Journal of the Korean Society of Surveying, Geodesy, Photogrammetry and Cartography
Vol. 38, No. 5, 455-465, 2020
https://doi.org/10.7848/ksgpc.2020.38.5.455

ISSN 1598-4850(Print)
ISSN 2288-260X(Online)
Original article

Three-dimensional Mixed-use Complex Spaces and Setting Criteria for Road Sections for Three-dimensional Addressing

Kim, Ji Young[1)]

Abstract

As cities continue to expand and additional underground structures are constructed, a policy is being planned to expand addresses, which are national framework data. In this study, the application scope of a proposed 3D (three-dimensional) mixed-use complex space for assigning 3D addresses was defined, based on past research on 3D address systems and by analyzing related laws. Underpass shopping malls, underground walkways (excluding underground shopping malls), and 3D mixed-use transfer centers with a gross floor area of 2,000㎡ or more are connected with each space by underground walkways or public paths. In addition, the detailed space corresponding to the public space of the 3D mixed-use complex space was presented and distinguished from the space to which the detailed address is assigned. The criteria for setting the road section were presented based on the intermediate space, which is a characteristic of 3D mixed-use complex spaces. The proposed criteria were applied to the Express Bus Terminal station (3D mixed-use transfer center) and COEX mall (underpass shopping malls). Thus, the road section was set for an unfamiliar 3D mixed-use complex space. However, by applying the proposed criteria to various 3D mixed-use complex spaces, additional and detailed criteria for different cases should be prepared.

Keywords : Address Conceptual Model, Road Section, Framework Data, Intermediate Space, Main Routes

1. Introduction

Addresses, especially geocoded addresses, are managed as framework data in other countries. In the UK, the OS (Ordnance Survey), an organization corresponding to the national geographic information institute, is constructing an OS MasterMap that will be consistently maintained and will contain spatial information that has been obtained since 2002. The OS MasterMap consists of four themes: a topography layer, an integrated transport network layer, an OS MasterMap address layer 2, and an imagery layer. In the INSPIRE (Infrastructure for Spatial Information in Europe), an annex was prepared following rules based on international standards for the interoperability of data from member states. Annexes 1 and 2 contain topics similar to basic spatial information, and Annex 1 includes addresses, administrative districts, coordinate systems, grid systems, geographical names, floodgates, protected areas, and transportation networks. The ANZLIC (Australia New Zealand Land Information Council) uses geocoded addressing as well as ten themes of boundaries, location criteria, geographical names, cadastral images, traffic, hydrology, elevation, and land cover.

In addition, as per Article 19 of the Framework Act on National Spatial Data Infrastructure (MOLIT (Ministry Of Land, Infrastructure and Transport), 2020c), buildings, roads,

Received 2020. 09. 27, Revised 2020. 10. 04, Accepted 2020. 10. 13
1) Member, Research Professor, Social Eco Tech Institute, Konkuk University (E-mail: elliekim@konkuk.ac.kr)

addresses, and 3D models were announced as framework data in 2018 in ROK (Republic Of Korea). As such, addresses need to be managed as important spatial information.

Accordingly, ISO (International Organization for Standardization) defines an address as structured information that enables a single object to be identified for name and location, and an address conceptual model is established as a standard (ISO, 2015). Currently, in the ROK, the address is not recognized as information, but as the location of a person or corporation. However, the MOIS (Ministry Of the Interior and Safety), which is in charge of address policy, intends to expand addresses by indicating the location based on the definition of the address as per ISO standard. To this end, a total amendment to 'Road Name Address Act' has been announced in 2018, and addresses are provided to facilities related to public safety and disaster management. In addition, expansion of the address to a 3D address which reflects the characteristics of the larger and underground city, is being formulated.

In 2018, the MOIS conducted a pilot project to assign 3D addresses in Bupyeong-gu, Incheon-si, ROK and Uijeongbu-si, Gyeonggi-do, ROK (Jeong, 2019; Hong, 2019). Under this project, an attempt was made to distinguish a building with a detailed address from that with a 3D address. For example, apartments are currently assigned a detailed address but do not need to be assigned a 3D address. It is necessary to define a building or structure, that is, a 3D mixed-use complex space, where it is difficult to predict the location of a building using only a detailed address. In addition, the road name address is assigned in the same manner as that for setting the road section and creating a road network in consideration of the movement flow. As a result, a 3D address can be given only when a road section is set and a network is formed in the inner passage of a 3D mixed-use complex space. However, in previous studies, only the method of setting the road section specialized in the characteristics of the pilot site has been suggested; hence, it is necessary to supplement this method. Therefore, to supplement the aforementioned method with introduction of a 3D address system, this study proposes a spatial range (3D mixed-use complex space) to which 3D addresses are assigned and suggests criteria for setting the road section as the basis for the address.

