

The occupant's physical characteristics were classified into age, height, shoulder width, and walking speed, and are shown in <Table 4>. Based on age and gender, it was prepared by referring to the data of the Korean Agency for Technology and Standards ' the Korean Human Body Size Survey'. For the walking speed according to age and gender, the study by Park Se-jin and 5 others (2007)[11] was referred to. In the case of a new multi-use establishment without safety facilities installed, a power outage due to a fire, and occupants not familiar with the internal structure, the walking speed was set at 0.3m/s following the design guidelines of the Architectural Institute of Japan Safety Design Subcommittee.[12]

Table 4. Physical Characteristics of the Occupant

Division		Height(cm)	Shoulder width(cm)	Gait speed(m/s)
> 10	M	133.9	28.9	1.3
	F	132.5	28.8	1.4
10' S.	M	173	39.3	1.3
	F	159.8	35.7	1.4
20' S.	M	175.3	44.2	1.49
	F	162.4	39.7	1.35
30' S.	M	175.8	44.4	1.49
	F	162.7	39.5	1.35
40' S.	M	173.8	43.1	1.41
	F	161.2	38.9	1.41

2.3.3 Behavioral characteristics of occupants when evacuating

In the case of an escape room cafe, it was set to evacuate on its own, considering that both users and workers are adults. In the case of Kids Café, as a result of analyzing previous studies, by Asan Fire Station, regarding an expected escape from darkness experience in case of fire, targeting preschool children, such as infants and elementary school students in lower grades, in 2008, children actively attempted to evacuate, whereas children under the age of 6 were shown to be immature.

2.3.4 Behavioral characteristics of occupants when evacuating

In the case of an escape room cafe, it was set to evacuate on its own, considering that both users and workers are adults. In the case of Kids Café, as a result of analyzing previous studies, by Asan Fire Station, regarding an expected escape from darkness experience in case of fire, targeting preschool children, such as infants and elementary school students in lower grades, in 2008, children actively attempted to evacuate, whereas children under the age of 6 were shown to be immature.[13]

Table 5. Children's responsive behavior in the event of a fire

Age	Behavioral characteristics
Under 4 years old	Not moving or just crying
5, 6 years of age	In the beginning, they showed the will to escape, but as time went by, they easily gave up and crouched in a corner.
7, 8 years of age	Actively tried to escape, but the method was immature and tended to take repetitive actions.
9 years old	Found an escape space while groping with their hands to evacuate

Considering the results of these preceding studies, 86 children aged 1 to 3 and 148 children aged 4 to 6 were classified as those who evacuated with the help of their parents or workers, and parents and workers were alone in the event of a disaster such as a fire. It was set up not to carry out the evacuation, but to carry out evacuation by helping the children in the Kids Café. In the case of children between the ages of 7 and 9, it was set to evacuate on their own.

2.4. Configuration of scenario and set of evacuation initiation time

Simulation of the evacuation situation of existing escape room cafes and kids cafes that were not installed safety facilities by continuing their business before and after the revision of the law, escape room cafes and Table 6 shows the result of constructing the scenario for comparative analysis of evacuation time at kids cafe. In the case of the evacuation initiation time, the kid's cafe equipped with safety facilities, etc., monitors the time when the detector reacts and operates due to the generation of heat or smoke after ignition, the time when the detector detects and notifies the fire signal to the receiver, and the earth audio device operates. It was set after 60 seconds in consideration of the time for cafe users and workers to recognize the fire and prepare for evacuation. In the case of kids' cafes without safety facilities, etc., it takes time for users and workers to recognize a fire, and to notify occupants of a fire after recognizing a fire so that it is set after 120 seconds.

The evacuation start time of the escape room cafe was set after 60 seconds, the same as that of the kid's cafe when safety facilities were installed. However, when safety facilities were not installed, it would take a long time to inform the guests in the room divided into the theme of the fire. In consideration of a such case, it was set after 180 seconds.

