Initiatives for Formation and Effective Utilization of Underground Pedestrian Networks in Japan

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Abstract. In recent years, cities in Japan have faced a strong demand for improving urban environment and securing disaster prevention functions in response to changes in the socio-economic situation such as rapid development of information technologies, globalization, declining birthrate and aging population. In this context, underground pedestrian networks have not only the purpose of alleviating chronic congestion aboveground, but is expected to play various roles such as improvement of convenience by directly connecting to offices and commercial facilities, and provision of temporary occupancy function in the event of a disaster. Furthermore, it is possible to promote sophistication of underground space and to enhance various functions as a city, and efforts for implementation have already started. This paper introduces examples of underground pedestrian network projects that are being implemented in line with urban renewal, as well as efforts on effective utilization of underground space with new technologies in major cities in Japan.

1. Introduction
In the heart of Japan’s major cities are vast networks of spaces located below ground coupled with high-density underground railway stations and the basement level of buildings. Here we can find a number of “underground malls” financed by public and private sectors located in the vicinity of terminal stations where public corridors and shops have been integrated using spaces below roads and station squares. Today, there are underground malls in about 80 locations in 21 cities across Japan with a total floor space of 1.18 million m² (as of the end of March 2019). Many of these underground malls see 100,000 visitors per day (Figure 1) and serve as highly comfortable and convenient pedestrian networks connected to surrounding buildings with endless streams of people.

In cities in Japan, public-private partnership efforts are underway to further enhance the underground space network, and projects that contribute to the improvement of urban functions are being promoted by securing multi-layered flow lines that connect the underground and the town. Furthermore, with the progress of digitalization and the emergence of various new technologies, there is an increasing need to digitize underground spaces for more advanced management.

This paper introduces examples of projects on developing underground pedestrian networks in line with urban renewal in major cities in Japan and efforts on effective utilization of underground spaces using ICT (Information and Communication Technology).
Figure 1. Number of visitors and connection points per day in underground malls
Source: Data from the City Bureau, Ministry of Land, Infrastructure, Transport and Tourism

2. Formation of underground pedestrian networks in line with urban renewal
The aim of urban renewal projects is to improve the quality of life of local residents and revitalize the local economy and society with the development of unique urban areas that take advantage of local features, such as the history, culture and natural environment. Many projects include the construction of underground spaces, which are expected to have a ripple effect on enhancing functions to prevent or mitigate disasters. This section highlights some examples of urban renewal projects in recent years.

2.1. Toranomon (1- and 2-chome district and 1-chome 3 and 17 district)
With the opening of Toranomon Hills Station on the Tokyo Metro Hibiya Line in June 2020, this district, which is located close to the center of Tokyo, has the potential to become a conveniently accessible transportation hub. In addition, area-specific urban development policies in the “Minato City Master Plan for Community Development” call for the formation of a base for international business exchange through the expansion of transportation functions.

In this context, a decision was made to develop an urban plan for a special district for urban regeneration based on the Act on Special Measures Concerning Urban Reconstruction. The construction of the Toranomon Hills Station on the Tokyo Metro Hibiya Line and urban development were integrated to form a plaza connected in three dimensions to surrounding spaces to strengthen traffic hub functions and create a vibrant atmosphere. The area is being developed with the aim of creating a hub for international business and exchange with the introduction of a variety of business, commercial, cultural and exchange functions, as well as lifestyle and business support functions and by strengthening the area’s ability to respond to disasters.

Special districts for urban regeneration permit the relaxation of floor area ratios (FARs) in accordance with the degree to which it contributes to urban renewal, allowing for a higher degree of flexibility in planning within urban renewal areas designated for urgent development, regardless of usage and FAR restrictions based on existing zoning.
In the special district for urban regeneration (Toranomon 1- and 2-chome district), one of its contributions to urban renewal is the formation of a pedestrian network linked to surrounding development projects through the construction of a station square integrated with the new station (Figure 2). In addition, the development of a ground level and underground pedestrian network has been positioned in the plan for the Toranomon 1-chome 3 and 17 district for urban regeneration with the expansion of the platform at Toranomon Station using private land and the development of a station square both above and below ground linking the new station with Toranomon Station, the bus terminal, and the surrounding area to provide a safe and comfortable environment for people to walk around.
(Figure 3). These improvements are expected to turn the area into a new transportation node in the city center.