2. Theoretical Consideration

2.1 Addressing standard and 3D address

The ISO defines a conceptual model that can express the addresses of various countries (Fig. 1.) Table 1 describes the classes in the conceptual model for road name addresses in the ROK (Kim and Yang, 2020). The core aspect of the address model is that the type of address, and street name address corresponds to the address class.

An address consists of one or more AddressComponents, and the AddressComponent value is a label that refers to the ReferenceObject. The name of the administrative district, name of the road, and building number used as characters when marking the address are addressComponent, and the object of the administrative district, road section, and basic number interval become the ReferenceObject. The reference object is a class of objects in the real world which form the basis for configuring addresses, and characters such as names or numbers assigned to these objects are defined as AddressComponent. An appropriate combination of these AddressComponents constitutes the address reference system. The specification describing each class of the address reference system, address model, or metadata for the document is the AddressSpecification, and laws related to street names and addresses are applicable to it. In the ROK, the AddressableObject is a real-world object to which an address is assigned, such as a building or a group of buildings, and the building name is denoted as AddressAlias. Considering the address model, the real-world object to which the address is to be assigned must be defined; in addition, the characters constituting the address and the real-world object corresponding to the characters are important elements. Therefore, in order to assign a 3D address, it is necessary to define the object to which address is to be assigned the address, the 3D mixed-use complex space, and the reference object that constitutes the address in this 3D complex space.

