The Mission of NILIM: Research that Pursues the Essential by Focusing on Reality

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1. Introduction

The Mission of the National Institute for Land and Infrastructure Management (NILIM) is "to use technology as a driving force to create an attractive society that is safer, more secure, and more vigorous, both now and in the future." On April 1 of this year, NILIM celebrated the 20th anniversary of its establishment. During these two decades, both Japanese society and the international environment surrounding this country have changed significantly, and even faster and larger changes are expected in the future. Under these circumstances, I would like to offer several perspectives on matters that we should consider in our present research in light of the Mission of NILIM.

2. The essential is immutable and transcends the times

There is an expression in Japanese, *fueki ryuko*, which is derived from haiku and combines the concepts of "transitoriness" and "immutability." At a glance, these two concepts may appear to be complete opposites, but in fact there is no contradiction between the two, since it is possible to approach the essential, which transcends the times, by responding flexibly to changes in surrounding conditions (transitoriness) when we pursue the unchanging essence (immutability). Our research at NILIM is truly an embodiment of this principle, since we pursue our essential Mission by responding flexibly to an ever-changing environment by incorporating new viewpoints that answer the needs expressed by society.

The immutable Mission of NILIM includes the words "attractive, safe, secure, and vigorous," which are analogous to "strength," "utility," and "beauty," the three principal elements of architecture according the classical Roman architect Vitruvius. It would be fair to say that this transcends the times and touches on the essential, since those ideas were advanced in the first century before Christ, and were still picked up in one of my courses at a university. Although national land and society are different from individual architectural structures, the land of a nation is constructed by human efforts to shape nature, and society (social capital) is created by humans through close contact with that national land. Considering this, it is possible to regard national land and society as forming a complex structure. From the viewpoint of our mission at NILIM, "Strength" is the structure that provides "safety," "Utility" is the functions that produce "vigor," and "Beauty" is the "attractiveness" that supports a pleasant, secure life. It can be said that our goal at NILIM is to explore and develop the technologies to sustain the national land, housing and social capital that provide these three elements, both in the present and in the future, and to realize social implementation of those results.

3. "Strength": A structure supporting safety

The greatest challenge for NILIM is research to ensure the resilience of Japan's national land, and the most important issue at present is responding large-scale earthquakes and climate damage, which we fear will become both more severe and more frequent as a result of ongoing climate change. Research for disaster prevention and mitigation of these natural disasters includes the conventional research fields of resilience measures such as structures (e.g., seawalls, earthquake-resistant buildings, etc.) and other "hard" countermeasures, and "soft" measures such as damage prediction and estimation technologies. Although the importance of these fields will remain unchanged in the years to come, if that is so, what points should we consider in the future?

When studying resilience of Japan's national land, the most important technical issue is how to set the external forces that require a response. Since the scale of natural disasters is essentially unlimited, the most recent knowledge of the fields of meteorology, geology and seismology is necessary when assessing the scale and frequency of natural disasters caused by torrential rain and earthquakes that may occur in the future as the

boundary conditions surrounding national land, housing and social capital. However, research cannot be limited to the laboratory. Results that will be useful in creating a resilient society are demanded, and for this, an insatiable appetite for exchanges with many academic fields, and a greater knowledge than in the past of natural external forces and techniques for evaluating the topographies that express the action histories of actions of those forces will be required.

It is also necessary to establish a response strategy based on an evaluation of external forces obtained from that knowledge, and in doing this, it is essential to exclude the "unexpected." Of course, technical development to expand the range that avoids damage in a natural disaster (i.e., strengthening disaster prevention capabilities) is necessary. Bur when a disaster exceeds that range, it is essential to minimize the damage, including economic damage, with protection of human life as the highest priority. When responding to complex disasters, not only strength, but also social implementation of what might be called "smart failure" designs and plans is necessary. Achieving this will require simultaneous research aiming at resilience based on a total understanding of the national land and society, and not simply individual projects and facilities.

4. "Utility": Functions that produce vigor

Japan's 5th Science and Technology Basic Plan proposed Society 5.0 as "a human-centered society that balances economic advancement with the resolution of social problems by a system that highly integrates cyberspace and physical space." From this viewpoint, it will be necessary to utilize cyberspace to enhance the future functions of the national land and society.

At present, the keyword in this field is DX ("digital transformation"). As a metaphor for DX in the infrastructure field, DX can be likened to innovating functions by incorporating a nervous system (corresponding to the human brain and sensory organs), into the national land, housing and social capital (which corresponds to the skeleton and muscles of the body). Integrating this "nervous system" into infrastructure will not only realize higher efficiency in work in the construction field, but can also be expected to enhance the effectiveness and efficiency of infrastructure by enabling easy feedback of the state and use condition of infrastructure under management. In turn, this will increase the vigor of society. This will require great strides in research and development, referring to the nervous system functions of living beings, aiming at DX that coordinates the totality of infrastructure, from individual structures to the national land, so as to demonstrate the functions of infrastructure in harmony, without waste, and in a robust manner.

5. "Beauty": Attractiveness for a comfortable and secure life

Daily life is not realized without a safe and vigorous national land and society, but at the same time, life is not worthwhile without comfort and security. However, the requirements that must be satisfied by the element of "beauty," as exemplified by comfort and security, is difficult to evaluate by an objective index. Although it is frequently hard to determine the proper form of measures and projects from this viewpoint, measures and projects in the field of national land, housing and social capital should be developed in line with a shared sense of values in society, based on the common culture of the region or country. Thus, this is a field where it is necessary to systematize research so as to contribute to enhancing the quality of life through appropriate evaluations.

It is essential to include preservation and improvement of the living environment and natural environment as purposes of measures to provide safety and vigor in society. In particular, as we accumulate individual measures and projects, we must construct sustainable national land, housing and social capital from diverse viewpoints, including decarbonization, looking at those efforts as a whole. Here, the question is how to construct research in a way that will increase the attractiveness of the national land and society.

6. Conclusion

The target research fields of NILIM are broad and cannot be completed independently. Thus, we will continue to update the organization of our research fields, but in areas where our own capabilities are insufficient, we must also carry out research in cooperation with other organizations with different specializations.

Our research results are materialized as technology policies, and they fulfill the Mission of NILIM by contributing to society. Therefore, our research results must be capable of social implementation. However, we must go far beyond that. As I have described in this paper, it is my hope that NILIM will continue to adopt a stance toward research that systemizes the chaos of "reality," and exhaustively pursues "the essential" in order to manage that reality more appropriately.

Study on Comprehensive Management of Sewer Pipelines

Water Quality Control Department

Sewer pipeline facilities are a representative example of underground installation, but it is difficult to determine the condition of deterioration. The purpose of this research is to optimize the management cycle of drafting and implementing sewer inspection survey plans, collection of information, and repair and reconstruction.

Social background and issues

- The total length of sewers in Japan is about 480,000 km, which is enough to circle the globe 12 times, and aging of these buried facilities is progressing rapidly.
- The poor condition of sewer lines causes about 2,900 road collapses every year.
- There are no concrete standards for the selection of sewer pipeline inspection survey methods and repair and reconstruction techniques, which is left to the judgment of local public bodies. However, efficient implementation is difficult, particularly in medium- and small-sized cities which lack the capability to make technical judgments.

Study contents

Proposal of a method for setting the starting period of sewer pipeline inspection surveys.

Set the starting period of inspection surveys by evaluating the social impact of road collapses and other types of accidents caused by sewer pipeline facilities.

- Classify sewer facilities in the management classes “Highest priority management,” “Priority management” and “Normal management.”
- Set the start periods of inspection surveys for each management class by utilizing the soundness ratio forecast formula released by NILIM.

• Soundness ratio forecast formula
This formula shows the relationship between the soundness ratio and the age of pipeline facilities (elapsed time since construction). The “soundness ratio” is the percentage of sound pipes in all pipes based on the data of inspection survey results collected by local public bodies.

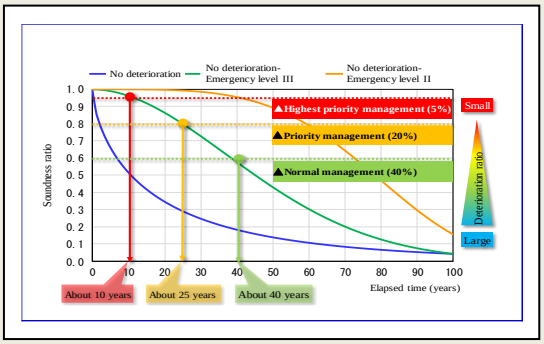


Image of setting the timing of start of inspection surveys (Highest priority management: 10 years, priority management: 25 years, normal management: 40 years)

Proposal of method for selecting the optimum inspection survey technology by using O&M information

Since various technologies are available for inspection surveys of sewer pipelines, the Water Quality Control Department will propose a method for selecting the optimum inspection survey technologies by arranging the following items:

- Pipe type, abnormality occurrence tendency (abnormality items, occurrence position, etc.)
- Use of operation and maintenance (O&M) information, including past inspection survey data, etc.
- Characteristics of inspection survey technologies (abnormalities that can be discovered, cost, risk, etc.)

Arrangement of points that require attention when selecting inspection survey technologies, to enable the local public bodies that actual perform O&M to select the optimum technique.

Examples of technologies for inspection surveys of sewer pipelines

High efficiency in inspection surveys of sewer pipelines by using O&M information. Securing continuous functioning and optimization of the cost of sewer pipeline systems.

☞Relevant article

• NILIM Press release http://www.nilim.go.jp/lab/bcg/kisya/journal/kisya20171222.pdf

Coastal Engineering for Taking Action to Climate Change

River Department

For taking action to sea level rise, stronger storm surges and waves, and more severe coastal erosion caused by climate change, the River Department is conducting research on coastal erosion prediction techniques and countermeasures considering future external forces, and seawalls with resilience against storm surge and high waves.

Social background and issues

- Disasters caused by storm surge and high waves, for example, during Typhoon No. 21 (Typhoon Jebi) in 2018, have occurred with increasing frequency in recent years.
- Rises in the mean sea level due to the effects of climate change have already been observed, and the effects of further increases in the mean sea level, larger and more powerful typhoons, etc. in the future are feared.
- Japan's Basic Policy for Coastal Protection was revised in 2020 and requires concrete implementation of measures for coastal protection in order to pass on "beautiful, safe, and flourishing coastal areas" to the next generation, which is the basic philosophy of the policy.

Study contents

Techniques for coastal protection considering the effects of climate change

If the mean sea level rises due to climate change, the cross-sectional shape of beaches will change toward a new equilibrium state corresponding to the rise in sea level. Therefore, the shoreline will retreat to the landward side to more than the distance submerged by the rise in the sea level. Since the wave runup height on seawalls will also increase due to the combined effects of shoreline retreat and the increased size of storm surges and waves, new countermeasures will become necessary.

The Coast Division of the River Department is studying practical techniques for predicting the amount of future shoreline retreat due to sea level rise, etc. and coastal protection measures based on the results of that research.

As shown at the right, countermeasures for sea level rise and larger storm surge and waves are not limited to raising the height of seawalls, but also include planar protection by increasing the wave dissipating function of sandy beaches by beach construction and raising the height of offshore wave-dissipating facilities.

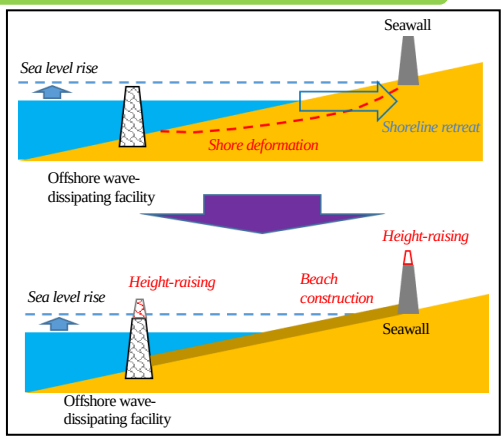
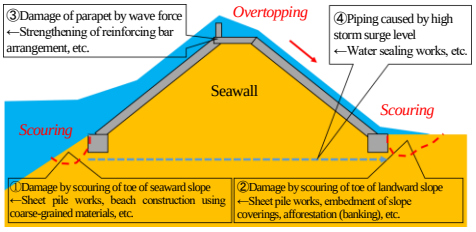


Image of measures for sea level rise

Seawalls with resilience against storm surge and high waves exceeding design target

As storm surges and waves become larger and more powerful due to climate change, wave overtopping of seawalls will also increase, and seawalls be damaged more easily by wave overtopping and scouring. Therefore, it is necessary to review the design external forces of seawalls considering climate change, and promote the construction of seawalls with resilience against storm surges and high waves that exceed the design targets. The Coast Division is engaged in research on seawall structures which can resiliently demonstrate an inundation prevention function.

Based on the results of hydraulic model experiments conducted to date, the Coastal Division has proposed countermeasures for four assumed seawall damage modes under storm surge and high wave conditions that exceed the design scale, as shown at the right, and is studying the scale of those countermeasures.



Assumed damage modes and their countermeasures

Coastal protection considering the effects of climate change
To leave "beautiful, safe, and flourishing coastal areas" to the next generation.

☞Related article is here (Introduction of related article by Coast Division)

• Preparing for Future Beach Erosion Caused by Climate Change Focusing on Beaches with Experience of Sea Level Rise （P.49）

Technology Development to Mitigate Damage by Sediment Disasters Accompanying Large-Scale Earthquakes

Sabo Department

In the Kumamoto Earthquakes of 2016, massive damage occurred as a result of a large number of slope failures over a wide area, and landslide-prone conditions continued after the initial disaster, hindering the reconstruction of the region. NILIM is developing a technology which enables quick estimation of the occurrence of sediment disasters accompanying large-scale earthquakes and a technique for setting the standard rainfall for forecasting sediment disasters after earthquakes.

Social background and issues

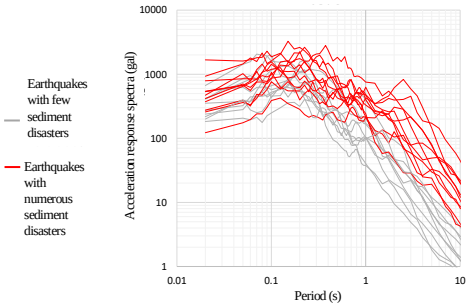
- In order to contribute to a fast, efficient emergency response to sediment disasters caused by earthquakes, a technique that enables estimation of the occurrence or non-occurrence of sediment disasters immediately after earthquakes is considered necessary.
- Because smaller-than-usual rainfall sometimes triggers sediment disasters for some time after a large-scale earthquake occurs, a risk assessment technology for sediment disasters that appropriately considers the effect of earthquakes is also considered necessary.

Study contents

Quick estimation of occurrence of sediment disasters accompanying large-scale earthquakes

The Sabo Department will propose guidelines for estimating the occurrence or non-occurrence of sediment disasters based on a comparison and analysis of the acceleration response spectra of earthquakes with numerous sediment disasters or with few sediment disasters in recent years.

Slope failures caused by 2016 Kumamoto Earthquakes



Comparison of acceleration response spectra of earthquakes according to sediment disasters occurrence

Preparing for hightened likelihood of sediment disasters caused by rainfall after earthquakes

Considering slope destabilization by earthquake ground motion, the threshold for issuing Sediment Disaster Alert was provisionally reduced by 20-30% in areas with JMA seismic intensities of >5+. The warning system was operated with rainfall less than pre-designated, based on this threshold.

Decisions to make the provisional threshold to the normal threshold are made based on the actual data on rainfall and sediment movements, and confirmed and recommended by NILIM.

During 2019, technical recommendations were made for Niigata Prefecture (Yamagata Offshore Earthquake) and Hokkaido (Hokkaido Eastern Iburi Earthquake).

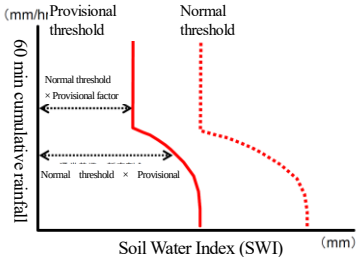
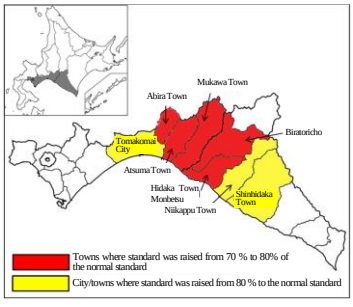


Image of provisional threshold



Target municipalities of provisional threshold
(Iburi / Hidaka areas of Hokkaido)

Damage mitigation and rapid reconstruction, made possible by On-time, streamlined response to rain-induced sediment disasters after large-scale earthquakes.

☞ Related article is here (Introduction of related article by division in charge)

• Analysis of Factors in Occurrence or Non-Occurrence of Sediment Disasters by Spectrum Analysis of Observed Seismic Waves (p. 58)

Technical Assistance to Restoration and New Challenges Based on the Damage Caused by the Heavy Rain Event of July 2020

Road Structures Department

The heavy rain event of July 2020 caused road-related damage in many areas from the Tohoku to Kyushu Regions.
We conducted a field survey in cooperation with the Regional Development Bureau and other organizations to provide technical support for restoration in the future. Based on the results of this survey, we are conducting the development of damage risk assessment methods, which is introduced in this paper.

Social background and issues

- In recent years, heavy rains have caused road-related damage every year, and at the request of local communities, we have conducted field surveys and provided technical advice on restoration.
  On the other hand, some parts of the road have been entirely closed for a long time.
- Because a wide range of damage was caused, including the loss of the superstructure / substructure of bridges, loss of roads and shoulders along the river, and slope failure, it is required to analyze the causes of the damage, identify the structures that require countermeasures based on the results of the analysis, and select the priority structures for countermeasures.

Survey and research contents

Damage assessment and emergency technical support immediately after the disaster

After the heavy rain event of July 2020, NILIM, in cooperation with the relevant departments of the Public Works Research Institute (PWRI), has been conducting damage surveys and emergency technical support, as well as continuing technical study and assistance for recovery and restoration.
As for personnel dispatch to the site, we participated in local responses at various fields as an expert and a member of the advanced technical guidance group of the MLIT's Technical Emergency Control Force (TEC-FORCE), and conducted various surveys by organizing independent survey teams.

Road sections that were entirely closed to traffic due to the road-related damage caused by this heavy rain amounted to 16 lines in expressways, 29 sections in national highways under direct control, about 120 sections in national highways managed by the prefectural government, and about 600 sections in prefectural roads. etc.
In the area of roads, the personnel of NILIM were dispatched to the affected areas about one month from July 5 to August 5, totaling 30 man-days
They quickly conducted on-site surveys and provided technical support for emergency opening and permanent restoration methods and countermeasures at the request of local communities.

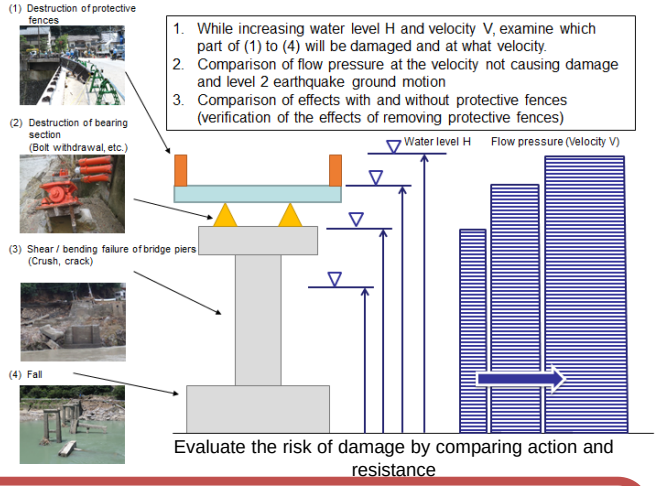
Okitsuru Bridge Survey (July 10)

Survey on the Slope Failure in Nagasaki Prefecture (Aug. 4)

Activities to analyze the causes of the disaster and develop damage risk assessment methods

In recent years, heavy rains have caused many traffic closures due to the destruction of various bridge components, damage to retaining walls in sections parallel to rivers, and landslides and slope failure that occurred outside the road area.
For example, bridges crossing the Kuma River and its tributaries were damaged in various ways, as shown in the Figure on the right. We are developing damage risk assessment methods by analyzing the resistance of protective fences, bearing section, and bridge piers against destruction and the resistance of foundation against falling, which are caused by the action of flowing water.

We are also developing damage risk assessment methods for road earthwork structures, etc.
Through the analysis of the condition and collapse mechanism of structure, we are conducting analysis focused on the degree of impact on road functions (road closure period, emergency opening period, etc.).



Evaluate the risk of damage by comparing action and resistance

Minimize the duration of road closures due to heavy rain and support early opening to emergency transportation during disaster and general traffic.

A study on the Observation Method of Pedestrian Flow in Urban Space Using New Technology

Urban Planning Department

The Urban Planning Department is conducting research on observation methods for understanding pedestrian flows at various scales, such as from street space to inter-city travel, by introducing new technology that analyzes the movement of mobile phones and other devices using big data etc. in order to predict and analyze the effects of measures to revitalize city centers in a sophisticated and efficient manner with the aim of realizing an intensive urban structure and smart cities.

Social background and challenges

- In developing measures, such as the reconstruction of street space to create a space that is comfortable and makes people want to walk, it is important to develop plans based on objective data, such as the volume of pedestrian flow, and evaluate the results of implementing the plans.
- In recent years, pedestrian flow observation methods using new technologies, such as mobile phone base stations, Wi-Fi packet sensors, and GPS, are becoming more and more popular. Yet, each has its own advantages and disadvantages. Thus, it is necessary to select and combine methods according to the situation.

Contents of research

Observation of pedestrian flows using Wi-Fi packet sensor

The Wi-Fi packet sensor can be used in buildings and underground spaces where GPS observation is not available and can perform observations at a finer scale than mobile phone base station data.

In this study, the effectiveness of the Wi-Fi packet sensor will be verified by acquiring pedestrian flow data in areas, such as the city center where underground space exists, and comparing it with statistical data and manual observation data. Characteristics of pedestrian flow observation method using the Wi-Fi packet sensor and points to pay attention to will then be summarized.

Wi-Fi packet sensor

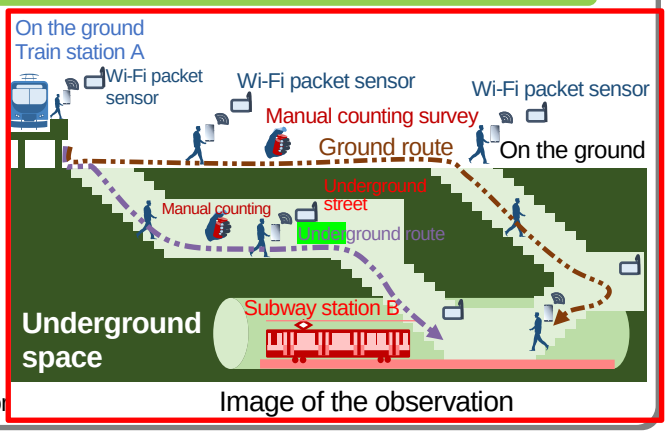


Image of the observation

Verification of mutually complementary methods based on the combination of new technologies

There is a limit to the amount of data that can be acquired by individual methods alone even if the pedestrian flow observation method uses new technologies. Thus, methods are being explored to increase the accuracy and usefulness of acquired data by combining and mutually complementing multiple methods.

In this study, in order to compensate for the shortcomings of Wi-Fi packet sensors, such as the unstable capture rate of pedestrians, the effectiveness of the following two methods are examined: (1) combination with infrared counters, which can relatively easily estimate the actual value of pedestrian cross-sectional traffic volume; and (2) combination with mobile phone base station data, which can obtain wide- area flow and attribute information, in order to expand the use of the Wi-Fi packet sensors.

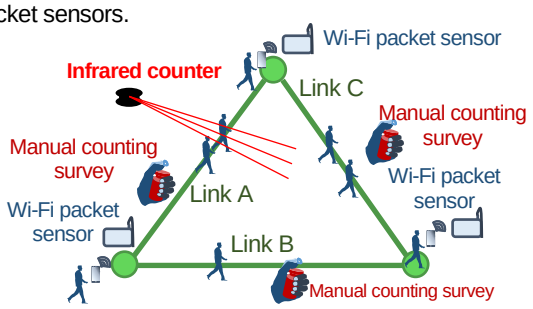


Image of the combination with infrared counter

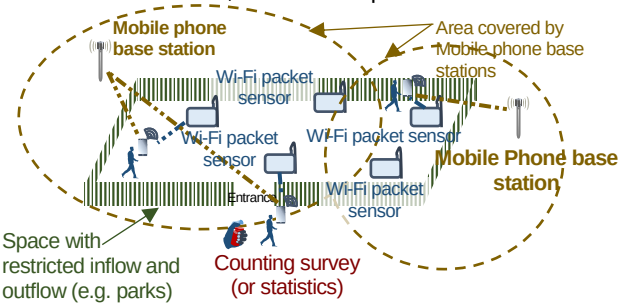


Image of the combination with mobile phone base station data

By using new technologies to improve the efficiency and sophistication of methods for understanding pedestrian flow, and by enabling smart planning by local governments and other entities, this study will contribute to the improvement of urban sustainability and the realization of smart cities.

Perspectives of NILIM's Activities

KIMURA Yoshitomi, Director for Research Affairs

key words: technical support, diverse perspectives, experience and history,

1. NILIM seen in the recovery from the Kumamoto Earthquake

On March 7, 2021, a ceremony was held to inaugurate the New Aso Bridge, which was constructed under the authority of the national government to restore the Aso Bridge (managed by Kumamoto Prefecture) on National Route 325, which had collapsed in the Kumamoto Earthquake. The ceremony was attended by Mr. Akaba, Minister of Land, Infrastructure, Transport and Tourism, and Mr. Amano, Director-General of NILIM (photo). In the ceremony, Mr. Tetsushi Sakamoto, Minister of State for Special Missions of the Cabinet Office, gave a speech on behalf of the locally elected Diet members as a congratulatory speech by the guests of honor, stating "NILIM, as the best brain of the Ministry of Land, Infrastructure, Transport and Tourism, also provided us with human resources. With the world's top level of technology, we were able to open a tunnel exceeding our expectation, as well as Hohi Line, Route 57, and the Choyou Great Bridge. As a local resident, I would like to express my heartfelt gratitude. I believe that today's opening ceremony is the result of the united efforts of the local community, Diet, government, technology, and State."

As stated in this congratulatory speech, immediately after the Kumamoto earthquake, NILIM dispatched staff in cooperation with the Public Works Research Institute to conduct on-site surveys and advise on emergency restoration.

In April 2017, NILIM established the Kumamoto Earthquake Recovery Division in the affected area, which has been working together with the Kumamoto Restoration Division of the Kyushu Regional Development Bureau, the main implementer of the construction work, as a two-wheeled team.

In parallel, we are investigating the characteristics and causes of damages in order to prevent the occurrence of similar damages, and explaining them at the relevant councils and proposing revisions to engineering standards. In addition, the Kumamoto Earthquake Recovery Division is conducting research unique to a laboratory established in the affected area.

Photo: New Aso Bridge Opening Ceremony

These research activities can be regarded as practical examples of "Advanced technical support for response to disasters / accidents and upgrading of countermeasure technologies" as stated in the research policy of NILIM. The following introduces some perspectives of these research activities of NILIM.

2. Diverse perspectives

When the Kumamoto Earthquake occurred, I had the opportunity to respond to it as the head of the Road

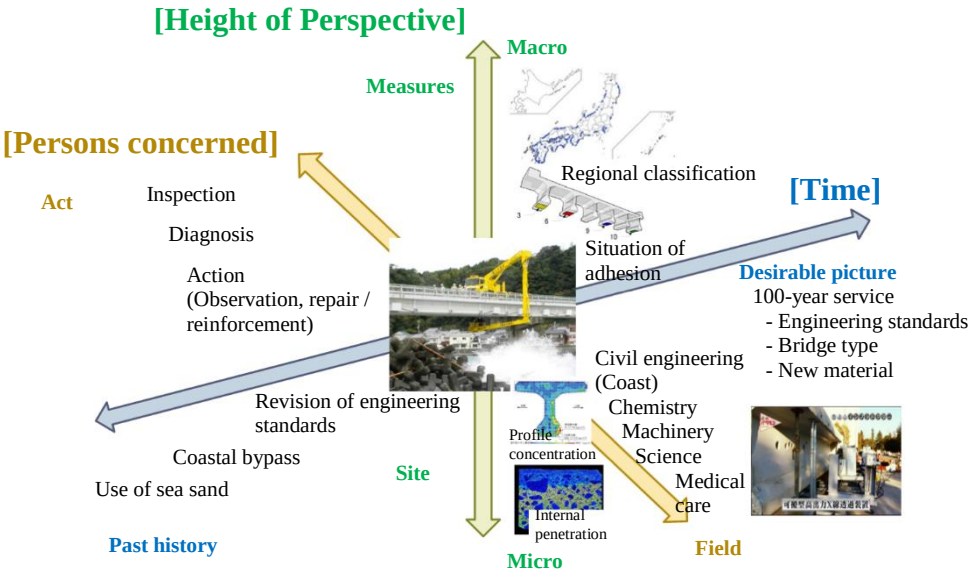


Fig. Three perspectives of research activities

Structures Department. Then, as an action policy, I presented two roles and three basic attitudes. One of the basic attitudes is to "Look at three points."
The three perspectives are "Look ahead" (What is required next?), "Look up and down" (What are the supervisor and staff doing?), and "Look sideways" (What are the neighbors and each institution doing?). These three perspectives referred to a "hawk's eye and ant's eye." As similar expressions, there are "bird's eye, insect's eye, fish's eye, and bat's eye."
Diverse perspectives are essential to research activities as a research institute that supports the planning, formulation, and dissemination of national land transportation policies. As an example of such activities, let me introduce a case of salt damage to a road bridge. In the center of the Figure is a photo of a road bridge built at the entrance of the port. It was damaged by salt and has been reinforced with external cables. The three axes can be considered the perspectives of response.
The vertical axis shows the height perspective, which can be referred to as the hawk's eye and the ant's eye mentioned above. The analysis ranges from macroscopic analysis, such as the location of the bridge construction and situation of damage, to microscopic analysis, such as salt adhesion to the surface of each bridge member, salt concentration in the cross-section, steel corrosion, and penetration into the interior of the bridge. There are also such perspectives as planning measures that apply commonly across the country and measures that correspond to the specific site.
One of the horizontal axes is the time axis. It might be close to the "fish reading the current" as introduced above. In order to respond to current structures, we need to understand the past history, which includes the use of sea sand as a material, coastal bypass construction as a location of road construction, and the revision of engineering standards. In addition to addressing such existing structures, it is necessary to prevent similar damage from occurring in future construction. Accordingly, we need to set a service period of 100 years as a desirable picture and establish engineering standards for achieving it, desirable bridge types, and methods for using long-durable materials.
On the horizontal axis, "act" and "field" were also set as diverse stakeholders. This includes the "bat's eye seen from upside down" as stated above. The acts include inspecting deformations, conducting soundness diagnosis, and determining and implementing measures such as observation, repair, and reinforcement, and each of these actions is carried out by different entities. As for fields, not only the structural field, but also the coastal field is necessary in this case, and knowledge of the chemical field is also imperative to clarify mechanisms. In addition, some technologies for inspection and diagnosis can be used not only for machinery but also in the science and medical care fields. The latest information from overseas is also useful.
As described, research and development to support national policies requires diverse perspectives and practice from various approaches, but it is obviously impossible for a single researcher or laboratory with a limited number of researchers to conduct all of these actions. At NILIM, as a general research institute, researchers in each field engage in research activities by sharing information as appropriate, and work in cooperation with various research institutes, government agencies, and private companies by sharing roles according to the stage of technological development.

3. Learn from experience and history

Researchers at NILIM, which is responsible for the aforementioned activities, are required to have the knowledge and experience of high-level experts in their fields, as well as the ability to propose and implement realistic solutions by understanding the positions and intentions of the persons concerned.
There is a saying, "Fools learn from experience, wise men learn from history." This is known as a saying of Bismarck, the first Chancellor of the German Empire, and means that a fool learns only from his own experience, but a wise man learns from the history experienced by others. Based on this train of thought, I think that a man is no longer a fool if he can learn from his own experiences and accumulate his own experiences as knowledge. In addition, a wise man will learn many things, including history, as the accumulated experiences of others, which is academic knowledge. In the civil engineering field, existing structures and past technical standards represent history, and research papers can also be considered history.
The Kumamoto Earthquake Recovery Division, mentioned above, not only provides technical advice on the restoration of damaged structures, but also actively compiles and generalizes technical findings as research papers. In this way, NILIM also has the mission of recording history for the benefit of other engineers. The message of Director-General Amano in this NILIM Report is that the "proper research attitude is to thoroughly pursue the essence in order to systematize the chaotic reality of this world and manage that reality more appropriately." Through research activities, NILIM will contribute to the realization of a safe, secure, active, and attractive homeland and society.

What is Happening in Small-City Sewerage Systems?

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Director Water Quality Control Department

key words: public sewerage, depopulation, small-scale sewerage system, facility management, Research and Development Committee on Sewerage (RDCS)

1. Introduction

In Japan, sewerage is a type of infrastructure that is managed by local public bodies, and no projects are implemented directly under the jurisdiction of the national government. In public sewerage systems managed by municipalities, the scale of the city which is the responsible organization varies widely, from major "ordinance-designated" cities with populations exceeding 1 million to small cities, towns and villages with populations from several 10,000 to several 1,000 persons. Among these, a total of 1,201 responsible organizations manage sewerage systems in cities with populations of less than 50,000, towns and villages (colored areas in **Table-1**; hereinafter called "small cities"), accounting for 70 % of all responsible organizations nationwide. At present, however, little information is available on the types of problems confronting sewerage systems in these small cities, and those issues seldom become a topic.

Table-1 Number of responsible organizations of public sewerage systems

Population class, etc.		Number of responsible organizations
Ordinance-designated cities		21
Cities	500,000 or more	7
	300,000 or more to less than 500,000	45
	100,000 or more to less than 300,000	192
	50,000 or more to less than 100,000	253
	Less than 50,000	274
Towns and villages	Towns	744
	Villages	183
Total		1,719

Source: Prepared based on p. 20 of "Sewerage of Japan (FY 2019), Materials."

2. Large problems of small cities

Until now, large cities were the driving force for sewerage system construction and were in the forefront in carrying out projects in all parts of the world. In Japan as well, technical guidelines, etc. were arranged based on the actual results of large cities, and were then applied in smaller cities with revisions suitable for small-scale systems. The Japan Sewage Works Agency (JSWA), which is a group of technical experts in the sewerage field, provided powerful support for the construction and improvement of small-scale sewerage systems by dispatching many engineers from large cities.

However, sewerage systems are now confronted with various changes in social conditions, such as population decline. These changes will directly affect small cities first, making common use of the "urban-driven model" difficult. The trend of low birthrates and aging of the population in Japan is the most serious in the world, and depopulation of local areas is progressing rapidly. Under these conditions, planning and design methodologies for sewerage systems are extremely difficult, and it is also difficult to see how operation and management of small-scale sewerage systems can be maintained in the future.

As an additional problem, facility management inherently tends to be inefficient in small cites. In addition to the small scale of the facilities, mergers of cities, towns and villages increase the number of facilities that must be managed, but the number of staff in charge of that work decreases. Moreover, in many cases, drainage and other facilities for agricultural communities are managed centrally by the section in charge of sewerage in the town office, but this tends to result in a business structure in which facilities are scattered over mountainous areas, making it difficult to avoid inefficient management.

In spite of these obvious problems, we found that it was unexpectedly difficult to identify the concrete issues confronting small cities, and to find hints of their solution, even when looking at the large tendencies of these problems.

3. Listening earnestly to problems and needs

The essential purpose of the Research and Development Committee on Sewerage (RDCS), which is hosted by the Water Quality Control Department of NILIM, is to follow up on Japan's Technical Vision on Sewerage in order to ensure its achievement. On the other hand, however, identifying the technical problems and needs of sewerage of local public bodies is also one of the

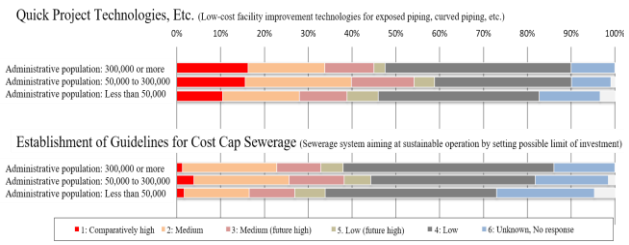

Fig.-1 Partial results of questionnaire on technical needs by city size
(Excerpted from the results of a survey of technical needs by the RDCS in FY 2017. Participants responded by indicating the necessity of development and application of the technical items shown above by selecting the options shown in the legend.)

roles of the RDCS.

One relatively easy technique for identifying these problems and needs is analysis of the technical issues proposed and discussed at meetings sponsored by cities. However, almost none of those meetings targeted small cities, or it was difficult for the persons in charge of sewerage systems to participate in meetings and training due to the small size of the local staff. As a result, the difficulty of creating cross-connections and building networks with more advanced cities and related organizations by this approach became clear.

Although the RDCS has also conducted nationwide questionnaire surveys on technical needs, the results were somewhat difficult to understand (**Fig. 1**), for example, because the reported necessity of technologies intended for small cities was lower in small cities than in cities with larger populations. Thus, it was extremely difficult to understand the actual situation. Ultimately, ongoing interviews since the RDCS was launched in 2016, although conducted at only a limited number of locations, have been effective in grasping the actual conditions, and clarified some of the problems of small cities. (For example, the aforementioned problem of management inefficiency of scattered facilities was raised at an interview.) The following are some examples of technical problems.

(1) Feeling that there are no technologies applicable to small cities

B-DASH and other new technologies are perceived as not being applicable to small cities (opinion at interview).

(2) Difficulty of obtaining information on new technologies

Manufacturers rarely make sales calls, and even when they do, it is difficult to assess the suitability of the information received. There is also nobody available for technical consultations (same as in (1)).

(3) Lack of time even for technical studies

Due to the pressures of general desk work, staff cannot visit the actual site. There is a tendency to choose simply not thinking about introduction of new technologies as the best option (opinion expressed by member of the RDCS, estimated to be one reason for the results of the questionnaire in Fig.-1).

Although these comments involve various factors other than technical problems, it became clear that there is no single quick remedy that can solve these problems. Hence, a variety of steady efforts will be needed.

4. Toward problem-solving for small cities

For example, in response to issue (1), in the B-DASH Project, we made a rather bold shift toward technological development for medium- and small-sized cities in recent years in order to solve this problem (**Fig.-2**). However, this alone is not sufficient to solve the problem because issues (2) and (3) are also obstacles to those efforts. Of course, measures such as wide area and joint projects are also effective, but early realization on a nationwide basis is considered difficult.

As one way to break this impasse, steady trial efforts are underway in the Energy Subcommittee of the RDCS. For example, based on the results of a study by the Subcommittee, it was considered possible to reduce electric power rates by a maximum of about 40 % in small-scale sewerage systems by innovations in the general wastewater treatment method (OD method). However, those in charge in the town office were not interested in the actual site, and there is no merit for the contractor entrusted with management of the treatment plant if the contractor made efforts to improve operation, even if an energy saving was achieved. As a result, no progress was made implementing this carefully-developed economy plan. However, various efforts were made to overcome this problem, including information sharing among the persons in charge at NILIM, the town office and the plant management contractor, popularization and educational activities with the cooperation of related organizations, and recommendation of incentives for the contractor through a full-scale consignment of plant operation to the private sector. This trial in sharing information and networking in the model district lowered the barriers to problem-solving at the site, and activities aimed at horizontal development of these efforts to other regions have begun.

Although this kind of effort to approach small cities probably cannot be considered an efficient research activity, I feel that it is an effort that somebody must make to solve this kind of problem. In addition to the example introduced here, the RDCS is also developing other efforts for small cities. Those initiatives have only begun, and

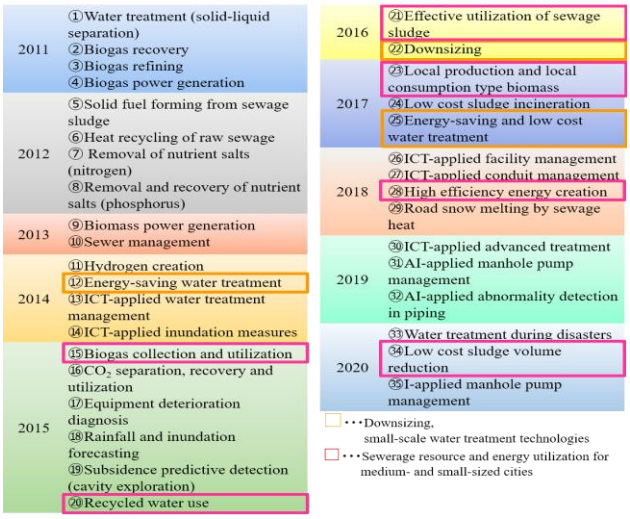

Fig.-2 Transition of publicly-offered themes of B-DASH Project
(Areas enclosed in the yellow and red boxes are technologies mainly for small-scale sewerage systems. In labor-saving technologies utilizing ICT and AI, there are also some suitable small-scale systems.)

slow-but-steady efforts will also be needed in the future

☞ **See the following for details:**

Website of the Research and Development Committee on

Sewerage (Energy Subcommittee)
http://www.nilim.go.jp/lab/eag/gesuidougijyutsukaihatsukaigi.html
http://www.nilim.go.jp/lab/eag/pdf/7_r2-1_enerugibunkakainotorikumi.pdf

Research and Activities of the River Department Contributing to Basin-Wide Flood Management

SASAKI Takashi (Ph.D. in Engineering) Director, River Department

key words: climate change, river basin management, disaster prevention and mitigation, information provision, facility response

1. Introduction

The extensive flooding in Kyushu, the Chubu District and other parts of Japan caused by torrential rains in July of 2020 is still fresh in memory, and heavy rains also triggered severe flooding in western Japan in July 2018. The East Japan Typhoon (Typhoon Hagibis) in 2019 caused damage in various parts of the country, and the cost of flood damage for the year was the largest since record-keeping began. According to an analysis by the Japan Meteorological Agency and the Meteorological Research Institute, the effects of climate change affected the torrential rains that actually occurred in the heavy rains of July 2018 and in the East Japan Typhoon of 2019.

In July 2020, the Council for Infrastructure Development of Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT) issued a report entitled "Basic Strategy for Climate Change Adaptation Measures against Water-Related Disasters," which recommended i) Change of the basis of flood control planning from the actual results of past rainfall and storm surge events to the future precipitation predicted from climate change and ii) Change to sustainable flood control measures called "Basin-wide Comprehensive Flood Management," which are conducted with the cooperation of all stakeholders in the entire river basin. "Basin-wide Comprehensive Flood Management" has been positioned as a key measure in MLIT's "Meeting the Challenge of Disaster Prevention and Mitigation in an All-Out Struggle – Disaster Prevention and Mitigation to Protect Human Life and Livelihood."