2.2. Shibuya (station block area, Shibuya Station area)
This area is located directly above Shibuya Station, one of Japan’s most well-known stations, on the JR Yamanote Line and the Tokyo Metro Ginza Line. Shibuya is undergoing a major transformation as a result of a chain reaction of developments triggered by the renewal and reorganization of functions of the station’s facilities. The momentum for development around Shibuya Station is gaining speed, with the need for the Shibuya Station area and surrounding districts to work together in developing and passing on what makes Shibuya unique to create a sustainable city for the future.

In addition, area-specific policies for urban development in the “Shibuya City Urban Development Master Plan” call for the development of multi-level plazas, decks and walkways and a three-dimensional urban structure to connect them. Against this background, a decision was made to develop an urban plan for a special district for urban regeneration (station block area, Shibuya Station area) based on the Act on Special Measures Concerning Urban Reconstruction. Positioned in the plan were the expansion of free passageways connecting the plazas on the east and west sides of the station, development of an urban core (open vertical space in a multi-level urban structure connected from top to bottom by elevators and escalators, guiding people to ground level from the basement levels and decks) (Figure 4), construction of a sky-deck linked to the area around the station, and the development of functions for temporary occupancy for people who are unable to return home in the event of a disaster. In cooperation with the land readjustment project in the area around Shibuya Station and railroad improvement projects, pedestrian decks on and around the site and a square in front of the station are being integrated and developed to secure space in an effort to provide support for people who have difficulty returning home in the event of a disaster, which will strengthen traffic node functions, improve convenience for pedestrians and enhance functions to prevent disasters.

![Figure 4. Future image of East Exit urban core](source: Shibuya Station Block Joint Building business)

3. Efforts on effective utilization of underground spaces using ICT
Many underground malls have been developed by utilizing underground spaces of roads and station squares near terminal stations in order to deal with issues such as congestion of road traffic during the period of high economic growth. Currently, the public passages in the underground mall have a role as an important pedestrian space used not only by the users of the underground mall stores but also by many citizens, and we will need to properly secure the urban functions continuously. On the other hand, it is also a fact that the malls are aging, and more than 80% of the underground malls in Japan have been...
in operation for more than 30 years, and it is necessary to systematically and steadily promote safety measures (Figure 5).

![Figure 5. Number of Years Passed Since the Opening of Underground Malls (As of March 2019)](image)

Source: Data from the City Bureau, Ministry of Land, Infrastructure, Transport and Tourism

Japan is promoting smart city initiatives utilizing new technologies and data, such as AI and IoT, to realize Society 5.0, which integrates cyber and physical technologies at a high level. The future of urban planning and development of underground spaces will require the use of new technologies and data to solve the challenges that cities are facing. In particular, against the background of the need for safety measures and disaster countermeasures for underground malls mentioned above, there is a strong need to digitize underground spaces and perform more advanced management. On the other hand, the current situation is that digitization in underground spaces, such as the underground malls introduced in this paper, has not progressed much. This section introduces advanced efforts being made by the government and local bodies on effective utilization of underground spaces using ICT.

3.1. Accessibility of indoor digital maps for the public through the Geospatial Information Center

The Government of Japan is developing a spatial information infrastructure to realize seamless indoor and outdoor navigation including underground spaces. One of the efforts is to release indoor digital maps at the Geospatial Information Center.