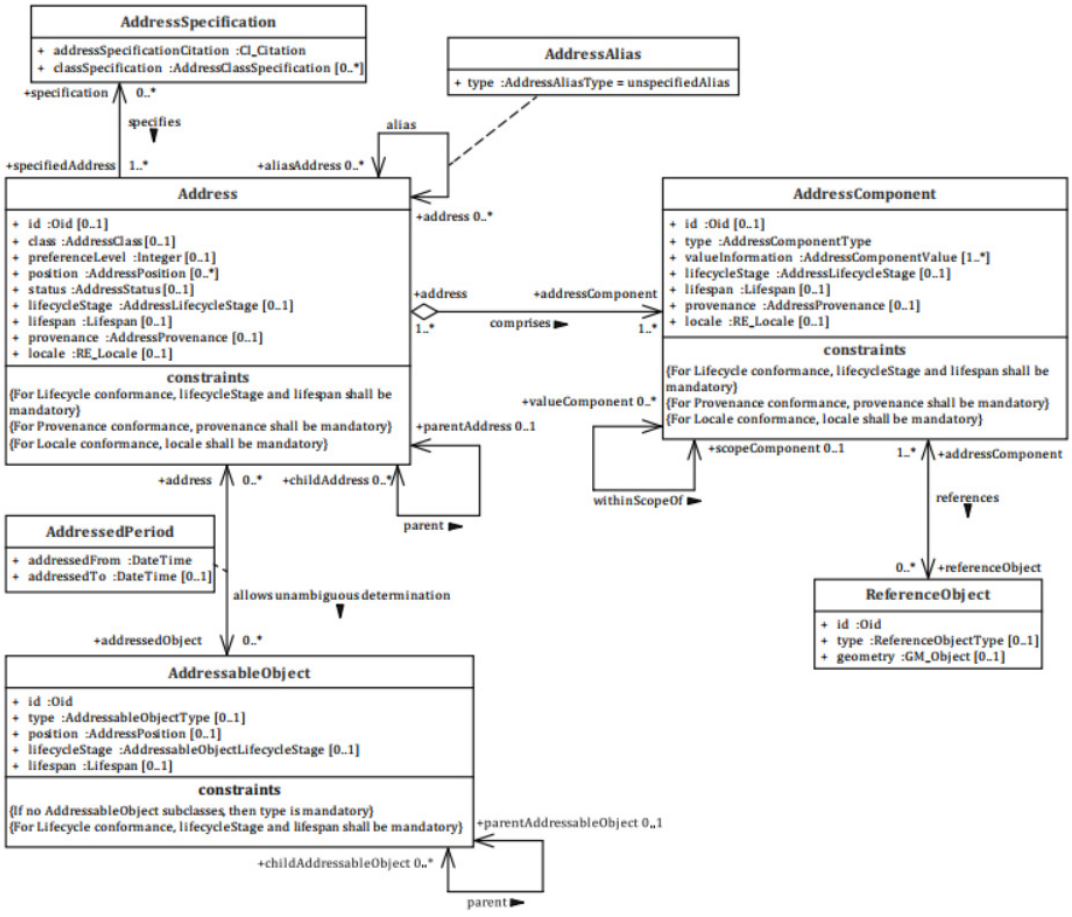

Fig. 1. Address model overview in UML (ISO, 2015)

Table 1. Classes of street name address in ROK

Class	Example
Address	Road name address
AddressableObject	Building or a complex of many buildings
AddressComponent	Administrative district name, road name, building number
ReferenceObject	Administrative district, road section, building or a complex of many buildings)
AddressedPeriod	Assignment date, notification date, modification date and disuse data
AddressSpecification	Road Name Address Act
AddressAlias	Building name

In Bupyeong-gu (Jang, 2019), the object to which a 3D address is assigned was defined as a 3D mixed-use complex space, and it was classified into six types, including an underground shopping mall, a 3D complex transfer facility, and the top and bottom of a 3D road. Although, the use of a 3D mixed-use complex space is suggested where it is difficult to mark the location with only a detailed address, there are some areas where it is difficult to cope with the 3D mixed-use complex space of real-world buildings or structures. In addition, when the station is connected to the surrounding buildings, there is no specific scope of application for assigning detailed addresses and 3D addresses to the connected buildings. Furthermore, although criteria for setting road sections and creating a road network were suggested, there is a limit to general application as the criteria are specialized for the pilot project site.

Therefore, when performing administrative work, a 3D mixed-use complex space, which is a real-world object to which a 3D address is assigned, should be defined so that it can be distinguished from a building with a detailed address.

2.2 3D Mixed-use Complex in laws

A 3D complex space to be assigned an address should be a building with an assigned road name address. Under the Road Name Address Act, buildings are defined as being pursuant to Article 2 (1) 2 of the Building Act (MOLIT, 2020a), according to which artificial structures and naturally formed structures are those that have been settled for more than 30 days. In other words, it includes both structures that are registered and not registered in the building register. Therefore, there is a limit to defining a 3D mixed-use complex space only for a building registered in the building register, and it is necessary to consider the definition of a law that includes the concept of a 3D mixed-use complex space. A "3D complex architectural space or facility," which is similar to a 3D complex space, is defined as a combination of 3D and distributed facilities that are vertically developed for use of limited land in one place (Choi, 2008; Moon and Lee, 2009; MLTMA (Ministry of Land, Transport and Maritime Affairs), 2011a; Moon *et al*., 2011).

Consequently, laws related to buildings or structures containing the concept or terminology of vertical development or complex uses were reviewed to determine the object of address assignment when performing administrative tasks.

In the statute, complex buildings, underground public walkways, underground-linked complex buildings, multi-use buildings or facilities, and transfer complex centers were defined as 3D complex spaces Table 2. Although the term "3D" is not specifically mentioned in the statute, it indicates a space with an enlarged vertical location, such as underground public walkways and underground spaces, which are structures installed underground. The complex was used when it was a building or structure for two or more uses, and these buildings or structures were also defined as a form linked to an underground plaza, underground walkway, and underground station. Finally, the 3D complex space was characterized by whether it is open to an unspecified number of people, such as a multi-use facility (building), as well as by its structure and use.

As such, it is a space used by a large number of unspecified people and is subject to emergency management of fire, disaster, indoor air quality, etc.; moreover, related laws limit the size of a 3D mixed-use complex space. The Indoor Air Quality Management Act (Ministry of Environment, 2020) covers all underground stations and large stores, underground shopping malls with a GFA of 2,000㎡ or more, railway stations, passenger terminals, indoor parking lots, and multi-purpose (more than 2) buildings with a GFA of 430㎡ to over 3,000㎡ depending on their use.