2. Basin-wide comprehensive flood management

Basin-wide comprehensive flood management is a concept that includes further acceleration of basic flood control countermeasures such as construction and improvement of levees and construction and renovation of dams, together with countermeasures for water-related disasters (disaster prevention and disaster mitigation) with the cooperation of all concerned parties related to the river basin. It is a strategy for promoting i) Countermeasures for preventing and reducing floods as far as possible, ii) Countermeasures for reducing objects of damage and iii) Countermeasures for damage mitigation and early recovery and reconstruction by integrated hard and soft countermeasures corresponding to the special features of the region, in which the entire river basin, including not only the catchment area and river area, but also the flood plain is treated as a single basin. **Fig.-1** shows examples of countermeasures i) to iii).

3. Research and activities of River Department contributing to basin-wide flood management

(1) Outline of activities

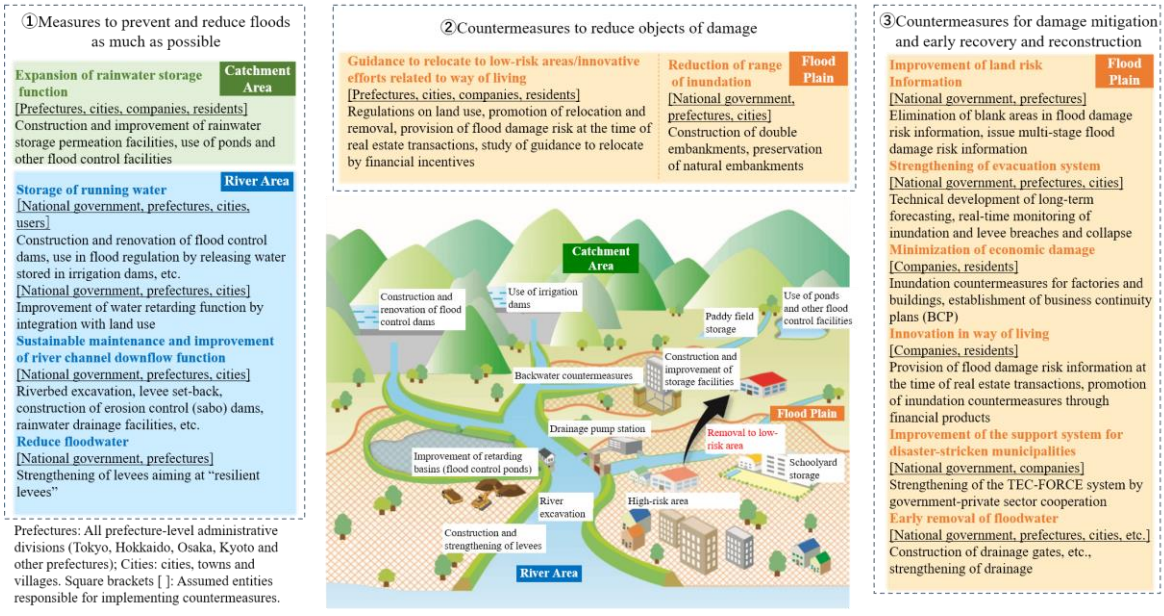

Fig.-1 Outline of "Basin-wide Comprehensive Flood Management" (https://www.mlit.go.jp/river/kasen/suisin/pdf/01_kangaekata.pdf)

The River Department has conducted research on climate change adaptation measures from an early date through NILIM activities such as the "Climate Change Adaptation Group." The research and activities carried out by the River Department, either in the past and presently in progress, are also useful in the basin-wide comprehensive flood management described above. **Fig.-2** lists the research and activities of the River Department classified according to the 3 types of countermeasures for basin-wide flood management. Together with "Research on facilities" contributing to ⅰ) in Fig.-1, it is also necessary to consider future efforts to evolve "Research on information provision" that will contribute to ⅱ) and ⅲ). The following introduces examples of research related to these efforts.

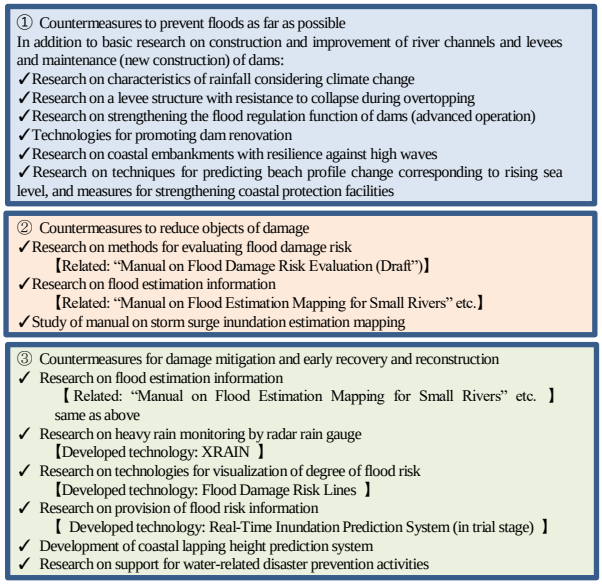

Fig.-2 Research and activities of River Department contributing to basin-wide flood management

(2) Research on information provision

Research on flood estimation information is related to the development of technologies for advance provision of information on inundation danger, such as maps of assumed inundation areas (flood hazard maps), etc. This type of information is useful for advance disaster prevention, for example, in improving evacuation plans, guiding residents to move to low-risk areas, etc. Although flood inundation estimation maps are provided for large rivers, the River Department is conducting research aimed at providing information quickly and efficiently by using airborne laser survey (LP: Laser profiler) data, targeting medium and small rivers for which hazard information is not available in many cases. The department also issued the "Manual on Flood Estimation Mapping for Small Rivers" in 2020, reflecting the results of research so far, and is now working to further upgrade its content.

In research on flood risk information provision to support countermeasures for damage prevention and mitigation when inundation occurs, we are developing a real-time inundation prediction system that distributes inundation prediction information to those concerned, covering the time period from the present to 1 hour in the future, within 10 minutes after receiving rainfall and river water level data, etc. This technology will support timely and appropriate evacuation, etc. by providing information immediately before inundation occurs. Although this system was developed from the viewpoint of countermeasures for prevention and mitigation of inundation damage in large cities, the River Department is now studying expansion of the system to assumed flood inundation areas, including rural and agricultural areas, because disasters frequently occur in areas outside large cities when residents are caught in flooding while moving by automobile. We are also developing a method for effectively utilizing the information from this system in water-related disaster prevention.

(3) Research on facilities

Research on a levee structure with resistance to collapse during overtopping is linked to levee strengthening measures as a response to crisis management, and contributes to minimizing the damage caused by inundation even in case overtopping occurs. Although several construction methods can be considered as strengthening measures, at present, there is some latitude (uncertainty) in their effects. Therefore, NILIM is conducting large-scale levee experiments and studying levee design and management. It may be noted that this research is not limited simply to overtopping resistance performance for crisis management, but is also considered to be linked to study of the basic performance design of levees.

In research on strengthening of the flood regulation function of dams, the aim is to support dam operation management in order to increase their flood control effect, while considering the latitude (uncertainty) of predictions, by utilizing "ensemble forecast precipitation" information. At present, all dams in Japan, including irrigation dams, practice preliminary release of water to secure a larger empty capacity for floodwater storage in advance, when judged necessary for flood control. However, we would like to link this research to a study of preliminary release to enhance the flood management effect in the total river system.

4. Conclusion

The River Department is conducting research on river improvement and management as such, as introduced in part here, and is also studying provision of information related to the risk of flood damage in river basins. While research on river improvement will continue to be our main focus in the future, we also hope to support the development of the new technology of long-term flood forecasting utilizing the "Flood Damage Risk Lines" technology developed by the laboratory.

Research on Increasingly Severe and Frequent Sediment Disasters and Their Countermeasures

NAGAI Takayuki, Director, Sabo Department

key words: *climate change, sediment and flood inundation, sediment disaster warning information, deep-seated catastrophic (rapid) landslide*

1. Condition and challenges of sediment damage in recent years

In Japan, the number of sediment disasters has increased in recent years. During the 10-year period from 2010 to 2019, the number of sediment disasters (annual average) increased by approximately 1.5 times in comparison with the earlier annual average (average for 1982-2018: 1 081 cases). In particular, a historical high of 3 459 sediment disasters occurred in 2018, and the numbers for 2019 (1 996 cases) and 2020 (1 316 cases) also greatly exceeded the average. Moreover, extremely heavy rain (50 to 80 mm/h) has also increased in numbers due to the effects of climate change. Accompanying this, sediment disasters have shown an increasingly severe tendency, and serious sediment disasters occurred in various parts of Japan in 2020, beginning with the western island of Kyushu. New modes of sediment disasters different from those in the past have also become apparent, and the phenomenon called "sediment and flood inundation" has caused heavy damage in various areas (**Photo-1**). This type of sediment disaster has shown a tendency to become more severe, to extend over wide areas and to occur simultaneously in many locations. Thus, elucidation of its mechanism, appropriate risk assessment and study of effective countermeasures are demanded.

Photo-1 Scene of sediment and flood inundation at Sendai River, Kuma Village, Kumamoto Prefecture (photographed in August 2020)

With local disaster preparedness continuing to decline to depopulation, the advancing age of the Japanese population, the vulnerability of communities in urban areas, etc., effective evaluation of information that leads to evacuation action is required. This includes improved accuracy of sediment disaster warning information.

On the other hand, the occurrence of deep-seated catastrophic (rapid) landslides and emergence of natural dams caused by large-scale earthquakes is also a concern, and with a gigantic Nankai Trough earthquake and a major earthquake directly under Tokyo now considered imminent, evaluation of the risk of sediment disasters triggered by earthquakes and study of countermeasures are required (**Photo-2**).

Photo-2 Condition of slope collapse caused by 2018 Hokkaido Eastern Iburi Earthquake

2. Priority research subjects

Based on these circumstances, the Sabo Department is currently grappling with the following research as high priority subjects.

Sediment and flood inundation is a phenomenon that occurs when large amounts of sediments are washed out by heavy rains in an upper river basin and accumulate in the river channel downstream from the mouth of the valley. This causes river bed aggradation (river bed rise) and channel blockage, and results in inundation by sediments and muddy water. In some cases, inundation includes driftwood in addition to sediments. This phenomenon had always occurred in varying degrees, but has emerged as a critical issue in recent years due to the increased amount and intensity of rainfall when a disaster strikes. Because large amounts of sediments accumulate together with the flood waters in valley plains and downstream areas, the countermeasures for such areas are partially different from those for the mud flows and landslides that occur in mountainous upstream areas. Elucidation of the phenomena as such, and study of effective countermeasures for these areas are also necessary. To

address this problem, the Sabo Department is conducting research including studies of a high accuracy predictive model of sediment production and downflow related to sediment and flood inundation countermeasures, evaluation techniques and planning and design techniques for countermeasures facilities.

(2) Development of sediment disaster risk evaluation system supporting warning and evacuation, and research on improvement of its accuracy

Linear rainbands have caused severe damage in recent years. To improve the accuracy of the sediment disaster warning information currently in use, the Sabo Department is developing a function that enables quick automatic identification of the occurrence of these rainbands, and is studying techniques which will make it possible to evaluate the risk of sediment disasters with higher accuracy by using this function in combination with primary factor data based on topographical and geological conditions (**Fig.-1**). In joint research with Kyoto University, we are also studying improvement of the accuracy of judgments of the degree of sediment disaster risk by combining various rainfall indexes, with the largest value of past rainfall in which a disaster did not occur as a standard.

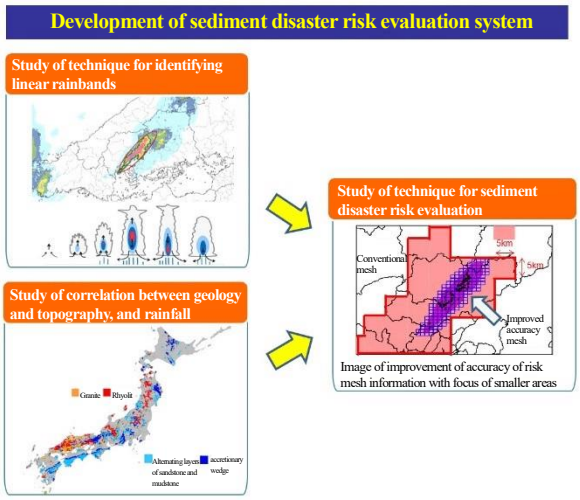

Fig.-1 Image of sediment disaster risk evaluation system

(3) Processing and use of sediment disaster information by applying digital technology

The Sabo Department has applied digital technology to sediment disaster analysis and information collection, and is working to employ these technologies more efficiently in disaster countermeasures by further utilization. For example, investigations to determine whether new slope collapse has occurred after heavy rain are currently carried out by visually interpreting satellite SAR (synthetic aperture radar) images, but we are now studying the possibility of automatic extraction of slope collapse information, and are constructing various types of databases of information related to sediment disasters.

3. Large-Scale Sediment Disaster Countermeasures Research Center

In 2011, Typhoon No. 12 (Typhoon Talas) caused record-breaking heavy rains in Japan's Kii Peninsula, resulting in massive damage that included many deep-seated catastrophic (rapid) landslides. Since 2017, NILIM has dispatched a senior researcher to the Large-Scale Sediment Disaster Countermeasures Research Center (located in Nachikatsuuracho Town) of the Kinki Regional Development Bureau. The Center was established in 2014 following the above-mentioned disaster, and conducts research necessary to establish countermeasures for deep-seated landslides and other large-scale sediment disaster with the cooperation of the NILIM Sabo Department, the Center itself and Wakayama Prefecture. Up to the present, the Center has achieved a large number of research results, including elucidation of the mechanical of deep-seated landslides. The results of research to date are scheduled to be compiled on the 10-year anniversary of the disaster in fiscal year 2021.

4. Conclusion

This report has described the condition and challenges of sediment disasters and the efforts of the NILIM Sabo Department to solve those problems. Nature is inherently diverse, and no lands are the same in their richly varied topographies, geologies, etc. The weather phenomena that cause these natural features are also diverse, and the sediment disasters that occur as a result are extremely varied. Amid the constant change in social structures and the environment surrounding people's lives, research on sediment disasters was realized through the challenging efforts of our many predecessors, and is continuing to progress through a process of trial and error even today. Precisely because the related phenomena are so diverse, in our research efforts, it is necessary to firmly face the actual site, look at the events in the field with both a "bird's eye" and an "insect's eye" while grasping the total image, and slowly-but-surely accumulate a strong basis of facts and verification. This will enrich our thinking, and will make it possible to implement the results of our research in society in a way suited to the site. In the future, our aim is prevention and mitigation sediment disasters in collaboration with MLIT proper.

☞**See the following for details:**

1) Development of Sediment Disaster Occurrence Probability Frequency Maps Using Topographical and Geological Thematic Maps, p. 59

2) Elucidation of Mechanism of Deep-Seat Catastrophic (Rapid) Landslides Utilizing Drone Airborne Electromagnetic Survey Technology, p. 56

For the Realization of the Roles That Roads Should Play

TAKAMIYA Susumu, (Ph.D.), Director, Road Traffic Department

key words: road traffic management, traffic safety, road space reconstruction, automated driving

1. Introduction

Roads constructed across the land of Japan have greatly contributed to the improvement in affluence and quality of life as important infrastructure that connects the nation. Roads need to continue to fulfill this role while accurately incorporating factors such as technological innovation even in the recent social environment that has been characterized by a decline in population, the arrival of a super-aged society, and the need to revitalize regional economies. On the other hand, from the perspective of the direction of medium- to long-term road policy, the roles that roads should play have been reconsidered, e.g., roads should not only be spaces for the movement of people and goods, but roads themselves should become places where people stay. In this regard, points are summarized in the suggestion of the Road Subcommittee of the Panel on Infrastructure Development [1)] and the proposal of the Basic Policy Group of the same Subcommittee [2).] This paper, focused on the field of road traffic in particular, introduces some typical approaches made by the Road Traffic Department in relation to the roles that roads should play.

2. Effective use of road networks

In addition to the existing approaches to developing road networks, we should also focus on the stable use of road networks and maximizing the demonstration of road functions. From this perspective, it is necessary to realize "road traffic management" that maximizes the functions of roads and uses roads wisely through a proper understanding of road traffic conditions and guiding effective improvement measures by fully utilizing ICT (big data, AI, etc.), which is rapidly advancing in technological innovation.

The Road Traffic Department conducts research to grasp road traffic conditions in real-time by mainly obtaining traffic volume data from traffic counters, as well as from the images of road management cameras using AI technology, and obtaining travel speeds, distribution of generated / congested traffic, information on vehicle routes, etc. from ETC2.0 probe information and analysis using the same information, etc. We also continue research into road traffic management by predicting the road traffic situations in the near future based on the information above and studying how to actively control the road traffic situations.

3. Realization of traffic safety

It is desirable to create a road space where everyone can move around safely and comfortably by further promoting traffic safety measures on arterial roads, community roads, school routes, etc. From this perspective, it is necessary to effectively identify accident risk points and to accurately plan and implement traffic safety measures by using big data in addition to traffic accident data. In addition, for community roads used as a part of daily life, it is desired to spread the awareness that "people have priority on roads for daily life" deeply into the public and to create a traffic environment where cars naturally show consideration for pedestrians and other traffic.

The Road Traffic Department, using big data including traffic accident data and ETC2.0 probe information, has been working to effectively identify risk areas where accidents or sudden deceleration occurs and, particularly for community roads, accurately identify the routes where traffic travels through the community. Furthermore, regarding community roads, the Department has been studying effective measures to control vehicle travel speeds and through-traffic in communities.

4. Road space that meets various needs

It is desired to study the reconstruction of road space in the entire road network and to make previously used roads (existing roads) into a safe, comfortable and lively road space through bypass development and revitalization of existing roads as a human-centered road space, etc. In addition, it is desired to develop "curbside management" for roads located in the center of towns, where space can be used in various ways, according to the day of the week and time of the day, such as a space for getting in and out of cars or an open cafe, in addition to the integrated use of roads and privately owned land along roads and the easing of roadside use by restaurants, etc. along roads under the social environment affected by the COVID-19 pandemic. With regard to the creation of a lively road space, the Road Act, etc. were revised in May 2020 to establish a "Road system that promotes pedestrian convenience" and allow the development of a space where pedestrians can pass the time in addition to conventional space reserved for sidewalks, etc. (**Fig. 1**).

The Road Traffic Department is compiling useful knowledge through the collection and analysis of examples of reconstruction of existing roads in line with bypass development and the integrated use of roads and privately owned land along roads. We also are studying how to create lively road spaces by collecting examples and knowledge, examining approaches to road space formation, etc.

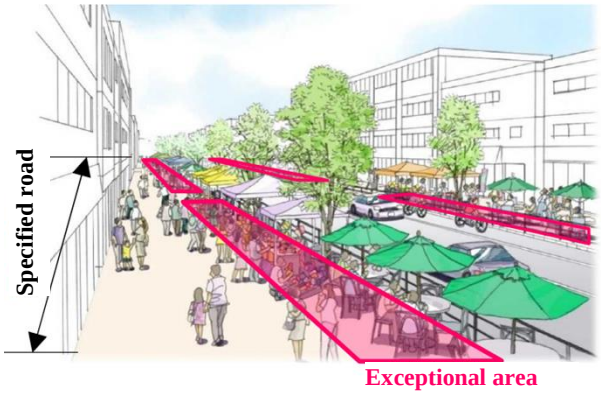

Fig. 1: Image of a road that promotes pedestrian convenience

5. Realization of automated driving

By automating and reducing the labor of moving people and goods through automated driving, it is desired to realize a safe and efficient road service and contribute to the formation of communities where people's lives and livelihoods can be sustained, business productivity can be improved, and thereby realize sustainable economic and social activities. As examples of automated driving applications, in addition to realizing automated driving services on expressways and other roads that connect the nation, it is also desired to realize automated driving services based out of "roadside stations in mountainous regions" where administrative offices and other services necessary for daily life are concentrated.

As for automated driving technologies, autonomous vehicle technologies for safe driving, such as automatic braking based on information detected by onboard sensors, have been developed and are being installed in vehicles. However, in order to achieve more effective automated driving, information that supports precision control of the vehicle in situations where information from only autonomous vehicle technology is insufficient can be provided to vehicles from the road (**Fig. 2** shows an example). In May 2020, as a result of revision to the Road Act, etc., automated driving support facilities such as magnetic markers have been positioned as road accessories in order to assist position correction, etc. from the road side for the safe operation of automated vehicles.

The Road Traffic Department is studying the technical specifications, etc. for "merging traffic support information services", etc. to be realized on expressways, using a framework of public-private joint research. In order to realize automated driving services around roadside stations, etc. in mountainous areas, we are studying how to set up automated driving support facilities, etc.

- A service for supporting smooth merging by using sensors to monitor traffic conditions on the main line at expressway junctions and providing information to automated driving vehicles that are about to merge.

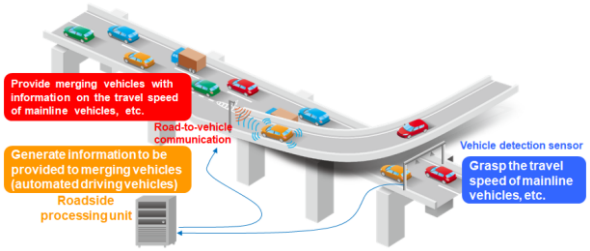

Fig. 2 Merging traffic support information system

6. Conclusion

This paper has introduced some of the efforts of the Road Traffic Department to realize the roles that roads should play. The Road Traffic Department will continue to conduct research that is needed, as well as to accurately recognize the roles that roads should play.

[References]

1) Suggestion of the Road Subcommittee of the Panel on Infrastructure Development: "Road and Traffic Innovation: --- Toward the Realization of Affluent Lifestyles through the Pursuit of Functional Improvement and Utilization of Roads---", 2017.8 https://www.mlit.go.jp/common/001201778.pdf
2) Proposal of the Basic Policy Group, the Road Subcommittee of the Panel on Infrastructure Development: "How Road Scenery Will Change in 2040 --- Roads Designed to Make People Happy ---", 2020.6 https://www.mlit.go.jp/road/vision/pdf/01.pdf

Approaches of the Road Structures Department for National Land Resilience

FUKUDA Keidai, Director, Road Structures Department

key words: road structures, maintenance, aging, disaster prevention/mitigation, national land resilience

1. Introduction

Road structures, such as bridges, tunnels, earthworks, and pavements, contribute to safe, secure, and smooth road traffic, and support local life and socioeconomic activity. In order to support the efficient maintenance and proper management of these structures, the Road Structures Department drafts technical standards, conducts surveys and research necessary for them, and provides technical consultation on the problems that arise at the site of damaged structures, etc.
This paper introduces the efforts of the Road Structures Department for the maintenance of structures and national land resilience.

2. Issues in the second stage of maintenance

The statutory inspection of road structures that started in 2014 finished its first round in FY2018, and the second round of inspection started in FY2019. In September 2020, the annual report on road maintenance (data for FY2019 / First year of the second round) was released, clarifying the issues in the second stage of maintenance, increased deterioration from the first round of inspection, and progress with countermeasure implementation. For example, of the bridges that were diagnosed as Judgment Category I or II (sound / preventive maintenance stage) in the first round of inspection, 5% shifted to Category III or IV (stage requiring action) in the second round of inspection. In addition, the percentage of bridges for which repair work was started on the bridges diagnosed as Judgment Category III or IV in the first round of inspection was 69% for those under management by the national government and 34% for those managed by local governments. This suggests that local governments have made progress in inspections, but repairs have not kept pace with the inspection. In order to provide systematic and intensive support for repair, renovation, and removal, a road maintenance project subsidy system was established in FY2020, but there are still issues to be solved not only with budgeting but also with human resources and technology.

3. Five-year accelerated measures for national land resilience

In FY2020, the heavy rain event of July 2020 caused severe damage throughout the country. Particularly, many bridges over the Kuma River and its tributaries in Kumamoto Prefecture were washed away, and there was also damage to road earthwork structures and natural slopes along roads in Nagano, Gifu, Miyazaki, and Nagasaki Prefectures.
In order to deal with the increasing frequency and severity of natural disasters, in December 2020, the government approved by Cabinet Decision "Five-Year Accelerated Measures for Disaster Prevention, Disaster Mitigation, and National Land Resilience," and decided to promote additional projects worth about 15 trillion yen over the next five years. Previously, "Three-Year Emergency Measures for Disaster Prevention, Disaster Mitigation, and National Land Resilience" had been implemented from FY2018 to 2020. In the latest "Five-Year Accelerated Measures," it is very significant that not only measures against windstorms, floods, earthquakes, etc., but also "measures against aging as part of a shift to preventive infrastructure maintenance" was positioned as one of the pillars to be focused on.
As measures to address the aging of road facilities, the "Five-Year Accelerated Measures" suggests focusing the implementation of measures on bridges, tunnels, road accessories, and pavements in need of repair as identified in periodic inspections. One of the specific numerical targets stated in the Measures is to increase the repair rate of bridges on roads managed by local governments that require urgent or early action (Category III / IV) from the current 34% to 73% in five years. Since it is estimated that about 6,000 bridges managed by local governments are recategorized from Category I/II to Category III/IV every year, the "Five-Year Accelerated Measures" aim to shift from after-the-fact maintenance to preventive maintenance by taking focusing measures where best served during the period. In the future, the efforts of local governments will become increasingly important.

4. Measures and field support

In order to respond to the aforementioned needs, the Road Structures Department continues to provide measures and field support through the following activities.

(1) Survey research for repair and reinforcement of existing structures

For the repair and reinforcement of existing structures that differ according to traffic conditions, environmental conditions, and aging conditions, it is necessary to systematize standards that take into account the unique issues of each structure, so we are continuing to research these issues. Parallel to that, in order to facilitate work execution, we have been collecting information on the application of typical materials and construction methods, and in July 2020, published the "Collection of Details for Consideration in Improving the Reliability of Road Bridge Durability, "[1)] as a collection of devices and simple techniques used in the field.

(2) Survey research for the third stage of maintenance (third round of statutory inspection starting in FY2024)

In periodic inspections, it is necessary to achieve two objectives at the same time, i.e. better quality and greater labor-savings in field work. Accordingly, we are considering establishing rules on how periodic inspections should be planned so that the items, methods, and accuracy of grasping the condition can be planned in consideration of the characteristics of each structure. We also support on-site monitoring and use of non-destructive testing techniques.

(3) Survey research for performance evaluation of roads

To enable emergency transportation in the event of a disaster, it is necessary to ensure the disaster-resistant performance of all road structures such as bridges, tunnels, and earthworks so that they can function as a road network when the need arises. Based on the results of recent disaster site surveys, such as the heavy rain event of July 2020, we are developing methods to assess the risk of damage to individual structures and the performance of roads in the event of disaster. (See Closeup of the Road Structures Department at the beginning of the book).

(4) Survey research on grasping road conditions in disasters and predicting road surface conditions when snowfall is expected

As seen in the earthquake off the coast of Fukushima in February and a series of heavy snowfalls, a quick grasp of road conditions and reliable forecast information are essential for accurate disaster response. Accordingly, we are conducting survey research to establish and implement automatic UAV navigation technology for disasters and road condition prediction technology for snowfalls.

In addition, we directly visit the sites to provide technical consultation and advice on individual issues raised by the sites. The following is an example of technical consultation about the restoration method for Route 41 in Gero City, Gifu Prefecture, which was damaged by the heavy rain event of July 2020.

Fig. Photographs of damage to National Route 41 and the state of restoration

On July 8, in the Kadosaka district of Osaka-cho, Gero City, a long stretch of road was washed away by rising water in the adjacent Hida River. The section of damage is adjacent to the JR Takayama Line, and restoration work was carried out in cooperation with the road, railroad, and river sectors. Consequently, the JR Takayama Line was restored on July 23 and National Route 41 was temporarily restored on August 17.

On the other hand, since priority was given to the restoration of the adjacent JR Takayama Line, work to remove the collapsed retaining walls was kept to a minimum, which became an issue in proceeding with the permanent restoration. NILIM provided technical advice on the restoration method including the handling of earth pressure of the remaining retaining walls, and construction work is progressing steadily at the site (See **Fig.**).

We will continue to promote the above-mentioned survey research and provide support for measures and fieldwork, with the aim to achieve national land resilience.

☞See the following for details.

1) Technical Note of NILIM No.1121 Reference 1
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1121.htm

Respond to social demands by mobilizing knowledge, experience, and wisdom

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Keywords: Collaboration, wood-mixed structure, pile foundation, retaining wall on residential lot, housing complex regeneration, wind management measure

1. Introduction

The world is constantly progressing and changing, and the social needs for buildings are changing along with it. With this in mind, the Building Department is working to realize a safer, more secure, more comfortable, and more attractive building environment. Examples of specific activities include preparing drafts for the establishment and revision of technical standards, including the Building Standards Act, based on scientific and technical knowledge. Other activities are to apply and disseminate investigation and research outcomes to society, such as by conducting field investigations in disaster-hit areas, the study of future countermeasures, and the preparation of technical manuals for practical use and to provide technical support to organizations inside and outside of Japan.

In these activities, efforts are being made to collaborate with as many people as possible and gather their knowledge, experience, and wisdom in order to reflect the best and greatest results to society. Examinations are also being conducted together on the state of technology, standards, and systems so that Japan's technological capabilities can be further enhanced, they can be applied in society without fail, and Japan can become a more vibrant country. This paper introduces some of these activities using examples of the department's recent activities.

2. General Technological Development Project on Wood-Mixed Structure

In 2015, the Basic Policy on Regional Empowerment for Japan's Growth was approved by the Cabinet of Japan. The basic policy aimed to accelerate regional revitalization, respond to environmental problems, and create spaces in which wood was used. To achieve these objectives, it promoted the development and the use of cross-laminated timber (CLT) to increase the number of wooden buildings, including the construction of wooden public buildings. A General Technology Development Project on the development of technologies to install and construct mixed-structure architectures using new wooden materials (2017-2021) (shortened name: General Technology Development Projects on Wood-Mixed Structures) is now underway to effectively use wooden materials that fix carbon dioxide, provide versatility in architecture, shorten construction periods, and respond to the need to utilize the designability of wooden materials, and to utilize them to satisfy various demands such as regional revitalization.

Here, a new architectural space is being created with CLT, a large wooden panel, and other wooden materials as structural members and combining them with RC structures and steel structures. In particular, creating a space where wooden structural members are visible on the surface of the interior used to be difficult in mid-to-high-rise buildings. Yet, the project will conduct examinations based on various experiments and then present multipurpose design methods and bonding methods that can achieve the necessary structural performance, durability, and sound insulation performance by actively using the fire safety and evacuation regulations revised in 2018. The results of the study are compiled as design examples of several prototype buildings and are now being studied for dissemination as a general technology (Figure).

The purpose of this project is to present a general-purpose technology that can be used by many private companies and to establish it as a new general technology in the world so that it can respond quickly to social needs. Future expectations are that companies and universities with technological capabilities will use the technology as a basis for developing and implementing more advanced technologies, thereby increasing the technological capabilities of the entire Japan and meeting

the diverse needs of society.

A government building with a wooden structure installed within a large frame double-layer RC structure.

Figure: Design example of a building of wood mixed-structure

3. General Technological Development Project on Foundation and Ground

As a part of regional development, there is a need to redevelop cities into compact and strong cities, and basic technologies that can smoothly realize these goals are essential. The following two topics are covered in the General Technology Development Project that started in FY 2020 as the development of technologies to contribute to the redevelopment and robustness improvement of cities through the rationalization of structural regulations related to architecture and the ground (May 2020) (shortened title: General Technological Development Project on Foundations and the Ground): what to do with already installed piles which pose challenges in renewing and redeveloping architectures in cities; and robustness improvement of deteriorating residential lands and retaining walls in hilly areas.

In the first topic, as a way to reuse piles from previous buildings, which is an obstacle when renewing buildings, a method is developed to verify the structural safety of the piles themselves and the ground reinforcement, as well as a method to use them together with newly installed piles (different types of piles) and put them into wide use. The project also covers the development of performance evaluation methods that take into account the ground properties that tend to become soft and loose when ground soil is refilled after removing piles in cases where they are removed. In the second topic, technologies are developed to diagnose and reinforce existing housing sites and retaining walls so that deteriorated or damaged retaining walls and housing sites will not be deformed or collapsed by earthquakes, interfering with traffic in the area and the safety and usability of the houses. In the end, by presenting and applying them to society, these developments will contribute to the redevelopment and robust improvement of cities.

This project is now in the process of establishing an all-Japan system in this field and exploring appropriate social applications of technologies that contribute to urban regeneration, such as the implementation of full-scale horizontal loading tests of piles reconstructed on the ground where piles were once removed, and large-scale horizontal loading tests of actual retaining walls as shown in Photo-1, conducted through the cooperation of the industry, academia, and the government.

Photo 1: Removal of existing piles in the experiment

4. General Technological Development Project on Suburban Housing

With regard to the revitalization of suburban cities, there is a need to revitalize suburban residential complexes to meet the needs of the future society. Thus, in the General Technological Development Project supervised by the Housing Department, which is titled, Development of Technology for Regeneration of Suburban Residential Areas for a Mature Society (2018 to 2022) (shortened title: General Technological Development Project on Suburban Housing), the department is currently developing technologies to sophisticate the durability evaluation technology needed to ensure continued use of buildings for many years and to ensure the necessary seismic performance for space expansion renovations that convert two housing units into one, with the cooperation of construction companies, specialized engineers, and academic experts.

5. Measures against strong winds for tiled roofs, wooden sheds, and front sashes

Typhoon Jebi (typhoon number 21) of 2018 and

Typhoon Faxai (typhoon number 15) 2019 (the typhoon landed on the Boso Peninsula) hit Japan in quick succession, causing extensive damage to the exterior materials of buildings, including tiled roofs, and to wooden structures. Strong winds and rainwater penetrated the interior, causing the loss of functionality of the house, which required a great deal of money and time to restore. Given the recent trend of increasing extreme weather events, improving the wind resistance of buildings is considered an urgent issue.

The NILIM focused on damage to roofing materials, wooden shed frames, and fixtures (front sashes) facing the outdoors of stores and conducted damage surveys together with specialized contractors involved in these works to identify issues. In addition, the NILIM led a working group of industry, academia, and government to study countermeasures to mitigate damage, and has conducted tests as shown in Photo 2. Then the team has proposed detailed countermeasure technologies for new buildings by reflecting the results in existing design and construction guidelines. In FY 2021, the team is also going to start to study the methods of wind resistance diagnosis and repair of existing roofing materials, and the wind resistance performance rank of roofing materials, which will lead to measures to promote more robust roofs.

Photo 2: Tension loading test on the upper part of a tile roof

Housing study to coexist with the coronavirus

HASEGAWA Hiroshi (Ph.D. in Engineering), Director, Housing Department

Keywords: Coronavirus, housing study, safety net, new style of living, vacant house

1. Effects of the COVID-19 pandemic on the housing style

The spread of COVID-19 has had two impacts on housing policies. The first is the expansion of the housing crisis brought about by the loss of income due to employment adjustments and layoffs. The second is the creation of new ways of living brought about by changes in work styles in response to the "new normal."

This paper discusses the future of housing study in the era of coexistence with the coronavirus and the new era that comes after that from the above two perspectives, based on the current activities of the Housing Department.

2. Research in response to the growing housing loss crisis

According to figures released by the Ministry of Health, Labour and Welfare, the number of workers expected to be laid off or otherwise dismissed because of the COVID-19 pandemic was approximately 87,000 as of January 22, 2021. In addition, many workers also experienced a drop in income due to leaves of absence or employment adjustments. From April to October 2020, more than 110,000 cases of housing security benefits were paid to needy people who may lose their homes because of difficulties in paying rent. These numbers could increase further if the state of emergency is extended or repeated. In addition to natural disasters, there are always risks or threats that can lead to the loss of housing, such as the global financial crisis and the current COVID-19 pandemic.

In order to ensure housing stability and security in the face of a housing loss crisis, it is essential to strengthen the housing safety net function in normal times and to ensure institutional continuity to emergency situations, such as disasters. In October 2017, the Act on Promotion of Offering of Rental Housing to Persons Requiring Special Assistance in Securing Housing was revised. With that, a system to register private rental housing (hereinafter referred to as “the accepting housing”) that accepts tenants, such as low-income earners, the elderly, and disaster victims who require special assistance in securing housing, was established. Based on these new systems, the Housing Department has developed a program for estimating the future number of households requiring special attention in securing housing in order to assist in the appropriate calculation of the number of units required for public housing stock and the target number of units to be registered for housing to accommodate people requiring special assistance in securing housing.

In addition to theoretical research like this, practical research that is more in tune with issues in the field will be required in the future. For example, as of January 2021, there were approximately 205,000 registered accepting housing units. Given the demand from people requiring special assistance in securing housing, it is necessary to further increase the number of registered units. In order to do so, it is necessary to consider promotional measures based on the supply mechanism of private rental housing. Private rental housing in Japan is often short-term management properties supplied by small business owners who are not real estate professionals as part of their tax-saving measures. Some landlords think that it is better to leave the houses vacant than to let people requiring special assistance in securing housing, who may have some risks, move in, because even if the houses are vacant, it will not have a big impact on their rental business if the construction costs are repaid in a short period of time. To deal with these disincentives for registration, for example, NPOs and other organizations could lease vacant houses and sublease them to people requiring special assistance in securing housing in combination with the provision of housing support services.

This is only one example of how to deal with disincentives for registration. In the future, it will be necessary to accurately identify the various concerns that landlords have and conduct further research on how to supply accepting housing and provide housing support services that respond to each factor.

Table: Anxieties and countermeasures related to moving in for people requiring special assistance in securing housing (example)

unit

	Anxiety	Housing support service
Upon signing a/while tenants contract are in a rented	- Difficulty in finding a guarantor	- Guarantor agency service
	- Inability to understand contracts, inability to understand the language	- Contract procedure support service (accompanying contracting service, dispatching interpreter, etc.)
	- A risk of failure to pay rent	- Rent debt guarantee service - Rent subsidies, proxy payment of housing assistance fees for welfare recipients
	- A concern about troubles with neighbors	- Daily life support services (watching over people, confirming their safety, providing various types of daily life consultation, etc.) - Arrangement and disposal of household goods and leftover items, funeral service
	- A risk of sudden changes in health condition	
Upon moving	- A risk of lonely death	
	- A concern about troubles surrounding the restoration to the original state	- Restoration rules, witnessing and assessing when moving out by a third party

3. Research to respond to new housing values

The COVID-19 pandemic triggered changes in the way we work, such as the spread of teleworking. These changes enable new lifestyles, such as choosing a place to live that is not tied to one's workplace and living in two regions.

(1) Revaluation of suburbs and revitalization of suburban residential areas

In the suburbs of cities, a large number of housing complexes have been systematically supplied since the period of rapid economic growth. Many of these residential areas are now facing a declining birthrate and an increasing elderly population due to the separation of households as the child generation gradually moved out over time, and their sustainability is often in jeopardy. Under these circumstances, the COVID-19 pandemic has triggered a reevaluation of suburban residential areas where people can enjoy spacious living areas and a good natural environment for raising children.

The Housing Department, together with the Building Department and the Urban Planning Department, is implementing the General Technological Development Project, Development of Technology for the Revitalization of Suburban Residential Areas to Accommodate a Mature Society (FY 2018–20222. In this research, technological developments are underway to realize revitalization through the following: (1) ensuring safety (ensuring the durability of housing), (2) creating mixed communities (promoting the influx of the child-rearing generation), and (3) improving the quality of life of residents (introducing daily life support functions).

In order to accelerate the revitalization of suburban residential areas through the influx of households of child-rearing generation, the housing distribution market needs a system that can objectively evaluate not only the performance of individual houses but also the performance of residential areas. In fact, residents often say, "I didn't think it was such a good residential area until I lived here." It will be necessary to work on developing evaluation criteria for suburban residential areas from the overall perspective including safety, convenience, comfort, and sustainability.

Photo 1-1:
The number of vacant stores in shopping center districts in residential areas has increased, reducing the convenience of living.

Photo 1-2:
On the other hand, there are many spacious parks and rich green environment.

(2) Utilization of vacant houses to support regional development and two-area residence

Changes in the way of working may accelerate the practice of the UIJ-turn to rural areas and two-area residences between rural and urban areas. As this way of living goes into full swing, it is hoped that the effective use of the increasing number of vacant houses will lead to the realization of regional development.

As a countermeasure for the increasing number of vacant houses, a subject-based research, "Research on the Quantification of the Effectiveness of Preventive Measures against the Inadequate Management of Vacant Houses" (FY 2020–2022) is being conducted. The number of vacant houses with no purpose of use, such as renting or selling is on the rise, and there are concerns that they will become unmanageable in the future. Therefore, this research aims to develop a quantitative evaluation method for the effectiveness of measures to prevent the occurrence of unmanaged vacant houses (e.g., minimum management level and systematic removal).

By the way, there is usually a certain time lag between the time a house becomes vacant and the time it becomes available in the market and then reused. The longer the period and the worse the management condition during that period, the more difficult it becomes to be reused. In order to expand the variety of ways to live and the choice of places to live by using vacant houses, it will be

necessary to study the management level and methods with an assumption that the vacant houses will be distributed in the market. Meanwhile, there is no common system for the proper management of houses, unlike condominiums or apartment buildings, which require consensus building among many owners. To create a recycle-oriented market for existing houses, proper management must be practiced in all houses. Also, research is needed to establish mechanisms, such as long-term repair plans and reserve funds, especially for wooden houses. It goes without saying that it is important to take proper care of occupied houses as a matter of course, which will lead to the proper management of vacant houses.

Photo 2-1: A properly managed vacant house

Photo 2-2: A vacant house without proper management

☞For more information:

1) NILIM Project and Research Report No. 62, Edition I
http://www.nilim.go.jp/lab/bcg/siryou/kpr/prn0062.htm

Thinking about the future of public transportation

BASHOUMIYA Soichiro, Director, Urban Planning Department

Keywords: BRT, green slow mobility, the future of public transportation

1. Study of BRT

There are many reasons why people do not take the bus as much as transportation policymakers expect, but the following three are probably the main ones: (1) the hassle of walking to (from) the bus stop, (2) the discomfort of waiting for the bus, and (3) the indefinite departure-to-destination arrival time. A countermeasure for reason (1) is to increase the number of bus stops, but the effect is limited because the number of routes is limited. A countermeasure for (2) is to improve the comfort of bus stops. In addition to a roof, shelter from the wind, and benches, it is nice to have video equipment to pass the time, and heating if the bus stop is in a cold region. Yet, it is difficult to find installation places and to perform continuous maintenance. On the other hand, the countermeasure for (3) is simply to operate buses on time. If the waiting time is minimized, it also serves as the countermeasure for (2), so ensuring punctuality is the key to promoting the use of buses. However, this is easier said than done because the presumption is that buses operate while sharing roads with many other types of vehicles.