Table 6. Configuration of the Scenario and Evacuation start time

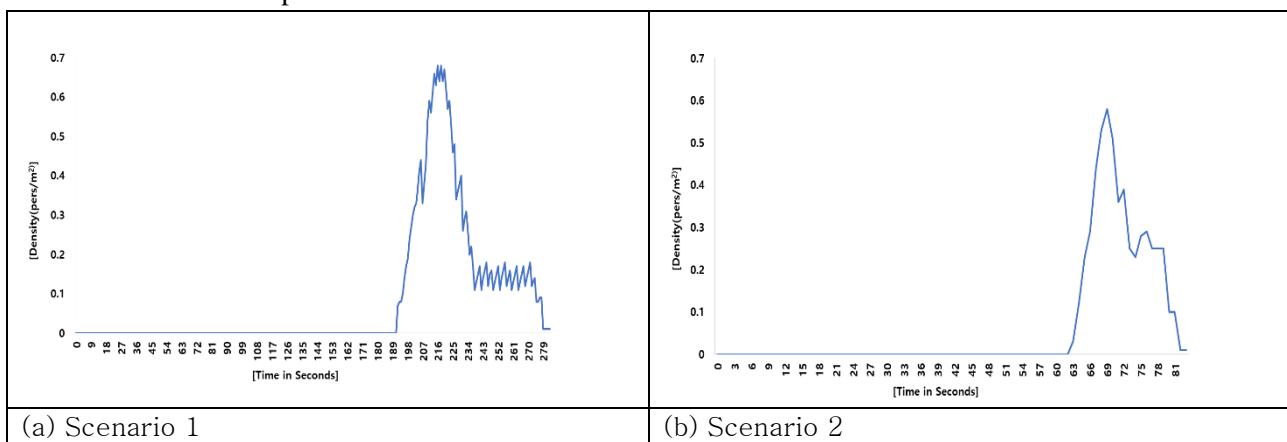
No	Scenario	Evacuation start time
1	Simulation of a Room-escape cafe without safety facilities	180sec
2	Simulation of a Room-escape cafe with safety facilities installed	60sec
3	Simulation of a kids' cafe without safety facilities	120sec
4	Simulation of a kid's cafe with safety facilities installed	60sec

3. EXPERIMENTAL RESULTS AND ANALYSIS

To measure the change in evacuation patterns of new multi-use establishments depending on whether safety facilities are installed or not, the section set as the main analysis section in this study is the section near the main entrance. According to the characteristics of a new type of multi-use establishment without an emergency exit, it was set as the analysis section because it was judged that a bottleneck would occur in the section where the crowd density of occupants increases as evacuees flock to the main entrance.

In the case of an escape room cafe, the evacuation time in scenario 1 without safety facilities was 282.53 seconds, whereas, in scenario 2 with safety facilities installed, it took 82.53 seconds for all occupants to evacuate which is considered a significant decrease. In the case of Kids Café, the evacuation time in Scenario 3 where safety facilities were not installed was 1,757.78 seconds. On the other hand, the evacuation time in scenario 4 where safety facilities were installed was 1,399.53 seconds, and it was confirmed that the evacuation time varied depending on the installation of safety facilities.

Fig. 3 is a chart analyzing the trend of cluster density in the section near the main entrance set up to analyze the evacuation patterns of escape room cafes. In the case of Scenario 1, where safety facilities are not installed, crowd density increases as people flock to the main entrance 180 seconds after evacuation begins. The bottleneck phenomenon occurred for about 16 seconds from 210 seconds to 226 seconds, and then the cluster density decreased. This result can judge that the bottleneck is maintained for a long time, considering the current situation of personnel allocation in the escape room cafe where 31 people are occupied. On the other hand, in the case of scenario 2 where safety facilities were installed, the crowd density increased as the evacuation started and then rapidly decreased, confirming that the installation of safety facilities led to a great help in the evacuation. The highest cluster density of Scenario 1 was 0.68 persons/m² and the highest density of Scenario 2 was 0.58 persons/m².

**Figure. 3 Trends in cluster density in major bottlenecks**

The results of checking the evacuation pattern at the evacuation time of 1,399.53 seconds in Scenario 4 where safety facilities were installed are shown in Fig. 4. In the case of scenario 3, where safety facilities are not installed, high crowding density is shown in many places connected to the main entrance due to the number of people evacuating, while in case of Scenario 4, all personnel successfully evacuate.