According to the Special Act on the Safety Management of Multi-use Stores (National Fire Agency, 2020), the numbers of stores and floors or the areas of buildings are also considered as criteria for multi-use stores where fire risk assessments are performed. In addition, under the enforcement decree of the Special Act on Safety and Maintenance of Facilities (MOLIT, 2020f), all underground shopping malls, railway stations, urban railway stations, and buildings with 11 floors or more and a GFA of 3,000㎡ or more, depending on their use, should be managed. According to these laws and regulations, 2,000㎡ or 3,000㎡ is considered as a standard based on the GFA managed by the building register.

Finally, the 3D mixed-use complex space is a mixture of private spaces that can only be used by specific people, and open public spaces. Accordingly, it is necessary to

Table 2. 3D mixed-use complex spaces and detailed spaces in laws

Type	Characteristics and detailed spaces		Law
Complex building	Buildings with multiple uses pursuant to Article 2 (2) 5 of MOLIT(2020a)		MOLIT (2020c)
Underground public sidewalk facilities	Underground space of roads and squares such as Underground walkways, underground plazas, underground shopping malls, and underground access facilities (including entrances), and so on.		MOLIT (2012)
Underground space	Underground facilities (pipeline type, structure type), ground		MOLIT (2020g), MOLIT (2018)
Underground-linked complex building	• A building with 11 or more floors or 5,000 people or more per day, and the basement part is connected to the underground station or underground shopping mall • Buildings with multiple uses pursuant to Article 2 (2) 5 of MOLIT(2020a)		National Fire Agency (2019)
Multi-use building	• Buildings with a GFA (gross floor area) of 5,000㎡ or more that are used for cultural and assembly facilities, religious facilities, sales facilities, passenger facilities among transportation facilities, general hospitals among medical facilities, and tourist lodging facilities among accommodation facilities • Buildings with 16 floors or more		MOLIT (2020e)
Semi multi-use building	• Buildings other than multi-use buildings • Buildings with a GFA of 1,000㎡ or more		
Multi-use facility	• Underground stations, Underground shopping malls, Railway stations or Passenger car terminals, Waiting rooms at port facilities, Passenger terminals of airport facilities, Libraries, Museums and Art galleries, Medical institutions, and so on • Multi-family housing such as apartments and dormitories		Ministry of Environment (2020)
Transfer center	Walking mobility facility	Stairs, entrances, walkways, ESCs (escalators), EVs (elevators), moving walkways, and so on	MOLIT (2020d)
	Transfer convenience facilities	Ticket gates, concourses, restrooms, and so on	
	Linked transportation facilities	Railroad platforms, bus stops, waiting spaces for bus passengers, taxi stands, transfer parking areas, drop-off parking areas, bicycle storage, and so on	
Complex transfer center	A transfer center to perform complex support functions such as commerce, culture, housing, and lodging		
Urban rail facilities	Open spaces, connecting paths (public paths, dedicated paths), transfer passages, landing, concourses, platforms (side platforms, island platforms), free zones, paid zones		MOLIT (2020h), MOLIT (2019)
	Facilities on the station	Passenger facilities (passages, waiting rooms, gates, toilets, rest facilities such as nursing rooms, and so on), elevator facilities (interior stairs, exterior stairs, ESCs, EVs, moving walkways, and so on), paths	
	Service and support facilities	Evacuation facilities (evacuation elements), horizontally moving elements (platforms, waiting rooms, paths), vertical moving elements (stairs, stationary ESCs), ESCs in operation	

analyze the aforementioned detailed spaces of buildings or structures and to limit the scope to only public spaces. As a result, detailed spaces and facilities were defined in depth in transport-related stations and transfer centers (Table 2).

2.3 Types of intermediate spaces and circulation systems

3D mixed-use complex spaces, unlike existing architectural spaces, appear as intermediate spaces that can connect the interiors and exteriors of buildings, link various functions within the facility, and house concentrations of various movement lines (Yang and Lee, 2012).

Moon and Lee (2009) classified them into rest and walking functions and vertical positions (in the air, ground, and underground) through analysis and demonstration of past studies. Yang and Lee (2012) subdivided intermediate spaces into rest and event functions, walking functions, and movement guidance functions (Table 3).