For this reason, the Urban Planning Department is studying bus rapid transit (BRT) as the research on city development using advanced bus transportation systems (R1 to R5).

BRT is a system that ensures punctuality and speed by providing dedicated bus lanes and roads and by controlling traffic signals synchronized with bus operations. In addition, taking advantage of the exclusiveness and priority given by the system, articulated buses will be introduced to double or triple the transportation capacity per bus, thereby reducing operating costs and alleviating the labor shortage at the same time. Since the system ensures the exclusiveness and priority for the bus, the convenience for vehicle traffic other than buses will naturally decrease. Yet, this can be expected to have the effect of promoting a shift from the use of private cars to bus use.

In Japan, Niigata City, Gifu City, Fukuoka City, and other cities are operating BRT. In October last year, the Tokyo BRT connecting Tokyo's Toranomon Hills and Harumi began preliminary operations. Outside of Japan, Curitiba in Brazil, and Buenos Aires in Argentina are the areas with advanced use of BRT (Photo 1).

Photo 1: BRT in Curitiba, Brazil

The Urban Planning Department is going to ascertain the actual operating conditions in cities in Japan and abroad that have been using BRT, identify the conditions and factors that enable BRT to achieve its objectives, and prepare a BRT introduction manual for local governments.

2. Study of green slow mobility

Next study to introduce is the study on green slow mobility that provides the so-called last one mile travel, which is being carried out as an elemental subject of the General Technological Development Project, Development of Technology for the Revitalization of Suburban Residential Areas to Accommodate a Mature Society (2018–2022).

Green slow mobility is defined as electric public mobility for four or more passengers on public roads at speeds of 20 km/h or less. While there are no restrictions on the type of vehicle, the most realistic option at this point is to use golf carts. Since it can handle narrow roads and steep slopes, it has the potential of operating in fishing villages with hilly terrain, for example. Also, since passengers can get on and off the vehicle directly from each seat, the vehicle can easily operate while allowing passengers to get on and off at any point along the route (Photo 2).

A noteworthy point is the openness of the vehicle, which allows passengers to talk and wave to passing acquaintances, making it more than just a community transportation vehicle, but a vehicle with the excellent

characteristics that promote communication.

On the other hand, there are issues of generating operating expenses, such as labor cost for drivers, matching personal demands and operation, and balancing convenience and safety. Thus, based on the analysis of the results of the test operation conducted at the Komamusashidai Housing Complex in Hidaka City, Saitama, draft guidelines will be prepared for the introduction, efficient operation, and safety assurance of green slow mobility.

Photo 2: Example of green slow mobility

* Taken in the FY 2018 experimental study support project for the examination of green slow mobility conducted by Ministry of Land Infrastructure and Transport

3. Based on an example of an elderly couple

This is a personal story, but I would like to introduce an incident that happened to an elderly couple in their 80s, who are relatives of mine and have a house on reclaimed land near Tokyo. While the husband was on his way home from a social gathering of his photography class, he fell and lost consciousness about 200 meters midway between the bus stop and his house, and it took two hours for a neighbor to find him. He was immediately transported to a hospital by ambulance, where he was hospitalized for three months, suffering from a neck injury that left him unable to move half of his body. Now, the function of his limbs has largely returned, but his lowered strength has not fully recovered.

The wife, on the other hand, drove herself to gymnastics classes at the community center, ballroom dancing, which is her hobby, and daily shopping. Six months after her husband's accident, she caused a traffic accident: when she started her car, it collided with a car parked across the aisle of the parking lot of a supermarket she frequently visited.

After experiencing the two accidents, family members discussed what to do with the old couple's car. Since buses are operating, they were able to get by without a car. Yet, going out for daily shopping and running errands would become inconvenient. They considered replacing the car with a three-wheeled electric vehicle, but this would raise concerns about the safety of the drivers. The couple had a strong will to use the car for a while. Thus, the family decided to buy a new car that was just about to be released. Although there are still some concerns, the safety features of modern cars, such as anti-collision devices for objects and pedestrians, have evolved to the point where we can expect a considerable degree of all-round safety assurance in driving. Now, about six months have passed since the couple started using the car, and they love it because it is small and easy to drive.

This case reminded me once again that the QOL of the elderly is significantly reduced when they lose their means of transportation, and that the risks of going out on foot and other means should be considered for the elderly. The elderly are the ones who need personal mobility that provides door-to-door convenience and protection from the outside world. In the future, if public transportation is going to be responsible for the mobility of the elderly, it should be oriented toward the personalization of public transportation that can cover the entire trip for each person.

4. What will happen to public transportation in the future?

Automated driving technology will advance, and fully automated driving with AI will become widespread. The probability of accidents will be greatly reduced by advanced sensing and control technologies that far exceed human capabilities. Cooperative control of vehicle groups and traffic signals will enable efficient operation at high speeds with minimal distance between vehicles, which will greatly reduce road congestion. As the decarbonization of power generation progresses as the use of electric vehicles increases widely, the CO_2 emissions associated with driving will be minimized. This means the arrival of a universal design mobility society in which everyone can safely operate a car.

What should public transportation be like then? In terms of intra-city transportation, it is assumed that cabs will be unmanned, and their fares will be lower. The widespread use of car sharing and the integrated operation of shared cars and cabs will contribute to lower fares. For those who still find it difficult to pay the fare, cab coupons can be distributed electronically as a social minimum. At this point, the route bus would end its role.

It is uncertain if this prediction will come true or not, and even if it does, it is unclear how many years it will

take to realize it. However, mobility that is free in time and space is a universal value, and any plan that goes against it will not succeed in the long run. BRT and green slow mobility also need to be studied with this in mind.

Activities of Research Center for Infrastructure Management and Future Perspective for DX

SHIMIZU Akira, Head, Research Center for Infrastructure Management

key words: DX, productivity improvement, BIM/CIM, public bidding / contracting method, public design, Kumamoto Earthquake

1. Introduction

Researches in Research Center for Infrastructure Management (the "Center") cover a wide range of fields, including estimation, public bidding / contracting methods, project evaluation, analysis of economic effect, construction work using ICT, utilization of three-dimensional data, urban greening, landscape / historical community development, and support of recovery from the Kumamoto Earthquake disaster. The following describes main activities of the Center, which has entered the fifth year from the establishment, and the future direction of approach to DX.

2. Efforts for productivity improvement

For productivity improvement in construction sites, the Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") is working for "i-Construction" as one of the important measures, which utilizes three-dimensional data, ICT, etc. in each stage of construction process, including research, design based on research, construction, inspection, maintenance, and renewal.

(1) Works using ICT

Technologies to obtain position data using satellite positioning and three-dimensional data using laser scanner, etc. are progressing, and works using ICT that utilizes such technologies to conduct engineering survey, automatic control of construction machines, as-built management, etc. have been implemented in earthworks and pavement works. The Center has been studying formulation of standards for promoting the introduction of the above-mentioned devices into construction sites. In FY2020, based on the research results, ICT ground improvement works, ICT slope works, and ICT pavement works (repair works) were newly developed. We continue to study on the expansion of types of works and utilization of new technologies.

(2) Introduction / dissemination of CIM

The MLIT has been using CIM models since FY2012 as one of the activities for utilization of three-dimensional data. CIM (Construction Information Modeling/Management) aims to facilitate information sharing among the persons concerned with the project and thereby achieve efficiency improvement / upgrading of the construction production system by introducing 3D models, ranging from the stages of planning, research, and design to the stages of construction and maintenance.

The Center is also studying procedures and standards for the introduction and dissemination of CIM. The Center will continue to study methods of creating simple 3D models for existing structures, etc. in order to further utilize CIM models.

The Center is also studying on the use of DX Data Center to store and share information on 3D data and point group data obtained from construction works and operation.

Moreover, research will be conducted on the introduction of CIM and the use of 3D data in machinery and equipment.

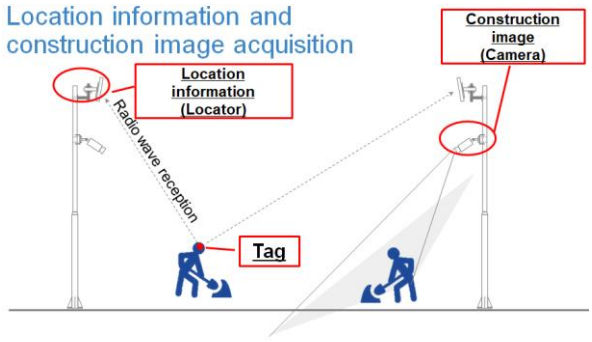
(3) Infrastructure data platform

The MLIT has been constructing "Infrastructure data platform," which will reproduce the information about national land, such as data on structures and ground data, in the cyberspace. This infrastructure data platform aims to improve operational efficiency and upgrade measures by collecting data on structures etc. obtained in the construction production process ranging from survey, research, design, construction, and maintenance and linking the collected data with the data on economic activities such as movement of people and goods and natural phenomena. The Center has been studying on the linkage, etc. between the infrastructure data platform and various databases, and will continue the research to enable linkage with more data in the future.

(4) Acquisition and analysis of the data in a construction site

In order to analyze the actual conditions of construction sites and to promote the use of new technologies, it is necessary to grasp and analyze the actual conditions of construction sites using digital data.

To this end, research on data items to be acquired, data acquisition methods, analysis methods, etc., is being conducted at actual construction sites with the cooperation of the people concerned, as shown in **Figure**.



[Acquired data item]
Location information (worker and crane hooker)
Construction image of the site

Fig. An example of data acquisition

3. Improvement of public bidding / contracting methods

Public bidding / contracting methods have been continuously improved according to the demand of the times and changes in social situations. As a result of the 2014 revision of the Act on Promoting Quality Assurance in Public Works ("Quality Assurance Act"), quality assurance for the present and future public works and development / securing of human resources responsible for quality assurance on a mid- and long-term basis were added to the purpose of the Act, and introduction / utilization of various public bidding / contracting systems were included. Such systems include the technical proposal / negotiation method, which requires the builder's technical cooperation from the design stage, and is also consistent with the concept of front-loading / concurrent engineering (parallel / joint work), which aims at total optimization of the construction production process.
Since the technical proposal / negotiation method mentioned above is applied to construction works in which the owner cannot determine optimal specifications or conditions requisite for specifications are difficult in determination, we intend to continue the research to facilitate the progress of such works.

4. Research on high-quality public design

Since the enactment of the Landscape Act in 2005, landscape administration has spread across the country, and the issues of consideration for landscape in public projects and qualitative improvement of designs have been arising.
Under these circumstances, local governments have begun to implement a variety of design administrative frameworks to improve the quality of design, and public design initiatives to effectively link public projects to regional revitalization through total project design.
Therefore, based on these examples, the Center is studying with the aim to propose the construction of design administration frameworks according to the scale of local governments and the landscape characteristics of regions, and measures for total design that will enhance the quality of public projects. We would like to continue to study for the development of unique and good communities.

5. Support of restoration from the Kumamoto Earthquake disaster

In the works for restoration from the Kumamoto Earthquake disaster, which occurred in April 2016, advanced technical knowledge about bridges etc. has been required and a laboratory was built on the site in April 2017 to station research personnel on the site in order to accelerate the project. This laboratory is providing prompt and elaborate technical support on the site and contributing to early restoration for projects led by Regional Development Bureaus and local governments.
As the Aso Ohashi Bridge Route on National Route 325 was opened to traffic in March 2021, the restoration has been steadily progressing. While continuing to provide technical support for recovery, we would like to study on reflection of the knowledge obtained in technical standards, quake-resistant structure enabling easy functional recovery, etc.

6. Initiatives related to DX in the infrastructure field

As the term "Digital Transformation" (DX) has become widely used, the MLIT has established the DX Promotion Division, and NILIM has installed an Infrastructure DX Research Promotion Division in March 2021.
In the construction process, the progress of digitization is not uniform, and there are many areas where digitization is not yet advanced. Therefore, it would be important to set immediate and future goals, and promote research and on-site implementation, according to the progress of digitization, such as those that are being digitized first, and those that are already digitized and can transform the method of operation.
We would like to study on social capital management that improves productivity and meets on-site needs by using the latest technology and the data obtained.

Development of Technology for Capture of Levee Collapse from Water Level Observation

(Research period: FY 2019 - 2020)

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River Department

key words: levee collapse, water level observation, flood flow

1. Introduction

The necessity of understanding the occurrence of flooding more quickly, even under difficult circumstances in which a large number of overflows occur in a concentrated manner, has become clear from the damage caused by heavy rains in recent years. When a levee collapses, the large outflow (flooding) of river water causes a depression in the water surface in the vicinity of the levee breach, and that depression then propagates upstream and downstream in the river as a kind of wave. The following presents an outline of the development of a technology for detecting the occurrence of levee collapse from this phenomenon and, in addition, estimating the volume of the flood flow.

2. Reading the signal of levee collapse

An example of water level observation in the vicinity of a levee breach is shown in the upper part of **Fig.-1**. The video taken at the site recorded the two points in time of collapse of the backside slope of the levee and flooding caused by the levee breach. Although the levee collapse occurred at some point during this interval, no conspicuous change can be seen. Therefore, the figure was redrawn (lower part of Fig.-1) as the water level change ΔH from the immediately prior water level observation, and showed that a sudden water level drop of about 10 cm occurred. This is the signal of levee collapse, and the method of reading that signal in real time is the core of the detection technology. It was possible to extract signals (although containing noise) by quantifying whether a sudden change occurred (raw score) using an autoregression (AR) model, and then filtering for a sudden water level drop of a magnitude that could occur during a levee breach (score including propagation characteristics). When the scores of water level gauges at other locations were calculated in the same manner, signals were also extracted at almost the same time, as predicted from the propagation characteristics of the depression. We are currently attempting to eliminate noise and improve the accuracy of levee collapse detection through repeated ingenuities based on these propagation characteristics.

3. Estimation of flood flow from change of water surface during flooding

The flood flow volume changes depending on the width of the opening in a levee (width of the levee breach). Here, the key to the development is how to overcome the difficulty of determining the width of the levee breach, which expands instant by instant during a breach. Reasoning by analogy from experiences showing that the water depth in a tank can be reduced more rapidly by opening the tap wider, it should also be possible to back-calculate the width of a levee breach from the progress of water level decrease. The core element of the estimation technology based on this idea is a technique for capturing the water surface depression under increases and decreases in the water level by flooding. Here, the particle method which is used in "flood damage risk lines" was applied. A large number of real-time flood flow analyses (called "particles") which were given different levee breach widths were conducted, and the results were narrowed to particles having a breach width corresponding to the depression by assimilating the observed water levels to the results (lower part of **Fig.-2**: The C-value is a parameter equivalent to the breach width). When the flood flow volume was estimated assuming that detection is possible 20 minutes after a levee collapse occurs (i.e., after 2 water level observations) by the above-mentioned score, satisfactory results were obtained, as shown in the upper part of Fig.-2. We are currently conducting further research on use of this technique in flood prediction, for example, in forecasting the extent of the inundated area.

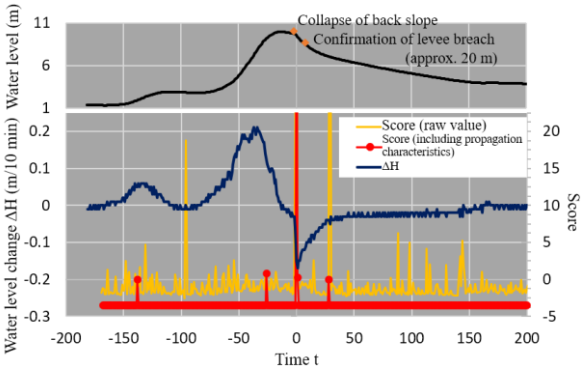

Fig.-1 Water level observation in vicinity of levee breach and score values

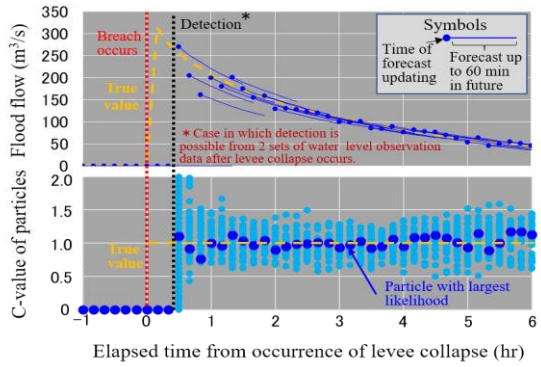

Fig.-2 Example of estimation of flood flow by particle method

Preparing for Future Erosion of Sandy Beaches Caused by Climate Change by Focusing on Beaches that Experienced Sea Level Rise

(Research period: FY 2019 - 2020)

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River Department, Coast Division

key words: *coastal erosion, climate change, future prediction*

1. Sea level rise caused by climate change

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) reported that the global mean sea level is already rising and predicts that sea level rise will also continue in the future. The "Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC)," published in 2019, predicts that the global mean sea level will rise 0.71 meters (0.51 to 0.92 meters) by the end of the 21st century (2081-2100) under the most severe RCP8.5 emission scenario.

Since one effect of sea level rise on coastal areas is retreat of the shoreline to the inland side, disappearance of many sandy beaches is feared. Therefore, the Coast Division is conducting research on a simple technique for estimating the shoreline response to rising sea levels as a technique that can be used by coast administrators when studying the necessity of countermeasures for coastal areas under their jurisdiction.

2. Beach erosion caused by sea level rise

The amount of shoreline retreat in response to sea level rise cannot be predicted simply by multiplying the slope of the beach by the amount of water level rise. This is because a beach has an equilibrium cross-sectional profile, and its topography changes so as to maintain that profile, resulting in larger shoreline retreat (**Fig.-1**).

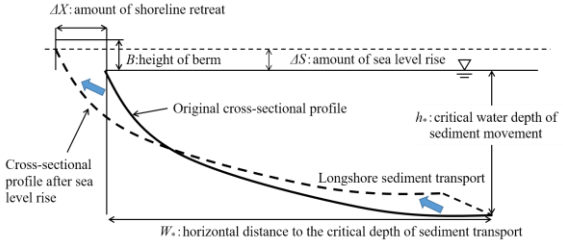

Fig.-1 Schematic diagram of topographical change due to sea level rise

This rule is called the Bruun rule. Although the Bruun rule is widely used worldwide as a technique for predicting the shoreline response of beaches to climate change, the premise that the amount of sediment in the cross section in the shore-to-offing direction does not change is considered to be unsuitable for the actual condition of beaches in Japan and has rarely been used in work at the practical level.

Recently, however, a model (hereinafter, called the modified Bruun rule) that can consider changes in the amount of sediment due to longshore sediment transport (littoral drift), beach nourishment, etc. has been proposed. Therefore, we verified the applicability of the modified Bruun rule to coastal areas in Japan by comparing the results of predictions by the proposed model and the topographical changes actually measured at local sites.

3. Focusing on coasts that have experienced relative sea level rise

In Japan, some coastal areas have experienced relative rises in sea level as a result of decreases in the ground level caused by crustal movement or ground subsidence (**Fig.-2**). Five of those coastal areas (Iburi, Niigata, Kujukuri, Fuji and Suruga coasts) were selected, also considering whether sounding measurements were carried out in the past. Among these, the fastest rate of ground level decrease was 15.0 mm/y at the Kujukuri coast, which is far larger than the 3.6 mm/y global average rate of mean sea level rise observed to date.

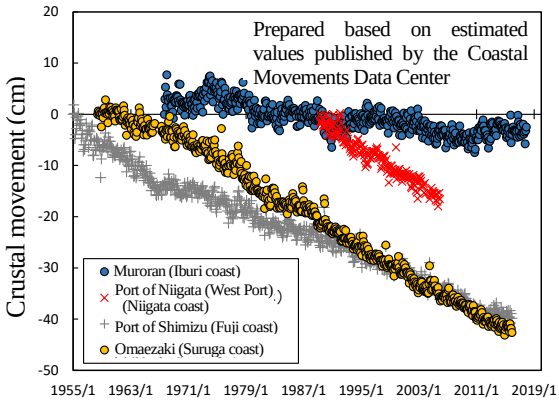

Fig.-2 Crustal movement near coastline

The change in the amount of sediment in the cross section at these five coasts was obtained from the sounding results at two different times, and the amount of ground subsidence observed in the vicinity during the same period was regarded as the amount of relative rise in the sea level. This relative sea level rise was then

substituted in the above-mentioned revised Bruun rule, and the amount of shoreline retreat between the two times (periods of 6 to 42 years) was calculated. At some survey lines, the calculations showed shoreline retreat even though virtually no changes were observes in the shorelines in the actual measurements. However, the calculation results were close to the measured values at lines where there were no detached breakwaters, jetties or similar structures in the water (**Fig.-3**). Although care is necessary when applying the revised Bruun rule under some coastal conditions, it was considered to possess sufficient accuracy for use in the stage of identifying coastal areas where countermeasures are required from among this country's very long coastline.

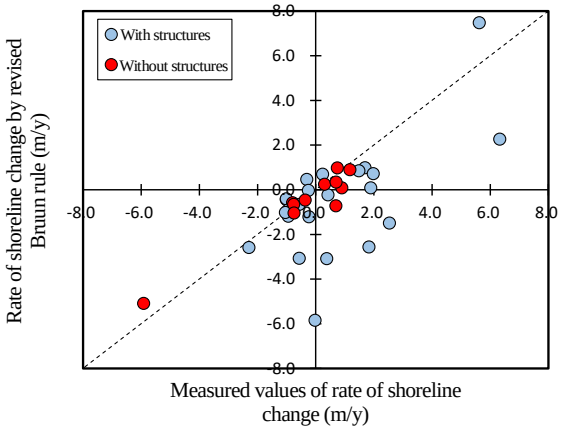

Fig.-3 Calculated and measured results of shoreline change

4. Degree of influence of sea level rise on eroded coastlines

On the basis of the results of calculations by the modified Bruun rule, we analyzed the shoreline response observed in the past at the five coasts due to changes in the amount of sediment in the cross section in the shore-to-offing direction, and due to relative sea level rise, and found that the influence of changes in the amount of sediment had been predominant in shoreline change at virtually all of the survey lines at four of the coasts, with the exception of the Kujukuri coast (**Fig.-4**).

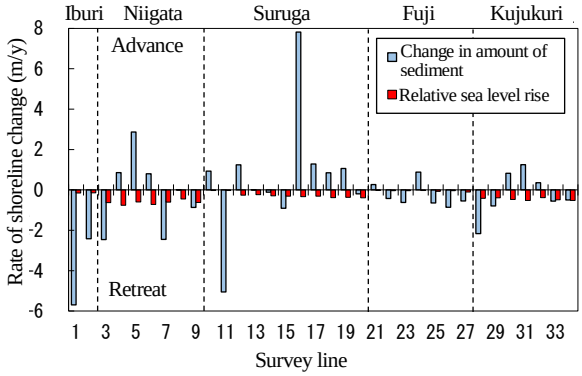

Fig-4 Shoreline change due to change in amount of sediment and due to sea level rise

This result means that the locations where countermeasures should be implemented on a priority basis are places where there is a disequilibrium in the balance of sediment inflow and outflow, and this is also applicable when considering the predicted sea level rise in the future. At eroded coasts, it is important to proceed steadily with the current erosion countermeasures, but in addition to those measures, a general wide-area survey by a simple technique such as the modified Bruun rule method is also required so as not to overlook sandy beaches where it will no longer be possible to secure the necessary beach width due to sea level rise.

5. Prediction of shoreline response at long coastlines

In order to confirm the applicability of the modified Bruun rule to long coastlines containing a mixture of accumulation sections and erosion sections, we attempted to reproduce the shoreline response observed over a period of 38 years from 1977 to 2015 at the Minami Kujukuri coast (from Katakai fishing port to Taito fishing port). In 8 of the 10 calculation target sections (excluding the two end sections), the average measured value of shoreline retreat was 31.0 m, but the predicted value was limited to an average of 10.0 m. This is not a negligible difference for this coastline, which includes many locations where the beach width is already less than 50 m. In this study, a decrease in the amount of littoral drift was not anticipated in sections where headland groups have been installed, but this is considered to be a cause of the above-mentioned difference. This result suggests that it is important to improve the accuracy of predictions of the distribution of littoral drift for future predictions of shoreline response.

6. Future development

In spite of issues such as development of a prediction method with high accuracy for future changes in the amount of sediments, it was possible to confirm that the prediction technology verified in this research is also applicable to synoptic studies by persons in charge of coast administration. However, the effect of climate change considered in this study was limited to mean sea level rise, and study of future changes in waves, which affect drift sand, are currently in progress. Moreover, research on a detailed technique which can be used in future predictions of individual coasts, as in the example of the Kujukuri coast presented here, is also underway. Together with the simple method introduced in this paper, we would also like to provide information to coast administrators.

☞For more information:

1) Kunihiro Watanabe et al.: Journal of the Japan Society of Civil Engineers, Ser. B2 (Coastal Engineering), Vol. 76, No. 2, pp. I_529-I_534, 2020.
https://www.jstage.jst.go.jp/article/kaigan/76/2/76_I_529/_article/-char/ja

Development of Technique for Visualizing Floods Using VR Technology

(Research period: FY 2020 -)

AKITA Saya, Researcher TSUCHIYA Shuichi, Senior Researcher (Ph.D. in Engineering) KAWASAKI Masaki, Head

key words: flood risk visualization, VR (virtual reality), flood prediction

1. Introduction

In recent years, disasters caused by heavy rains have become both more frequent and more serious, heightening the importance of providing information which will lead to appropriate evacuation action during floods. As an effort in NILIM's "Flood Risk Visualization Project," we are engaged in research and development to communicate the urgency of river flooding during floods in real time and easily-understood terms. As a result, "Flood Damage Risk Lines," which representing the degree of flood risk of rivers with resolution of roughly neighboring land units, etc. have been applied practically. This article introduces research on visualization of flood risk by using virtual reality (VR) technology as an effort for more effective information dissemination.

2. Outline and status of efforts for VR display system

It is now possible for residents to obtain information on the degree of flood risk of familiar rivers in real time through webpages such as "River disaster prevention information" and "Flood damage risk lines." However, even assuming residents have this information, they cannot make a judgment to evacuate if the urgency of flooding is not conveyed correctly, and as a result, will delay evacuating and become victims. Therefore, as a measure for conveying the degree of flood risk to residents correctly and in real time, NILIM is developing a VR display system which provides flood prediction information. As shown in the accompanying **Figure**, the display of this system synthesizes a 3-dimensional river surface model created by a game engine on photographs taken at the site in advance and existing 3D geodetic data. The height of the river surface is based on the results of flood predictions obtained by a river water level simulation, and the condition of striking waves, water spray, floating driftwood, and the like is shown by animation to make the river surface seem more real. Because the system shows the actual scenery in the background, including buildings, bridges and other structures, the difference from the normal condition which residents usually see is clear, and residents can easily form a concrete image of the degree of flood risk danger. Moreover, by using the VR display system, residents can understand the condition of the river in real time when the actual condition cannot be seen due to darkness or heavy rainfall.

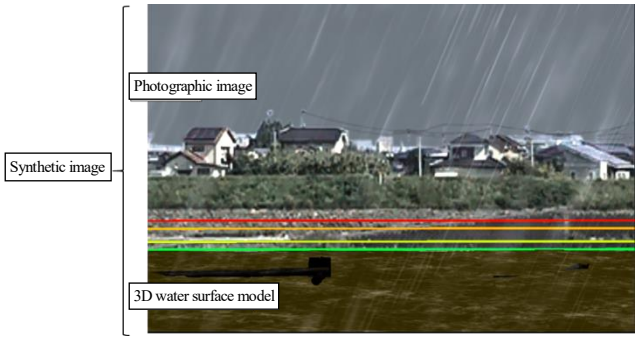

Fig. VR display system

At NILIM, we are also studying photographic techniques for use in the VR display system and techniques for expressing the river surface during floods with greater realism, focusing on model rivers, and we are currently preparing a manual envisioning application of this system to Class A rivers throughout Japan. In the future, we plan to construct a prototype system for model rivers based on the results of these efforts, and will conduct trials and improve the system aiming at practical application in the future.

☞For more information:

1) NILIM, River Department, Water Cycle Division
http://www.nilim.go.jp/lab/feg/index.htm

Trial of Visualization of Risk Structure for Effective Operation and Maintenance of Dams

(Research period: FY 2017 - 2021)

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key words: *dam, operation and maintenance (O&M), risk management*

1. Introduction

At dams in Japan, operation and maintenance (O&M) are conducted through daily inspections by patrol and measurements and periodic inspection by experts other than the dam administrator. Recently, efforts of detailed investigation, analysis, testing, etc. for soundness assessments of dams in long-term operation are also being made as Comprehensive Dam Inspections (CDI), [1] in order to prepare the future O&M plan for life extension of each dam. Although the most important purpose of these efforts is to determine the condition of the facility and identify issues for O&M, they can also be considered significant when used as an opportunity to recognize the location of risks that can have undesirable effects on the safety and functions of dams.

In individual dams, siting conditions such as the geology and environment of the site, the dam materials and structure, construction conditions, and operating conditions differ widely. Moreover, there is also a possibility that dams may be affected by large-scale external actions in the form of heavy rain, earthquakes, etc. while in service for many years. In addition, the effect of deterioration of the materials of the dam body over time, although slow, is also a conceivable problem. To enable more rational and effective O&M of dam structures over the long term, it is essential to recognize, as well as possible, the characteristic risks of each individual dam due to combinations of various types of factors and the structure of those risks (scenarios), and to implement appropriate management of those risks.

As one risk management technique in O&M of dam structures, we have been discussed a practical work method which makes it possible to recognize diverse risks and their levels by visualization of the risk structure. As a case study, this article introduces a trial attempt of this method to a model concrete dam where a comprehensive dam inspection was conducted.

2. Visualization of risk structure (scenarios)

In this trial, first, we attempted to visualize the structure of the conceivable risks at the model dam. Since no evidences that would clearly affect the safety and functions of the model dam have been reported, we wrote out various events that may have occurred in the past and may have occur in the future on the basis of site conditions (including geological ones) which were recognized and handled at the time of construction, slight changes in condition of the dam reported in past inspections (including the trend of measurement data) etc. and grouped them that are considered to be interrelated. Then, assuming that risk can be

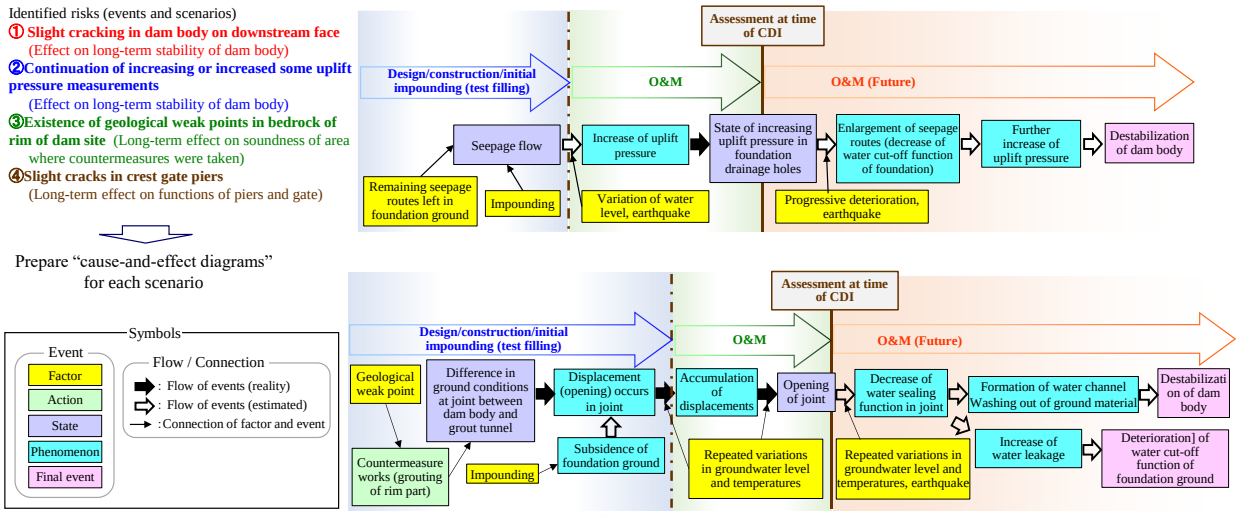
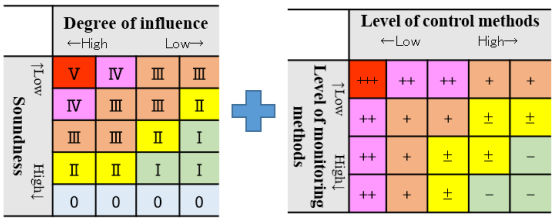


Fig.-1 Creation of "cause-and-effect diagram" by risk scenario (example in trial)

captured by these group units, we prepared multiple "cause-and-effect diagrams" (**Fig.-1**) plotting the internal factors (geology, materials, construction, etc.) that may possibly become causes or inducing factors for various known events, external factors (external actions, etc.), the mutual (cause-effect) relationship between events and the scenarios assumed in the future.

3. Assessment of risk levels of scenarios

Next, we attempted a trial assessment of the risk levels of each of the scenarios shown in the "cause-and-effect diagrams," considering the possibility of risk materialization and its final degree of influence on the safety and functions of the dam. It should be noted that quantitative assessments are difficult in the case of dams, because the examples of risk materialization are limited and, as a result, adequate data for a cause analysis are not available. Therefore, in this trial, the level of risk for each scenario was assessed in several levels based on a combination of the "soundness" assessment results (reported in the recent CDI) related to events included in each "cause-and-effect diagram" and the degree of influence in case the risk finally materialized as a result of further progress of a series of related events in the future. The assessment of the "management level" was then added considering the assessment of the "risk level" based on a combination of factors, that is, whether some monitoring methods (e.g., measurements) are available or not, and if so, their reliability, and the status of the control methods (i.e., countermeasures) applied to the facility (**Fig.-2**). The following **Table** shows the levels of risk assessed on a trial basis by this method for each of the scenarios in **Fig.-1**.



(a) Assessment by soundness and degree of influence (basic method)

(b) Addition of management level

Fig.-2 Method of assessing risk levels

Table Assessment of risk levels of scenarios (example in trial)

Scenarios	Soundness ×Degree of influence	Management level	Levels of risk
①	Ⅱ	++	Ⅱ$^{++}$
②*	Ⅲ	+	Ⅲ$^{+}$
③	Ⅱ	++	Ⅱ$^{++}$
④	Ⅲ	±	Ⅲ

* : Implementation of countermeasures has been completed for ②, which was assessed as having the highest risk level in these four scenarios.

4. Risk communication

The visualization of risk structure (scenarios) and risk level assessment must be performed as far as possible on the basis of objective information such as design and construction records, inspection results, etc. However, none of this work can be performed mechanically. Therefore, in this trial, preparation of the "cause-and-effect diagrams" and the assessment of the risk level based on the diagrams were carried out through a process of discussions as "risk communication" (**Photo**) in order to reach a mutual understanding, on the basis of sharing of design- and construction-related materials, inspection records, etc. and joint site confirmation, with the participation of the dam administrator, and experienced persons with different standpoints and fields of expertise, including engineers and experts in various fields such as geology, structures, hydraulic design, etc.

Photo Discussions for risk communication

5. Conclusion and future development

The method we have tried is expected to be useful in enhancing the quality of O&M of dam facilities, particularly from the viewpoint of facilitating an understanding of the locations of risk and the necessity and importance of action responding to individual risks, through the process of capturing the organic linkage of information such as the trends in measurement data and information on changes in the dam condition, etc., which tend to be perceived at a glance as separate events, and studying their progress along the temporal axis. One of the key to achieving practical effectiveness in these efforts is risk communication and enhancement of its skill. We would like to continue this trial in the future, and compile some technical materials showing how to use this methods effectively in combination with existing approaches such as CDI, so as to contribute to securing even greater safety and realizing long life in dam structures.

Reference

1) Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Water and Disaster Management Bureau, River Environment Division: Comprehensive Dam Inspection Manual and Commentary" (in Japanese)
https://www.mlit.go.jp/river/shishin_guideline/

Efforts for Flood Hazard Mapping of Small- and Medium-sized Rivers

(Research period: FY 2017 -)

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Flood Disaster Prevention Division, River Department,

key words: *small- and medium-sized rivers, flood hazard map, airborne laser profiler data*

1. Introduction

Heavy rains and floods unlike those experienced in the past have now become a frequent occurrence, and devastating flood damage has continued to occur at rivers throughout Japan. Although river improvement works and other structural measures are essential for preventing these disasters, in addition, disaster prevention/mitigation by promoting non-structural measures such as timely evacuation is also important. For promoting non-structural measures , flood hazard maps, which illustrate possible flooded areas and depths, are necessary, but have not been provided for many small- and medium-sized rivers. Swift elimination of these no--risk-information areas has become an issue.

In Japan, there are approximately 21,000 rivers under the administration of prefectural government (as of April 2018), and flood forecasting or water level reporting is legally required at only about 2,000 rivers nationwide (as of October 2019; hereinafter, "flood forecasting or reporting river"). At a flood forecasting or reporting river, river administrator is also legally required to specify the possible flooded areas and depths with assuming the largest flood scale. Specification of these areas has been completed at all of the approximately 400 rivers administered by the central government, and about 1,700 rivers, in which approximately 1,600 rivers with the assumed largest flood scale, under prefectural government (as of July 2020). On the other hand, among remaining approximately 19,000 rivers, i.e. the rivers not designated as flood forecasting or water level reporting river (as of October 2020; hereinafter, "small- and medium-sized rivers"), flood hazard maps with the assumed largest flood scale have been provided for only about 4,000 of these rivers (as of June 2020), or fewer than one-in-four of all small- and medium-sized rivers.

Based on these circumstances, the Flood Disaster Prevention Division has conducted research on techniques for preparing flood hazard maps for small- and medium-sized rivers by utilizing airborne laser profiler (hereinafter, LP) data in cooperation with the Water and Disaster Management Bureau of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). A technical review committee (Chair: Prof. IKEUCHI Koji, University of Tokyo Graduate School) was organized in the Bureau in January of 2020, and "Guide to flood hazard mapping for small- and medium-sized rivers" (hereinafter, "Guide") was released in June of 2020 (**Table**)[1].

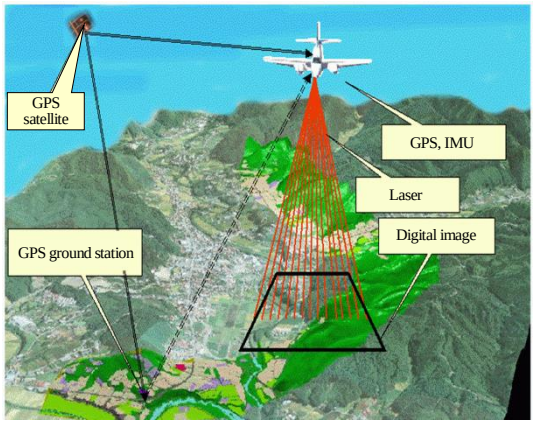


Fig.-1 Airborne laser profiler

Table Chronology of discussions in Technical Review Committee

Date	Main agenda
1st Session January 7, 2020	Background of study Results of survey of prefectural needs Simpler flood hazard assessment method
2nd Session March 25, 2020	Secretariat's response to items pointed out at 1st Session Guide (preliminary draft)
3rd Session May 25, 2020	Secretariat's response to items pointed out at 2nd Session Guide (draft)

Besides, it is planned to increase the number of rivers where the possible flooded areas and depths are specified, from approximately 2,000 rivers in FY 2020 to approximately 17,000 rivers in FY 2025, following the revision of the law in 2021.

2. Features of Guide

To prepare flood hazard maps quickly for the enormous number/ length of small- and medium-sized rivers, the Guide adopts new analysis techniques as follows:

(1) Setting the river channel and flood plain cross section based on available LP data and Digital Elevation Model.

(2) Adopting rational formula where the flood run off analysis has not yet been conducted for reducing the flood run off analysis

workload.

(3)Adopting one-dimensional non-uniform flow calculation technique without assuming levee breaching for reducing the possible flooded areas and depths analysis workload.

The following points were also mentioned as remaining technical challenges in the Guide.

- Setting appropriate interval of the cross sections of the river sections for one-dimensional non-uniform flow calculation.
- Developing a method to consider the large content of sediments in flood where complex disaster of sediment and flood is concerned.
- Clarifying conditions for avoiding remarkable under estimation of the possible flooded areas and depths without considering levee breaching.
- Setting the appropriate boundary river water level at the lower end of the river for one-dimensional non-uniform flow calculation.
- Developing a method for estimating the possible flooded areas and depths at river sections with mixture of multiple types of flood flow, such as parallel-flow-type, diffusion-flow-type, and storage-type.
- Judging river sections where the proposed analysis technique is applicable based on available information such as LP data.

3. Trial application of Guide

Together with collecting and analyzing examples of the application of the Guide, which are necessary in study to solve the above-mentioned technical challenges, NILIM is also promoting trial application of the Guide in order to support quick elimination of no-risk-information areas throughout Japan. Due to budget limitations and other reasons, trial applications are limited to the parallel-flow-type river sections. It should also be noted that this work has been greatly delayed under the condition of the strengthening of infection prevention countermeasures against the novel coronavirus.

4. Current status of trial application

The following work is being carried out for approximately 8,000 rivers (with a total length of approximately 40,000 km) based on the available LP data.

(1) Screening rivers for the trial application based on request from prefectural government and LP data availability information.

(2) Borrowing the LP data from the Geospatial Information Authority of Japan.

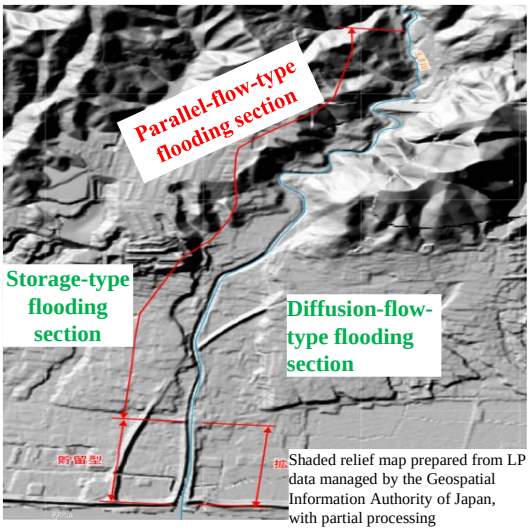
(3) Checking whether the LP data cover the target river.

(4) Dividing the target river into river sections with roughly the same peak flood discharge.

(5) Collecting the necessary data for calculating the peak flood discharge in each river section.

(6) Identification of river sections which are considered to have the parallel-flow-type flooding during assumed maximum flood scale based on topographic data (and peak flood discharge).

Fig.-2 shows an example of identification of a river section with parallel-flow-type flooding.