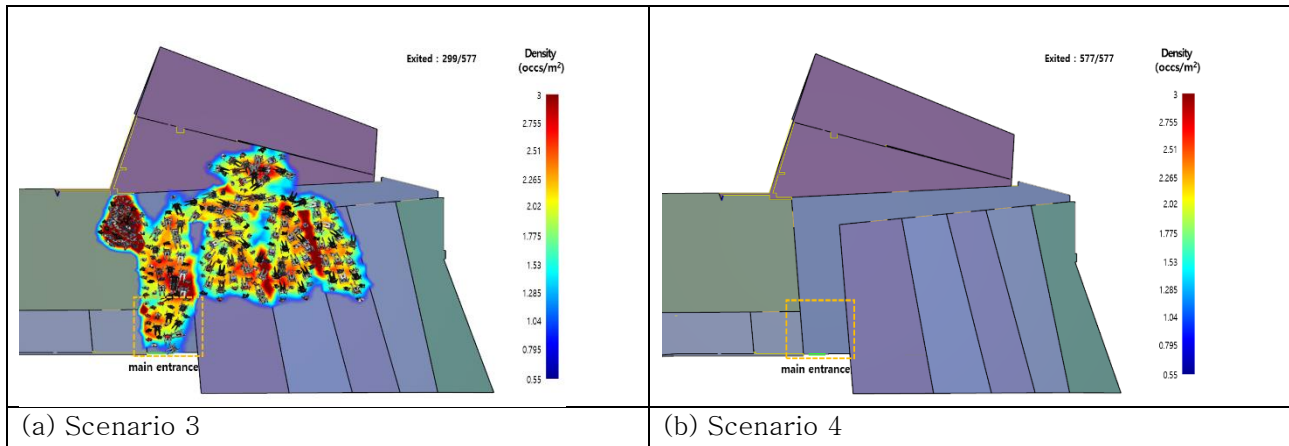


Figure. 4 The occupant evacuation situation at 154 Seconds

Table. 7 compares and analyzes the evacuation time and the number of occupants unable to evacuate at 1,399.53 seconds for a comparative analysis of Scenarios 3 and 4, and the difference in evacuation time with Scenario 4. In the case of scenario 3 where safety facilities are not installed, it takes 358.25 seconds longer than that scenario 4 where safety facilities are installed. Based on 1,399.53 seconds when the evacuation was completed in Scenario 4, the number of people who could not evacuate was 278. In other words, it was confirmed that 48.72% of the personnel failed to evacuate, confirming the need to install safety facilities.

Table 7. The number of occupants unable to evacuate at 1,399.53 seconds and the difference in evacuation time from Scenario 4

Division	Scenario 3	Scenario 4
Required time to evacuate(sec)	1757.78	1399.53
Difference between scenario 4 and evacuation time(sec)	358.25	-
Number of persons unable to evacuate at 1,399.53 sec(persons)	278	-

Fig. 5 is the result of charting the trend of cluster density in the section near the main entrance, which was set as the main analysis section of Kids Cafe. Both charts show a trend in which the cluster density gradually increases, maintains the bottleneck for a certain period, and then rapidly decreases as the bottleneck is resolved. Scenario 3's maximum cluster density was 4.61 people/m², while scenario 4's maximum crowd density was 3.75 people/m², showing a difference in the maximum cluster density. This increase in the maximum cluster density hinders evacuation, leading to a vicious cycle in which evacuation time is delayed.