In a 3D mixed-use complex space, the intermediate space is an element that composes the pedestrian movement system along with passages, entrances, and vertical movement lines (elevators or escalators) (Lee and Kim, 2014). Lee *et al*. (2014) analyzed the physical characteristics of the components of these movement systems based on the extent of walking. Consequently, the traffic line system in which the entrances, passages, intermediary spaces, and vertical movement lines were connected to the subway station, or the movement system in which the intermediary spaces or vertical movement lines and passages were sequentially connected, was analyzed as a movement system requiring a high extent of walking. In addition, when there was no entrance, the extent of walking was high in the vertical space connected to the intermediate space, and in case of the passage, the extent was high at the entrance or the passage connected to the intermediate space.

The MLTMA (2011b) presented travel routes by classifying the purpose of travel into commuting to school and work, leisure and shopping, and transportation through the 3D complex transfer facilities. Although the destination differed depending on the purpose of the passage, the route was set as transportation-pedestrian mobility facilities-(ticket gates)-platform (leisure or shopping facilities). According to Jeong and Sohn (2018), the main movement line of the stroller users appears around the EV, and the strollers move from the parking lot to EV or are rented and moved to the automatic entrance-path-EV-destination(such as a stroller rental office) (Lee and Kim, 2019).

As such, the 3D mixed-use complex space appeared intermediate spaces as a general characteristics, and these intermediate spaces were connected to appear as the main moving route. The main space was an underground plaza, a mega store, and an ESC or EV that can move vertically. In addition, it was found that the main moving route actually moves several people. The paths connected to the entrances for connection to public transportation or transfer, and the paths to the ticket gates or platform also appeared as the main moving routes. Therefore, it is possible to propose a criterion for setting road sections applicable to general 3D mixed-use complex spaces, such as road sections that connect intermediate spaces, entrances, and ticket gates; paths connecting to the platform; and transfer paths.

Table 3. Types of intermediate spaces

Function	Intermediate space	Source
Rest	Public parks	Moon and Lee (2009)
Walking	Aerial streets, bridges, arcades, walkways	
Rest and walking	Parks, tech areas, squares, pilots, sunken areas	
Rest and event	Atriums, plazas, sunken areas, parks, and so on	Yang and Lee (2012)
Walking	ESCs, arcades, decks, bridges, walkways, and so on	
Movement induction	Mega store, theme park, and so on	

3. Scope and criteria for assigning 3D addresses

3.1 Definition of a 3D mixed-use complex space

A building or structure shown in Table 4, in which each has a GFA of 2,000㎡ or more or that this building or structure are connected to each other is defined as a 3D mixed-use complex space to which a 3D is assigned.

At this time, the scope of application to which 3D addresses are assigned to public spaces that are open to an unspecified number of people in each 3D mixed-use complex space type is defined. In detail, a 3D address is not assigned to a complex building with a shopping mall in the basement with a GFA of 2,000㎡ or more. However, when multiple complex buildings with shopping centers in the basement are connected, 3D addresses are assigned to spaces corresponding to underground shopping centers, underground public walkways, and transfer facilities. Spaces connected with these facilities are assigned a 3D address, and other spaces connected with exclusive paths or entrance spaces that are available only to specific people are not covered. These spaces are assigned a detailed address.

3.2 Criteria and application for road section setting

3.2.1 Criteria for road section setting

In this study, for the detailed space of a 3D mixed-use complex space (Table 4), we presented a general criterion for setting road sections considering the characteristics of the main moving route mentioned above.

At this time, the criteria of the road section set for roads on the ground were applied mutatis mutandis.

First, it is set as a continuous straight line (shortest path) considering possible movement flow. Second, the road sections are set to start in the west and south and end in the east and north. Third, the passage with the object to which the address is assigned is set as a road section.

These are the characteristics that are only applicable to a 3D mixed-use complex space.

First, a road section is set as a passage with a large extent of walking. This passage then connects the external entrance with the 3D mixed-use transfer center (ticketing areas, underground plazas, and connected traffic spaces), the 3D mixed-use transfer center with the internal entrance, and the underground plaza or vertical movement line with the external or internal entrance. EVs and ESCs are included in passages that connect to the shopping mall. Inside the underground shopping mall, there is a passage that connects mega stores such as bookstores and theaters or vertical moving routes to the exterior or interior entrance.

Second, for convenience and safety, a passage with an ESC or the shortest transfer passage is used.

Third, the passage from the ticket gate to the platform, which are paid zones, is set as a separate road section.