Shaded relief map prepared from LP data managed by the Geospatial Information Authority of Japan, with partial processing

Fig.-2 Example of identification of parallel-flow-type flooding section

5. Conclusion

Through ongoing trial applications, the Flood Disaster Prevention Division continues the studies to validate the proposed analysis technique, and to solve the technical challenges of the Guide, together with facilitating the elimination of no-risk information areas at small- and medium-sized rivers.

☞For more information:

1) Flood Risk Reduction Policy Planning Office, River Environment Division, Water and Disaster Management Bureau, MLIT, and Flood Disaster Prevention Division, River Department, NILIM: “Guide to flood hazard mapping for small- and medium-sized rivers”
https://www.mlit.go.jp/river/shinngikai_blog/tyusyokasen/pdf/manual.pdf (in Japanese)

Elucidation of the Mechanism of Deep-seated Catastrophic Landslides Utilizing Drone Airborne Electromagnetic Survey Technology

(Research period: FY 2018 -)

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key words: *deep-seated catastrophic landslide, drone airborne electromagnetic survey, electrical survey, fault crushing belt, groundwater*

1. Introduction

During typhoon No. 12 (Typhoon Talas) on August 25, 2011, total rainfall in Japan's Kii Peninsula exceeded 1 000 mm over a wide area, and caused deep-seated catastrophic landslides (DCL) with a landslide area of 1 ha or more at 72 locations in the Kii Peninsula.

Research on the mechanism of DCL was carried out from various angles, including topography, geology, hydrology, etc., from immediately after the disaster. In particular, from past research, there is a possibility that fault crushing belts crossing a slope may either induce infiltration of the surrounding groundwater or dam up groundwater. This paper introduces efforts to elucidate the collapse mechanism of a DCL (**Photo-1**) in the Kumano region of Tanabe City, Wakayama Prefecture by utilizing drone airborne electromagnetic surveying.

2. Outline of Kumano region and content of survey

The Kumano region, which is the object of this research, lies in the upper basin of the Kumanogawa River in the Hikigawa river system. Sedimentary rocks are widely distributed in the area. **Photo-1** shows the condition of the Kumano region 1 day after the disaster. Note that the solid yellow line is the survey line of the drone survey, and the dotted white lines show the locations of fault crushing belts determined from the results of a geological reconnaissance and electrical survey. The scale of the DCL is 440 m in width, 250 m in height and 480 m in length, and the volume of the collapsed sediment is approximately 5.26 million m^3. In this study, the resistivity distribution at depths of approximately 0 to 200 m below ground was measured by a drone airborne electromagnetic survey 3 days after typhoon No. 14 (Typhoon Chan-Hom) in October 2020 and during the dry season in the early part of December of the same year in order to investigate the effect of the fault crushing belts on the behavior of the groundwater during heavy rain.

3. Characteristics of resistivity distribution in vicinity of fault crushing belts by drone airborne electromagnetic survey

Photo-2 shows the condition of the drone airborne electromagnetic survey. A magnetic field is generated by passing a current through a cable laid on the ground surface, and the underground vertical component of the field is measured by a magnetic field sensor suspended from the drone.

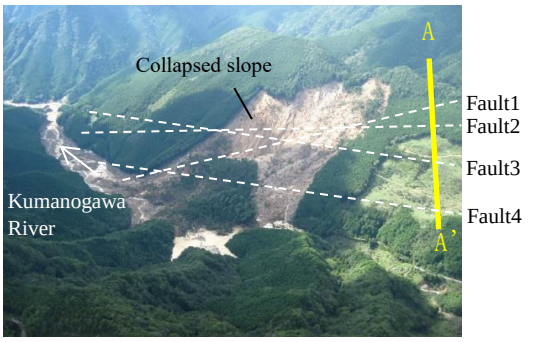

Photo-1 Condition of Kumano region 1 day after disaster (photographed on Sept. 5, 2011)

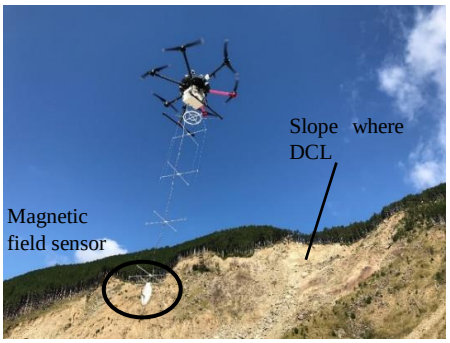

Photo-2 Condition of drone airborne electromagnetic

First, an airborne electromagnetic survey was conducted by a helicopter on November 28, 2012 to grasp the general geology and distribution of groundwater and spring water. This survey was carried out 2 days after total rainfall of 98.5 mm (at the Japan Meteorological Agency's Nishikawa observation point) due to the passage of a weather front. **Fig.-1** shows the resistivity distribution at approximately 0 to 10 m below ground. As above, the yellow solid line represents the survey line of the electrical survey and drone survey, and the white dotted lines show the locations of fault crushing belts. Low resistivity was detected from the middle to the bottom part of the collapsed slope. The groundwater level is considered to be located at a position

shallower than about 10 m below ground in the results of groundwater level observation of the same area during the dry season, and it is thought that this low resistivity zone was formed by groundwater and spring water.

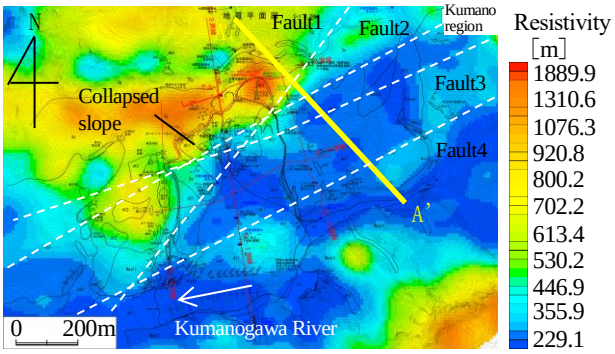

Fig.-1 Result of airborne electromagnetic survey (approx. 0 to 10 m below ground)

Next, **Fig.-2** shows the results of an electrical survey (survey line A-A' in **Photo-1** and **Fig.-1**) during the period November 25-27, 2020. The electrical survey was carried out by the two-electrode method using an electrode spacing of 10 m and a survey depth of 200 m. This survey measured resistivity during the dry season, as there have been almost no rainfall for 4 days at the start of the measurements. Locations where resistivity varied greatly were considered to be faults, and 4 such locations were found.

Fig.-3 (a) shows the resistivity distribution diagram (survey line A-A' in **Photo-1** and **Fig.-1**) obtained by the drone airborne electromagnetic survey on December 2, 2020, and **(b)** shows the longitudinal (vertical) section distribution diagram obtained by dividing the resistivity value on October 13, 2020, 3 days after the end of rain caused by typhoon No. 14 in October 2020, by the resistivity values in (a). From Fig.-3 (a), it can be understood that a high resistivity zones exist on the A side from fault 1 and on the A' side from fault 2. These zones are thought to contain a large number of voids as a result of crushing. From (b), the groundwater has infiltrated into the crushed zone on the A side of fault 1, and movement of that groundwater has stopped in the vicinity of fault 1. Thus, fault 1 is estimated to be a type of fault that dams up groundwater. Between faults 1 and 2, the altitude becomes higher as the light-blue zone moves toward the A' side, and it is thought that the groundwater flows downward toward the Hyakkendani valley in this area. Between faults 1 and 3, it is thought that the groundwater flows down from near the ridge toward the A' side at a depth of around 80 m underground. Based on the facts that fault 2 contains many cracks and the width of the light-blue zone also becomes wider around fault 2, fault 2 is considered to be a type that induces infiltration of groundwater from the surrounding area. Around fault 3, the width of the light-blue zone becomes smaller as it approaches fault 4, and the light-blue zone disappears near fault 4. Therefore, it is considered that faults 3 and 4 are faults of a type that dams up the groundwater, in the same way as fault 1.

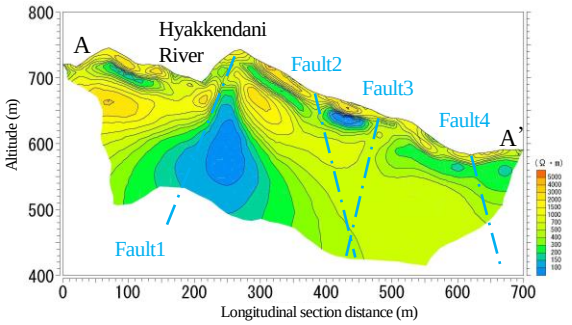

Fig.-2 Result of electrical survey at A-A' survey line in Photo-1 and Fig.-1

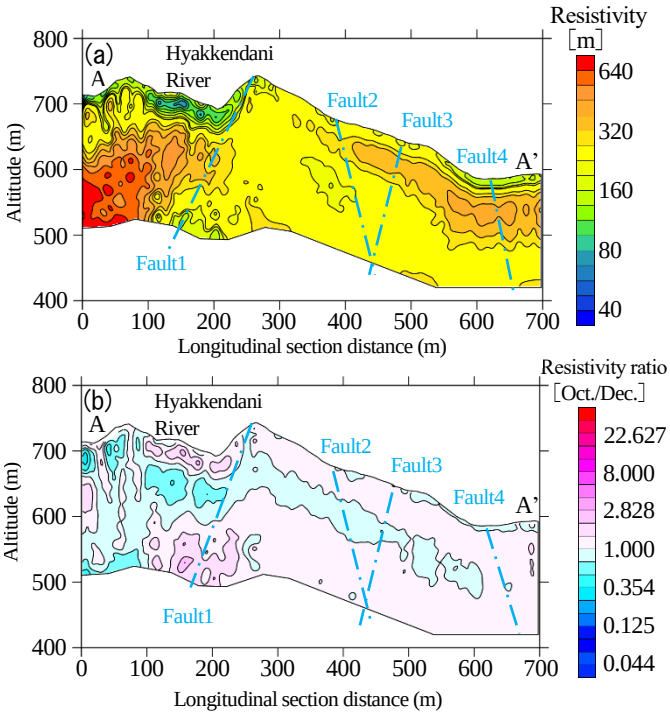

Fig.-3 (a) Longitudinal distribution of resistivity in dry season (Dec. 12, 2020) by drone survey at A-A' survey line in Photo-1 and Fig.-2, (b) Longitudinal distribution of value obtained by dividing resistivity value 3 days after the end of rain (total rainfall: 217 mm) caused by typhoon No. 14 of 2020 by the resistivity values in (a) at same survey line

4. Conclusion

In this study, the mechanism of deep-seated catastrophic landslides in the Kumano region was investigated from the results of an airborne electromagnetic survey by a drone, and it was suggested that fault crushing belts had a large effect during the disaster. Based on the results of this research, we plan to establish a risk assessment technique for deep-seated catastrophic landslides.

☞For more information:

Kinoshita et al. (2021): Elucidation of mechanism of deep-seated catastrophic landslides by drone airborne electromagnetic survey in Kumano region where DCLs occurred during typhoon No. 12 in 2011, Abstracts of the FY 2021 Annual Conference of the Japan Society of Erosion Control Engineering (in Japanese)

Joint Research on the Maintenance of Concrete Deck Bridges

(Research period: FY2018 to FY2021)

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key words: concrete deck bridge, lateral-fastening PC steel fracture/protrusion, periodic inspection, preventive maintenance

1. Introduction

The concrete deck bridge is a bridge type that has been built in large numbers due to its advantages such as a lower girder height than other structures, relatively simple structure, and excellent workability. Of the bridges managed by the government, about 12,500 bridges are of this type, and about 60% of them or about 8,000 bridges, are more than 50 years old (**Fig. 1**). NILIM has been conducting joint research with the Public Works Research Institute (PWRI) and the Japan Prestressed Concrete Contractors Association (JPCA) to systematize inspections and countermeasures for the maintenance of concrete deck bridges. This paper reports the status of that joint research, particularly related to the lateral-fastening PC steel protrusion in pretensioned deck bridges.

2. Protrusion of lateral-fastening PC steel bars

In recent years, among the deck bridges managed by the government, there have been cases of fracture or protrusion of the lateral fastening of PC steel due to corrosion in pretensioned deck bridges (**Photo 1**). At present, about 5,900 pretensioned deck bridges have been built, and as shown in the schematic diagram in **Fig. 2**, their structure consists of precast concrete members that were manufactured in factories and constructed on the site, and integrated using lateral-fastening PC steel.

Water infiltrates the joints between precast members and cast-in-place sections from the bridge surface, etc., but the lateral-fastening PC steel is usually protected by grout. However, if the filling is insufficient for some reason, the lateral-fastening PC steel will corrode and, in some cases, break. If the grout does not adhere sufficiently, the prestressing force released by fracturing may lead to protrusion as shown in Photo 1.

Such an accident may reduce the load-bearing capacity of the bridge, and further cause serious damage to passersby and others in the vicinity of the bridge. Moreover, since there are multiple lateral-fastening PC steels in one bridge, there are concerns about protrusion of other steels, which may cause secondary damage during inspection or

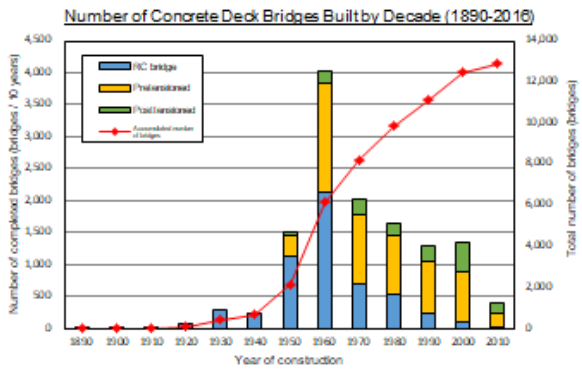

Fig.1: Years of construction of concrete deck bridges

Photo 1: Fracture / protrusion of lateral-fastening PC steel

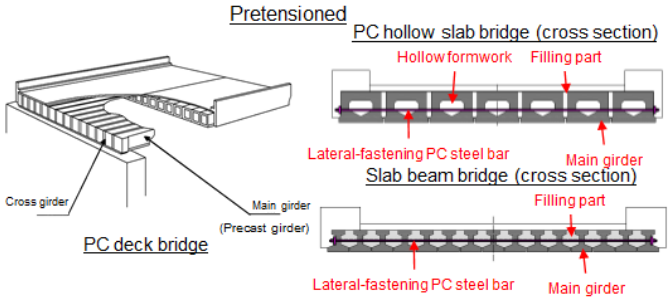

Fig. 2: Outline of pretensioned deck bridge

investigation.
Therefore, it is necessary to organize how to deal with these issues when taking preliminary measures to prevent them or when an emergency response is needed in the event of a protrusion accident.

3. Case collection / analysis and field survey

Although there are several cases in the past where lateral-fastening PC steel broke or protruded, we decided to investigate the cases of protrusion of lateral-fastening PC steel bars in 12 road bridges managed by the government through a literature survey, etc. In addition to collecting design documents and past inspection reports from the administrators, we are conducting field surveys by selecting five bridges. As a result, we found the following.

(1) Bridges with protruding lateral-fastening PC steel do not depend significantly on the environment of the bridge location, such as whether airborne salt was attached or freeze-thaw material was dispersed, but rather tend to depend on factors such as the year of construction, bridge width, and type of steel used. In other words, accidents can occur on any bridge, regardless of environmental conditions.

(2) It was found that the bridges where protrusion occurred were those built before 1980, when the material quality of grout, which plays a role in rust prevention and integration of the PC steel, was inferior.

(3) The bridges where protrusion occurred used PC steel bars as the PC steel. It is assumed that PC steel stranded wire will gradually break and the process of breaking as a stranded wire is progressive, while steel bars will suddenly break if the cross-sectional area of the steel decreases.

(4) It was found that protrusion often occurred to a bridge with a width of more than 8.0 m. This is considered attributable to the high possibility of using couplers as joints for the PC steel bars and the possibility that the presence of the couplers may easily hinder filling during grout injection.

(5) In the bridge where protrusion occurred, water leakage and free lime were observed at the interface between the precast concrete member of the bridge and the cast-in-place section. Even if it is impossible to directly check the lateral-fastening PC steel bar itself, close visual inspection is considered to be effective to a certain extent in early detection of abnormalities.

(6) In the field survey, we also investigated the bridges that were located in the vicinity of the bridges stated above and were expected to have no broken or protruding lateral-fastening PC steel. Although most of the bridges satisfying the conditions (2) to (4) did not have any protrusion of the lateral-fastening steel, we newly confirmed a bridge where protrusion occurred. For this reason, we will continue to investigate other conditions that should be considered. We also investigated the actions taken against the fracture or protrusion of lateral-fastening PC steel. As mentioned above, it is difficult to conduct a detailed survey, etc. in close proximity to the bridges where an accident was observed because of the risk of secondary damage during the survey. Therefore, it is necessary to take measures to prevent secondary damage before conducting a detailed survey. For example, regarding the bridge shown in Photo 1, we installed steel on the sides of the bridge as an emergency measure to reduce the risk of protrusion in the event of fracture (Photo 2a) as a measure to prevent secondary damage before conducting the detailed survey. After that, as a permanent measure, the grout was re-injected into the insufficiently filled areas of all lateral-fastening PC steels, and then preventive measures were taken to prevent protrusion by attaching steel strips and fiber sheets (Photo 2b). In order to systematically summarize the know-how described above, we will continue to conduct surveys, etc.

a. Emergency measure **b. Permanent measure**

Photo 2: Prevent protrusion measure

4. Conclusion

In the joint research, we plan to investigate bridges for which preventive measures were taken to expand our knowledge of their durability, etc. Results of the research will be compiled as a reference material for periodic inspections.

Research and Study on Management Methods to Meet the Required Performance of Embankments, Cuts, etc.

(Research period: FY2017 to FY2020)

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MATSUMOTO Masaaki, Guest Research Engineer,
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key words: Technical Standards for Road Earthwork Structures, Guidelines for Inspection of Road Earthwork Structures, soundness, early action stage

1. Introduction

In recent years, heavy rains and other natural disasters have caused slope failures and other damage to road earthwork structures such as embankments and cuts, which have affected the function of roads. In August 2017, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) established the "Guidelines for Inspection of Road Earthwork Structures"[1] ("Inspection Guidelines") to improve the safety and ensure the efficient maintenance of road earthwork structures by identifying deformation and determining the necessity of measures.

The specified earthwork inspection of relatively large road earthwork structures (about 5,000 structures) was conducted on national highways under the direct control of MLIT during the two years of FY2018 and FY2019. This paper reports the results of analyzing the data of this inspection and organizing the trends of deformation in order to obtain basic data for improving reliability, increasing the efficiency of inspection work, and studying effective repair / reinforcement methods.

2. Analysis of inspection results

The Inspection Guidelines classify the soundness levels into I (sound), II (observation stage), III (early action stage), and IV (emergency action stage).

Figure 1 shows the results of inspecting the level of soundness for embankments and cuts. The trend of soundness level distribution of embankments and cuts is almost similar, and Soundness Level III accounts for about 7%.

Figure 2 shows the distribution of soundness levels in each completion year, but there is no clear relationship between the completion year and soundness. **Figures 3** and 4 show the percentage of deformation by facility for embankments and cuts. The top three facilities for both embankment and cut are drainage facilities, sprayed concrete, and concrete retaining walls, which are all concrete facilities. As known from the above, it can be conjectured that soil itself, which is the main component of road earthwork structures, is less affected by deterioration with age. On the other hand, since deformation has often occurred to concrete facilities such as slope protection works and drainage systems, the effect of deterioration with age is expected to be large and the analysis should, therefore, be continued.

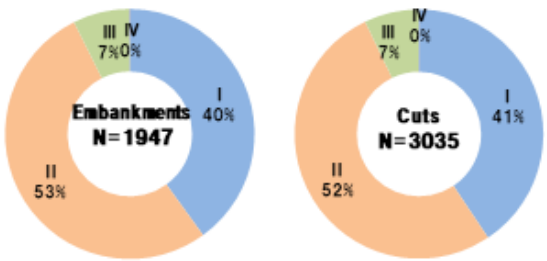

Fig. 1: Soundness judgment result

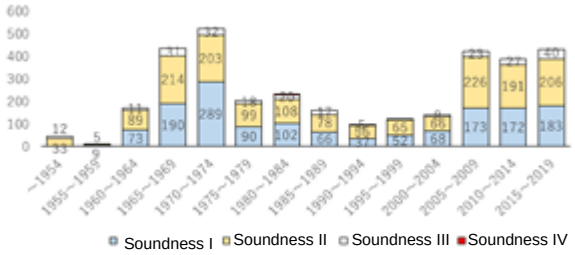

Fig. 2: Distribution of soundness levels in each completion year (construction year)

3. Organization of the factors of early action stage (Soundness Level III)

Since the Inspection Guidelines explain soundness Level III as "When it is desirable to take measures as soon as possible because the structure is expected to collapse due to the presence of deformation that is expected to progress before the next inspection", we will organize the factors by focusing on this soundness level. **Figures 5 and 6** show the types of deformation identified in the main body of embankments and cuts, as a percentage of each soundness assessment. The following is a list of characteristics of each type and their influence on the judgment, with focus on Soundness Level III.

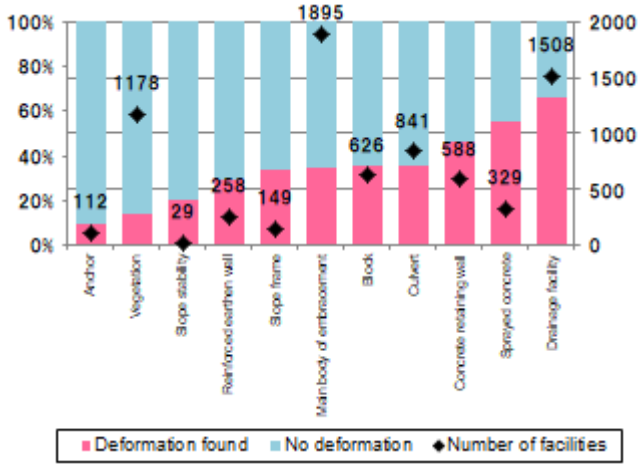

Fig. 3: Ratio of deformation in embarkements by facility

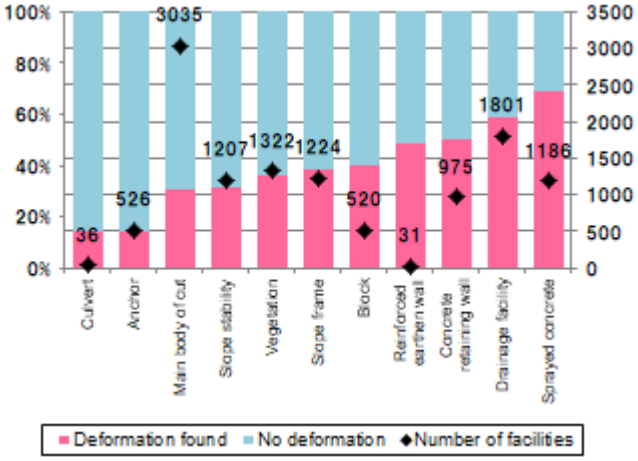

Fig. 4: Ratio of deformation in cuts by facility

[Main body of embankment]

- If there is "collapse" or "swelling," it tends to be judged as Soundness Level III.
- Deformation caused by "surface slippage" tends to be judged as Soundness Level I or II, and is difficult to be judged as Soundness Level III.

[Main body of cut]

- When there is spring, collapse, or level difference, it tends to be judged as Soundness Level III.
- "Swelling" tends to be judged as Soundness Level I or II, but not as III in any example.

As described above, since the tendency of deformation that is likely to be judged as Soundness Level III is different depending on the type of structure, even for road earthwork structures, it is necessary to conduct inspections with a focus on the characteristics of each structure. Note that the inspection results cover a period of two years and the number of facilities analyzed is uneven, so the data will continue to be accumulated.

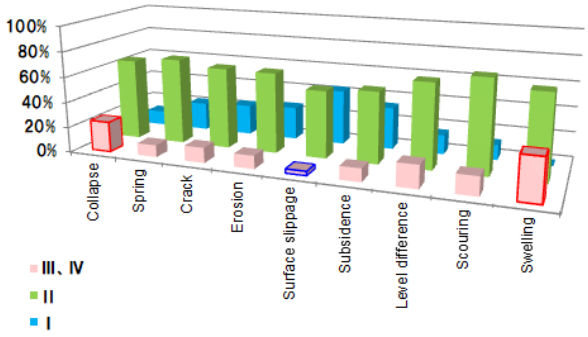

Fig. 5: Soundness judgement for each type of deformation (Embankments)

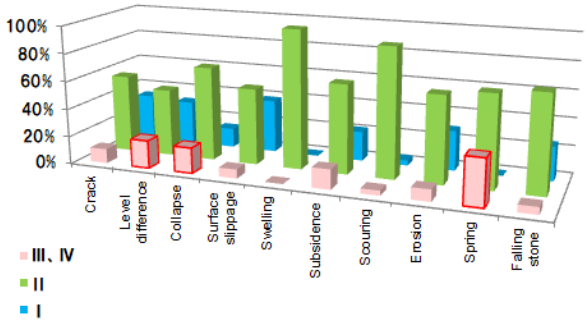

Fig. 6: Soundness judgement for each type of deformation (Cuts)

4. Conclusion

This paper summarized the results of the specified earthwork inspection for two years on directly managed national highways. Although the Inspection Guidelines provide that soundness diagnosis should be conducted based on the identification of deformation, there is also the issue that diagnosis is not directly related to the required performance of the road earthwork structure. We will continue to accumulate inspection results, analyze the facilities and points to focus on in the inspection, and study ways to improve the reliability of the inspection, including the relation to the required performance.

☞See the following for details.

1) Guidelines for Inspection of Road Earthwork Structures (Aug. 2017)
http://210.248.150.32/road/sisaku/yobohozen/tenken/ty_h2908.pdf

Efforts to Estimate and Provide Information on Damage to Infrastructure Facilities Immediately After an Earthquake

(Research period: FY1992-)

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key words: disaster prevention / mitigation, initial response, spectral analysis information

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and other organizations that manage public infrastructure need to grasp the status of their facilities in the event of an earthquake, and promptly conduct inspections of the facilities under their control. However, when a disaster impacts a wide area, as in the case of the 2011 Tohoku Earthquake off the Pacific Coast , or when an earthquake occurs at night, as in the case of the 2016 Kumamoto Earthquake, it may take several hours or more to grasp the state of damage.

NILIM has been continuously conducting activities to estimate damage to infrastructure using seismic observation records and provide the information obtained, in order to support disaster response in the information vacuum immediately after the occurrence of an earthquake. This paper introduces the transition and current status of these activities.

2. Development of a "Real-time Earthquake Damage Estimation System" (from 1992)

At the time of the 1995 Southern Hyogo Earthquake, which gave rise to the importance of organizational systems immediately after an earthquake, seismic intensity information was shifting from sensory perception at two or three meteorological offices in each prefecture to mechanical measurement using seismic intensity meters.

Accordingly, in order to support the decision-making process of road administrators responsible for the initial response in the information vacuum immediately after an earthquake, MLIT's seismograph network was established by networking about 700 locations along national highways and rivers nationwide under its direct control, and the "Real-time Earthquake Damage Estimation System," which uses earthquake observation information to predict liquefaction of the ground and damage to infrastructure such as bridges, was developed. Damage prediction is made about 15 minutes after an earthquake and made available to disaster response personnel online. Damage prediction methods for infrastructure are based on estimated seismic motion distribution and damage functions of infrastructure, and we are still working to improve the accuracy of prediction.

3. "Reference Earthquake Information" based on comparison with previous earthquakes (2009 - 2015)

Since the Technical Emergency Control FORCE (TEC-FORCE) was established in 2008 to support local governments in disaster areas in the event of a large-scale disaster, it has been necessary, at the time of an earthquake, to grasp the state of damage to not only facilities under the control of MLIT but also to infrastructure and housing in the affected areas, as well as human damage, in order to consider the scale of the support system.

Accordingly, we created a database of various types of information on earthquakes that have caused damage in recent years (seismic observation data and numerical information on the distribution of seismic motions and damage) and established a system to extract from the database earthquakes (reference earthquakes) with similar distribution and maximum values of SI values and regional characteristics (urban areas, mountainous areas, etc.) observed and collected by the seismograph network, and then provided the information obtained to the relevant departments of MLIT as "Reference Earthquake Information" (**Fig.1**). Thus, having this reference earthquake information has made it easier to imagine the extent of damage and the scale of the disaster response.

Then, we automated the data collection and information comparison, and improved the accuracy of the estimated seismic motion distribution by adding the observation records of K-NET of the National Research Institute for Earth Science and Disaster Resilience (NIED), which consists of strong-motion seismographs installed in about 1,000 locations nationwide, to the observation records of the seismograph network.

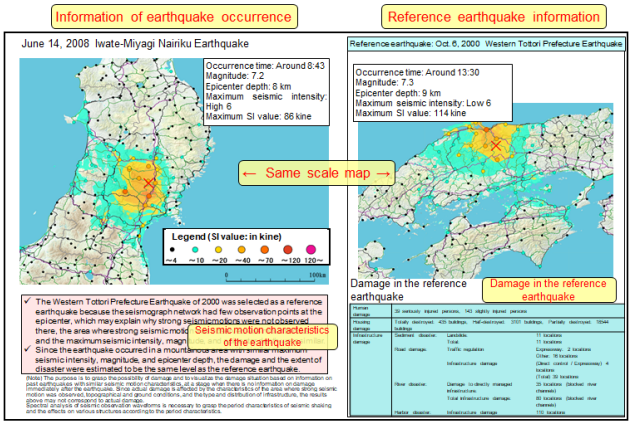

Fig. 1: Reference earthquake information

4. "Spectral analysis information" by comparison with damage occurrence lines (2009-)

The reference earthquake information cites the state of damage caused by previous earthquakes. However, in the case of unprecedented widespread earthquake, such as the 2011 Tohoku Earthquake off the Pacific Coast, there are cases where there are no existing earthquakes to refer to in the database. In addition, even if the SI value distribution was presented as a seismic motion index that correlates relatively well with the degree of damage to infrastructure, it is an index with which civil engineers are not familiar, so a more engineering-oriented evaluation method was required.

Therefore, at the time of an earthquake, we are distributing "Spectral analysis information" to estimate the scale of damage by comparing an acceleration response spectrum (**Fig. 2**, colored line) having a natural period of 1 to 2 seconds, which is considered to be highly correlated with damage to infrastructure and medium and low-rise buildings, with the "damage occurrence line" (**Fig. 2**, black line). In Fig. 2, since the acceleration response spectrum of the relevant earthquake is below the damage occurrence line, the damage is estimated to be very limited.

In order to distribute the spectral analysis information, staff had been downloading the data and creating the spectral analysis information themselves until 2016. However, in the 2016 Kumamoto Earthquake, it took 3-4 hours after the earthquake for the spectral analysis information to be distributed partly because it occurred at night, so the information could not be utilized during the information vacuum immediately after the earthquake.

Accordingly, we built a system in 2017, which automatically obtains information necessary for spectral analysis information and automatically distributes it within approx. 15 minutes after an earthquake.

By reviewing the spectral analysis information, the extent of damage to infrastructure can be immediately estimated. Meanwhile, since spectral analysis information is considered to predict damage at the seismic motion observation points, we are making improvements in order to create spectral analysis information that takes into account the records of observation points of the Japan Meteorological Agency, from the viewpoint of observation density improvement.

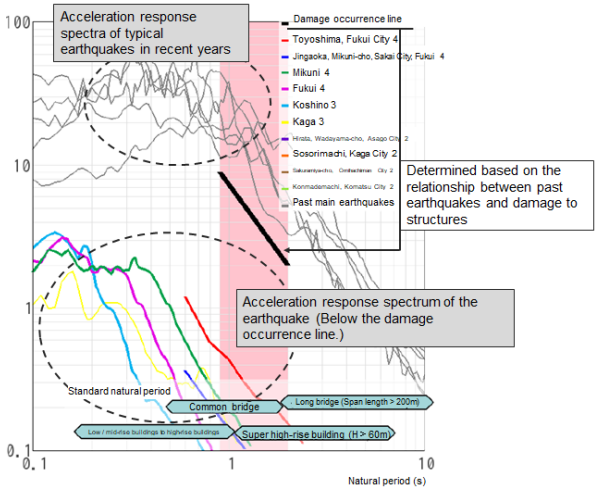

Fig. 2: Spectral analysis information (extract)

5. Conclusion

At present, spectral analysis information is distributed to disaster response personnel at Regional Development Bureaus, etc., and is used as reference information during information vacuums, such as at night. However, the 2021 earthquake off the coast of Fukushima Prefecture exposed the problem that it would take time to obtain the information necessary to create spectral analysis information. We will continue to address these issues as needed and improve the accuracy of our damage prediction.

In addition, as an incidental benefit of distributing spectral analysis information, it will also provide an opportunity for disaster response personnel to think about what an acceleration response spectrum, an engineering index, is. We will continue to work on the distribution of information and promotion of understanding, as the benefits should be important.

☞See the following for details.

1) "Automatic distribution of seismic motion analysis information to reduce the information vacuum immediately after an earthquake," KATAOKA Shojiro, NAKAO Yoshihiro, ISHII Yosuke, OMICHI Kazuho, Proceedings of the 39 JSCE Earthquake Engineering Symposium, p. 8, Oct. 2019

Development of technology to quickly evaluate the robustness of core facilities damaged by an earthquake

(Research period: FY 2019–2021)

ISHIHARA Tadashi (Ph.D. in Engineering), Head, Evaluation System Division, Building Department, KIKITSU Hitomitsu (Ph.D. in Environmental Science), Structural Standards Division, WAKIYAMA Yoshio (Ph.D. in Engineering), Head, Housing, Production Division, Housing Department

Keywords: Core building, robustness, judgment criteria

1. Introduction

Government buildings often become the core base of disaster management to facilitate quick restoration from earthquake damage. In the past earthquakes, it took too long for experts to check whether government buildings were robust enough for people to enter (Figure-1), which slowed down restoration processes.

This study aims to present technical references about structures and non-structural members of buildings that are necessary for building administrators to judge whether people can enter the building.

Figure 1: Robustness is unclear immediately after an earthquake

2. Contents of the study

This study aims to solve the following two points.

a) The use of devices, such as the accelerometer, is a possible option in quickly judging the robustness of a building structure immediately after an earthquake without depending on experts. Yet, there are no common engineering evaluation criteria to use.

b) Technical references used in the visual inspection of the robustness of non-structural members immediately after an earthquake are not yet available.

The following studies are going to be implemented to address these issues.

(i) The engineering criteria for structural robustness evaluation using accelerometers (Figure 2) will be presented by the structural analysis of the building model. Technical precautions are also organized for practical applications.

(ii) Visual inspection guidelines for non-structural members are prepared (including the evaluation of damages on suspended ceiling materials [Figure 3]).

In (i), standards are going to be prepared for the robustness judgment of a structure by using acceleration sensors installed in the structure to numerically capture properties that go through rapid changes during an earthquake. Specifically, the robustness of a structure is estimated based on level of changes in the natural period of a structure during an earthquake. In (ii), current situations of earthquake damage evaluations of non-structural members are organized. Then, standards for robustness judgment are prepared after conducting experiments on the evaluation of damage in suspended ceilings where there is a shortage of knowledge and insights.

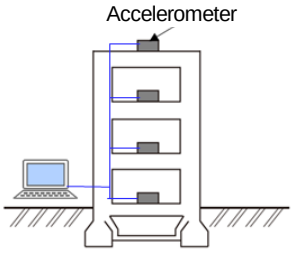

Figure 2: Practical application of the robustness judgment system in a building

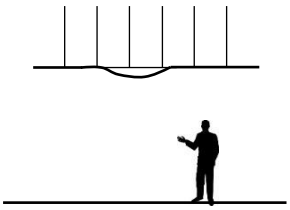

Figure 3: Damage to a suspended ceiling

3. Examinations in FY 2020

Regarding (i), the relationship between the residual performance of the entire building and the degree of change in the natural period was grasped by simulation as in the previous fiscal year, and the judgment criteria were examined. Regarding (ii), the relationship between dislodgement and deflection of the joint fittings (clips) of the base of the suspended ceiling was ascertained through experiments.

Development of technologies that contribute to the regeneration and strengthening of cities through the rationalization of structural regulations related to buildings and the ground

(Research period: FY 2020–2023)

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NAKAZAWA Atsushi, Head, SAKASHITA Masanobu (Ph.D. in Engineering), Chief researcher, Standards and Accreditation System Division
KIKITSU Hitomitsu (Ph.D. in Environmental Science), Head, KASHIWA Hisatoshi (Ph.D. in Engineering), Chief researcher, Structural Standards Division
TSUCHIYA Naoko (Ph.D. in Engineering), Chief researcher, Material and Component Standards Division
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Keywords: Existing pile, ground, structural standard

1. Introduction

About half of all non-residential buildings in Japan are more than 30 years old, and the number of cases where reconstruction is being considered is increasing. Amidst this growing momentum for urban renewal, it is necessary to develop rational structural regulations for buildings that address issues related to existing piles in order to promote the renewal of buildings while responding to diverse needs and to rapidly strengthen cities. The objective of this study is to develop a safe and rational use of sites that have existing piles. In FY 2020, in order to contribute to the development of a design method for pile foundations on the grounds of a site where existing piles have been removed, loading tests and response analyses were conducted to understand the effects of pile removal. Details of the development of technology related to the retaining wall of existing residential sites conducted in this study are reported separately.

2. Outline of technological development

(1) Loading test to evaluate the effect of removing existing piles from the ground

On the grounds of a site with existing piles, the existing piles were removed and backfilled, followed by the installation of new piles, and vertical and horizontal loading tests were conducted (photo). The experimental data will be used to demonstrate how changes in the ground characteristics of the site caused by the removal of piles would affect newly installed piles at the site, thereby moving on to the development of a rational earthquake resistant design method for pile foundations and superstructures that includes the handling of existing piles.

(2) Analysis to evaluate the effect of the removal of existing piles and installation of new piles on the superstructure of buildings

In order to understand the effects of pile removal and new installation, the study used numerical analyses to investigate the effect of ground loosening and other conditions caused by the removal of existing piles and new installation on the stress and seismic response performance of the superstructure of a newly constructed building (Figure).

Photo: Vertical load test (rapid loading method)

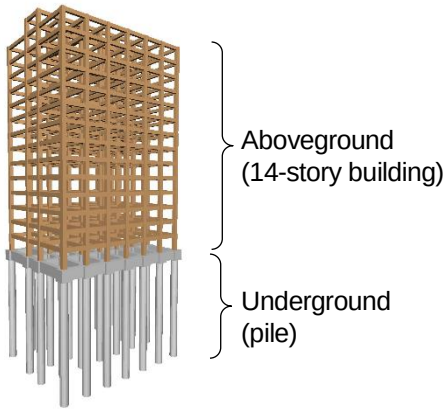

Figure: Subject of study (a 14-story model integrated with piles)

3. Future plans

Technological development will be conducted while

continuing the collaboration with the relevant departments of the Ministry of Land, Infrastructure, Transport and Tourism, the Building Research Institute, academic experts, and related organizations, such as industry associations related to building foundations and geotechnical engineering.

Development of a new performance evaluation index and evaluation program for improving the fire control performance of non-residential buildings

(Research period: FY 2020–2022)

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Keywords: Non-residential building, fire control performance, function maintenance performance, performance evaluation index

1. Introduction

The fire control performance required by the Building Standards Act for buildings is limited to the minimum level deemed necessary from the perspective of protecting life. Therefore, compliance with the legal standards does not necessarily guarantee the prevention of major fire damage. In recent years, there have been some cases of extensive fire damage in buildings that have complied with the standards, causing the buildings to become unusable for a long period of time or requiring reconstruction. Under such circumstances, it is believed that there is a certain level of demand for securing fire control performance that exceeds the minimum level. However, especially for non-residential buildings, evaluation frameworks, such as performance index systems, remain yet to be developed.

Therefore, this study focuses on non-residential buildings and examines a framework for the quantitative evaluation of their performance to maintain functions after fire damage.

2. Function maintenance performance

This paper defines function continuity performance as the percentage of the total length of time during which the functions provided by a building during its service period are maintained after a fire that reduces the building performance (Figure-1).

$$R = \int_{t_0}^{t_L} \frac{F(t)}{t_L - t_0} dt \quad (1)$$

Here, $F(t)$ is the function ratio of the building, t_0 the point of the start of the analysis, and t_L the end period of the analysis. The functionality $F(t)$ is a variable that represents the condition of the building as a whole. Meanwhile, fires that occur within a building are considered to spread independently in each of the fire compartments that make up the building. Therefore, the functionality is going to be evaluated in units of fire compartment, and the functionality $F(t)$ for the entire building is calculated as follows.

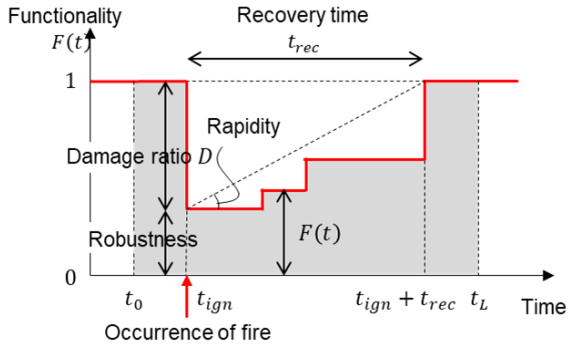

Figure 1: Function maintenance performance of a building with fire damage

$$F(t) = \frac{\sum_{i=1}^{N} w_i \cdot f_i(t)}{N} \quad (2a)$$

$$f_i = \begin{cases} 1 & (t < t_{ign}) \\ 0 & (t_{ign} \le t \le t_{ign} + t_{rec,i}) \\ 1 & (t_{ign} + t_{rec,i} < t) \end{cases} \quad (2b)$$

Here, N represents the number of fire compartments within the building, i the identifier of the fire compartments, w_i weighting factor ($\sum_{i=1}^{N} w_i = N$) according to the functional importance of the fire compartment, $f_i(t)$ the functionality of a fire compartment i, t_{ign} the time of the occurrence of fire, and $t_{rec,i}$ the recovery time.

Incidentally, buildings are made up of various components with different resistance to the heat of fire. Even within the same fire compartment, the degree of damage and the process of restoration work in case of damage vary greatly depending on the component. Thus, the components of a building are classified into structural component S, nonstructural component NS, equipment E, and stored material F. Since the restoration of all these components is a prerequisite for the fire

compartment to be usable, the recovery time $t_{rec,i}$ of the fire compartment i is expressed as follows.

$$t_{rec,i} = max\{\sum_x t_{rec,i(x)},\ t_{rec(R),i}\}\ (x = S, NS, E, F) \quad (3)$$

Here, $t_{rec,i(x)}$ is the recovery time of the component x $(x = S, NS,\ E, F)$ of the fire compartment i. Yet, to make it simpler, this study assumes that the restoration work at individual sections cannot proceed simultaneously, and that the work on the next section can be started when the work on one section is completed. Also, $t_{rec(R),i}$ is the time required for other fire compartments to be restored, which is a prerequisite for a fire compartment i to be operational.