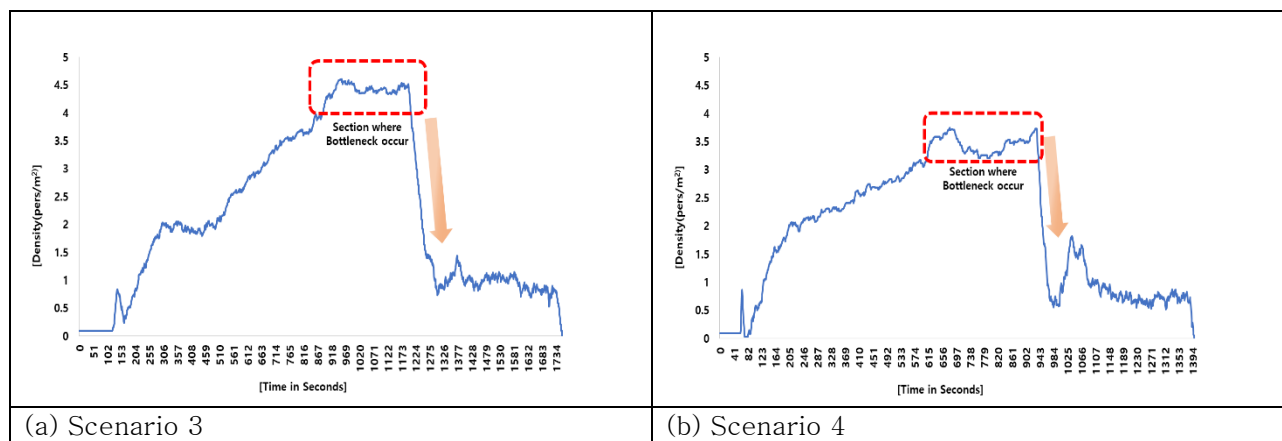


Figure. 5 Trends in cluster density in major bottlenecks

The contents of the comparison and analysis of the evacuation simulation results and the current system of fire risk assessment for multi-use establishments according to Article 15 of the Special Act on Safety Management of Multi-use Businesses were actively utilized and analyzed. Based on this, it is suggested that it is necessary to add new multi-use businesses that are rapidly changing as objects of multi-use businesses so that safety facilities can be installed.

4. DISCUSSION AND CONCLUSION

This study compares and analyzes the evacuation time of new multi-use establishments depending on whether safety facilities are installed using evacuation simulation. From June 8, 2022, the 「Enforcement Rules of the Special Act on the Safety Management of Publicly Used Establishments」 was amended. Per this, in the case of a new multi-use establishment whose business owner is changed after the revision of the related laws despite the addition of an escape room cafe business, kids cafe business, and cartoon cafe business as a new multi-use business Under the Special Act on Safety Facilities, etc., installation, maintenance, and safety management of safety facilities, etc. are carried out, but safety management is insufficient in existing business places, and evacuation of new multi-use establishments equipped with safety facilities and new-type multi-use establishments without safety facilities, etc. As such, an evacuation simulation was conducted for the situation. The results obtained through the experiment are as follows.

(1) In the case of escape room cafes with safety facilities, etc., it took 82.53 seconds, while in the case of escape room cafes without safety facilities, etc., it took 282.53 seconds, confirming that the evacuation time was increased.

(2) The evacuation time for kids' cafes equipped with safety facilities was 1,399.53 seconds, whereas the evacuation time for kids' cafes without safety facilities was 1,757.78 seconds. Based on 1,399.53 seconds, the successful evacuation number of kids' cafes without safety facilities was 299 people, and only 51.28% of the people were able to evacuate.

This study has limitations in that it failed to conduct an evacuation simulation for new multi-use establishments in several places and conducted an evacuation simulation for new multi-use establishments in a specific area and Failure to consider the situation in which the degree of evacuation may occur in various ways depending on the degree of fire spread. However, it can be said that it is meaningful in that it confirmed the need to install safety facilities by comparing and analyzing the results of evacuation simulations of new multi-use establishments equipped with safety facilities and new-type multi-use establishments without safety facilities. Considering the results of these evacuation simulations, it is necessary to actively utilize the fire risk assessment system for multi-use establishments, which is currently stipulated in Article 15 of the Special Act

on the Safety Management of Publicly Used Establishments. Reducing the number of new multi-use establishments that operate without safety facilities, etc. by promptly adding multi-use businesses to new multi-use businesses will be a way to secure the safety of the people who use multi-use establishments.

In the future, for new multi-use business sites conducted in this study, fire simulation analysis is used to calculate ASET (Available Safety Escape Time) and to compare with REST (Required Safety Escape Time) for evacuation safety analysis and actual evacuation. An analysis of the evacuation and simulation results will be needed.

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