Table 4. The proposed 3D mixed-use complex

Type	The detailed space		
Underground shopping mall	Underground walkways		
Underground public sidewalk facilities	Underpass access facilities, underground connection passages, underground plazas		
3D mixed-use transfer facility	Transfer center and complex transfer center	Walking space	Internal stairs, ESCs, EVs, entrances, and walkways
		Convenience space	Concourse (ticket gate)
		Linked transportation space	Railroad platform, bus stop, waiting space for bus passengers, taxi stand, transfer parking, drop-off parking, bicycle storage, and so on
	Station	Public connection passage, transfer passage, landing, platform	

Fourth, the horizontal movement on the platform can be set by dividing the road section considering the driving direction of the train. At this time, one road section at the center of the platform may be set for an island type platform with only one platform, regardless of the driving direction.

Fifth, the passage or stairs connected with the road section setting with the above criteria in the moving flow are set as one road section.

Sixth, all external or internal entrances (connected to underground shopping malls, connected traffic spaces, underground parking lots, etc.) and ticket gates are indicated by the starting point of the road section.

The criteria were suggested so that the detailed spaces of the 3D mixed-use complex space can be connected according to the main moving routes. However, more detailed road section setting criteria should be prepared by applying them to the 3D mixed-use complex space in the future.

3.2.2 Application of road section setting

The road section was set for the 3D mixed-use complex space proposed in this study. For this, a 3D indoor or underground space map was required. However, there are restrictions on disclosure of this information to the public. Therefore, using the guide map, the road section was applied to an EBT (Express Bus Terminal) station, a 3D mixed-use transfer center, and COEX underground shopping mall. At present, the EBT station and COEX mall are assigned road name addresses (a detailed address), and the position can be clearly indicated by assigning a 3D address inside these 3D mixed-use complex spaces.

The EBT station is a 3D mixed-use transfer center with many people, which is connected to Seoul Subway Lines 3, 7, and 9 as well as to underground shopping malls and buildings. The solid yellow line is the road section that leads to the outside entrance and ticket gate, and the purple solid line is the road section that connects to the outside entrance, shopping mall, and interior entrance. The solid red line is a road section that connects the ticket gate corresponding to the toll space to the platform. The road section is set in this instance by considering the movement flow of the stairs leading to different platforms. The yellow-green solid line is a road section that is the shortest transfer route from Line 3 to Line 9. The road section from the inside of the ticket gate connected to this road section to the platform is then considered as the road section corresponding to the shortest transfer route based on the movement flow. The sky-blue solid line is the road section set according to the direction of the train operation at the platform.

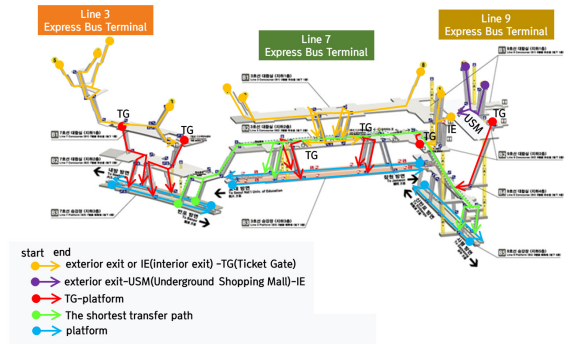

Fig. 2. Road section setting results in the EBT station

We considered further application to the COEX underground shopping mall where subway stations and surrounding complex spaces are connected, and mega bookstores and theaters are housed inside. The yellow solid line represents a road section connected to the underground parking lot from the interior entrance, while the purple solid line represents that from the outside entrance to the large bookstore or theater. In addition, there are other sections connected to these road sections in terms of movement flow. The green and yellow-green solid lines indicate the flow of movement or the road section starting from the west or south. Because the set road section starts from the west and south based on the main traffic line connecting to the main external and internal entrances and intermediate spaces, it is helpful to understand the space independently using the road section.

Fig. 3. Road section setting results in the COEX mall

The characteristics of spatial information data were such that it could be applied only to two types of a 3D mixed-use complex spaces., However, the route could be set according to the criteria presented for unfamiliar 3D mixed-use complex spaces.

In order to assign a 3D address in the future, the road section should be divided at regular intervals, and the criteria for assigning a number to the interval should be additionally studied. In addition, a method to register a 3D road section as a 2D spatial object should be studied. It is an essential part of construction and maintenance in the KAIS (Korea Address Information System) that currently manages 2D spatial information.