The evaluation of a recovery time $t_{rec,i}$ of a fire compartment requires the understanding of what type of fire will start in a building and then the evaluation of the area and the extent of the damage. However, since the nature of the fire occurring in the fire compartment cannot be uniquely determined because of the influence of various uncertain factors, the following probabilistic approach is adopted here to obtain $t_{rec,i(x)}$.

$$t_{rec,i(x)} = \int_t t(D_{i(x)}) \cdot p(D_{i(x)}|t^*_{fire,i}) \cdot p(t^*_{fire,i})\, dt^*_{fire} \quad (4)$$

Here, t^*_{fire} is the equivalent fire duration, D the fire damage rate, and $t(D)$ the recovery time if the degree of damage is D.

3. Case study

To summarize the characteristics of the above method, a case study was conducted on the steel-framed, three-story office building with a total floor area of 3,432 m^2 as shown in Figure 2. Here, we focused on the three items shown in the table (fire resistance period t_R (RS), installation of sprinkler system (SP), and sectioning of room D (C)) and examined the change in functional continuity performance according to the combination of these measures. However, the analysis period $t_L - t_0$ required to determine the functional continuity performance was fixed at one year after the occurrence of the fire. For simplicity, it was assumed that the entire building becomes closed when restoration work is being done in any of the fire compartment after the fire.

Figure 3 shows the outcome of the calculation. The basic condition O means that a fire resistance time t_R is 60 minutes for the main structure with no sprinkler system, and no compartmentalization for room D. In this case, the restoration time t_{rec} was 82.6 days, and the function continuity performance 0.774. In contrast, for conditions RS, C, and SP, where one of the three items was improved, the recovery time t_{rec} ranged from 49.4 to 70.3 days (reduction rate against condition O was 14.9 to 40.2%), and the functional continuity performance ranged from 0.807 to 0.865 (increase rate against condition O was 4.3 to 11.8%). Among the conditions in which multiple items were improved, RS + C + SP was the condition in which the functional continuity performance improved the most, with a recovery time t_{rec} of 29.9 days (reduction rate 63.8%) and functional continuity performance of 0.918 (increase rate 18.6%).

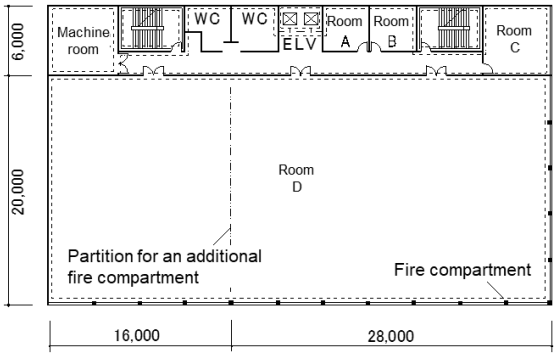

Figure 2: Standard floor plan of the subject building

Table: Conditions of calculation

Condition	Item		Basic proposal (O)	Improved proposal
RS	Fire resistance time t_R	Main structure	60 min	90 min
		Exterior window	20 min	
SP	Sprinkler system		Available	Not available
C	Number of fire compartment in room D		1	2

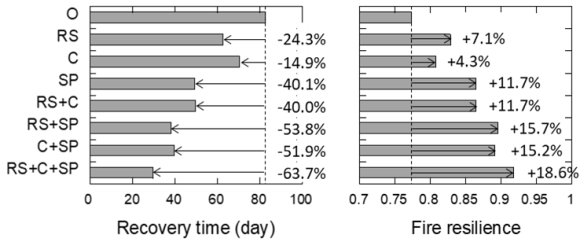

Figure 3: Result of calculating restoration time and function continuity performance

4. Summary

Since the impact of damage to equipment E and stored material F is considered particularly significant for the continuation of functions, future studies will be conducted to enable appropriate assessments.

Research for Improving the Wind Resistance of Tile Roofs

(Research period: FY 2019–2020)

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Keywords: Tile roof, Typhoon Faxai

1. Introduction

The strong winds of Typhoon Faxai (Typhoon no. 15) that hit the Kanto region including the Boso Peninsula in September 2019 caused damage to the roofs of many houses, especially in Chiba Prefecture, and the vulnerability of tile roofs became apparent. Based on the damage, the NILIM analyzed the damage to tile roofs in collaboration with academic experts and tile industry organizations as part of the Review Committee for Measures to Protect Buildings from Strong Winds in Light of the 2019 Boso Peninsula Typhoon (chair: Yasushi Uematsu, dean of the National Institute of Technology, Akita College). In the 2019 project conducted under the supplementary budget, the "Research for Improving the Wind Resistance of Exterior Materials and Roofs of Buildings," the validity of the current Guideline for the Standard Design and Construction of Tile Roofs (hereinafter referred to as "the Guideline"; Fig. 1) was verified, and revisions were made to reflect the latest findings and research results. The section below introduces the outline of the verification.

2. Outline of technological development

(1) Analysis of damage to tile roofs caused by the 2019 Boso Peninsula Typhoon (Faxai)

To examine the necessity of improving measures against strong winds in the future, conditions of damage, and their factors were analyzed based on the results of surveys that examined damage to tile roofs caused by the 2019 Boso Peninsula typhoon (Faxai). A large number of tile roofs installed using methods that did not follow the Guideline were found to fall off or lift up from wind pressure. This damage has been particularly common in flat areas of the roof, excluding the ridge, eaves, and verge sections, which were not subject to fastening according to the notified standards. On the other hand, the analysis found that tile roofs installed according to the Guideline suffered very little damage from falling off and lifting due to wind pressure, although damage from flying objects were observed. However, for some tile roofs in coastal areas, damage due to wind pressure was observed even when they had been installed according to the Guideline.

Based on the results of this analysis, the notified standard for the structural method of roofing materials, etc., the 1971 Notification of the Ministry of Construction No. 109, was partially revised in December 2020.

(2) Verification of the current guideline on tile roofs

In order to ensure that the Guideline could complement the revised notified standard, the verification of the Guideline was carried out in cooperation and coordination with tile industry organizations, and the revision of the current version was conducted. In this verification, the standard construction methods for tile roofs were reorganized, and the standard specifications were developed through loading tests etc. as shown in Figure 2. In addition, a loading test method for evaluating the allowable bearing capacity was proposed, and recommended specifications that could be adopted in coastal areas to induce higher wind resistance performance and the concept of wind resistance diagnosis and repair of existing tile roofs were newly presented.

Figure 1: Standard design and installation guideline for roof tiles

Figure 2: Example of load test on a tile roof (F-shaped tile)

3. Future plans

In the future, the use of tile roofs that comply with the revised notified standard will be promoted through the publication and dissemination of the revised guideline reflecting the results of this study.

☞For more information:

Website of Structural Standards Division, Building Department (in Japanese)
http://www.nilim.go.jp/lab/hcg/taifu_hp/taifu.htm

Development of a building deterioration monitoring system using a digital image correlation method

(Research period: FY 2019–2020)

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Keywords: Digital image correlation method, deterioration detection, crack, lifted tile

1. Introduction

Digital image correlation (DIC) is an image measurement method that calculates the displacement and distortion of an object from the difference in images taken before and after the formation of the deformation of the object to be measured. In this method, a common way is to apply a random pattern on the surface of an object to ensure measurement accuracy. Yet, it was found that it was possible to detect cracks using DIC by using exterior patterns of a building, such as exterior tiles.[1] This study attempted to develop a lower-cost long-term deterioration monitoring system for buildings by applying two-dimensional DIC that can use monocular camera images.

2. Outline of the long-term deterioration monitoring system with DIC

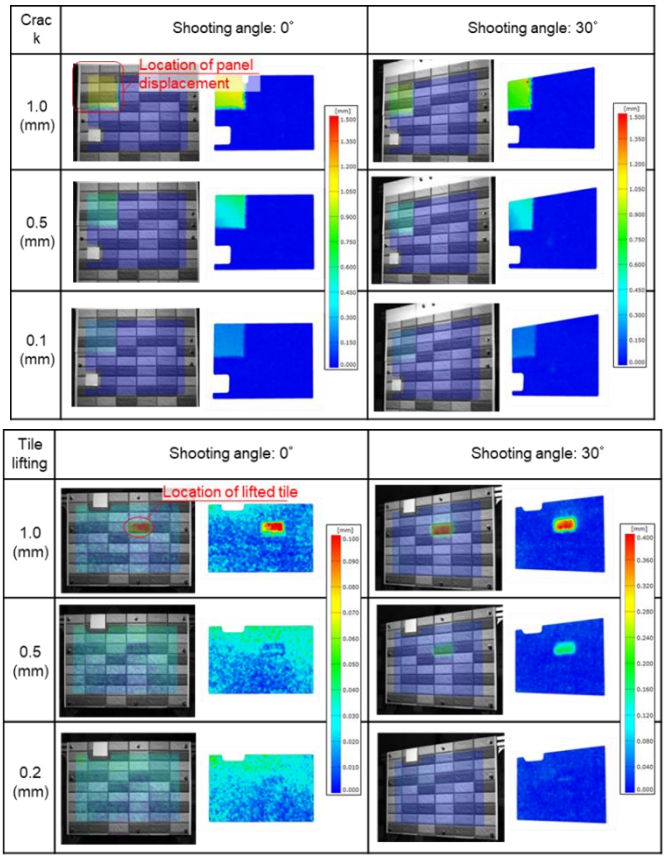
Since two-dimensional DIC requires images of the same position and angle of view taken before and after deterioration, two images taken before and after deterioration were selected for analysis, assuming they were captured continuously with a fixed camera. The camera used in this study had a pixel count of eight megapixels, a shooting distance of one meter, and shooting angles from the front and at 30 degrees.

3. Evaluation by simulated test piece

An example of evaluation results for cracks and tile lifting using simulated test piece is shown below. Cracks are reproduced by cutting and shifting part of the panel. The results show that cracks can be detected down to 0.1 mm and tile lifting down to 0.5 mm when the shooting angle is set to 30°.

In the future, using commercially available security cameras, a system is going to be constructed to send an alert and an image by e-mail when a predetermined threshold of deterioration is exceeded. Also, the possibility of actually using such system in the society is going to be explored.

Table: Example of evaluation results of cracks (top) and tile lifting (bottom) by DIC



☞For more information:

1) Fundamental experiment on the possibility of the practical use of a damage detection system for buildings using digital image correction method, the Architectural Institute of Japan: Summaries of Technical Papers of Annual Meeting, Information System Technology, pp. 181-182, July 2019

2) Fundamental experiment on the possibility of the practical use of a long-term deterioration monitoring system for buildings using digital image correction method (1 and 2), the Architectural Institute of Japan: Summaries of Technical Papers of Annual Meeting, Material Construction, pp. 1037-1040, September 2020

Development of technology for seismic retrofitting of retaining walls in old housing

(Research period: FY 2020–2023)

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Keywords: Retaining walls in housing lot, aging, anti-seismic reinforcement

1. Introduction

Most of the land in Japan is mountainous, and cities have been formed mainly on the limited area of the plains. However, with the increase in population and the resulting progress in urbanization, residential areas have been built on the slopes of hills (Photo 1). In 1961, the Act on Regulation of Residential Land Development was enacted to prevent disasters caused by cliff collapses and landslides when building housing on the lots on slopes. As a result, it became possible to designate areas for regulating housing lots and land development work (as of April 2019, 1,024,140 hectares had been designated nationwide), and technical standards were established for retaining walls on housing lots.

However, in recent years, there have been many cases of aging residential retaining walls being damaged by earthquakes, and it has become important to implement seismic countermeasures in response. This paper introduces the outline of the research on seismic retrofitting of retaining walls in old housing, which started in 2020 and is scheduled to last for four years.

Photo 1: Example of a hilly urban area (Nagasaki City)

2. Situations surrounding retaining walls on housing lots

There are various types of retaining walls in housing lots, and according to the *Manual for the Determination of Aging of Retaining Walls in Housing Lots* published by the City Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, a risk assessment should be made for the following types of retaining walls: masonry, stacked concrete blocks, gravity concrete, reinforced concrete, empty masonry, added layer, double-stage, and with overhanging slabs (Photo 2). It should be noted that the manual is only intended to determine the degree of danger associated with aging and not to evaluate earthquake resistance itself.

The Great Hanshin Earthquake of 1995 led to the establishment of a risk assessment system for damaged housing to mitigate and reduce secondary disasters. The system takes into account damage to retaining walls on the housing lots. During the 2011 off the Pacific Coast of Tohoku Earthquake, 5,728 residential lots were classified as dangerous or requiring caution in Sendai City. In addition, more than 10,000 retaining walls collapsed during the 2016 Kumamoto earthquake, mainly due to existing unqualified retaining walls, which made it an issue not only to address the aging of retaining walls in residential areas but also to improve earthquake resistance.

(a) Brick masonry (b) Concrete block masonry

(c) Empty brick masonry (d) Reinforced concrete retaining wall

Photo 2: Example of retaining walls in housing lot

3. Outline of the study

With the need to improve the seismic resistance of retaining walls on housing lots, the study was designed to examine seismic reinforcement methods, block piled retaining walls and brick piled retaining walls, and to deal with aging retaining walls that were difficult to reconstruct.

(1) Organizing damage patterns and seismic

reinforcement methods

Based on past damage that occurred during disasters, such as the Kumamoto earthquake, the type of damage to retaining walls in residential areas is classified by extracting the factors that affect seismic performance (figure), and the seismic reinforcement methods for retaining walls in housing lots are organized according to the classified damage types.

(2) Identifying situations of aging

Cases that require identification of the actual situation are selected, and evaluation tests of seismic performance are conducted.

(3) Verifying the effect of anti-seismic reinforcement

Based on the experimental results, an experimental model is designed and created for aging retaining walls in housing lots and for verifying the effectiveness of anti-seismic reinforcement, and the effectiveness of the anti-seismic reinforcement is verified through model vibration tests. In addition, a model for evaluating the reinforcement effect of retaining walls in housing lots will be developed through simulation analyses.

(4) Examining performance evaluation method

Based on the results of model vibration tests and simulation analyses, a sensitivity analysis is conducted, simple evaluation methods are discussed, and indicators of anti-seismic retrofit effectiveness and design examples to achieve target performance are presented.

Based on the results, an experimental model is designed and created for aging retaining walls in housing lots and for verifying the effectiveness of anti-seismic reinforcement, and the effectiveness of the anti-seismic reinforcement is verified through simulated vibration tests. In addition, a model for evaluating the reinforcement effect of retaining walls in housing lots will be developed through simulation analyses.

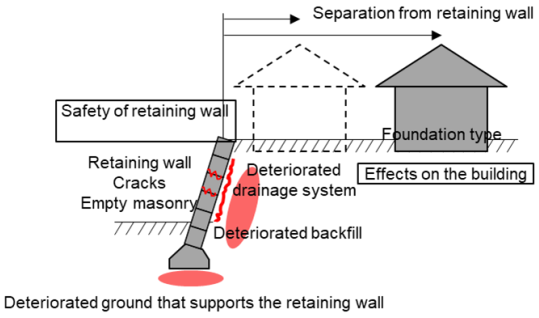

Figure: An example of items to be considered upon implementing the anti-seismic performance evaluation of retaining walls

4. Conducting full-scale experiments on retaining walls in existing housing lots

Load tests were conducted to measure the seismic performance of a retaining wall in a housing lot that was constructed nearly 50 years ago. The load was applied by cutting the retaining wall of the housing lot at a width of two meters and applying pressure with a jack from behind (Photos 3 and 4).

The results of the experiment are currently being analyzed, but it is assumed that the performance of the retaining wall was high from the beginning. Also, since there was almost no deterioration after a long period of time after installation, it was confirmed that the wall maintained very high seismic performance.

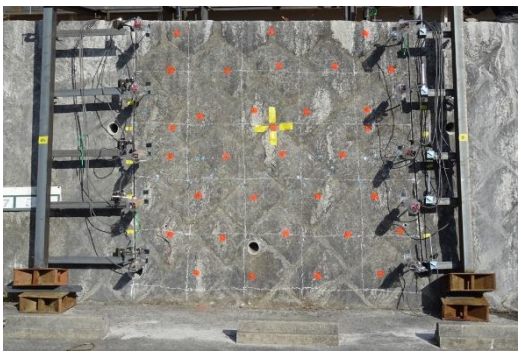

Photo 3: Retaining wall (brick masonry) with which the load test was conducted

Photo 4: Loading system at the back of the retaining wall

5. Conclusion

Based on the research plan, experiments and simulation analysis will be conducted to verify the effect of anti-seismic reinforcement of old retaining walls on housing lots, and design examples for seismic reinforcement will be examined.

☞For more information:

1) Outline of “Development of Technologies that Contribute to the Regeneration and Strengthening of Cities through the Rationalization of Structural Regulations Related to Buildings and the Ground”
http://www.nilim.go.jp/lab/hcg/kisojiban_hp/kisojiban.htm

Attribute Information Assignment to the Point Group Data of Machinery and Equipment and Construction of 3D Modeling Method

(Research period: FY2019 to FY2020)

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key words: machinery and equipment, point group data, CIM

1. Introduction

With regard to the reduction of creation effort, which is an issue in CIM (Construction Information Modeling/Management) for civil engineering machinery and equipment, this research has specifically indicated, using the level of detail as a scale, "how much creation effort should be made" based on the assumption of applications in each stage from the planning and design stage to construction and maintenance.[1)] However, if you want to use a 3D model for existing machinery / equipment, you have to model it from scratch if there is no existing model, but the reality is that there is little incentive to do so because much labor will be required.

At present, point group data using laser scanners is used in the finished-shape management of ICT-applied construction projects, and point group data is also utilized in the maintenance of private machinery plants. Since the technological progress of laser scanners has enabled easy acquisition of highly accurate point group data, this research proposes a method to assign attribute information to point group data for maintenance and a method to construct a 3D model based on point group data.

2. Attribute assignment to point group data

For roads, the "Attribute Management Specifications for Point Group Data [Road Part] (Draft)" (the "Standard Specifications") has been proposed and published to serve as the foundation for the distribution infrastructure of 3D data utilizing the accumulated point group data. [2)]

The Standard Specifications define point group metadata (text data that defines how the data was measured, location, accuracy, etc.), area data (text data that defines the shape of external area (location and range) where any structure, etc. exists), and file data that manages multiple area data. Each definition file is in XML format, and the point group editor software that can read this file can recognize the structures included in the point group data and assign the necessary attribute information without processing the point group data itself. This research, focused on the point group data of drainage pump stations (**Fig. 1**), studied a method to specify the area of main equipment, assign and manage necessary attribute information, using 3D Point Studio[3)], point group editor software that conforms to the Standard Specifications.

Fig. 1: Point group data of drainage pump stations

In designating the areas of main equipment such as main motor and reduction gear, the area data file was constructed with reference to the method of designating "features" in the Standard Specifications. As a result, it was possible to specify the area as a simple cube as shown in **Fig.2**, and in 3D Point Studio, it was also possible to display the specified area separately and assign attribute information as shown in **Fig. 3**.

Attribute information that complies with the "CIM Introduction Guideline (Draft) Part 7: Machinery and Equipment" (MLIT) could be assigned to the area data file for each of main equipment. However, the current software has some room for improvement in usability, such as the inability to specify areas according to complex shapes such as piping.

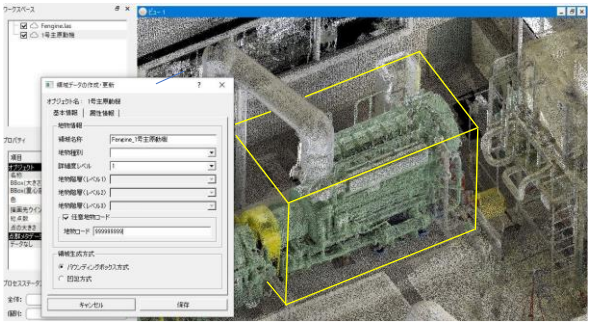

Fig.2: Designation of the area of main motor

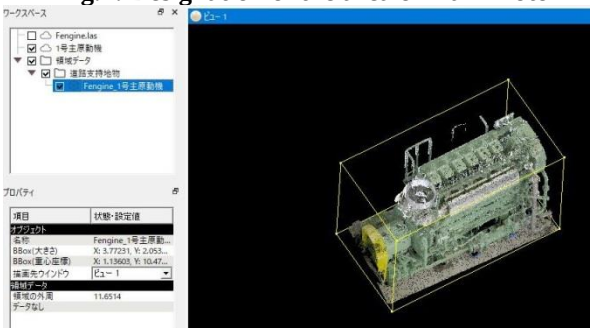

Fig. 3: Separate display of areas (main motor)

3. 3D modeling of point group data

3D modeling of point group data is commonly used in the private plant management and shipbuilding industry, and multiple packages of dedicated point group editor software have been developed. The key to software selection is the modeling of piping and the generation of surfaces (especially complex shapes such as motors and reduction gears), and there is a difference in effort and precision depending on the functions of the software used, especially when creating models with a detail level of 400 that can be used for maintenance. **Fig. 4** shows an example for creating a 3D model with a detail level of 400 based on point group data shown in **Fig. 1**. In this example, main motors and reduction gears with a detail level of 400 were made using the software that can model parts from point groups.

On the other hand, we also tried to use a point group editor that can automatically output surfaces (polygons) from point group data. Although it is advantageous in terms of labor, there are some characteristics, such as necessity for modification of automatically generated surface and difficulty in modeling at the component level. For piping, it was found that although many software programs can automatically generate piping materials and valves, there are differences in the creation method and the accuracy of models. Accordingly, in modeling, it is necessary not only to clarify the purpose and scope of modeling and then determine the level of detail, but also to evaluate the effort and the accuracy of model to determine the point group editor software to be used.

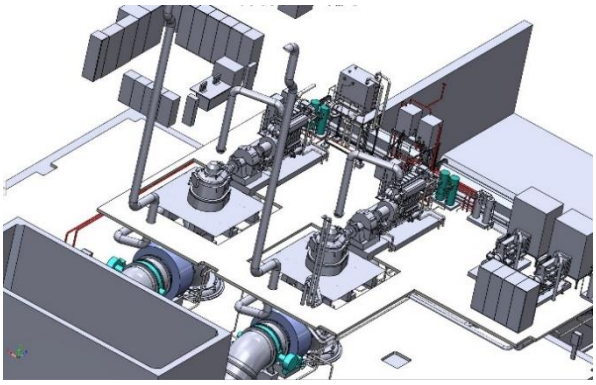

Fig. 4: Example of 3D modeling using point group data

4. Utilization method

Since the point group data includes color information, piping can be easily identified and the situation close to actual situation can be grasped. By assigning and managing attribute information, it can be used widely for everyday facility management operations.

The 3D model created from the point group data can easily eliminate deviations from the site that may occur in 2D drawings, and depending on the method of creation, the model can be deformed, which is a great advantage in maintenance and design for renewal of existing facilities, construction planning, etc.

5. Conclusion

The results of this research project and issues related to software will be compiled and disseminated to facility managers and related parties in industry and academia.

☞See the following for details.

1) Points of attention in creating a mechanical equipment CIM model (by level of detail)
http://www.nilim.go.jp/lab/pfg/bunya/mecha_cim/mecha_cim.html

2) Attribute management specifications of point group data [Road Part] (draft)
http://www.nilim.go.jp/lab/qbg/standards/standards.html#road-data

3) 3D Point Studio Official homepage
http://www.pointstudio.jp/

Technology for Automatic 3D Model Construction using 2D CAD Data

(Research period: FY2018 to FY2020)

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key words: *BIM/CIM, 3D model, automatic construction*

1. Introduction

NILIM has been promoting the research on BIM/CIM (Building / Construction Information Modeling, Management), which is an initiative to accumulate, link, and share information throughout the construction production process including survey, design, construction, and maintenance. BIM/CIM aims to improve productivity through the use of 3D data. However, the use of BIM/CIM in maintenance has not progressed, and one of the reasons for this is the difficulty to create 3D models of existing structures due to the need for highly skilled workers and the large creation cost. To solve these issues, NILIM is developing a technology to create 3D models of existing structures in a labor-saving and low-cost manner. This paper reports on the automatic 3D model construction technology using 2D CAD data in the "Research on 3D model construction technology by AI using 2D CAD data," which was conducted as part of this technology development in the form of commissioned research to RIKEN Center for Computational Science.

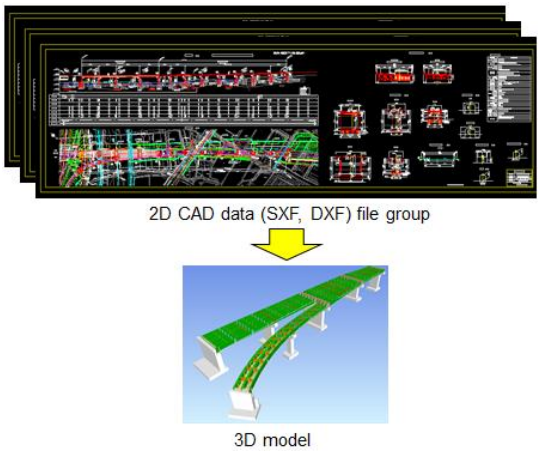
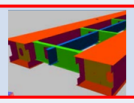
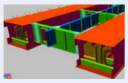


Fig. 1: Technology for construction from 2D CAD data

2. Detail level required for maintenance

The 3D model used for maintenance should be a model that accurately represents the external shape of main components, assuming that the 3D model will be used as a platform for integrated data management, inspection planning, etc. [2]. Therefore, this research will develop a technique to create 3D models with a target of detail level 300 as shown in the **Table**.

Table: Definition of detail levels for 3D models

Detail level	Common definition	Sample (bridge)
100	A model representing the location of the object with symbols, lines, or simple shapes.	
200	A model representing the structural form of the object. Representation of cuts and embankments in standard cross-section, or representation to the extent that the standard cross-section shown in the general drawing of each structure is created by sweeping it in the target range.	
300	A model that accurately represents the external shape of the object, excluding the detailed structure of accessories, etc. and joint structures.	
400	In addition to the detail level of 300, this model accurately represents the object including accessories, detailed structures such as joint structure, and bar arrangement.	
500	A model that accurately represents the real shape of the object.	

3. Automatic 3D model construction technology

The technology for automatic 3D model construction developed in this research is called "Top-down processing method," which automatically selects a template that is compatible with the structure from the 2D CAD data and automatically constructs a 3D model by setting parameters that indicate the shape, such as dimensions, to this template. The selection of template and the setting of parameters are conducted automatically by the production system, which is a kind of artificial intelligence (**Fig. 2**).

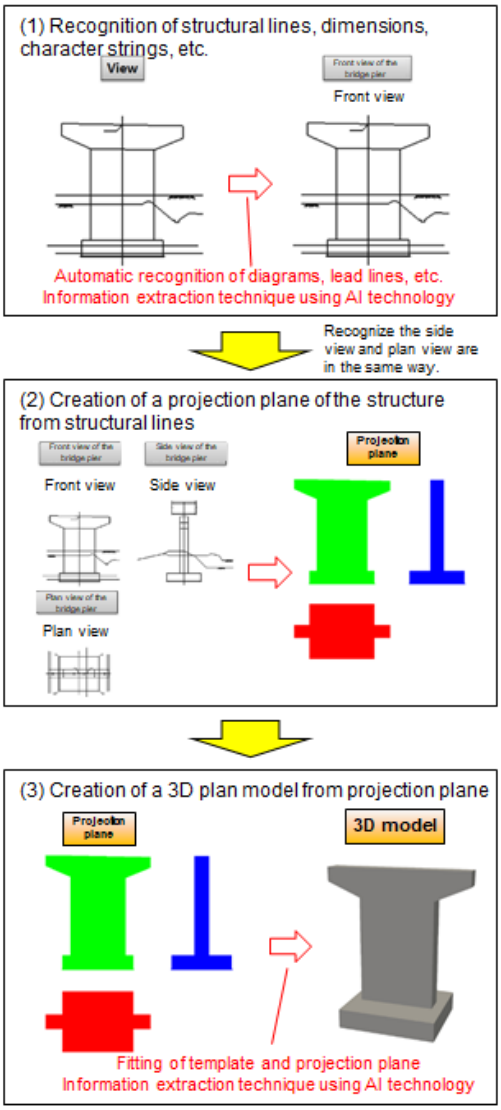


Fig. 2: Automatic 3D model construction procedure (bridge pier)

In this method, the structure and shape are the same to some extent.
This method is also highly compatible with civil engineering structures, and enables the modeling of the entire civil engineering structure on the whole, although some complex structures such as dams cannot be modeled.
The same technology can also be used to create 3D models of internal structures such as reinforcing bars.

4. Demonstration test on existing bridges

A 3D model of the substructure of the Shin-Arakawa Bridge managed by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), excluding the pile foundation, was created using the 3D model automatic construction technology.
Fig. 3 shows the 3D model created by the automatic construction technology and the 3D model created by manual input for comparison. As a result of comparing the 3D models in **Fig. 3**, we confirmed that the two models generally overlapped and could be reproduced as 3D models.

5. Conclusion

In this research, we developed a basic technology to automatically create 3D models with AI by reading information from 2D CAD data, and accurately created a 3D model of the external shape for the actual bridge substructure.
In order to make this technology available to more people, we plan to make it available from the National Land Transport Data Platform.

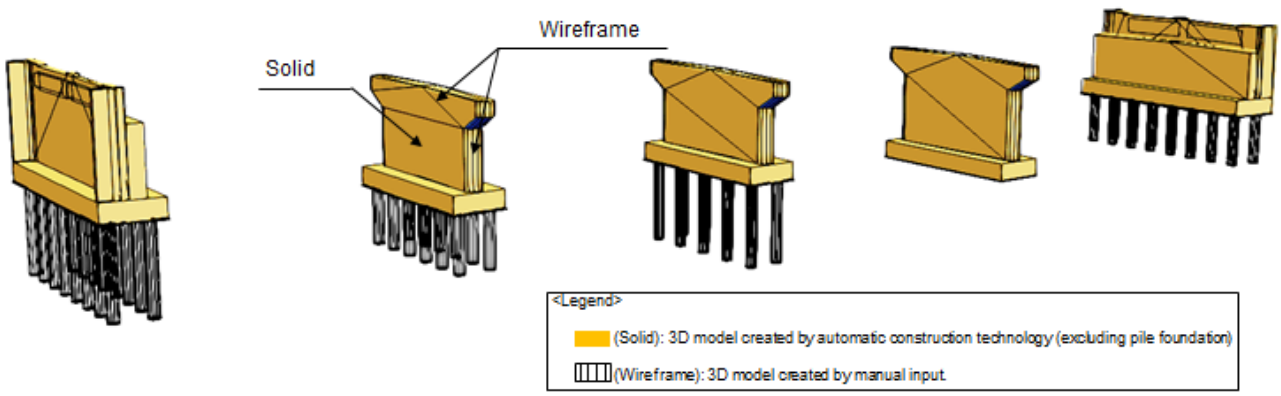


Fig. 3: Result of automatic 3D model construction for existing bridge

☞See the following for details.

1) Civil Engineering Journal, Nov., 2020, pp. 36-39
2) Civil Engineering Journal, Vol. 58, No. 4, pp. 20-23

Survey of local governments on their intentions to introduce new technologies (to shift to smart cities) to solve urban problems

(Research period: FY 2020–2022)

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SHINGAI Hiroyasu, Head, Urban Facilities Division, Urban Planning Department

Keywords: Smart city, urban problem, new technology, local government, intention survey

1. Introduction

Smart cities, which seek to solve urban problems through the use of new technologies, such as IoT, are expected to be the opportunity to practice Society 5.0 in the actual society. The theme of smart cities has expanded from energy conservation in the past to include transportation, lifestyle support, disaster prevention, crime prevention, tourism, and many other fields. Also, the new technologies expected to be utilized through technological innovation have also diversified.

The NILIM is systematically organizing new technologies that can be used to solve various urban problems, and is developing a prototype of a planning evaluation method to effectively use new technologies to solve major urban problems to support local governments in consideration of the direction of solutions to major urban problems through the use of new technologies, such as IoT (to shift to smart cities), in order to solve various urban problems.[1]

This paper introduces some of the results of a questionnaire survey on urban problems and the use of new technologies that was conducted among local governments in order to identify the actual situation for the systematic organization of urban problems and new technologies.

2. Summary of the results of a questionnaire survey on urban issues and the introduction of new technologies

The questionnaire survey was conducted in December 2020 with a 98% response rate among 61 local governments that applied for the call for proposals on needs and seeds for the realization of smart cities (hereinafter referred to as the "Needs and Seeds Survey") conducted by the Ministry of Land, Infrastructure, Transport and Tourism in FY 2018. In the survey, the respondents selected urban problems that they sought to solve by using new technologies and answered items in Table 1. The list of urban problems was based on the major categories (12) from the Needs and Seeds Survey, which were independently subdivided by the NILIM into medium categories (42) and minor categories (172). New technologies were similarly subdivided into major categories (9) and minor categories (62).

Table 1: Items of the survey

Items of the survey	Response method
① Urban problem to solve by using new technologies, its	Multiple urban problems can be selected. For the importance and
② New technologies to introduce to solve urban problems	Select types of new technologies from the list (up to three types)
③ Status of the introduction of new technologies to solve urban problems	Select the status of introduction from the list (already introduced/planning to introduce/considering to introduce)
④ Challenges upon introducing new technologies	Select all types of challenges from the list (with a space to write comments)
⑤ Method to evaluate the effect of solving urban problems	Freely describe evaluation index and method (e.g. KPI, B/C).

(1) Comparison of urban problems by the size of local governments

Table 2 compares the top 10% of urban problems (subcategories) with the highest selection rate by the size of local government as urban problems to be solved using new technologies. While the issues of the last one mile mobility support and mobility support for tourists are common, large cities (ordinance-designated cities, core cities, and special cities) are aiming to provide more efficient urban services by promoting the use of public transportation through such measures as the optimization of bus schedules and networks and the dissemination of information to users. In other types of cities, in addition to disaster prevention monitoring and forecasting of rivers, the use of new technologies tended to be considered mainly for supporting the lives of the elderly, such as watching over the elderly and supporting the mobility of people who have given up their driver's licenses.

Table 2: Urban problems by the size of local governments

Designated city, core city, special city (n = 33)	Other cities (except for prefectures) (n=23)
Last one mile mobility support (39.4%)	Last one mile mobility support (34.8%)
Optimization of bus schedule and network (33.3%)	River monitoring and forecasting for disaster prevention (34.8%)
Information distribution to users (30.3%)	Mobility support for tourists (34.8%)
Mobility support for tourists (27.3%)	Mobility support for those who gave up their driver's licenses (30.4%)
Shortage of workforce in public transportation (27.3%)	Mobility support in areas without public transportation (30.4%)
-	Watching over the elderly (30.4%)
-	Support for shopping by vulnerable people (30.4%)

(2) New technologies to introduce to solve urban problems

Figure 1 shows the responses to the question about new technologies that have been introduced or that should be considered for solving urban problems in major categories. For (a) transportation and mobility, 90.2% of the local governments selected it as a problem to be solved using new technologies. The most commonly selected new technology to solve this problem was (6) new applied technology using (1) to (5). The main breakdown of this by medium and minor categories was the introduction of route search, reservations, and payments using MaaS and the introduction of on-demand transportation by introducing remote sensing data and AI-based analyses through the use of communication networks to solve the problems of promoting the use of public transportation and supporting the mobility of transportation-vulnerable people. (7) Automated driving technology, robots, and new technology were also selected by many respondents. The main breakdown showed that automated driving technology, personal mobility, and sharing were considered transportation methods to solve the problems of promoting the use of public transportation and supporting the mobility of the transportation-vulnerable people.

The next most common urban problem to be solved by new technology was (e) tourism (54.1%). Many local governments selected (1) communication networks and sensing technology and (6) new applied technology using (1) to (5) as new technologies to solve this problem. As a major breakdown, the use of human flow data and the introduction of MaaS and automated driving technology for tourism promotion and the introduction of digital signage for tourism information distribution were considered.

		(1) Communication network and sensing technology	(2) Analysis and forecasting technology	(3) Data storage	(4) Data platform	(5) Data utilization (e.g. visualization technology)	(6) Applied technologies using (1) to (5)	(7) Automated driving technology, robot, and new technology (transport)	(8) Robot and new technology (other than transport)	(9) Other	Unknown
		35	30	30	21	29	51	43	15	16	20
(a) Transportation and mobility	55	18	24	14	2	7	92	60	0	4	4
(b) Energy	20	0	2	1	3	1	32	10	1	6	1
(c) Disaster prevention	28	52	11	5	13	10	15	1	1	2	42
(d) Infrastructure maintenance and management	26	0	0	0	0	0	0	0	0	0	0
(e) Tourism	33	17	1	9	3	10	17	8	1	5	4
(f) Health and medicine	27	9	11	17	5	1	28	2	0	0	2
(g) Productivity improvement	28	5	1	4	3	2	7	13	6	2	5
(h) Environment	5	1	0	1	0	1	1	0	0	0	1
(i) Security	15	9	1	4	1	0	11	0	1	0	0
(j) Logistics	17	0	0	2	1	0	3	8	9	1	3
(k) Compact city development	25	6	1	12	4	3	16	8	0	0	2
(l) Other	19	4	6	0	2	5	0	0	0	1	4

■■ Numbers among 61 local governments, ■ Number of local governments that selected (some are counted multiple times)

Figure 1: New technologies to introduce to solve urban problems

Photo 1: Example of the introduction of new technologies

(3) Issues upon introducing new technologies

In terms of the status of the introduction of new technologies to solve urban problems, new technologies have already been introduced to address only 14.9% of the 714 urban problems, are now in consideration for introduction in 73.2% of the cases, and are in the plan to be introduced in 11.8% of the cases (Photo 1).

Figure 2 summarizes challenges in introducing new technologies. Out of a total of 1,084 patterns of the combination of urban problems and new technologies, the most common challenges were operation cost (256 cases, 23.6%) and cost of introduction (249 cases, 23.0%), which were seen in a wide range of new technologies. The next most common challenge was social acceptability (62 cases, 5.7%). The breakdown of new technologies with this challenge include those related to

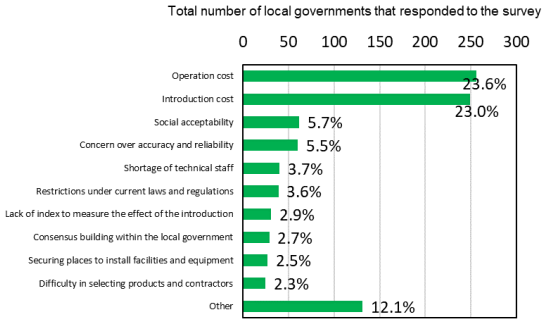

Figure 2: Issues upon introducing new technologies

personal information such as human vital data and information banking, and those related to safety, such as automated driving technology and personal mobility.

3. Conclusion

In the future, based on the results of the above analysis, detailed case studies will be conducted to prepare technical references (draft) on the use of new technologies according to the characteristics of urban

problems and to develop an evaluation method for the introduction plan of new technologies.

☞For more information:

1) Website of Urban Planning Department
http://www.nilim.go.jp/lab/jbg/smart/smart.html

Survey of Enhanced Added Value of Convenience in Lives of Residents Using Sewerage Facilities

(Study period: FY 2019 – FY 2022)

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key words: *aging society, sewerage facilities, paper diapers, enhanced convenience*

1. Introduction

In August 2017, Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT) formulated the "New Sewerage Vision Acceleration Strategy" and summarized the measures that the national government should implement in a selective and concentrated manner over approximately 5 years from the viewpoint of accelerating the realization of the New Sewerage Vision. Since one of the key elements of the New Sewerage Vision Acceleration Strategy is enhancing added value by utilizing sewerage, the possibility of accepting paper diapers (disposable diapers) in sewerage systems as a response to Japan's aging society and other issues was adopted as a topic for study. In January 2018, MLIT set up a "Study Group for Realizing Acceptance of Paper Diapers in Sewerage Systems," which drew up a "Study Roadmap toward Acceptance of Paper Diapers in Sewerage Systems," to be implemented over a period of roughly 5 years beginning in FY 2018 [1]. To support that effort, NILIM collected basic information on paper diapers, such as the types/weights of paper diapers and the pollution load and physical properties of each diaper material. NILIM also began arranging knowledge concerning the conditions for syneresis (separation of moisture from a gel, etc.) of superabsorbent polymer (hereinafter, SAP), which is one diaper material (assuming syneresis by adding Ca to urine-laden SAP (**Photo 1**, **2**)), behavior in sewage, and the technical effects on sewerage system facilities (manhole pumps, bedload transport) and wastewater treatment facilities (sedimentation characteristics). This article introduces a portion of the status of arrangement of this basic information concerning paper diapers.

2. Types and Weights of Paper Diapers

In accordance with the guidelines [2] on labeling of the materials of commercially-available paper diapers (disposable diapers), diaper materials are classified as 6 items, i.e., surface material, absorbent material, waterproofing material, fastening material, stretching material and bonding material. Except for the adsorbent material and the bonding material, the raw materials of these materials were virtually all plastic products derived from naphtha. The absorbent materials were frequently described as one of 3 types of materials: absorbent paper (nonwoven fabric), cotton-like pulp or the above-mentioned SAP.

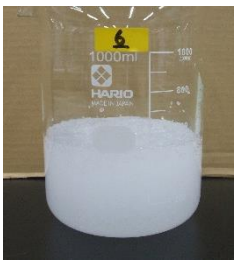

Photo-1 SAP before syneresis treatment

Photo-2 SAP after syneresis treatment

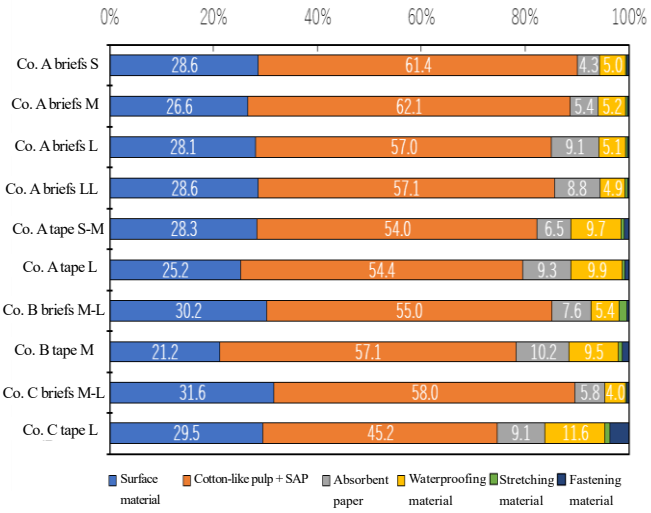

Fig. Weight ratios of materials used in paper diapers

The results of weight measurements of the paper diapers showed that the weight of the briefs type (38 samples) was 52 g to 107 g (average: 77.3 g), while that of the tape type (30 samples) was 84 g to 178 g (average: 117.9 g). Thus, the tape type tended to be heavier than the briefs type, and the weight of most tape-type diapers exceeded 100 g.