The Geospatial Information Center is a one-stop platform that handles geospatial information from industries, academia and the government and aggregates a variety of geospatial information maintained by various entities in the public and private sectors, which allow users to search, download and utilize information. One of the challenges in developing information infrastructure related to indoor spaces was that there was no electronic map for unified use like outdoors. In order to promote the creation of a diverse set of private sector services using location information, the Geospatial Information Center releases indoor digital maps that have been created based on “Data Specifications for Indoor Geospatial Information by Level”, published in March 2018 by the Geospatial Information Authority of Japan. For example, the areas around Tokyo Station and Shinjuku Station including the underground network can be accessed (Figure 6).

Data on indoor networks, including level differences and gradients in corridors is available along with map data, which makes it possible to develop apps for navigation that allow users to search for barrier-free routes and avoid level differences. In addition, in the event of a disaster, evacuation will be provided by providing information such as the location, availability, route, etc. of the temporary reception facility for people who have difficulty returning home according to their current location, indoors or outdoors, and providing appropriate guidance based on the congestion situation. It is expected that it can be used as a basis for providing guidance information. In the future, a variety of services are expected to be offered using the information found on the platform.
3.2. Initiatives around the Tokyo Station area

The Otemachi-Marunouchi-Yurakucho area around Tokyo Station (hereinafter referred to as the OMY area) covers a space of 120 hectares with 13 stations on 28 lines, and has multi-level pedestrian networks, including underground spaces. In line with initiatives in urban renewal throughout the entire district, the network of underground spaces is being upgraded and expanded to connect it with the basement levels of each building.

A “disaster dashboard” is being developed for the OMY area as one of the disaster prevention measures in the district, including the network of underground spaces. The disaster dashboard collects, analyzes and creates a visual picture of the movement of people, congestion, and damage in real time in the event of a disaster, and provides information on evacuation routes to disaster response agencies and visitors. The goal is to create a system that can be accessed through digital signage installed in the area and the internet to efficiently coordinate information using ICT in the event of a disaster (Figure 7). By combining outdoor digital maps and the indoor digital maps mentioned above, live information inside each facility and information on the location of live cameras and buses to transport injured persons can be viewed on indoor/outdoor digital maps. Several demonstrations have been conducted in the OMY area and efforts to move the system into the implementation stage are underway.
3.3. Initiatives in Sapporo City

Sapporo City is constructing the Sapporo Ekimae-dori Underground Walkway, a 520-meter-long and 20-meter-wide space connecting the central business district. By converting a section of the underground pedestrian space into a plaza, the city has created a comfortable space that can be used by many residents. Sensors have been installed in the Sapporo Ekimae-dori Underground Walkway that indicate the number of people and the direction in which they are traveling. This data is mainly used for disaster prevention measures. In addition, beacons have been installed in a wide area in the city’s underground spaces, including the Sapporo Ekimae-dori Underground Walkway, to collect data from smartphones on the movement and paths of users for the purpose of disaster prevention and area management.

Sapporo City is conducting a Kenko Point Project (Health and Happiness Point Project) with the aim of encouraging people to change their lifestyles to one centered on public transportation and walking with the use of ICT to realize the creation of a healthy and long-lived society by increasing opportunities for walking. For participants of the project, the number of steps taken during the project period, trajectory of walks above and below ground, the body composition of subjects, and information on purchases at stores is compiled using a smartphone app and analyzed with the results utilized for future projects promoting health and urban development. Participants in the project are able to earn points for use at stores and in other locations depending on the number of steps they take.

The Ministry of Land, Infrastructure, Transport and Tourism is promoting “smart planning” initiatives to examine facility layouts, formation of spaces, and transportation policies through simulations of human movement and predictions on the effects of policy implementation, based on data on individual behaviors.

4. Conclusion

This paper introduces examples of projects on developing underground pedestrian networks in line with urban renewal in major cities in Japan and efforts on effective utilization of underground spaces using ICT. The development and effective use of underground spaces will continue to be an important focus for Japanese cities to upgrade urban functions, improve the living environment in cities, and secure functions to prevent disasters in response to changes in socioeconomic conditions. We will continue to support initiatives related to the development of underground spaces, such as those described in this paper.

Reference

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