4. Conclusion

In this study, based on past research on the provision of a 3D address system, related laws were analyzed to define a 3D mixed-use complex space that allowed for 3D address assignments. Underpass shopping malls, underground walkways (excluding underground shopping malls), and 3D mixed-use transfer center with a GFA of 2,000㎡ or more or connected with each space by underground walkways or public paths. In addition, the detailed space corresponding to the public space of the 3D mixed-use complex space was demonstrated and distinguished from the space in which the detailed address is assigned.

Based on the intermediate space that includes the main routes in 3D mixed-use complex spaces, the criteria of the reference object for the road name address for setting the road section was presented. While applying the criteria of the road section for ground roads, general setting criteria specialized for a 3D mixed-use complex space (detailed space) was presented. A passageway with a large amount of walking and passage leading from the ticket gate to the platform were set as a road section. The platform can be set according to the direction of the train. In addition, all external or internal entrances and ticket gates were designated as the starting point of the road section, and the shortest transfer path was set.

The proposed criteria were applied to the EBT station, which is a 3D mixed-use transfer center connected to the underground shopping malls, and the COEX mall, which is connected externally to the subway station and the surrounding complex buildings. Consequently, it was possible to set the road section for an unfamiliar 3D mixed-use complex space. The proposed 3D mixed-use complex space definition and road section setting criteria built the foundation for the adoption of a 3D address system in the future.

However, by applying these criteria in various 3D mixed-use complex spaces, additional or detailed criteria according to cases should be prepared. In addition, the data structure of a 3D road section should be defined for use in the KAIS that constructs and maintains 2D spatial information. Furthermore, the scope of the proposed 3D mixed-use complex space can be considered as a reference data in setting the scope of construction for indoor spatial information. A new location-based service is expected to be provided if the digital twin, which will be built based on the “Digital New Deal” and the 3D address are linked and utilized.

Acknowledgment

This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education(No. 2020R1I1A1A01075363)

References

Choi, Y.K. (2008), The characteristics of mixed-use complex, *Construct*, Vol. 52, No. 7, pp. 48-50. (in Korean with English abstract)

Hong, W.S. (2019), *Underground City Advanced Address System and Research on the Creation of the 4th Industrial Revolution*, Report, Korea SGT, Seoul, pp. 87-92. (in Korean)

ISO (2015), ISO 19160-1 Addressing - Part 1: Conceptual model, pp. 7.

Jeong, W.R. (2019), *Three-dimensional Building (Bupyeong Station) Address System Development Pilot Project*, Report, Spatial Information Research Institute, Jeonlabuk-do Wanju-gun, pp. 63. (in Korean)

Jung, Y.K. and Sohn, D.W. (2018), A study on the pedestrian path by user in mixed-use building to improve access equality, *The Society of Living Environment System*, Vol. 25, No. 5, pp. 565-572. (in Korean with English abstract)

Kim, J.Y. and Yang, S.C. (2020), Definition of address of things based on standards in preparation for revision of road name address act, *Journal of Korean Society for Geospatial Information Science*, Vol. 28, No. 2, pp. 49-57. (in Korean with English abstract)

Lee, J.K. and Kim, C.J. (2014), Mutual connection among circulation elements in mixed-use buildings, *Proceeding of Annual Conference of the Architectural Institute of Korea, 26 April, Seoul, Korea*, Vol. 34, No. 1, pp. 69–70. (in Korean with English abstract)

Lee, J.K., Kim, C.J., and Lee, S.H. (2014), Connections among circulation elements and space activation in mixed-use buildings, *Journal of the Architectural Institute of Korea Planning&Design*, Vol. 30, No. 9, pp. 147–155 (in Korean with English abstract)

Lee, J.K. and Kim, C.J. (2019), The pedestrian integrated circulation system in mixed-use building based on user behavior, *Journal of the Architectural Institute of Korea Planning&Design*, Vol. 35, No. 12, pp. 21–29. (in Korean with English abstract)

MLTMA (2011a), *Three-dimensional · Complex Architectural Space Design Manual*, Construction and Transportation R&D Report, Urban Regeneration Project Team, Seoul, pp. 7-8. (in Korean)

MLTMA (2011b), *Three-dimensional Transfer System Design Manual*, Construction and Transportation R&D Report, Urban Regeneration Project Team, Seoul, pp. 77-81. (in Korean)

Ministry of Environment (2020), Indoor air quality management act, *Korea Law Information Center*, http://www.law.go.kr/법령/실내공기질 관리법 (last date accessed: 27 September 2020).