The above **Fig.** shows the weight ratios of the materials used in paper diapers. The bonding materials could not be distinguished by visual inspection. The average weight ratio of each material in the briefs type was surface material: 29.1 %, cotton-like pulp and SAP: 68.2 %, absorbent paper: 6.9 %,

waterproofing material: 5.0 %, stretching material: 0.5 % and fastening material: 0.3 %. The average figures for the tape type were surface material: 26.1 %, cotton-like pulp and SAP: 52.7 %, absorbent paper: 8.8 %, waterproofing material: 10.2 %, stretching material: 0.7 % and fastening material: 1.6 %.

3. Pollutant Loads of Paper Diapers

To clarify the pollutant loads of each material based on the types and weights of the materials used in the paper diapers, diaper samples were cut apart as shown in **Photos-3** to **7** and then analyzed. SAP was analyzed after performing syneresis treatment. The analysis items were CODcr, BOD, T-N and T-P. In this analysis, the samples were mixed with water at a mixing ratio of 5.0 % for SAP and 0.5 % for the other materials. CODcr was analyzed using a spectrophotometer (DR3900, HACH) and CODcr reagents (HR, HACH), BOD was analyzed by the sewage test method and T-N and T-P were analyzed using an automatic colorimetric analysis device.

Photo-3 Surface material

Photo-4 Cotton-like pulp

Photo-5 Nonwoven fabric

Photo-6 Waterproofing material

Photo-7 Fastening material

Photo 8 SAP

The following **Table** shows the results of the pollutant load analysis of each material. For CODcr, the values of the surface material, adsorbent paper, waterproofing material and fastening material, which are made from polyolefin material, were 174 to 285 g/100 g. The CODcr values for the other materials were cotton-like pulp: 99 to 111 g/100 g, stretching material (polyurethane): 19 g/100 g and SAP 23 g/100 g.

BOD was virtually undetectable, as the values for all the materials were 0.01 g/100 g. For T-N, the cotton-like pulp displayed the highest value, at 0.11 to 0.12 g/100 g, and T-P was substantially not detected, as the values for all materials were 0.01 g/100 g.

The average pollutant load for 1 briefs-type diaper was CODcr = 114.7 g, BOD = 0.01 g, T-N = 0.04 g and T-P = 0.01 g, whereas the average values for 1 tape-type diaper were CODcr = 181.7 g, BOD = 0.01 g, T-N = 0.06 g and T-P = 0.01 g. Since the main components of the diapers are naphtha-derived plastics and cotton-like pulp, CODcr was high while BOD was low.

Table Results of pollutant load analysis Unit (g/100 g)

	Surface material	Absorbent material			Waterproofing	Stretching material	Fastening material
	Polyolefin nonwoven fabric	Cotton-like pulp	SAP	Absorbent paper Nonwoven fabric	Polyolefin film	Polyurethane	Polyolefin
CODcr	234.7	111.0	23.1	285.3	174.2	19.4	250.5
BOD	0.01	0.01	0.01	0.01	0.01	0.01	0.01
T-N	0.01	0.11	0.01	0.00	0.00	0.02	0.00
T-P	0.01	0.01	0.01	0.01	0.01	0.01	0.01

4. Conclusion

Basic information on paper diapers was arranged, including the types of materials used in the diapers and their weights, pollutant loads and physical properties. Based on this information, the assumed effects when paper diapers are disposed in a sewerage system were studied by laboratory tests and desktop study of the effects on sewerage pipeline facilities (manhole pumps, bedload transport) and wastewater treatment facilities (sedimentation characteristics, etc.).

☞For more information:

1)Website of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT): Establishment of Study Roadmap toward Realization of Acceptance of Paper Diapers in Sewerage Systems
http://www.mlit.go.jp/report/press/mizukokudo13_hh_000368.html, March 2018

2)Website of the Japan Hygiene Products Industry Association: Guidelines for Labeling of Paper Diapers

Empirical Study and Guideline Formulation on the B-DASH Project Concerning Energy Saving / Creation Technologies in Wastewater / Sludge Treatment (Research period: FY 2019 -)

Water Quality Control Department, Wastewater and Sludge Management Division

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key words: global warming, AI, effective use of sewerage resources, effective use of existing stock, carbonization, wide-area implementation

1. Introduction

As a response to global warming in the sewerage field, it is important both to implement energy-saving measures and to utilize the potential of other available resources, beginning with the energy utilization of sewage sludge. At just this time, Prime Minister Suga declared in his general policy speech in October 2020 that Japan will aim to achieve carbon neutrality in 2050.

While the development of new technologies based on these social needs is continuing, the record of practical use is small, and many sewerage service providers have taken a cautious stance toward introduction. To address this problem, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) began the "Breakthrough by Dynamic Approach in Sewage High Technology (B-DASH) Project" in FY 2011, with the Water Quality Control Department of NILIM acting as the steering agency for B-DASH projects. The purpose of this effort is to demonstrate outstanding innovative technologies and then formulate guidelines for technology introduction to encourage widespread adoption with the aims of reducing the cost of sewerage service and creating renewable energy. This article presents 3 projects: 1) newly-formulated guideline for technology introduction that were completed during fiscal 2020, 2) the results of a feasibility study completed during the year, and 3) newly-started test project.

2. Outline of demonstration technologies

Based on the results of empirical research and the views of local governments, guidelines were formulated for each technology and evaluated by experts. The structure of the guidelines is shown in **Table-1**.

Table-1 Structure of proposed guidelines

Chapter 1 General Provisions	Objective, scope, definitions of terms
Chapter 2 Outline of the Technology	Characteristics of the technology, conditions of application, evaluation results
Chapter 3 Consideration of Introduction	Method for considering introduction, examples of consideration of the effects of introduction
Chapter 4 Planning and Design	Introduction planning, design
Chapter 5 Management	Inspection items, frequency, etc.
Data	Demonstration results, case studies, etc.

Next, each of the technologies will be introduced.

(1) Advanced treatment technology by ICT and AI control of single-chamber nitrification and denitrification process (formulation of guidelines through actual-scale demonstration)

The demonstration of this technology was conducted at the Naruse Clean Center, Machida City. The aims of the technology are to achieve water treatment quality equivalent to advanced treatment by using AI to control the air volume in response to fluctuations in the reaction tank inflow load, and to reduce electric power consumption by automatic calculation and control of the blower discharge pressure coupled to the air volume. As a result of the demonstration test, blower power consumption was reduced by more than 10 % in comparison with a constant pressure control system. Compared to the advanced treatment process, introduction of this technology is expected to reduce construction costs, achieve energy savings and promote advanced treatment (**Fig.-1**).

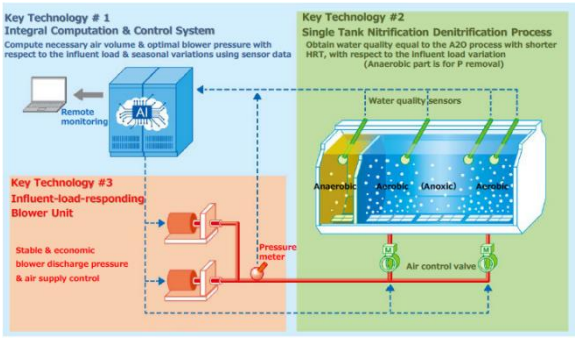

Fig.-1 Outline of technology

(2) Carbonization system with high project profitability combining high value-added utilization of sludge and energy saving and energy creation (feasibility study completed)

A feasibility study (FS) of a technology that enables carbonization of sludge with lower fuel consumption and higher temperature carbonization than the conventional technology by efficiently utilizing the heat of the drying and carbonization processes was carried out using a pilot plant, etc. to investigate performance of the technology, including the fuel consumption reduction effect and effectiveness of the carbonized sludge as a deodorizing material, etc., and the profitability of the project. The establishment of this technology is expected to lead to use of the carbonized sludge produced by the low fuel consumption carbonizing process in value-added products such as deodorizers, etc. (**Fig.-2**).

(3) Low-cost sludge volume reduction technology by biomass boiler contributing to wide-area coverage by medium- and small-scale treatment plants (new actual-scale demonstration)

To realize wide-area sludge treatment by medium- and small-scale treatment plants, a demonstration test of sludge volume reduction by consolidation, drying and incineration and reduction of the cost of sludge treatment by utilizing the waste heat of incineration is currently being conducted with a technology that combines a dehydration and drying system and a biomass boiler. In comparison with external landfill disposal of dewatered sludge, the introduction of this technology is expected to reduce both greenhouse gases (GHG) and the cost of sludge treatment. Regarding wide-area sludge treatment, the economic advantage of consolidating the treatment of the sludge generated by medium- and small-scale treatment plants at a large-scale treatment facility has been demonstrated with the conventional technology, but the introduction of this technology is expected to promote wide-area treatment because it will also be possible to consolidate sludge treatment on a medium-scale facility (**Fig.-3**).

4. Utilization of findings and future development

Based on the results of feasibility studies, etc., NILIM conducts actual-scale demonstration tests, prepares guidelines based on the test results and works to disseminate and develop technologies through explanatory meetings, etc. Until^ June 2020, a total of 48 technologies had been adopted as actual-scale test projects, 28 guidelines had been released, and 10 B-DASH technologies had been introduced in 113 cases.

In cooperation with the MLIT Sewerage Department, NILIM is making various efforts for further dissemination and development, including “Setting of energy performance indexes based on B-DASH technologies and adoption as grant projects,” “Improvement of guidelines through follow-up on voluntary research after demonstration test study,” “Creation of cost calculation tools,” etc., and will also continue to carry out empirical studies of new technologies and make efforts for technology dissemination and development in the future.

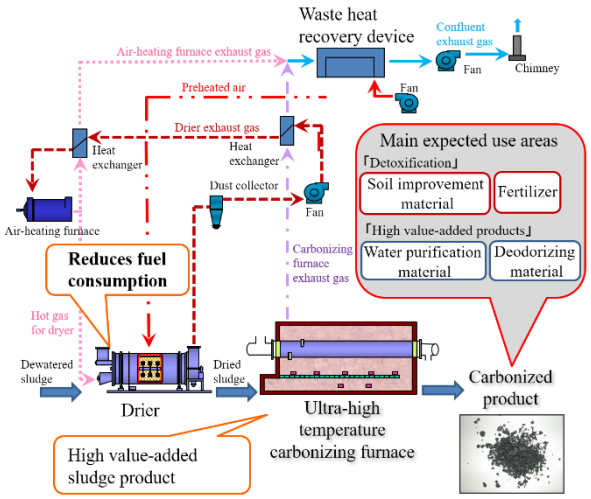

Fig.-2 Outline of technology

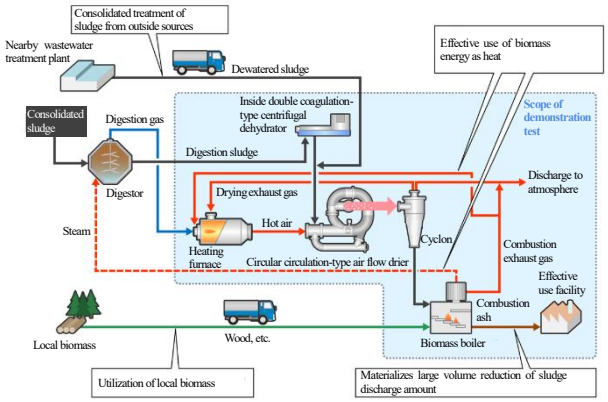

Fig.-3 Outline of technology

☞ For more information:

【Reference】 For various guidelines

http://www.nilim.go.jp/lab/ecg/bdash/bdash.htm

【Reference】 For list of B-DASH technologies, etc.

https://www.mlit.go.jp/mizukokudo/sewerage/mizukokudo_sewerage_tk_000450.html

Survey on Saturated Traffic Flow Rate at Signalized Intersections and Estimation Method

(Research period: FY2017-)

Road Traffic Department, Road Division

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Head YOKOCHI Kazuhiko

key words: signalized intersection, saturated traffic flow rate, estimation method

1. Introduction

In the planning of signalized intersections, it is important to set the traffic capacity appropriately from the viewpoint of traffic smoothness. This traffic capacity is calculated based on the saturated traffic flow rate (the maximum number of vehicles that can pass through each lane per hour at a green light). Normally, the traffic capacity is calculated based on the observed saturated traffic flow rate, but in cases where observation is difficult, such as in planning a new intersection, it is common to use, as the saturated traffic flow rate, the value estimated by multiplying the basic value (the saturated traffic flow rate assumed for ideal road and traffic conditions) by a correction rate based on various factors of road and traffic conditions such as lane width and longitudinal slope (the "estimated value"). However, since the basic value and correction rate used in the estimation were determined based on the results of observations made over more than 30 years ago, it is possible that they may deviate from the actual situation due to changes in vehicle performance, driver characteristics and awareness in recent years. In fact, in recent years, it has been reported that the observed saturated traffic flow rate has been on a declining trend. In this research, we surveyed the actual situation of the saturated traffic flow rate and conducted a basic analysis for the development of a new method to estimate the saturated traffic flow rate appropriately.

2. Fact-finding survey on saturated traffic flow rate

(1) Survey conditions

The fact-finding survey was conducted at 15 intersections in Tokyo from November to December 2019. The survey time was 6 hours and included peak traffic hours.

(2) Survey results

The saturated traffic flow rates observed in this research ("observed values") were 1,386 to 1,782 vehicles per hour of green light in through lanes, 1,382 to 1,595 vehicles per hour of green light in left-turn lanes, and 1,553 to 1,867 vehicles per hour of green light in right-turn lanes (**Fig. 1**). In the through lanes and left-turn lanes, the results were lower than the basic values (2,000 vehicles per hour of green light in through lanes and 1,800 vehicles per hour of green light in left-turn lanes and right-turn lanes) at all observation points. The observed values shown in **Fig. 1** are the results of intersections with relatively ideal road and traffic conditions, meaning that they do not contains any conditions that require correction.

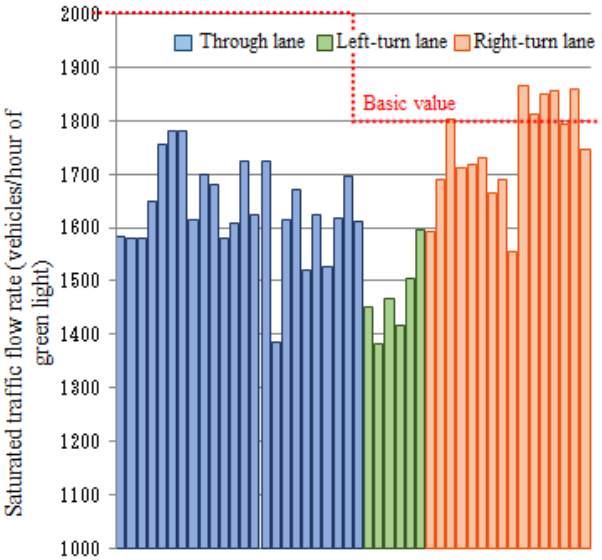

Fig.1 Observed value of saturated traffic flow rate

3. Basic analysis of methods for estimating saturated traffic flow rate

(1) Derivation of regression models based on survey results

The estimated value of saturated traffic flow rate is calculated by multiplying the basic value by a correction rate (all values are equal to or less than 1) based on various factors of road and traffic conditions, as shown in Equation (1).

$$S_A = S_B \times \alpha_W \times \alpha_G \times \alpha_T \times \alpha_B \times \alpha_{RT} \times \alpha_{LT} \quad (1)$$

[S_A: Estimated value of saturated traffic flow rate (vehicles/hour of green light),

S_B: Basic value of saturated traffic flow rate (vehicles/hour of green light),

α_W α_G α_T α_B α_{RT} α_{LT}: Each represents the rate of correction by lane width, longitudinal slope, heavy vehicle mixing rate, bus stop, right-turning vehicle mixing, and left-turning vehicle mixing, respectively]. On the other hand, as shown in **Fig. 1**, deviation from

the basic value was observed even under road and traffic conditions that did not require correction. Therefore, if we try to estimate the saturated traffic flow rate so that these actual conditions are reflected, it is necessary to consider a new estimation method. Accordingly, we focused on the relationship between saturated traffic flow rate and saturation speed, reaction time, and headway, and obtained Equation (2) in reference to previous studies, and derived the regression model shown in Equations (3) to (5) based on it.

$$S = 3600/(t_x + 3.6 \times h_j/V_S) \quad (2)$$

[S: Saturated traffic flow rate (vehicles/hour of green light), t_x: Reaction time (sec), h_j: Headway (m), V_S: Saturation speed (km/h)]

$$S_T = 3600/(1.35 + 3.6 \times 7.0/V_S) \quad (3)$$

$$S_L = 3600/(1.20 + 3.6 \times 7.0/V_S) \quad (4)$$

$$S_R = 3600/(1.04 + 3.6 \times 6.0/V_S) \quad (5)$$

[S_T: Saturated traffic flow rate of through lane (vehicles/hour of green light)
S_L: Saturated traffic flow rate of left-turn lane (vehicles/hour of green light)
S_R: Saturated traffic flow rate of right-turn lane (vehicles/hour of green light)]

(2) Evaluation of the estimation method of saturated traffic flow rate

Figures 2-4 show the relationship between the observed values and the estimated values (saturated traffic flow rate calculated by Equations (3) to (5) and the saturated traffic flow rate by the conventional estimation method). The estimated values calculated by Equations (3) to (5) are relatively accurate.

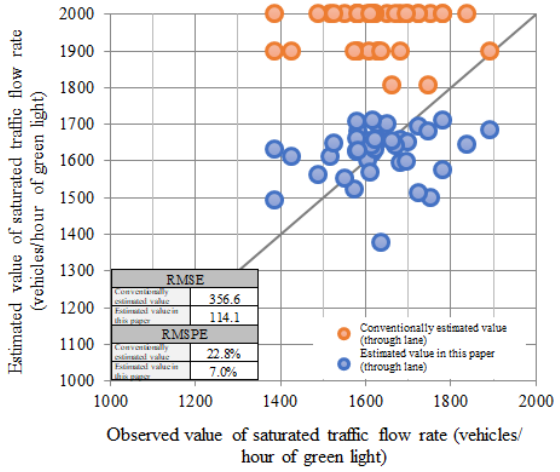

Fig. 2 Observed and estimated values (through lane)

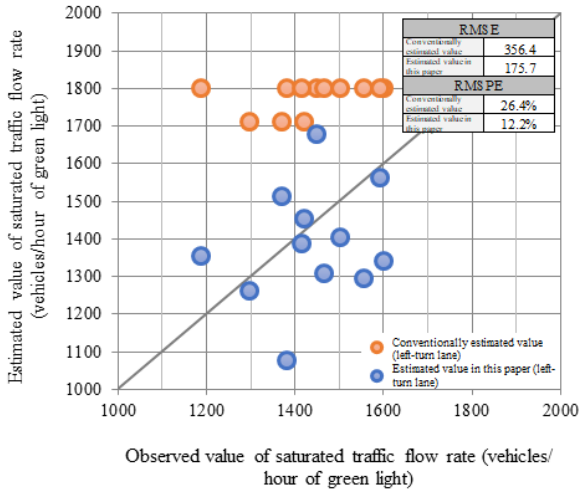

Fig. 3 Observed and estimated values (left-turn lane)

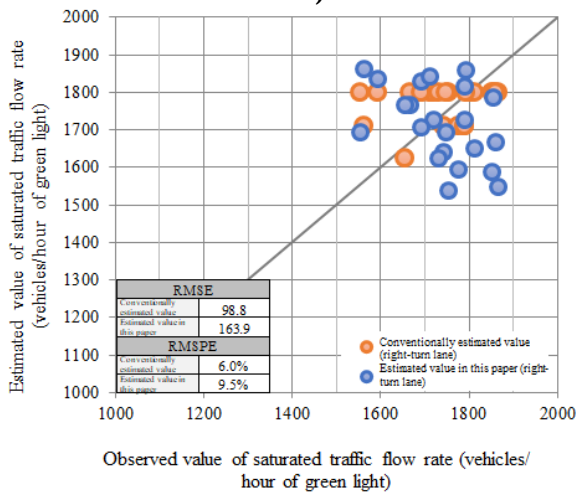

Fig. 4 Observed and estimated values (right-turn lane)

5. Conclusion

In this research, a fact-finding survey on saturated traffic flow rate was conducted and it was confirmed that all observed values were lower than the estimated values in the through lane and left-turn lane. Then, by focusing on saturation speed and other factors that are thought to affect the saturated traffic flow rate, we confirmed the possibility that a more accurate estimation could be obtained using a new equation that better accounted for these factors. In the future, based on this research, it would be necessary to conduct research from various perspectives, taking into account the workability in practice.

☞See the following for details.

1) Survey of saturated traffic flow rate at signalized intersections and basic study of influence factors, Collection of Presentations in the 62nd Conference of the Committee of Infrastructure Planning and Management

Utilization and Reconstruction of Road Space to Meet Diverse Needs

(Research period: FY2019-)

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key words: utilization of road space, reconstruction of road space, creation of liveliness

1. Introduction

The needs for road space are changing in response to social and economic conditions, and in addition to safe and smooth passage of vehicles, the need has been increasing in recent years for the creation of liveliness, effective use of space, etc. [1]. Therefore, NILIM has been studying on the utilization and reconstruction of road space that contributes to the creation of liveliness in road space according to local issues and needs.

2. Case study on the utilization of road space

In order to meet diverse needs for the utilization of limited road space, it is necessary to utilize the space according to the characteristics of road and roadside. Accordingly, hearing surveys on the cases that have contributed to the creation of lively space through the integrated use of road space and privately owned land, were conducted to grasp the status of space use, process of approach, and issues in space utilization, etc. (**Photo 1**, left side).

And, questionnaire surveys, field surveys, etc. on the cases where the relaxation of occupancy permit standards for roadside use by restaurants, etc. [2] was applied in response to the COVID-19 infection, were conducted to organize the issues and characteristics obtained from the survey results (**Photo 1**, right side).

Photo 1 Example of road space utilization

■Left Photo: Marunouchi Nakadori, Chiyoda-ku, Tokyo, (The roadway is open to pedestrians during lunch hours, and rest facilities, open cafes, etc. are available.)

■Right Photo: Kawaramachi Takoyakushi Shopping Street, Kyoto City, (As an emergency measure, relaxed standards for road occupancy permits were applied, and takeout service and terrace operation are implemented.

3. Case study on road space reconstruction

Since needs for road space will change in the existing roads where automobile traffic has decreased due to bypass construction, it is possible to reconstruct road space by reducing the number of lanes and widening the sidewalks for pedestrian traffic and the creation of liveliness. It is necessary to reconstruct road space considering with the effective use of limited road space, based on the network construction of surrounding roads and the roles and positioning of each road. Then, hearing surveys with the project owner on the case of reconstructing the existing road space due to bypass construction, etc., were conducted to grasp the ingenuity in creating a lively space and the technical and institutional issues in the consideration and implementation of reconstruction (**Photo 2**).

4. Future schedule

The results of this research will be published as a collection of examples for road administrators and local governments.

☞See the following for details.

1) Road Bureau, MLIT: Study Group on the ideal road space that meets diverse needs.
https://www.mlit.go.jp/road/ir/ir-council/diverse_needs/index.html

2) Road Bureau, MLIT: "Relaxation of occupancy permit standards for roadside use by roadside restaurants, etc. in response to the COVID-19 infection"
https://www.mlit.go.jp/road/senyo/03.html

Photo 2 Example of road space reconstruction

■Left Photo: Nagano City, Municipal road Nagano Chuo Dori Line (After the completion of the perimeter road in the traffic cell system, the width of the roadway was reduced and the sidewalk was widened.

■Right Photo: Tottori City, Municipal road Ekimae Taihei Line (After the completion of the Tottori Ring Road, the number of lanes was reduced, sidewalks were widened, and a lawn plaza was developed.

Effort for Realization of Automated Driving on General Roads

(Research period: FY2020-)

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key words: road surface facility, support of localization, field operational test

1. Introduction

All levels of governments in Japan are working on unmanned automated driving services in limited areas with the goal of "Social implementation in more than 100 locations by 2030".[1)] As a part of that , the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has been conducting the field operational tests for automated driving services based on roadside stations etc,. (hereinafter referred to as the "FOTs"[2)]) in collaboration with the Strategic Innovation Promotion Program (SIP) of the Cabinet Office.

In the FOTs, various automated driving vehicles were used according to the location of the FOTs. Of these vehicles, it was confirmed that autonomous vehicles that use only the high-precision GPS (RTK-GPS) or LiDAR to localize own vehicles could not continue automated driving when manual intervention became necessary because of terrain or weather conditions.[3)] On the other hand, with vehicle to infrastructure (V2I) type automated driving vehicles, which localize own vehicles using the magnetic force or radio wave emitted by road surface facilities (electromagnetic induction lines and magnetic markers installed on or under the road surface to support the localization of own vehicles; See **Figure 1**), no manual intervention was occurred due to the terrain or weather conditions, and stable automated driving was achieved.

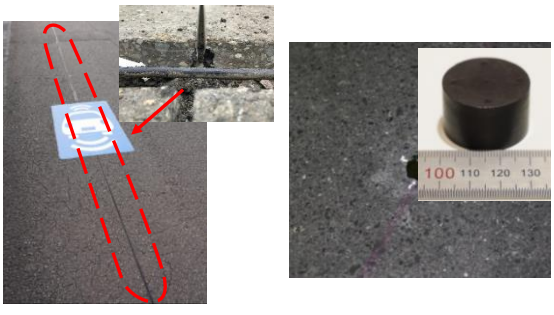

Figure 1: Example of road surface facility (Left: Electromagnetic induction line; Right: Magnetic marker)

This paper introduces the efforts to draft the technical standards and the manual for the installation of road surface facilities, as well as the survey research necessary for said facilities.

2. Technical standard for installing supporting infrastructure for automated driving (road surface facilities)

Since the effectiveness of road surface facilities was confirmed in the FOTs, the Road Act has been revised in May 2020, and road surface facilities have been positioned as the road accessories. NILIM has drafted the technical standards (installation standards) for the planning, design, and construction of road surface facilities, and the Director-General of the Road Bureau of MLIT notified the Regional Development Bureaus etc., of the standards in November 2020, through the research and deliberation by the Road Engineering Group in the Road Subcommittee of the Panel on Infrastructure Development. The standards are characterized particularly by the following.

- Defined the road surface facilities clearly.
- Specified the technical characteristics required for the road surface facilities in terms of "performance."
- Determined the design requirements of the road surface facilities not to affect the function of the pavement, the reuse of the pavement materials, or the performance of the road structure significantly.
- Stipulated that road administrators should publicly announce the locations of installed road surface facilities, so that vehicle operators can participate in automated driving services in such locations.

3. Drafting of a manual to explain the technical standard for installing supporting infrastructure for automated driving (road surface facilities)

NILIM has been conducting a series of the survey research to obtain the engineering knowledge on road surface facilities. Based on the knowledge obtained, we will draft a manual to explain the technical standard for installing supporting infrastructure for automated driving (road surface facilities), which will be reviewed by the Road Surface Facilities Sub-Working Group established in the Road Structure Standards Subcommittee of the Japan Road

Association. Here, as an example of studies, we introduce the work that was conducted to identify the optimal installation interval of magnetic markers.
In the FOTs, magnetic markers had been installed at two (2) meter interval based on empirical rules. However, if the installation interval of magnetic markers could be larger, the installation cost could be reduced. It is also assumed that the interval required for the installation of magnetic markers is different when the driving route of the automated driving vehicle is straight and when it is curved. For this reason, the tests were conducted on the test track at NILIM to analyze the relationship between the (linear) travel route of the automated driving vehicle and the installation interval of the magnetic markers, and to identify the optimal installation interval of the magnetic markers. Firstly, magnetic markers were placed on the test track under the conditions shown in **Table 1** and **Figure 2**. Then, the automated driving vehicles (**Figure 3**: Bus type, passenger car type) were driven at multiple speeds (5-30 km/h), and the vehicle's traveling track (the width of deviation from the center line of the magnetic marker) was measured using a (commercially available) drive recorder and laser pointer. At present, we are analyzing in detail the relationship between the vehicle's traveling track and the installation interval of the magnetic markers, and plan to organize a rational installation method of magnetic markers and reflect it in the draft of the manual.

Table 1: Installation interval of magnetic markers

Assumed road structure	Curvature (R)	Installation interval
Intersection (Left turn section)	12 m	(1) 1 m (2) 2 m
Non-intersection road (Curve section)	30 m	(1) 1 m (2) 2 m (3) 8 m
Non-intersection road (Straight section)	∞	(1) 2 m (2) 8 m (3) 16 m

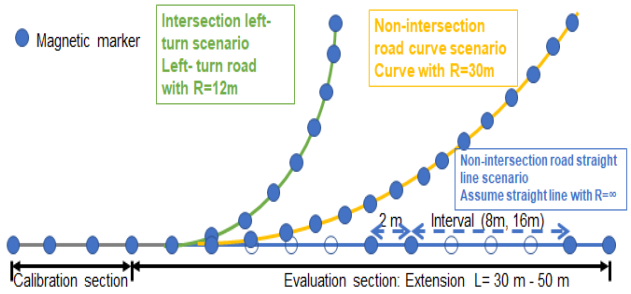

Figure 2: Installation method of magnetic markers (image)

Figure 3: Test on the installation interval of magnetic markers
(Left: Bus type, Right: Passenger car type)

4. Conclusion

A road surface facility is important infrastructure that is indispensable for continuously stable automated driving operation. The technical standard for installing supporting infrastructure for automated driving (road surface facilities) was drafted by NILIM and released by the Road Bureau of MLIT. We believe that the preparation of a manual for the technical standard will further improve the environment for the implementation of automated driving services in rural areas.
NILIM will continue to conduct the research on road surface facilities and provide the engineering support for local governments to support the social implementation of automated driving services.

☞See the following for details.

1) Public-Private ITS Initiative Roadmap 2019
https://www.kantei.go.jp/jp/singi/it2/kettei/pdf/20190607/siryou9.pdf
2) Website for automated driving service based at roadside stations, etc. in mountainous regions
https://www.mlit.go.jp/road/ITS/j-html/automated-driving-FOT/index.html
3) The 60th Conference of the Committee of Infrastructure Planning and Management, No.7172
Analysis of Issues and Responses to Automated Driving in Mountainous Regions through Demonstration Tests

Improvement of the Program for Estimating the Number of Households in Need of Securing Housing

(Research period: FY 2020)

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Keywords: Housing safety net, person requiring special assistance in securing housing, estimating program

1. Introduction

It has become an important policy issue to ensure the stable availability of housing for those who require special assistance in securing housing, such as the elderly and those with low incomes (hereinafter referred to as "people requiring special assistance in securing housing"). To deal with this issue, the Act that Partially Revises the Act on Promotion of Offering of Rental Housing to Persons Requiring Special Assistance in Securing Housing (hereinafter referred to as the "Housing Safety Net Act") came into effect on October 25, 2017. With this revision, a registration system was established for rental housing that accepts people requiring special assistance in securing housing (hereinafter "accepting housing"). In combination with the conventional supply of public housing, the system to strengthen the housing safety net function has been established.

The NILIM developed the Program for Estimating the Number of Household in Need of Securing Housing (hereinafter "the estimating PG" or simply "the PG") so that local governments would be able to set proper targets for the necessary number of public housing units and the number of accepting housing units using vacant houses, which was then distributed to local governments in August 2016.[note 1] Recently, the estimating PG has been improved based on subsequent policy needs and changes in the needs of local governments in terms of using PG.[note 2]

This paper introduces the outline of the improvements made to the PG.

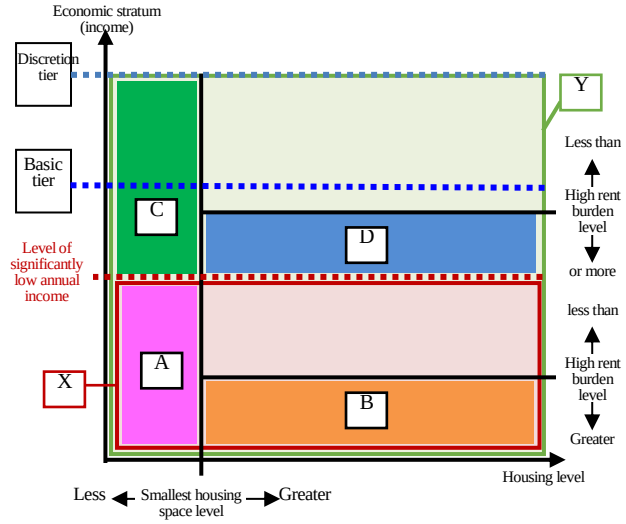
2. Outline of the improvements made to the estimating PG

The estimating PG is able to provide mid-to-long-term estimates of the number of applicable households, such as ones with significantly low annual income (X in Fig. 1) among the number of household eligible for public housing (Y in Fig. 1) at five-year intervals from 2020 to 2045 based on existing statistical data, such as the National Census and the Housing and Land Survey.

This improvement enhanced the following functions.

(i) Expansion of household attributes that can be estimated

Households with specific needs as shown in A to D of Figure 1, in terms of housing level and rent burden ratio, are added to the subject of the estimate.



Y: Household eligible for public housing (household designated in the Act on Public Housing)
X: Household with significantly low annual income among ones eligible for public housing*1
A: Household with less than the smallest housing space level among household with significantly low annual income
B: Household with high rent burden despite having more than the smallest housing space level among household of which the income is lower than significantly low annual income*2
C: Household where the income is at the significantly low annual income level or higher but the housing space is less than the smallest housing space level
D: Household where the annual income is at the significantly low annual income level or higher and the housing is at the smallest housing space level or larger but with high rent burden

*1: Household with significantly low annual income: A household with less than the annual income required to live in housing with a space that meets the minimum living space level (housing with average rent (rent per square meter) for private rental housing in a given region) specified in the Comprehensive Plan for Housing and Living (national plan) within the appropriate rent burden limit rate (set in the 7th Five-Year Plan for Housing Construction)
*2: Household with high rent burden: A household that pays rent that is at the average rent burden ratio or higher of households with the annual income of less than two million yen living in private rental housing in a given region

Figure 1: Concept of household subject to the estimate of the estimating PG

(ii) Expansion of options for each household attribute to be estimated

While the PG initially targeted households with residents at the age of 60 or over, an improvement was made for single-person households (basic and discretionary tier of public housing[note 3]) and married-couple households (discretionary tier) so that the target age range could be selected from 25 and over, 30

and over, 40 and over, 50 and over, 60 and over, and 75 and over.

An improvement was also made for childrearing households (discretionary tier) so that estimates could be made by selecting the age of the child from under 6, under 12, under 15, and under 18. Another improvement enabled the selection of households with many children, namely, three or more children.

(iii) Automatic calculation of person requiring special assistance in securing housing under the law

A function has been added to automatically calculate and display the number of low-income households (as specified to be 158,000 yen or less of monthly income in the Cabinet Ordinance), the elderly, household with small children, and foreign nationals that can be statistically identified among people requiring special assistance in securing housing as specified in the Housing Safety Net Act.

(iv) Preparation of PG by attributes of local governments

Since the accuracy of the available statistical tables differs depending on the attributes of local governments (prefectures, designated cities, municipalities, and towns and villages), PGs are prepared for each attribute of local governments.

3. Example of estimation results using the improved estimating PG

The following is an example of the result of the estimate of a designated city.

(1) Number of households with significantly low annual income

Figure 2 shows the example of estimating the number of households with significantly low annual income. The conditions of the estimate are as follows. (i) Applicable single-person household is a household with a resident aged 60 or over for both the basic tier and the discretionary tier. (ii) The basic tier for a household with two or more persons is applicable to all households. (iii) For the discretionary tier of a household with two or more persons, the married-couple household must have a resident at least aged 60, and the child-rearing household must have the eldest child under age 6. The number of households with significantly low annual income will increase until FY 2030 and then begin to decline, but will remain at a higher level than in FY 2020 until FY 2040.

(2) Number of households with specific needs

Figure 3 shows the estimated number of households with specific needs based on the housing level and rent burden ratio. The conditions of the estimate are the same as (1). The total number of households in A to D shown in Figure 1 will peak in FY 2025 and decline thereafter but will remain at about the same level as the FY 2020 value until around 2035.

(3) Number of households requiring special assistance in securing housing under the law

Figure 4 shows the estimated number of households requiring special assistance in securing housing as of 2030 as defined by the Housing Safety Net Act. The total number of households is approximately 267,000, of which 82,000 are low-income households (other than those listed below) up to the basic tier of public housing, 87,000 are elderly single-person households, and 68,000 are childrearing households. If all the households are limited to the basic tier of public housing, the total number of households becomes 205,000, including 62,000 elderly single-person households and 41,000 childrearing households.

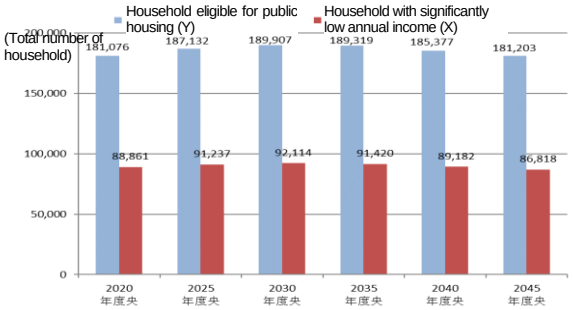


Figure 2: Example of estimating the number of households with significantly low annual income

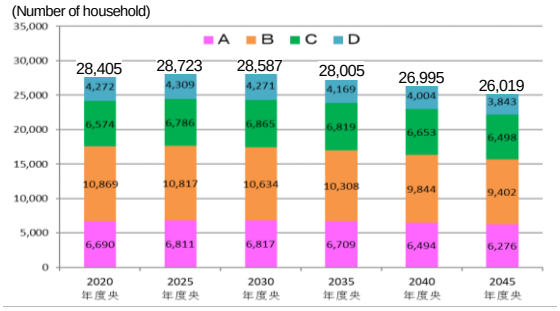


Figure 3: Example of estimating the number of households with specific needs

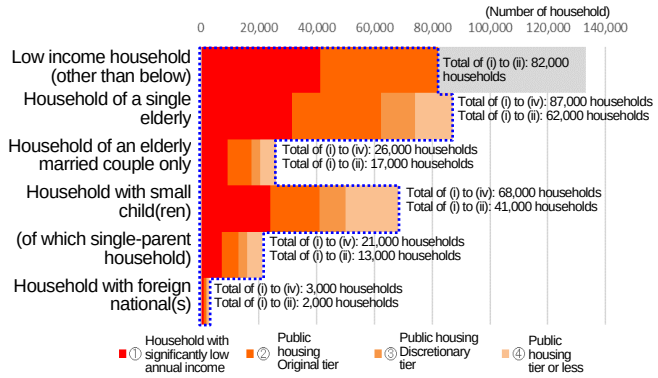


Figure 4: Example of estimating the number of households requiring special assistance in securing housing under the law (as of 2030)

4. Conclusion

The improvement of the estimating PG will enable detailed estimations based on the differences in policy targets among local governments and is expected to contribute to the strengthening of housing safety net measures in accordance with local situations. The improved estimating PG is going to be released on the NILIM website. The *PG User Manual* will also be prepared and released to support its use by local governments.

(Note)

1) NILIM Project and Research Report No. 62, Edition I, pages I-7 to I-34
http://www.nilim.go.jp/lab/bcg/siryou/kpr/prn0062.htm

2) Mr. Hasegawa, director of the Housing Department, who initially developed the PG, was in charge of improving the PG, and Mr. Utsumi, chief researcher, was in charge of preparing the data necessary for the estimation.

3) The basic tier is the household at the 25% income quintile or less. The discretionary tier is the household defined by ordinance as requiring assistance in securing housing and up to the 50% income quintile.

Design targets for self-sustaining energy systems for post-disaster residential continuity

(Research period: FY 2020–2021)

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Keywords: Solar power generation, storage battery, designtarget, housing, power outage, continuity of residence

1. Background and objectives

One of the ways to enable people to continue living in their homes when a power outage continues after a disaster is to use a system that combines solar power generation and storage batteries (hereinafter referred to as a "self-sustaining energy system"). The use of self-sustaining energy systems can be expected to contribute to both the enhancement of energy conservation measures and the avoidance and mitigation of disaster risks and is expected to grow in importance in the future.

In order to ensure the effectiveness of the self-sustaining energy system, it is important for building owners and architects to determine whether the system has adequate performance against disasters and changes in conditions. In terms of post-disaster residential continuity, however, there is no design target for a self-sustaining energy system in housing design, meaning that no indicator is available for use as a basis for judging the adequacy of performance. Thus, this urgent issue needs to be addressed.

Therefore, a study on the design targets for self-sustaining energy systems for post-disaster residential continuity was started in FY 2020. This study tries to identify the use of power necessary for the continuation of residence after a disaster, quantify the requirements for the design of a self-sustaining energy system in a house, and organize these results into a design target of a self-sustaining energy system for the continuation of residence after a disaster. In FY 2020, the study examined the use of power necessary to continue living in a house in the event of a power outage.

2. Examination of the use of power necessary to continue living in a house in the event of a power outage (FY 2020)

The use of power required to continue living in a house during a power outage was expected to change with the time elapsed since the start of the outage. A questionnaire survey was conducted of households that had experienced power outages in past disasters. In the survey, the time elapsed from the start of a power outage was divided into five periods: immediately after the start of the power outage (about half a day), one day later, more than one day to three days later, more than three days to one week later, and more than one week later. The survey then asked about the priority of daily activities and the necessity of various equipment and devices during each period (table). Based on the survey results, the verification of whether there was any change overtime and the organization of priorities are conducted regarding the use of the power necessary to continue residency.

Table: Outline of the survey

Subject of the survey	2018 Hokkaido Eastern Iburi earthquake 2018 Typhoon Trami (#24) 2019 Typhoon Faxai (#15)
Number of household that responded	600 households
Survey method	Online survey
Items of the survey	○ Basic information: - Type of housing building, year of construction, etc. - Facilities and equipment owned and their types ○ Condition of damage: - Condition of damage to the housing building - Length of period without lifeline ○ Condition of power outage: - Activities of daily living that were found to be inconvenient - Whether each type of facility and equipment was used - Status of the use of alternative power source ○ Demand to power uses during power outage: - Priority of daily living activities - Necessity of each type of facility and equipment

3. Future prospects

In FY 2021, assuming the use of electricity necessary to continue living at home based on the results of the above survey, a simulation-based parametric study will be conducted to calculate the amount of electricity

needed to continue living at home after a disaster and the amount of electricity that can be supplied by the self-sustaining energy system.

Visualization of the spatial distribution of light and heat by graphical representation for the improvement of the quality of indoor environment and energy efficiency

(Research period: FY 2019–2020)

MIKI Yasuhiro (Ph.D. in Engineering), Head, Building Environment Division, Housing Department

Keywords: Indoor environment, three-dimensional distribution, visual cognition, visualization

1. Introduction

In recent years, an increasing number of attempts have been made to improve both the quality of the indoor environment and energy efficiency in buildings.

Particular attention has been paid to the method of ensuring temperature and brightness at the required time and place by allocating air conditioning and lighting equipment locally in areas where they are insufficient, taking into account the effects of heat and light from the outdoors. Such methods can reduce energy consumption for the space as a whole while ensuring comfort for people.

However, an understanding of the relationship between the indoor environment formed by such methods and energy efficiency has been inadequate so far because it has been necessary to grasp the relationship in a two-dimensional distribution (cross-sectional or planar contour map) (Figure 1). Thus, in order to facilitate the understanding of the relationship between the indoor environment (elements related to light and heat radiation) and energy efficiency, this study attempted to visualize the spatial distribution of three-dimensional light and heat environment in the indoor space, both locally and in the entire space, through a graphical representation using visual cognition.

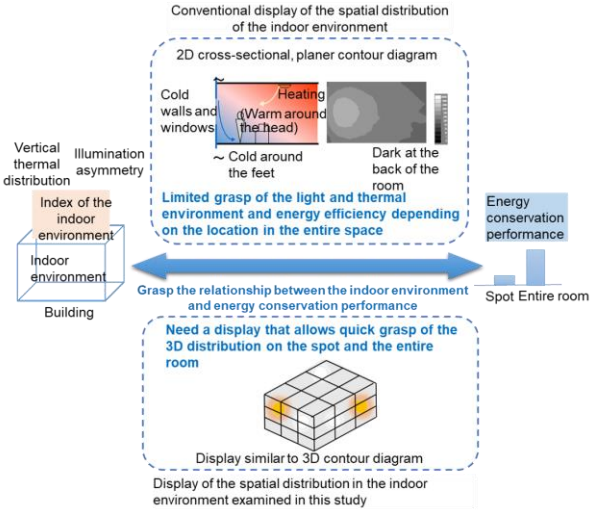

Figure 1: Necessity of graphical visualization of three-dimensional distribution

2. Graphical representation using visual perception of local distribution

The representation of light and heat by radiation could be a vector representation consisting of arrows extending in various directions from the surroundings because light and heat of different intensities are incident at a point in space from different directions. Still, it is difficult to display the various directions in a clear, three-dimensional manner (Figure 2, left). In this study, directions were narrowed down to the six basic directions of an architectural indoor room: up and down, left and right, and back and front. In addition, to make it easier to grasp the intensity of light and heat in different directions, an isometric diagram was used, which clearly shows the coordinate positions of the space and makes it easy to see the whole picture. However, since the simultaneous representation of vectors in six directions makes it difficult to intuitively understand the aspect of light and heat (Figure 2, center), the representation of a cube with surfaces that would easily express the brightness and color of light and heat were considered appropriate. However, a normal cube can only show three surfaces, and the convexity as a perceived figure is inverted (Figure 2, right). Therefore, a method to arrange the surfaces in a discrete manner was devised. Figure 3 shows how the discrete arrangement is organized by linking it to the theory of visual cognition. First, when the six surfaces that make up a cube are slightly discretized at the same spacing, the overlapping edges create depth perception using pictorial cues as higher order visual cognition (Figure 3, left). However, in a small discrete, it is difficult to see the surface at the back and cannot be perceived as the shape of the surface that makes up the cube. On the contrary, if the six surfaces are made into a large discrete with the same spacing, the depth perception of the back three surfaces

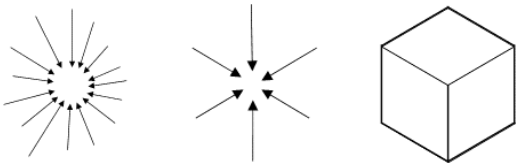

Figure 2: Limit to the three-dimensional representation of local light and thermal radiation

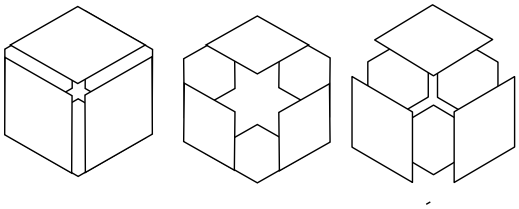

Figure 3: Representation by discrete arrangement of cubic surfaces

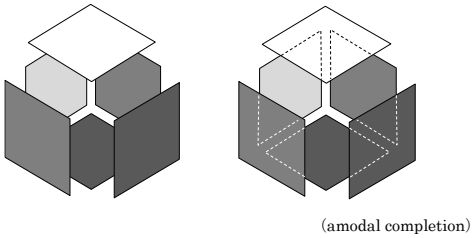

Figure 4: Local depth perception using light and dark surfaces and amodal completion

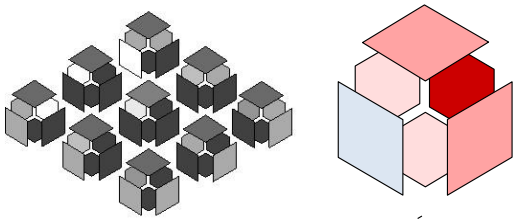

Figure 5: Display of multiple localized light and heat

becomes less, and they are not easily perceived as a cube (Figure 3, center). Therefore, the best way to display the image is to create a large discrete on the front three surfaces and small discrete on the three surfaces at the back (Figure 3, right). As an example of light, Figure 4 (left) shows different shading on the surfaces according to the amount of incident light. Here, amodal completion occurs in which the surface that is hidden behind another surface is perceived as an existing surface, and the entire surfaces including the back three surfaces are visible, and together with the pictorial cues provided by the overlapping of edges and shading of the surfaces, cubic shape is perceived as a depth that is not inverted. The three front surfaces with large hollow walls are filled in by the three back surfaces, and the pictorial cues similarly provide non-invertible depth perception. In the isometric view, an object with the same size at the back is perceived as relatively large, so the group of the three surfaces at the back is a little smaller than the group of the three surfaces at the front, but they do not seem strange. From these, the entire surfaces from six local directions are perceived, and the local distribution can be intuitively grasped. Figure 5 (left) shows the example of this representation of the light environment expanded into a layer of horizontal surface with multiple points. Figure 5 (right) is an example of representing the local thermal environment.

3. Attempt to graphically representing light and heat environment in a space as a whole

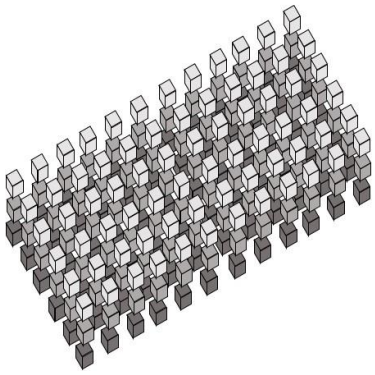

Figure 6: Trial display of the light environment of a space as a whole

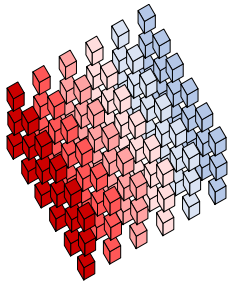

Figure 7: Trial display of the thermal environment of a space as a whole

When the displaying the light and heat environment in a space as a whole in the isometric diagram shown in Figure 5 (left), the multiple layers create overlaps in a cube itself, which depletes the perception of depth. Here, the study devised and tested a cubic representation of the entire space for the light and heat environment as scalar quantities. A method was devised that allows us to partially see and grasp surfaces even when each cube overlaps in the entire space because of the characteristics of the axonometric diagram that gives an overview of the entire space and the distortion of the displayed cubes. Figure 6 and Figure 7 show trial representation of the light and thermal environment, respectively. It is possible to

grasp through the space that, for the light environment, the brightness declines as it approaches the floor from the ceiling, and for the thermal environment, the temperature changes from the wall to the back of the room.

4. Summary

This study is a groundbreaking attempt to visualize the three-dimensional depth of an interior space with a two-dimensional graphical representation. The study will be continued to create practical graphical methods.

☞For more information:

1) Graphical Representation of Light Field by Discrete Arrangement of Cubic Surfaces Using Visual Congition, Technical Papers of Annual Meeting, Japan Society for Graphic Science Lecture, pp. 9-10, Nov. 2020.

Practical application of barrier-free environment assessment tools for houses to extend healthy life expectancy

(Research period: FY 2018–2020)

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Keywords: Life stage, barrier-free, physical activity level, iBeacon, METs (metabolic equivalents)

1. Introduction

The NILIM is establishing methods for visualizing the effect of providing barrier-free facilities to suit different life stages as an itemized project to be conducted as a three-year plan from FY 2018. The objective is to quantitatively express the ease of conducting activities within the housing environment using physical activity levels called metabolic equivalents (METs) as an index to evaluate the barrier-free performance of housing. The functions that the evaluation tool should have were examined and developed last year. In the final year of this study, the practical application of the evaluation tool were conducted. This paper introduces the outline.

2. Outline of the study conducted in FY 2020

(i) Verification of the evaluation tool in actual buildings for practical application

The amount of activity by residents in an actual building was measured with a simple activity meter (HJA-750C Active style Pro [Omron]), and the results were compared with the evaluation results of the developed evaluation tool (Figure 1) to verify the tool for practical application.

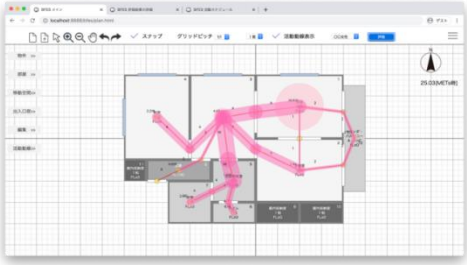

Figure 1: Barrier-free performance evaluation tool

The frequency of movement is indicated by the thickness of the line, and the amount of activity in the room is indicated by the size of the circle.

In the experiment using people as subjects for obtaining the amount of physical activity in a real building, the study used a total of 12 subjects who lived in the building to verify how different housing plans would affect the amount of physical activity in order to confirm whether the evaluation tool could evaluate the amount of physical activity in a real building. A total of six housing units were selected, including regular houses and apartments. The subjects wore simple activity meters and lived normally in the housing units (24 hours, weekdays, and holidays). The accuracy of the evaluation tool was adjusted by comparing and verifying the activity data of the meters with the calculated values of the evaluation tool.

(ii) Identification of the daily activity model of residents

A Web-based questionnaire was conducted to understand the patterns of daily life activities and the actions and behaviors of each resident attribute as a model of daily life activity (Figure 2) and to reflect them in the evaluation tool. In the screening, the target population was divided into eight age groups of men and women between the ages of 15 and 89 years, and a total of 500 responses were obtained. In this study, the population was divided into groups based on family structure, housing type, physical condition, etc., which were presented as a daily activity model.

Figure 2: Example of the daily activity model (Result of web survey)

3. Conclusion

The COVID-19 pandemic made it impossible to conduct the verification using actual buildings outside of the research facility. The research methods were thus reevaluated, and measurements were taken at the homes of the subjects by increasing their numbers. As a result, the study team believes that the initially expected results were achieved. The study will now move on to the examination of how the tool will be put into actual uses in society and spread its uses.

Publication of the implementation status of the relaxed building use restrictions and commentary (Research period: FY 2016–)

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ISHII Norimitsu (Ph.D. in Urban and regional planning), Head, Urban Development Division, Urban Planning Department:

Keywords: Building use restriction, relaxation, status of implementation, special use district, district planning, permission under Proviso of Article 48 of the Building Standards Act

1. Introduction

In July 2020, the NILIM published the implementation status of the relaxed building use restrictions and commentary (hereinafter referred to as the "Commentary") that explains the implementation status of the relaxed regulation that allows the installation of buildings that are not permitted in the region, although they are expected to contribute to regional revitalization, as an exception.[1,2] This paper introduces the background and objectives of the publication of this book and its outline.

2. Background and objectives of publishing the Commentary

In Japan, in order to realize the ideal image of urban areas, building use regulations (in addition to the prohibited uses in a given use district, standards for motor power output, and area for certain uses, etc.) are enforced in each use district defined in city planning. However, depending on the use districts, there are cases where buildings that have the potential to contribute to regional revitalization etc. do not conform to the building use restrictions, and their installation (new construction, extension, change of use) is abandoned. For example, as a general rule, stores and restaurants with the floor area of more than 150 m^2 cannot be installed in Category 1 and Category 2 low-rise exclusive residential districts, and inns cannot be installed in Category 1 and Category 2 low-rise exclusive residential districts, and Category 1 and Category 2 medium-to-high-rise exclusive residential districts (Figure 1).

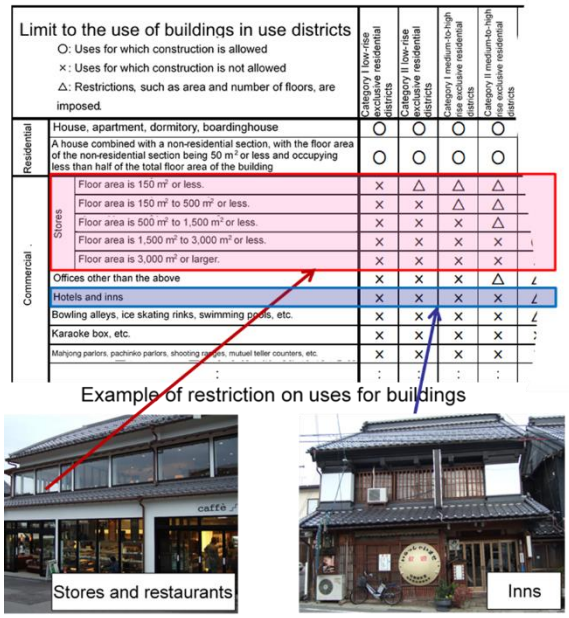

Figure 1: An example where it is difficult to conform to the building use regulation (image)

On the other hand, the City Planning Act and other relevant laws and regulations provide deregulation methods and special permission processes that allow the installation of buildings for prohibited uses according to local conditions (City Planning Act: special use districts, district plan, Building Standards Act: permission under Proviso of Article 48 etc.). However, according to a questionnaire survey conducted by the NILIM involving local governments, these methods and systems have not necessarily been used frequently for reasons, such as high hurdles in completing the procedures (special use districts and district plans), lack of established examination techniques at local governments, and applicants tend to postpone their applications due to the uncertain prospects of gaining permission (permission under the proviso of Article 48 of the Act).

In light of this background, this book has been prepared as a guide to the implementation of the deregulation of building use, which will serve as a reference for both local governments and applicants to facilitate the smooth implementation of the deregulated methods on building uses.

3. Outline of the Commentary

The Commentary covers the following three methods to relax the regulation on building use: (1) relaxation of the regulation of use through special use districts (Article 9 of the City Planning Act); (2) relaxation of the

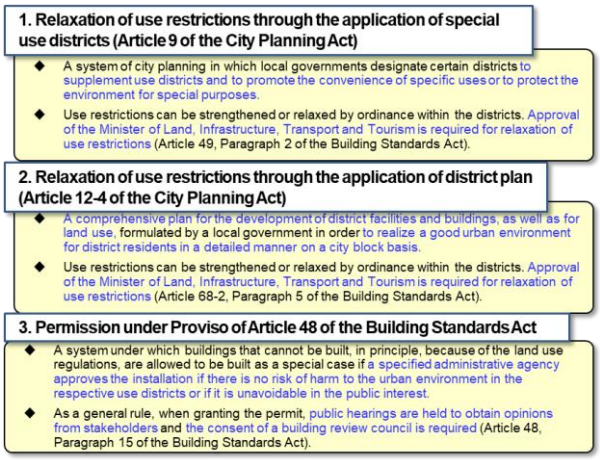

Figure 2: Outline of methods to relax building uses regulations mentioned in the book

regulation of use through district plan (Article 12-4 of the City Planning Act); and (3) the permission under Proviso of Article 48, the Building Standards Act (Figure 2).

Figure 3 describes the structure of the book. Chapter 1

Introduction

Structure of this book

Chapter 1. Outline related to the relaxation of use regulations
(1) Types of ways to relax main use regulations
(2) Characteristics of individual methods of implementation
(3) Concept of changing use districts

Chapter 2. Relaxation of use regulations through the application of special use districts
(1) Concept of relaxing use regulations through the application of special use districts
(2) Concept of setting areas
(3) Decision-making process and matters to pay attention to during the individual stages
(4) Discussion with relevant bureaus
(5) Effects on the surrounding urban environment
(6) Examples

Chapter 3. Relaxation of use regulations through the application of district plan
(1) Concept of relaxing use regulations through the application of district plan
(2) Concept of setting areas
(3) Decision-making process and matters to pay attention to during the individual stages
(4) Discussion with relevant bureaus
(5) Effects on the surrounding urban environment
(6) Examples

Chapter 4. Permission under Proviso of Article 48 of the Building Standards Act
(1) Concept of the permission under Proviso of Article 48
(2) Permission criteria
(3) Reviewing process and matters to pay attention to during the individual stages
(4) Points to keep in mind in the review of the permission under Proviso of Article 48 (examples)
(5) Effects on the surrounding urban environment
(6) Examples
(7) Q&A concerning the permission under Proviso of Article 48

References
- Excerpts from relevant laws and regulations (laws, government ordinances, public notices, operational guidelines, technical advice, old notices, etc.)
- List of districts with relaxed use regulations through the application of special use districts and district plans

Figure 3: Structure of the Implementation Status of the Relaxed Building Use Restrictions and Commentary

explains the characteristics of each method and how to properly use them. Chapters 2 and 3 explain the relaxation of use restrictions through special use districts and district plans, which are city planning methods (relaxation through ministerial approval and ordinances). Chapter 4 explains the permission under Proviso of Article 48 of the Building Standards Act, which is a special permission system applied for individual lots.

Chapters 2 to 4 explain the specific procedures and review process of each method, required documents, measures to mitigate the impact of the deregulated use on the surrounding area, and other points to keep in mind upon applying deregulation based on laws and regulations (laws, government ordinances, public notices, operational guidelines, technical advice, old notices, etc.) and based on the results of surveys on the actual implementation by local governments with plenty of examples (Figure 4). The reference section at the end of the book contains a comprehensive list of related laws and regulations (excerpts) pertaining to the relaxation of building use restrictions for easy reference, as well as a list of districts with relaxed use restrictions through the application of special use districts and district plans, allowing the reader to refer to the details of the relaxation in each district.

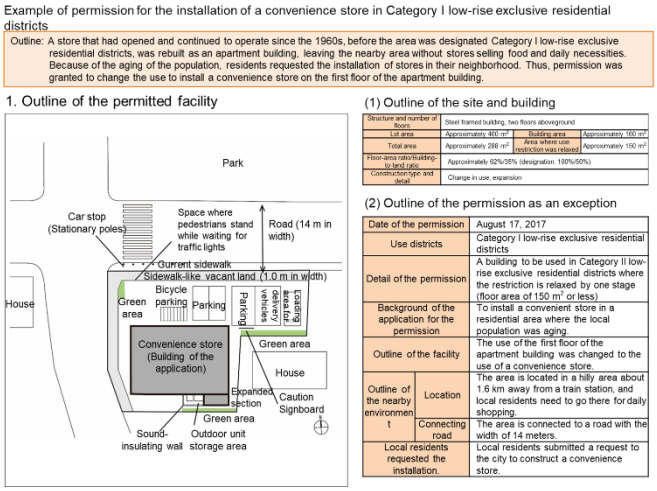

Figure 4: Example of the description of a convenience store that received the Permission under Proviso of Article 48 of Building Standards Act (image)

4. Conclusion

The Commentary is currently available as a free PDF file on the website of the NILIM.[1] We hope you will download it for use. It is expected that both local governments and applicants will be able to use this information to facilitate the effective use of vacant houses by changing their use, which will lead to regional revitalization and tourism promotion, as well as to help consider deregulation in the form of detailed building use restrictions to meet regional needs, regardless of the use

or condition of the building, whether it is a change of use or construction, or whether it is an existing building or not.

☞For more information:

1) NILIM Reference #1123, the "Implementation Status of the Relaxed Building Use Restrictions and Commentary" http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1123.htm
2) NILIM press release "Effectively use vacant houses for regional revitalization! - Publication of an instruction on the implementation of deregulation for the facilitation of changes in building use, etc. –" http://www.nilim.go.jp/lab/bcg/kisya/journal/kisya20200807.pdf

Development of technology for improving the mobility environment in suburban residential areas

(Research period: FY 2018–)

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ISHII Norimitsu (Ph.D. in Urban and regional planning), Head, Urban Development Division, Urban Planning Department

Keywords: Sustainable city, suburban residential area, convenience of living, new mobility

1. Background and objective of this study

In suburban residential areas that have been systematically constructed after the period of rapid economic growth, the number of residents who find it difficult to move about independently because of aging and other factors is increasing. Meanwhile, the level of public transportation services is declining markedly because of sluggish demand and a shortage of drivers. Under such circumstances, it is considered effective to introduce new mobility (e.g., small electric carts with excellent environmental performance and mobility) to improve the quality of life in suburban residential areas (Figure 1), which can become one of the core areas of cities for the realization of sustainable cities.

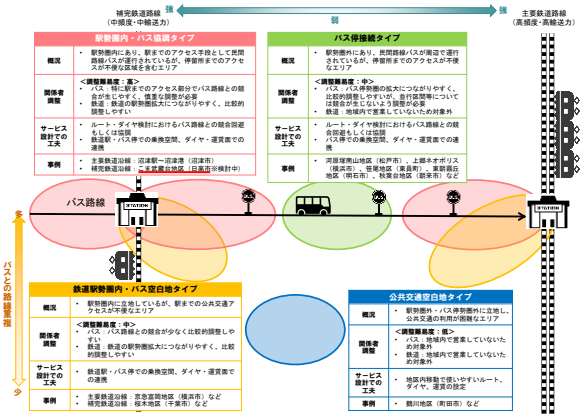

Figure 1: Categorization of suburban residential complex from mobility perspective

Therefore, in order to study a good way to introduce new mobility, a new mobility demonstration experiment (Figure 2) is conducted in Komamusashidai, Hidaka City, a residential complex with an aging population and hilly terrain that makes walking a burden, to analyze the effects of the introduction and issues.


小型電動カート(7人乗り)

Figure 2: Example of a new mobility

2. Outline of Komamusashidai residential complex

The population of this residential complex is aging (the housing supply started in 1977, population about 4,700 people with about 2,200 households, about one hour to Ikebukuro Station), and the largest proportion of the population is in the 65–69 age group.

The nearest station is Koma Station on the Seibu Ikebukuro Line, and there are three bus routes that run in the direction of Hanno Station and JR Komagawa Station.

The shopping centers in the district where convenience facilities are located have many vacant units, and since the withdrawal of the Tokyu store in 2008, many residents drive to stores outside the district.

3. Mobility of local residents

A questionnaire survey was conducted to understand the recent mobility situation and mobility needs of residents in the residential complex (Table).

Table: Outline of the questionnaire survey

Subject	- All residents of 1 to 7 chome (blocks), Musashidai, Hidaka City, Saitama
Method	- Distribution of the survey form to each household (one survey form (containing three copies) is distributed to each household and two forms to a two-family household.) - Survey form collected by mail
Period	- December 12, 2020 to January 6, 2021 (postmark deadline)

(1) Amount of travel

The number of visits to the area around Komamusashidai (hereinafter referred to as "Area A") was the highest among residents of all blocks. The ratio of visits to Area A is smaller among residents of block 6 compared to residents of other blocks (Figure 3).

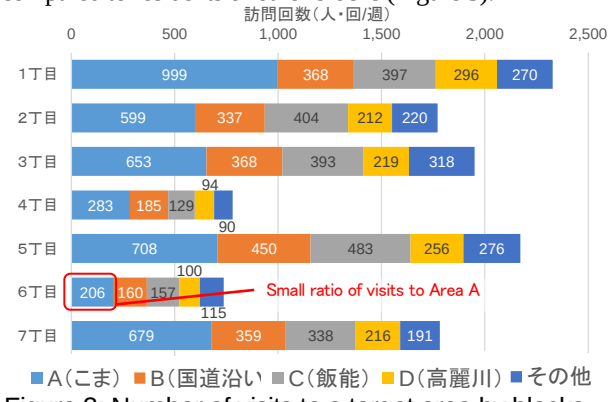

Figure 3: Number of visits to a target area by blocks

(2) Means of transportation used

Bus usage is relatively high among residents of blocks 2 and 5, where the access to bus stops is relatively good, while bus usage is low among residents of block 6, located far from a bus stop (Figure 4).

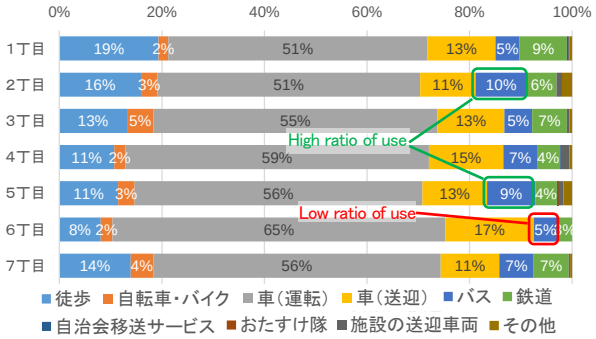

Figure 4: Means of transportation used by blocks

(3) Bus usage

The bus use to Area A is low among residents of all blocks, indicating that the use of buses is limited among residents of the residential complex. In comparison with Figure 3, bus usage is low in blocks 1 and 3, which are located near the train station and in blocks 4, 6, and 7, which are relatively far from the bus stop (Figure 5).

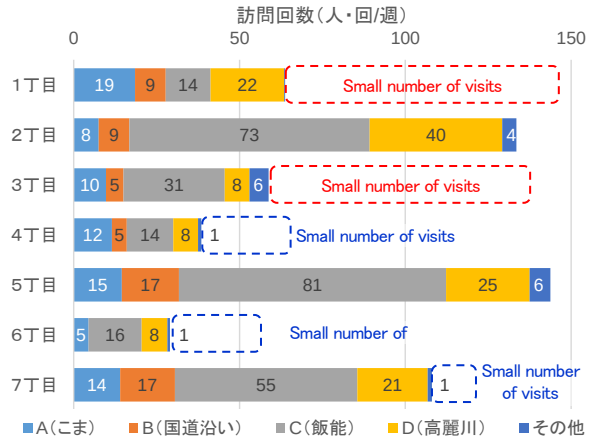

Figure 5: Number of visits made by bus users by districts and destination areas

(4) Request concerning the experimental route

Route C (Figure 7), which operates on Chuo Avenue, was the most preferred route and received the most votes from residents of blocks 5 and 6. The second most popular route was Route A, receiving many votes from residents of blocks 4 and 7, which were located along the route (Figure 6).

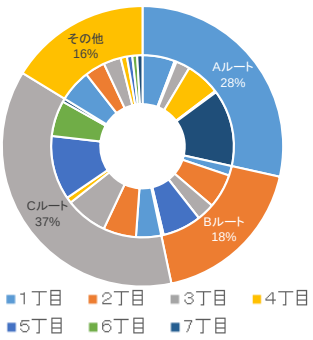

Figure 6: Preferred route

4. Verification experiment using small electric carts

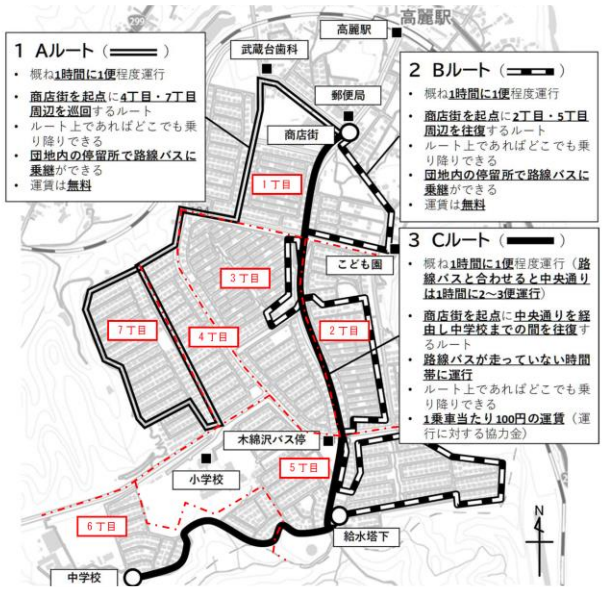

Figure 7: Routes presented in the survey

Based on the results of the questionnaire survey and other factors, routes were set up for the verification experiment (March 21 to April 11, 2021) from the perspective of measures to address areas lacking transportation (blue route) and to enhance existing transportation services (red route), and uses were assessed and analyzed (Figure 8).

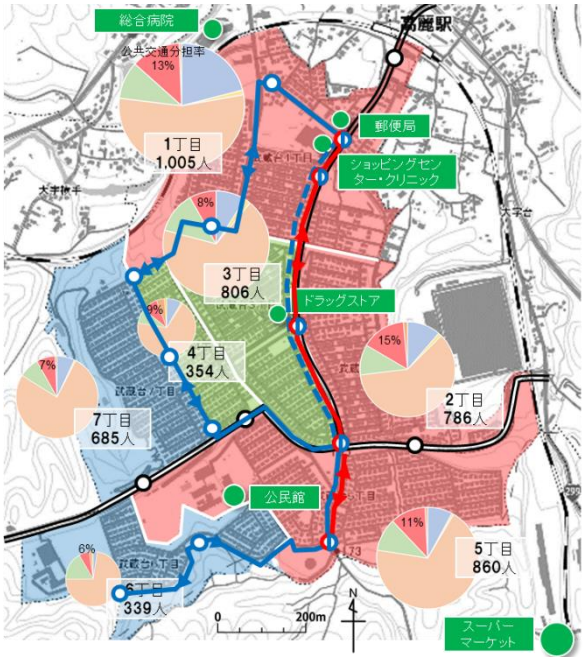

Figure 8: Verification experiment route (example)

5. Future activities

In this study, a new mobility route was set up based on the mobility needs of a district with train stations and bus routes.

In the future, longer term verification experiments will be conducted to collect and analyze data on behavioral changes and other aspects that will become available as a result of such experiments, while working to study methods for combining the introduction of new mobility and safety standards for each type of residential areas.

Research on the multi-functionalization of transportation nodes for effective use of urban space (Research period: FY 2019–)

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Keywords: Walkable, transportation node, environmental space, station characteristics, surrounding area *characteristics*

1. Introduction

In recent years, the formation of walkable spaces that are comfortable and make people want to walk has been emphasized. It is thought that the upgrading and multi-functionalization of transportation nodes that are core areas of a city, especially pedestrian spaces and green spaces within them (environmental space[1]), will also contribute to the realization of an integrated urban structure.

Therefore, in order to study the concept of securing the area (Figure 1) and other aspects of a transportation node, observation and analyses were conducted on the usage of the plaza in front of train stations with different characteristics, focusing on the environmental space.

2. Observation and analysis in the environmental space

Field observations were conducted at Musashi-Koyama Station and Nishi-Koyama Station (Table) on the Tokyu Meguro Line, which are stations with a similar number of passengers, plaza area in front of the train station, and environmental space area, but differ in other station characteristics (percentage of commuter pass users) and surrounding area characteristics (land use), for comparison.

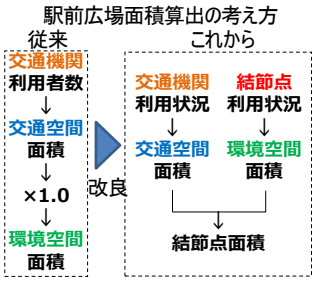

Figure 1: An example of the examination

	Musashi-Koyama Station	Nishi-Koyama Station
Number of passengers using the station	Approximately 54,000 persons/day Commuter pass: Approximately 55% Non-commuter pass: Approximately 45%	Approximately 37,000 persons/day Commuter pass: Approximately 68% Non-commuter pass: Approximately 32%
Plaza area in front of the train station	Approximately 3,800 m^2	Approximately 2,700 m^2

Table: Outline of Musashi-Koyama Station and Nishi-Koyama Station

(1) Average staying time

The staying time at Musashi-Koyama Station is long especially during daytime and early evening.

The staying time of multiple persons is long at Musashi-Koyama Station (Figure 2).

(2) Ratio of passengers using trains among users of the plaza in front of the station

At Musashi-Koyama Station, the ratio of users of the plaza in front of the station other than train passengers is high in the afternoon (Figure 3).

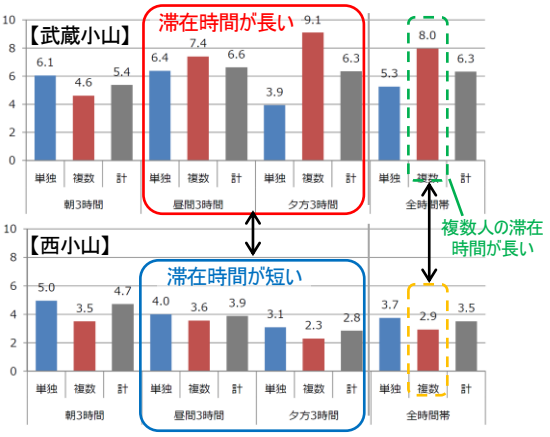

Figure 2: Average staying time

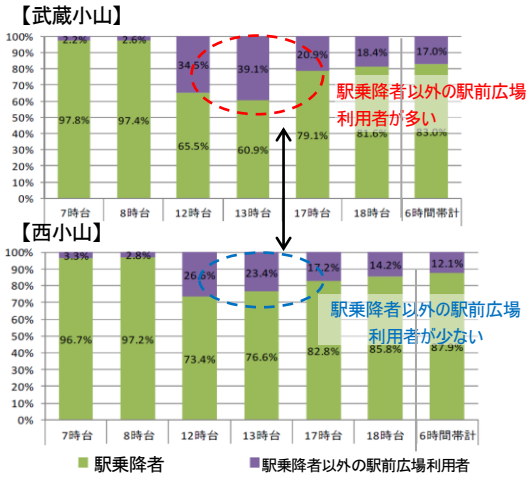

Figure 3: Composition of users of the plaza in front of the station

3. Future studies

This study revealed that even for stations of a similar size, there are differences in the number of people using the environmental space and how they use it, depending on the station characteristics and surrounding area characteristics. In the future, transportation nodes will be categorized based on the characteristics of train stations and surrounding urban areas to examine the planning and design methods for transportation nodes, including

transportation spaces, as well as the ideal environmental space.

☞ Reference
1) Station Plaza Planning Guideline (Japan Transportation Planning Association, 1998)

Survey of urban greenery using point cloud data

(Research period: FY 2018–2020)

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Keywords: Point cloud data, greenery survey, simulation

1. Introduction

Urban greenery is an important component of the city that brings a variety of benefits to the formation of a good urban environment, but it is difficult to grasp its current status. Therefore, the Urban Planning Department is working on a study of the methods for quantitative evaluation of the effect of greening to improve the urban environment.

The purpose of this study is to develop advanced methods for surveying the current status of greenery throughout the city, including privately owned land, using the latest measurement equipment and AI, as well as to develop technology for quantitative analyses of the benefits of greenery, to make the results of greening efforts visible and assessable, and to provide technical support for the greening policies of local governments.

This paper introduces the results of examining a three-dimensional survey method of urban greenery using point cloud data in consideration of its use in numerical simulations.

2. Three-dimensional measurement of greenery

The effects of greenery on the urban environment are diverse and wide-ranging. Yet, this study focuses on the multifaceted functions of greenery, particularly the effects related to physical phenomena, such as mitigation of the heat island effect and prevention of the spread of fire, as well as visual psychological effects, such as landscape enhancement.

In order to evaluate the effectiveness of the greenery present in the city, in addition to confirmation by actual measurement data, it is effective to model the physical phenomena and conduct numerical simulations to quantitatively analyze the effects.

To examine the effect of greenery in numerical simulations, it is necessary to model and incorporate the effect of greenery in the basic equation and to input its shape as a 3D model, as well as other components, such as buildings. Various numerical simulation models that take into account the impact of greenery have already been developed, but there is still no established method for obtaining current greenery data for use in such simulations.

The green coverage ratio, which is used as an indicator to grasp the total amount of greenery in a city, captures the amount of greenery in terms of the flat area of green coverage, so both lawns and trees are treated the same. This means that it is not possible to reflect the effects related to height, such as the shade effect of trees. By adding the height information of trees to this green coverage, it becomes possible to understand the three-dimensional distribution of greenery.

3. Acquisition of point cloud data targeting greenery

Point cloud data is already being used in various situations, such as i-construction and automated driving. The devices and technologies for acquiring point cloud data are becoming more widespread. Recently, LiDAR (light detection and ranging) has been installed in smartphones (Figure 1) and tablet devices, making point cloud data more accessible.

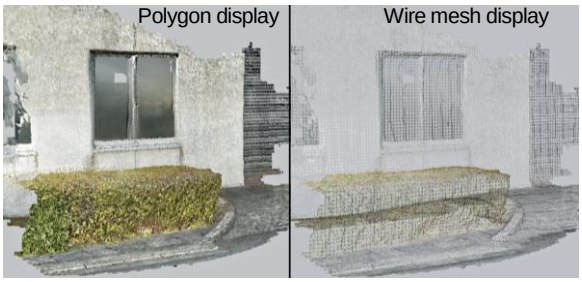

Figure 1: 3D data measured using a smartphone

① Measurement by aerial laser

The wavelength of the laser used in commonly available aerial lasers is in the near-infrared range, a wavelength that is highly reflective by plants. On the other hand, the Airborne LiDAR Bathymetry (ALB) for underwater depth measurement uses lasers with green wavelengths in addition to near-infrared light. It is possible, to a certain extent, to use this on land and classify plants and buildings by using the difference in reflection intensity depending on the wavelength. [1] (Figure 2)

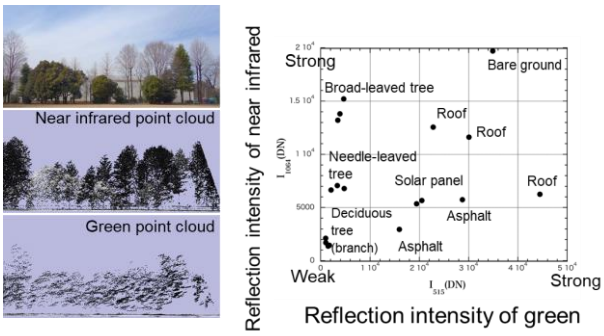

Figure 2: Difference of reflection intensity against laser wavelength

② Measurement by laser on board of vehicle

LiDAR mounted on a Mobile Mapping System (MMS) used for road surveys etc. can capture the condition of street trees and other plantings along the road (Figure 3).

Since the laser beam is emitted from the side, the conditions under the tree canopy can be captured, which is difficult to grasp with an aerial laser from above.

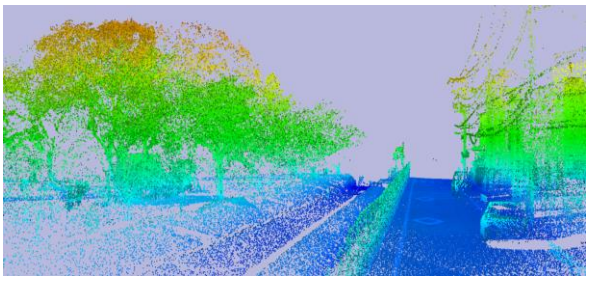

Figure 3: Point cloud data captured through MMS

In-vehicle lasers are already being used for the automatic braking of some vehicles, but they are expected to become an emerging technology for more advanced automated driving. The data developed by Simultaneous Localization and Mapping (SLAM) has the potential to be used for various purposes in the field of urban studies as city shape data that can be updated as needed.

③ Measurement through photogrammetry

There has been great technological advances in the methods of acquiring point cloud data, not only by laser measurement but also by photogrammetry. For example, Structure from Motion (SfM) is one of the technologies to create point cloud data from multiple photos, including GPS and other location information. This makes it possible to create point cloud data (Figure 4) from images captured by a camera mounted on a drone or a handheld compact camera. While it is difficult to survey an entire city with drones or through ground-based surveys, it is possible to survey a limited area, such as a park, at a reduced cost.

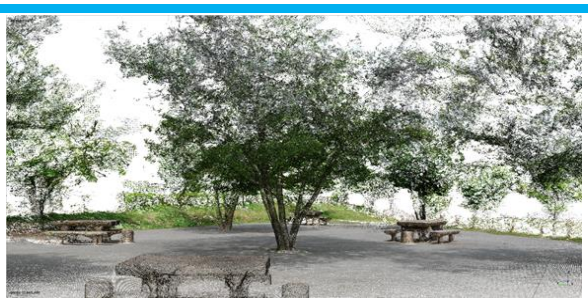

Figure 4: Point cloud data created from photos taken by digital cameras

4. Producing 3D model for simulation

The greenery surveyed by the point cloud data is represented as a 3D model (in this case, DCHM: Digital Canopy Height Model is used) for numerical simulation (Figure 5).

Figure 5: DCHM data (the darkness of the green color representing tree heights)

When representing the shape of a tree or other object in a simulation, the range of the tree canopy is shown on the computational mesh because the shape of leaves and branches cannot be reproduced in detail as polygons. As a specific example, in fluid flow calculations, tree parameters, such as resistance coefficients, obtained from wind tunnel experiments are set on the mesh where trees exist. Another method that is under consideration is to give the leaf area density, which indicates the condition of leaves in the mesh, by estimating it from point cloud density and other data.

5. Conclusion

Currently, 3D city models are being developed for urban DX (digital transformation), focusing on building data, but it is expected that tree data will also be developed in the same way as building data in the future in order to make it possible to study the urban environment, including the effects of trees.

☞For more information:

1) Masamiki Ohashi, “A Study on Vegetation Survey by Aerial Laser Profiler,” Lecture Compilation DVD-ROM of the 2018 Architectural Institute of Japan Assembly, pp. 871-872.

Study of the location conditions of convenience facilities in suburban residential areas

(Research period: FY 2018–2022)

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HASEGAWA Hiroshi (Ph.D. in Engineering), Director, Housing Department
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Keywords: Suburban residential area, convenience facility, location condition, commercial area population, age, household composition

1. Introduction

After the period of rapid economic growth, many residential areas had been planned and constructed in the suburbs of large cities and formed residential areas in the suburbs. Many of the housing complexes were developed more than 40 years ago, and the aging of houses and residential areas, the decline of commercial and service facilities in residential areas (photo), the increase in the number of vacant houses, the decline of public transportation, and other aspects of an outdated town have become apparent. Yet, such areas have advantages, such as higher coverage of public facilities, thanks to planned development from the past and an environment containing a lot of greenery. Thus, these areas can be described as valuable social assets of cities to be maintained and passed on to future generations.[1]

Therefore, the NILIM is developing technology to promote the regeneration of planned and developed suburban residential areas (housing complexes) in the General Technological Development Project Development of Regeneration Technology for Suburban Residential Areas in Response to a Mature Society (FY 2018–2022), with the aim of using these areas as a base to promote the reorganization and consolidation of suburbs.