MOLIT (2012), Rules on the criteria for determination, structure and installation of public underground pedestrian facilities, *Korea Law Information Center*, http://www.law.go.kr/법령/지하공공보도시설의 결정·구조 및 설치기준에 관한 규칙 (last date accessed: 27 September 2020).

MOLIT (2015), Design and layout criteria for transfer centers and complex transfer centers, *Korea Law Information Center*, http://www.law.go.kr/admRulInfoP.do?admRulSeq=2100000035760 (last date accessed: 27 September 2020).

MOIS (2017), Road name address act, *Korea Law Information Center*, http://www.law.go.kr/법령/도로명주소법 (last date accessed: 27 September 2020).

MOLIT (2018), Rules for the production of integrated underground space maps, *Korea Law Information Center*, http://www.law.go.kr/LSW/admRulLsInfoP.do?admRulSeq=2100000165613 (last date accessed: 27 September 2020).

MOLIT (2019), Guidelines for supplementary design of urban railway stops and transfer · convenience facilities, *Korea Law Information Center*, http://www.law.go.kr/admRulInfoP.do?admRulSeq=2100000118529 (last date accessed: 27 September 2020).

MOLIT (2020a), Building act, *Korea Law Information Center*, http://www.law.go.kr/법령/건축법 (last date accessed: 27 September 2020).

MOLIT (2020b), Enforcement decree of the building act, *Korea Law Information Center*, http://www.law.go.kr/법령/건축법 시행령 (last date accessed: 27 September 2020).

MOLIT (2020c), Framework act on national spatial information, *Korea Law Information Center*, http://www.law.go.kr/법령/국가공간정보 기본법 (last date accessed: 27 September 2020).

MOLIT (2020d), National integrated transportation system efficiency act, *Korea Law Information Center*, http://www.law.go.kr/법령/국가통합교통체계효율화법 (last date accessed: 27 September 2020).

MOLIT (2020e), Regulations on housing construction standards, etc., *Korea Law Information Center*, http://www.law.go.kr/법령/주택건설기준등에관한규정 (last date accessed: 27 September 2020).

MOLIT (2020f), Special act on safety and maintenance of facilities, *Korea Law Information Center*, http://www.law.go.kr/법령/시설물의 안전 및 유지관리에 관한 특별법 (last date accessed: 7 October 2020).

MOLIT (2020g), Special act on underground safety management, rules for the production of integrated underground space maps, *Korea Law Information Center*,

http://www.law.go.kr/법령/지하안전관리에 관한 특별법 (last date accessed: 27 September 2020).

MOLIT (2020h), Urban railroad act, *Korea Law Information Center*, http://www.law.go.kr/법령/도시철도법 (last date accessed: 27 September 2020).

Moon H.N., Jang S.Y., and Lee, Y.M. (2011), A study of user satisfaction in environmental-friendly intermediary space of mixed-use complex, *Journal of the Architectural Institute of Korea Planning&Design*, Vol. 27, No. 6, pp. 11-20. (in Korean with English abstract)

Moon J.I. and Lee S.H. (2009), A study on the characteristics and types of intermediate space in a large mixed-use complex - focused on case studies in Korea and Japan, *Journal of the Architectural Institute of Korea Planning&Design*, Vol. 25, No. 12, pp. 73-80. (in Korean with English abstract)

National Fire Agency (2019), Special act on disaster management of high-rise and underground-linked complex buildings, *Korea Law Information Center*, http://www.law.go.kr/법령/초고층및지하연계복합건축물재난관리에관한특별법 (last date accessed: 27 September 2020).

National Fire Agency (2020), Special act on the safety management of multi-use stores, *Korea Law Information Center*, http://www.law.go.kr/법령/다중이용업소의 안전관리에 관한 특별법 (last date accessed: 7 October 2020).

Yang, S.C. and Lee, H.C. (2012), An users satisfaction on publicness of intermediate space on mixed-use complex - focus on construction and structure, *Journal of the Architectural Institute of Korea Planning&Design*, Vol. 28, No. 1, pp. 207–216. (in Korean with English abstract)