This fiscal year, in order to introduce convenience facilities, which are in short supply in suburban residential areas, interviews and surveys were conducted with business owners of convenience facilities regarding their location conditions for opening new stores in suburban residential areas.

Photo: A shopping street where most stores are closed

2. Survey of location condition of convenience facilities

(1) Survey target: convenience facilities

Last fiscal year, a questionnaire survey was conducted (average response rate: 54.6%) of the four complexes (Komamusadai housing complex in Hidaka City, Seibu Kitanodai housing complex in Hachioji City, Shodo housing complex in Sakae, Yokohama City, and Asukano housing complex in Ikoma City) examined as case studies to identify convenience facilities that are preferred to be located in and around the complexes. Based on the results, the following five types of facilities were selected for the study.

(i) Commercial facilities that sell fresh food (mini-supermarkets and convenience stores)

Mini-supermarkets and convenience stores were selected rather than large supermarkets, expecting that elderly households will go there on foot or by bicycle.

(ii) Commercial facilities that sell daily goods (drugstores)

Small-scale drugstores are selected as a main target rather than large home centers.

(iii) Elderly facilities

In addition to fee-based nursing homes and senior homes with care service, a facility pattern was also examined where such facilities are combined with small-scale multifunctional in-home care facilities.

(iv) Childcare facility, regional childcare support base

In addition to the community childcare support centers based on the Child Welfare Act, temporary care service for children was also considered.

(v) Co-working space

Teleworking is expanding and taking root because of the influence of the COVID-19 pandemic, and this was considered in response to requests from residents in an interview survey.

(2) Survey method

The survey examined the basic units related to population, households, etc. that are necessary for the establishment of a location for convenience facilities. In order to collect the basic unit, interviews were conducted with commercial consultants, operators of convenience

facilities, and others to determine the average commercial area population required for the installation of the facilities.

Since the installation potential based on the projected income and expenditures of individual facilities is highly individualized and difficult to study as a theory of urban planning, the study was designed to examine the installation potential using population by age group and the number of households by type that live within a certain range from the facility as basic indicators (Figure).

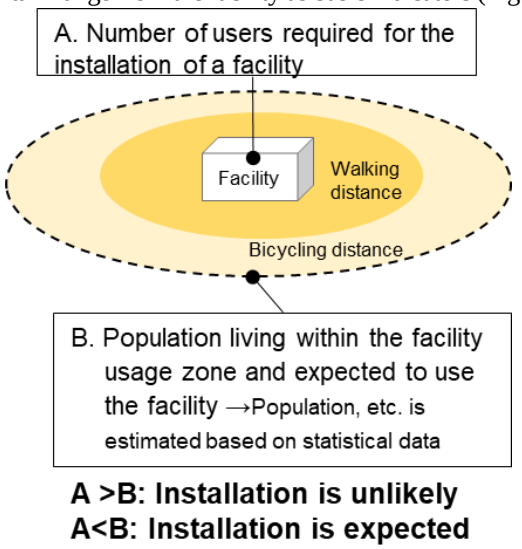

Figure: Image of examining installation potential

(3) Result of commercial population survey etc.

The table shows the result of surveys (i) and (ii) for commercial facilities among the convenience facilities to be studied in (1). The table also shows the data of home centers as a reference. The basic unit shown in the table is based on the assumption that there are no competing stores in the commercial area.

As for supermarkets, which were greatly requested by the residents in the questionnaire survey, it is said that even a mini-supermarket requires a population of about 10,000 people in the surrounding area. Meanwhile, since the four housing complexes that are the subject of the case study in this study all have a population of about 5,000 people, it is considered difficult to install a supermarket in or near these housing complexes. A convenience store can be located in this area in terms of population size.

	Retail area etc.	Population within commercial zone
Convenience store	• Basic retail area is 50 to 60 tsubo (*one tsubo is about 3.3 m^2)	• 3,000 people within the 500 m radius
Supermarket	• Basic retail area is 200 tsubo or more • The number of mini-supermarkets is increasing in recent years (less than 100 tsubo, installed after a convenience store is closed)	• 20,000 people or more within a 2 to 5 km radius • For mini-supermarkets, 10,000 people or more within a 2 km radius
Drugstore	• Basic retail area is 150 tsubo or more (when the store is in suburbs)	• 20,000 people or more within a 2 to 5 km radius
<Reference> Home center	• Basic retail area is 300 tsubo or more	• 30,000 to 50,000 people or more within a 5 km radius

Table: Result of the survey of retail area and commercial area population

(4) Effects of age composition and household composition etc.

When business operators were asked about the impact of age and household composition on the commercial area population of commercial facilities (i) and (ii) in (1), they said that such factors were not major issues for supermarkets and convenience stores and that they would respond by analyzing the sales of products after opening a store and changing the product mix to suit the area. Although not reported in this paper, it goes without saying that age and household composition have a significant impact on facilities for the elderly and children.

3. Conclusion

This study introduced some of the results of a survey on the basic unit, which is a condition for opening a new store in a suburban residential area that lacks convenience facilities. Studies are also being conducted on the conditions for providing services from facilities outside the housing complex, such as mobile stores and home care, which will be reported later. Future studies are going to cover the possibility of installing facilities by combining multiple convenience facilities.

☞For more information:

1) Regeneration of Housing Complex Meeting
https://www.mlit.go.jp/jutakukentiku/house/jutakukentiku_house_tk5_000067.html

Methods for Creating High-Quality Public Design in Foreign Countries

(Research period: FY2020)
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Research Center for Infrastructure Management, Landscape and Ecology Division

key words: public design, design administration, landscape, regional vision, project design

1. Introduction

In recent years, various activities in design administration have been implemented by local governments in Japan, while the issues of consideration for the landscape and improvement of design quality still remain in the development of public facilities. With the aim of supporting further activities for high-quality public design, National Institute for Land and Infrastructure Management (NILIM) has been systematically organizing a framework of design administration based on prior examples and preparing technical documents that show the advantages, challenges, and technical considerations of demonstrated methods.
In this context, focused on high-quality overseas public design initiatives, this paper, by investigating the matters that contribute to solving domestic issues, such as framework of design administration and continuous involvement of experts in the design field, has organized the methods for creating high-quality designs in view of the possibility of application of such matters to Japan with a medium- to long-term perspective.

2. Perspectives and targets of the investigation

As a result of investigating 22 domestic examples from past years, we found that the issues listed in **Table 1** exist in creating high-quality public spaces. In response to these issues, in domestic cases, high-quality public design has been realized under variety frameworks of design administration according to the characteristics of projects and the situations of local governments, and these can be broadly classified into five types: Committee type, Adviser type, Outsourced supervision type, In-house type, and Collaborative urban development organization type (**See the upper part of Fig. 1**).
In FY2020, based on the results stated above, we organized the methods of problem-solving and the framework of design administration by analyzing overseas examples. Of the 21 examples investigated in cities overseas, we conducted an in-depth study, including interviews, on the six examples shown in **Table 2**. In this paper, we present a comparative analysis between domestic examples and "Water Square" and "Dakpark Rotterdam" in Rotterdam, Netherlands, and "Uptown Normal Roundabout" in Normal, USA. (**Fig. 2** gives an overview of the three examples).

Table 1: Issues considered common to each example

No.	Issues
1	Comprehensive design of multiple facilities and projects
2	Clarification of local issues and visions
3	Active involvement of the designer up to the construction stage
4	Adoption of an appropriate ordering system
5	Securing experts who can assure the quality of design
6	Planning and design assuming programs
7	Ensuring an activity system leading up to the operation stage
8	Appropriate operation and management by the community
9	Securing financial resources for project operation and management
10	Transfer of know-how due to transfer of project personnel, etc.
11	Ensuring integration across vertical divisions
12	Follow-up on step-by-step explanations within the agency
13	Follow-up on small-scale projects

3. High-quality public design in overseas examples

As a result of investigating overseas examples, we found that the framework of design administration is greatly different from that of Japan. Overseas, there are two new types of framework: In-house team formation type and In-house director type (**See the lower part of Fig. 1**). What is common to these two types is that an internal team or director of the administration is coordinating the design of public spaces, without relying on outside experts. In addition, in order to ensure design quality, there are few personnel transfers during the course of a project, and once involved in a project, personnel are generally involved until completion. Therefore, it was found that some issues referred to in domestic examples were rarely recognized as issues in overseas examples,

including "Securing experts who can assure the quality of design," "Continuous involvement of designers throughout the construction process," and "Transfer of know-how due to changes in project personnel."
By city, Rotterdam in the Netherlands is characterized by the fact that the city's department in charge has about 600 engineers (in the fields of civil engineering, architecture, and landscape architecture), so they are able to take charge of design work (basic and detailed design). On the other hand, the town of Normal in the USA had the project director coordinate design for the whole development plan for the target project and the surrounding area, and reach a consensus with local residents and the City Council, which greatly contributed to the realization of the regional vision. Consensus-building with local residents is very important also in foreign countries, as was confirmed in examples like the "Uptown Normal Roundabout," where efforts were made to obtain the support of local residents by holding dozens of public meetings before creating a master plan, and thoroughly sharing the direction and content of the regional vision.

4. Summary of results

The results of this research will be summarized in the form of a guide that explains successful frameworks of design administration and key points for creating high-quality public design, together with the contents of domestic examples studied in past years, based on the results of interviews with experts.

Table 2: Six examples where in-depth study was conducted

No.	Location (City/Country)	Project name	Project type
1	Rotterdam Netherlands	Water Square	Square
2	Rotterdam Netherlands	Dakpark Rotterdam	Park
3	Auckland New Zealand	Wynyard Quarter	Port
4	Chicago USA	Chicago Riverwalk Expansion	Waterside space
5	Normal USA	Uptown Normal Roundabout	Road
6	Houston USA	Levy Park	Park

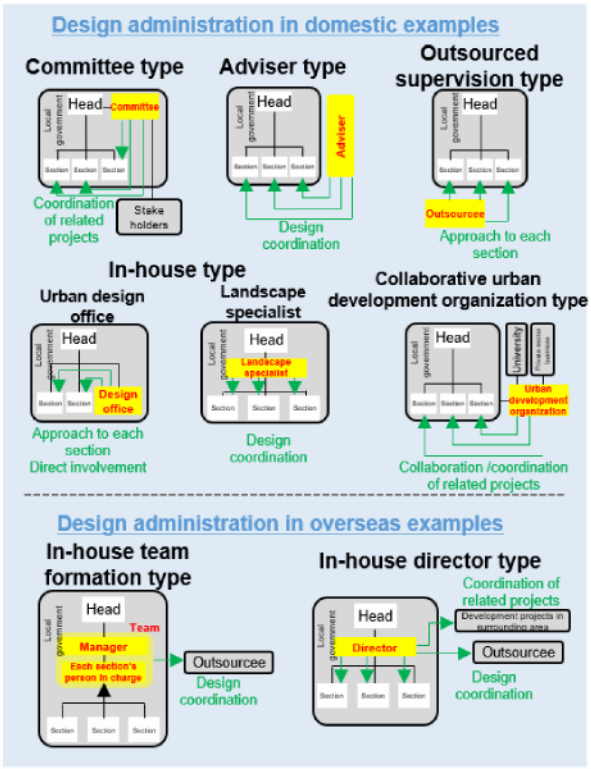

Fig. 1: Types of design administration in Japan and abroad

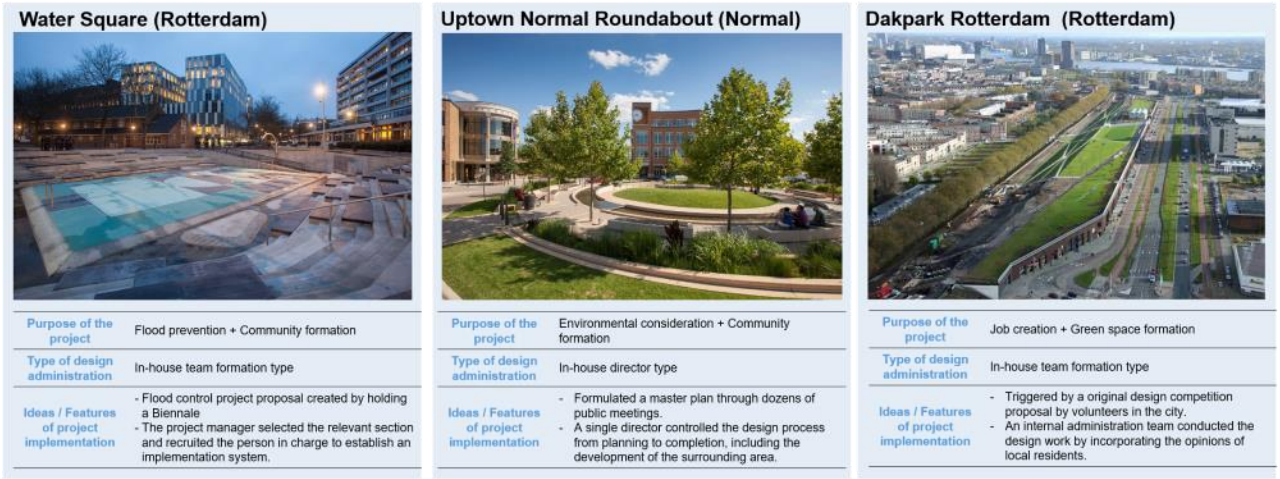

Fig. 2: Overview of the three overseas examples (Photos were provided by Rotterdam City and Normal Town)

Study for the social application of the draft manual for maintaining health in evacuation shelters

(Research period: FY 2020–2021)

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Keywords: Evacuation shelter, health, safety, building facility

1. Introduction

In previous earthquakes, it has been found that methods to improve the living environment of evacuation shelters are necessary to prevent health damage, including damage to mental health, and to ensure safety when people stay in evacuation shelters for a long period of time. Therefore, the department conducted the "Development of Repair Technologies for Facilities to Ensure the Health and Safety of Disaster Victims in Evacuation Shelters" from FY 2017 to FY 2019. This paper introduces an overview of the results of this study and future developments.

2. Outline of the study

2.1 Evaluation of partitions with sound absorption properties

As the evacuation of disaster victims becomes more prolonged, sound problems and noise issues, such as children's voices, become apparent as the evacuees start to seek the protection of privacy and improved comfort. Therefore, the department created a prototype of a partition for an evacuation shelter that considers both the sound environment and privacy and confirmed that the partition covered with sound absorption material reduces the sense of clamor by shortening the reverberation time in a gymnasium.

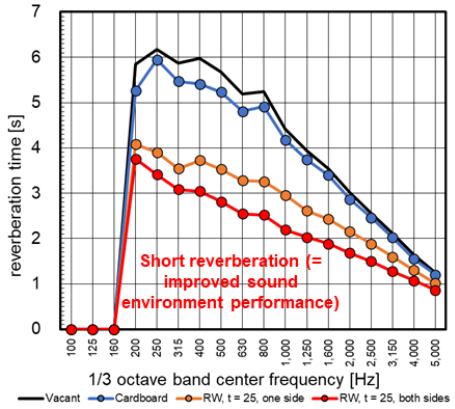

Figure 1: Example of reverberation time prediction calculation in a gymnasium with partitions

2.2 Proposal of a lighting method that achieves both security and better sleep environment

For lighting in evacuation shelters, lighting for evacuation and crime prevention purposes and lighting suitable for sleeping are required, but the brightness required for these conflicts. Therefore, the team developed an indirect lighting fixture that can be temporarily installed and checked the degree of glare during sleep based on the luminance distribution and the security function based on the illuminance distribution through actual measurement and simulation.

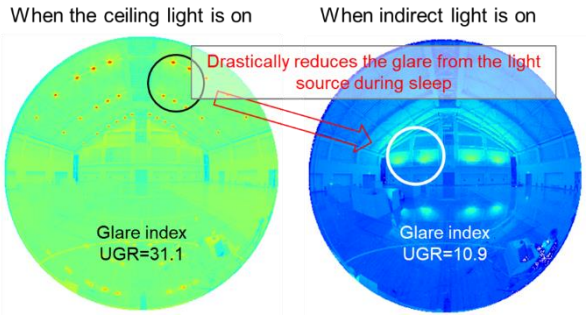

Figure 2: Examination of glare reduction effects of different lighting methods

2.3 Preparation of a draft manual for facility planning to ensure the health at evacuation centers

Specific methods for securing the living environment in evacuation shelters were organized through interviews with local governments and exchanges of opinions with academic societies etc., and a draft facility planning manual was prepared. The main contents of the report are setting up the target level for assuring health, summary of areas available to evacuees, and specific ways to secure facility functions to deal with lifeline disruptions. The report also describes an example of equipment capacity and cost estimation.

3. Future prospects

New issues have arisen regarding the response to issues, such as the COVID-19 infection, and other diseases. The basic policy is to avoid crowds, which will also be effective in improving the living environment of

shelters, as described above. The effective use of evacuation shelter facilities and equipment plans will be organized. Also, a *Manual on Facility Planning to Maintain Health in Evacuation Shelters* (draft) will be prepared as a specific and effective reference for setting up evacuation shelters for municipalities to use, which will then be published on the website and other channels.

Criteria for evaluating and judging the possibility of utilizing existing housing through renovations for early development of temporary housing and housing constructed after a disaster

(Research period: FY 2018–2020)

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Keywords: Temporary housing, housing constructed after a disaster, renting, private rental housing

1. Introduction

In the event of a major disaster, such as an earthquake that directly hits the Tokyo metropolitan area, a large amount of emergency temporary housing and reconstruction housing (disaster public housing) will be needed. To reduce the cost of supplying such housing and to ensure housing stability for disaster victims at an early stage, vacant private rental housing stock needs to be utilized in a new way. This paper introduces the examination of criteria for evaluating and judging housing that can be supplied as temporary housing (rented temporary housing) by quickly repairing and renovating not only the housing that is undamaged in a disaster but also housing with minor damage, or as housing to support reconstruction (rented housing for reconstruction) by improving the comfort of living through renovating and turning them into a rented housing for reconstruction.

2. Formulation of proposed criteria for determining the continuity of the use of damaged housing through renovation (conversion to rented temporary housing)

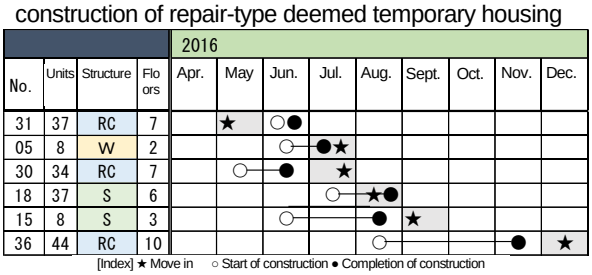
Fact-finding survey was conducted on cases where existing houses that had suffered minor damage during the Kumamoto earthquake were repaired and used as temporary rental housing (repaired and deemed temporary housing). The analysis was also conducted on the relationship between the repair work, construction period, and cost. In cases where disaster victims were able to move in quickly, many of the work was conducted for about one month after the earthquake in April (Figure 1). The work included repairing cracks in exterior walls (nonstructural walls) and water tanks in common areas, and repairing interiors, fittings, and water leaks inside individual units.

Based on the findings of this survey and assuming that buildings will be checked in stages immediately after an earthquake, a draft of the criteria was prepared consisting of the following items: (1) basic information to be identified by a local government during normal times (location, year of construction, floor plan, etc.), (2) safety confirmation etc. (confirmation of the structural safety of a building), and (3) criteria for determining the continuity of use (access to housing units, facilities, etc.).

3. Formulation of criteria for determining which houses can be used as rented housing for reconstruction (turning housing into rented housing for reconstruction)

Based on the survey of 20 municipalities with experience in converting existing housing into public housing by renting (including one municipality that had converted housing into to reconstruction housing), items of the criteria for renting housing and required levels were identified and organized (Figure 2).

Figure 1: Example of the timing of moving in and construction of repair-type deemed temporary housing



Implementing entity	Independent standard	Application of standards for providing public housing, etc. (consideration standard) (◎: Applicable, △: Partially applicable, ▲: Relaxed regulation applicable, X: Not applicable)						
		Thermal	Sound insulation	Deterioration	Maintenance and management	Sick house	Barrier free (residential)	Barrier free (common facility)
ST Prefecture		▲	▲	▲	▲	▲	▲	▲
NG City	○	–	–	–	–	–	–	–
YC City		X	X	X	○	X	▲	○
KM City		X	X	X	△	X	△	△

Figure 2: Example of applying standards for rented public housing (stock type)

Based on this, and taking into account that the number of housing units required as housing for reconstruction depends on the scale of the disaster, and the number of available units is affected by the local rental housing situation, the drafted criteria set two levels of standards: basic standards as housing for reconstruction (presenting

the basic concept of performances and required levels), and relaxed standards to meet the temporary demand that occurs after a large-scale disaster. The drafted criteria are designed to make it easy for local governments to set criteria for selecting target housing to be converted into rented housing for reconstruction, depending on the scale of the disaster and local situations.

4. Conclusion

In the future, the outcome of this research is expected to be used to formulate criteria for judgments and contribute to the realization of early housing stability in the event of a disaster by disseminating it to local governments.

* The outcome of this study has been obtained through the implementation of the PRISM project.

Research on Technology to Grasp the Conditions of Slopes Close to Roads Early after an Earthquake

(Research period: FY2019 to FY2021)

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key words: *road, slope, grasp of the condition*

1. Background and purpose

In the 2016 Kumamoto Earthquake, the functions of roads were affected by ground deformation, and some of these roads took a long time to investigate and restore because they were located close to steep slopes (**Photo 1**). Based on this lesson, in order to make decisions as quickly as possible on whether roads along such slopes are passable or not immediately after an earthquake and on emergency opening, it is considered that one of the most important factors is the early and comprehensive grasp of the existence, extent, and degree of deformation on the slopes. Therefore, in order to present a maintenance management method that contributes to the early and comprehensive grasp of the deformation of road slopes that are not easily accessible, we are studying the possibility of using existing technologies to detect deformations and the matters etc. that should be considered when acquiring data and interpreting the acquired information for implementation in maintenance. This paper reports the knowledge obtained based on the measurements made on the restoration sites of the Kumamoto Earthquake with regard to the issues that should be considered in implementation.

Photo 1: Road close to the steep slope

2. Study method

(1) Shape measurement method

This paper provides the results of three times of measurements made in March, August, and November at the lower slope of the Toshita Ohashi Bridge (**Photo 1, right**), where the progress of restoration work and vegetation conditions were different. In the measurement, we used two types of laser scanners, i.e., UAV-mounted laser scanner and terrestrial laser scanner (TLS), as a technique that has the potential to grasp the shape of steep slopes in planes without close proximity (**Photo 2**).

(2) Verification method by comparison of measurement results

After creating a TIN model, in which the 3D shape of the slope consists of a triangular surface, using the 3D point group data acquired by each technique, we calculated the difference between the vertical coordinates of the point group and the TIN model (**Fig. 1**) for various cases with different measurement time and methods, to create a difference diagram and compare the measurement results. The comparison was made focusing on the four sites shown in **Fig. 2** in order to verify the influence of topographical conditions and surface properties on the measurement results in addition to the shape change caused by the construction of the restoration work. Of the sites on which results of study were introduced in this paper, at Site 2, mortar was sprayed from March to November, while at Site 3, the construction of slope frames and in-frame anchors was carried out from March to August.

Photo 2: Technology used in the study

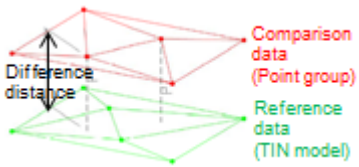

Fig. 1: Image of the difference calculation

Fig. 2: Points of focus in comparison of measurement results

3. Verification by comparison of measurement results

(1) Verification of basic measurement accuracy

Fig. 3 shows the difference diagram of measurement results between the TLS and UAV laser at Site 2 in November after the mortar spraying. The difference was close to zero on all the sides, and the average of the absolute difference was small at 0.023 m. If the conditions are smooth shape and little vegetation, it is possible to identify shape changes with a size of about 2 cm at minimum.

(2) Verification of issues to be considered in implementation

Fig. 4 shows the difference diagram in the results of UAV laser measurements before and after the construction of the slope frame and in-frame anchors at Site 3 (March and November). In both March and November, the surface point density was above 100 pts/m^2 over the entire surface. In this Figure, the area where a pressure receiving plate with a design thickness of 30 cm has been installed is colored red to represent a positive difference of 30 cm, which indicates that the change in areal shape due to installation could be grasped.

Fig. 5 shows the difference diagram of measurement results between the TLS and UAV laser in November after the installation of the slope frame and in-frame anchors at Site 3. The surface point density of the UAV laser is more than 100 points/m^2 over the entire surface, while that of the TLS is as small as 20 points/m^2.

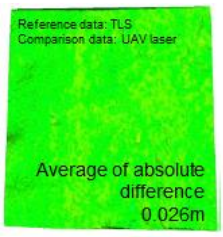

Fig. 3: Difference diagram (Nov., Site 2, Difference between TLS and UAV laser)

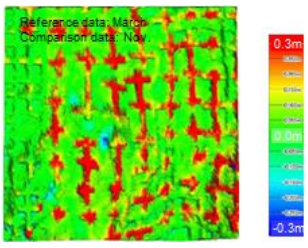

Fig. 4: Difference diagram (Site 3, UAV laser, Difference between March and November)

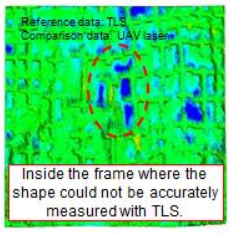

Fig. 5: Difference diagram (Nov., Site 3, Difference between TLS and UAV laser)

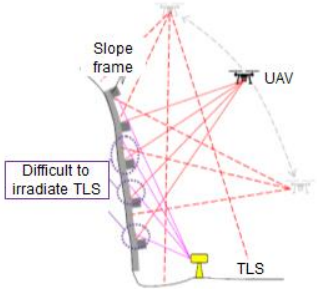

Fig. 6: Examples of conditions that make TLS irradiation difficult.

Fig. 5 shows that while there are many areas where the difference is close to zero, a portion of the frame is colored blue to represent a negative difference of 30 cm, which indicates that the TLS measures the slope as a convex shape better than the UAV laser.

This means that the shape of the concave in the frame could not be accurately measured by the TLS due to the relationship between the location of the measurement device installation and the shape of the measurement target (**Fig. 6**). On the other hand, when the UAV laser, which moves the position of the measurement device, is used, it was confirmed, as compared with the case of the TLS, that the flight route greatly affected the measurement accuracy, although the shape of the concave could be captured.

In general, it is assumed that when surveying the location and shape of topography and landforms, the manual established by the Geospatial Information Authority of Japan are often referred to. However, from the results stated above, for the purpose of maintenance of road slopes, it would be necessary not only to follow the manual but also to use the data acquired by an appropriate measurement method that considers the shape, surface properties, and field conditions of the measurement target in order to ensure the required measurement accuracy. As a proposal for specific requirements, it was confirmed that it may be effective to set the required surface point density according to the shape and surface properties of the measurement target.

From the measurement results of other sites not specified in this paper, some issues on data processing were also identified, including the fact that the method of calculating the difference of vertical coordinates adopted in this study may not be sufficient to grasp the shape change because the change in vertical coordinates of neighboring data is large due to the topography, especially in steep areas, and that the calculation results may differ depending on the method of creating TIN models and filtering vegetation. These data processing methods need to be considered in implementation, and studied as a subject for future research.

4. Prospect for future research

Considering that the accuracy varies greatly depending on the surface properties of slope, it is necessary to present the concept of setting the measurement method according to the measurement target and field conditions, the concept of setting data processing method, etc., as well as specific application methods considering the limitations of accuracy from the results of verification at the points of focus. The study on the concept of setting deformations as the measurement target and the required accuracy should also be consistent with the study on the performance expression mechanism of earthwork structures.

Development of Strength Performance and Practical Structure Required for Bollards to be Installed on Sidewalks at Intersections

(Research period: FY2019 to FY2020)

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key words: bollard, guard fence, strength performance, collision experiment

1. Introduction

A "bollard" (also known as buffer stop) is a type of guard fence that is defined as a "fence or guard fence on the road" installed as an "accessory of the road" in Item 1, Paragraph 2, Article 2 of the Road Act. Bollards are used for various purposes as they are installed to prevent vehicles from entering, parking, or crashing into road facilities. Furthermore, bollards can be an alternative to protective fences in areas where the continuous installation of guardrails or other protective fences is difficult or inappropriate. However, impact-resistant bollards that can resist vehicle collisions, like guardrails, have not been widely used in Japan.

In response to the growing need for measures to protect pedestrians, etc. waiting on sidewalks at intersections, NILIM and the Road Bureau of MLIT have studied the concept of using bollards at crosswalk connections and intersection corners ("crosswalk connections, etc."), listened to the opinions of academic experts and compiled the results. The results were published as the "Handbook for Bollard Installation" (the "Handbook") by the Japan Road Association (March 2021), which has been widely disseminated to road administrators, etc.

This paper presents an overview of the study on the setting, evaluation method, etc. for the strength performance required for impact-resistant bollards based on the analysis of traffic accident data, traffic accident simulations, and collision tests using actual vehicles.

2. Definition of bollard

Photo 1 shows an example of bollard installation at a crosswalk connection. These bollards are intended to deter vehicle entry by visually emphasizing the distinction between the crosswalk connection and other areas but do not stand up to vehicle collisions, etc. They are defined in the Handbook as an "N-type bollard". On the other hand, the Handbook defines an H-type bollard as an impact-resistant bollard that resists vehicle collisions and prevents vehicle entry, in addition to distinguishing the crosswalk connection, etc.

Photo 1: Example of bollard installation (N-type bollard)

3. Study on the setting of strength performance

The types of impact-resistant H-bollards shown in the **table** below are set according to the design speed of the roads where bollards are installed. The **table** shows the collision conditions to verify the strength performance. Collision tests with an actual vehicle are necessary to verify that H-type bollards have enough strength to prevent vehicles from significantly entering the sidewalk by stopping the vehicle or pushing it back.

Table: Setting according to types (collision conditions)

Type	Vehicle mass (t)	Collision speed (km/h)	Entry angle (Angle at entry into the sidewalk) (°)
H_C	1.8	35 or more	15
H_B	1.8	45 or more	15

* Hc "applies to roads with a design speed of 50 km/h or less, and "H_B" applies to roads with a design speed of 60 km/h.

Collision conditions were set based on the behavior of a straight-through vehicle that collided with a right-turning vehicle, after taking into account the tendency of collisions between right-turning and straight-through vehicles that occur at standard signalized intersections (see **Fig.**).

To be the safe (large mass) side, the vehicle mass was

set to 1.8 tons based on an analysis of traffic accident data, which confirmed that vehicles entering crosswalk connections, etc. (straight-through vehicles that collided with right-turning vehicles) are mainly passenger cars, and by organizing the number of passenger cars owned according to the mass of those cars.

The collision speed was set using traffic accident simulation software. Assuming the traffic accident shown in the **Figure**, we reproduced a situation where the speed of a straight-through vehicle decreased due to a collision with a right-turning vehicle and the straight-through vehicle entered the sidewalk. In reproducing the situation, the speed of the straight-through vehicle was set at the design speeds of 50 km/h and 60 km/h. Furthermore, to be on the safe (high speed) side, speeds of 35 km/h and 45 km/h were set by looking at multiple situations in which the vehicle enters the sidewalk under different timing scenarios for the collision with the right-turning vehicle.

The angle of entry at which a straight-through vehicle that collided with a right-turning vehicle would enter the sidewalk connected to the crosswalk in a standard road structure of the general national road or prefectural road class in urban area, was set to 15˚.

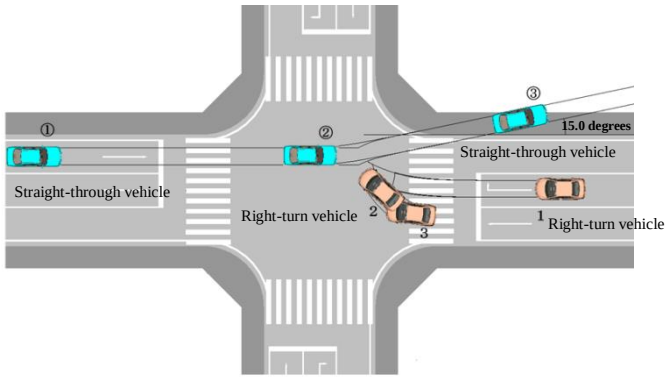

Fig.: Behavior of a straight-through vehicle that collided with a right-turning vehicle

4. Study on evaluation method of strength performance, etc. (collision experiment)

In order to verify the evaluation method of strength performance, etc., a collision test was conducted with actual vehicles under the collision conditions shown in the **table**. In this test, we decided to make a prototype of a H-type bollard, which was made of easily available materials and products, and structurally designed to be shallowly embedded in order to reduce the impact on underground structures in the sidewalk in consideration of practical use. At NILIM's collision test facility, four prototype H-type bollards of a practical structure were arranged (1.5 m apart) on a sidewalk connected to a crosswalk, and struck by a vehicle (passenger car) under the collision conditions of type H_B (see **Table**). Two out of the four H-type bollards were contacted by the vehicle. The vehicle ran up on the first bollard and was pushed back by the second one, and did not enter the sidewalk to a large degree, which was a good result (**Photo 2**). Through this test, we summarized the detailed procedure for evaluating the strength performance and proposed a practical structure for H-type bollards.

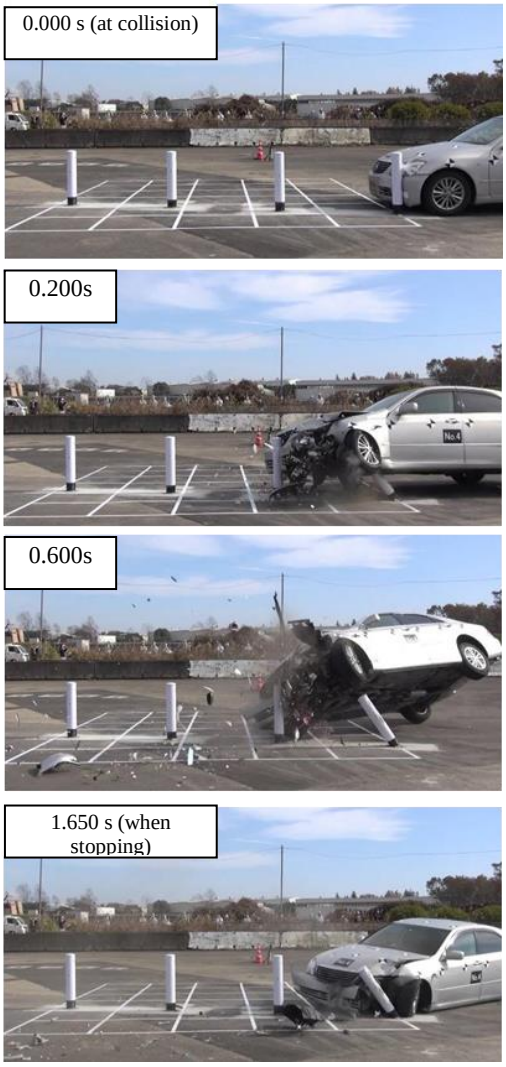

Photo 2: Test situation (Bollard stopped vehicle entry)

5. Conclusion

This paper mainly introduced the study on the strength performance of bollards. Please refer to the Handbook for the concepts of installation, structure, etc. We plan to continue the study on how to solve the issues of bollards and other traffic safety infrastructure.

Analysis of the Periodic Inspection Results of Sheds, Large Culverts, etc.

(Research period: FY2018 to FY2020)

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key words: shed, shelter, large culvert, periodic inspection, deformation tendency

1. Introduction

Road structures that were widely built during the period of rapid economic growth in Japan need to be efficiently maintained for continued use, and since FY2014, statutory inspections of road structures such as tunnels have been conducted once every five years. NILIM is collecting and organizing the results of periodic inspections of sheds, large culverts, etc. conducted by the government and other road administrators in order to efficiently maintain road earthwork structures, and is studying the rationalization of periodic inspections, etc.
This paper reports the results of analysis on the periodic inspection data of about 3,400 sheds and shelters and about 8,600 large culverts for the first five years (first round) from FY 2014 to FY 2018 and the first year of the second round in FY2019.

2. Organization of results from periodic inspection of sheds and shelters

The results of the soundness diagnosis for the sheds and shelters nationwide are as follows: about 6% are classified as Judgment Category I (sound), about 49% as Judgment Category II (preventive maintenance stage), about 45% as Judgment Category III (early action stage), and 0.2% as Judgment Category IV (emergency action stage) (**Fig. 1**). Of these, the results organized by shed material are shown in **Fig. 2**. By material, steel sheds in about 60% of the facilities were classified as Judgment Category III, which is a higher percentage than RC and PC sheds. This may be partly due to the fact that many of the steel sheds are old (**Fig. 3**).
As regards the installation environment of government-managed sheds, about 90% of the facilities are installed in areas designated as snow-covered area or cold region (including areas designated as both) (**Fig. 4**). The ratio of Judgment Category III is about 45% for facilities installed in snow-covered area or cold region, which is higher than outside the region (**Fig. 5**). This would be attributable to the effects of freezing and thawing, as well as the tendency of deterioration by salt damage resulting from the dispersion of snow-melting agents.

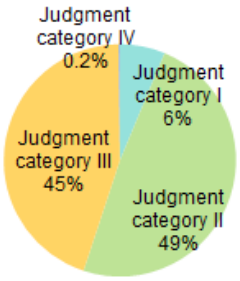


Fig. 1: Percentage of Judgment Category (Shed, shelter)

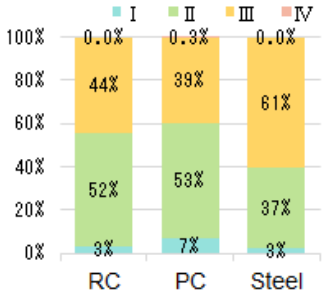


Fig. 2: Percentage of Judgment Category by material (Shed)

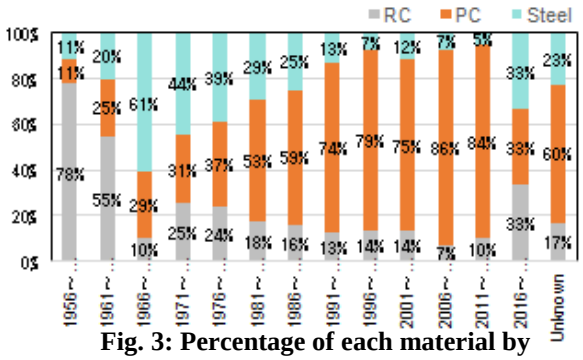


Fig. 3: Percentage of each material by construction year (Sheds)

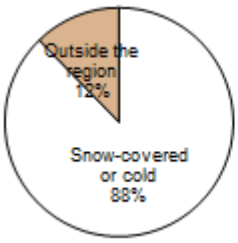


Fig. 4: Percentage of facilities by snow-covered area / cold region (Shed)

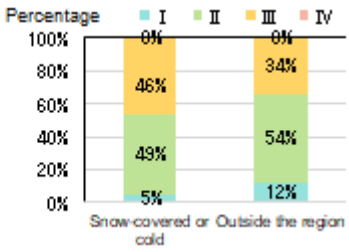


Fig. 5: Ratio of Judgment Category by snow-covered area / cold region (Shed)

3. Organization of results from periodic inspections of large culverts

The results of diagnosis on the soundness of large culverts nationwide showed about 20% were in Judgment Category I, about 72% in II, about 8% in III, and 0.01% in IV (**Fig. 6**). In general, for the soundness by construction year (decade basis), the older the construction, the lower the number categorized as

Judgment Category I, and the higher the number categorized as Judgment Categories II and III (**Fig. 7**). **Figures 8 and 9** show the diagnostic results for each year of construction since 1990, which were organized by material for the facilities managed by the government. For cast-in-place culverts, there is no trend over time in the percentage of judgment categories. For precast culverts, the trend of soundness was higher for the facilities of newer construction, although there are some differences depending on the construction year. The number of occurrences of deformation aggregated by type is shown in **Fig. 10**. Cracks are the most common type of occurrences of deformation, accounting for about 53% (31,950/60,386 locations) of the total number of deformation occurrences.

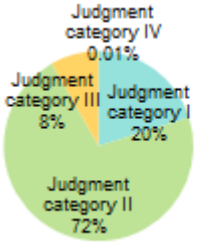


Fig. 6: Percentage of judgment category (Large culvert)

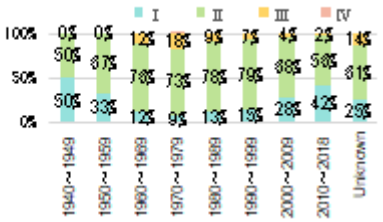


Fig. 7: Percentage of judgment category by construction year (decade, since 1940)

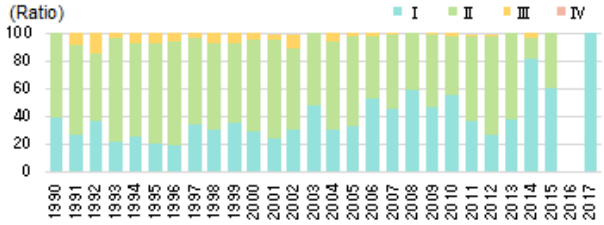


Fig. 8: Percentage of judgment categories by construction year (Cast-in-place culverts, since 1990)

Fig. 9: Percentage of judgment categories by construction year (Precast culvert, since 1990)

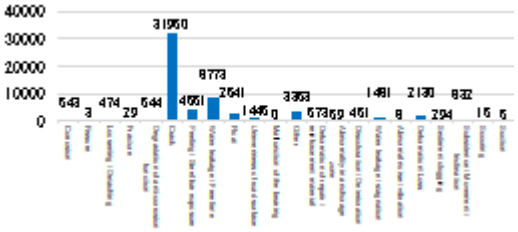
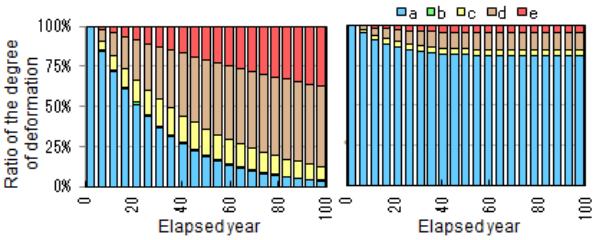


Fig. 10: Number of locations where deformations occurred by type of deformation

4. Comparative analysis of the results of the first and second rounds of periodic inspections

For sheds, shelters, and large culverts, the second round of periodic inspections was started in FY2019. Since 2020, NILIM has been conducting the comparative analysis on the results of the first and second rounds of periodic inspections since FY2020 to study the progress of deformation (deterioration characteristics). In the periodic inspection of government-managed facilities, results are recorded according to the types of deformation for each component by classifying the evaluation results of the degree of deformation into five levels, from Category "a" (no deformation) to Category "e" (the largest deformation). **Figure 11** shows the state probability distribution of the members for each 5-year period of time, based on the evaluation results of the degree of deformation of members in the first and second rounds. The comparison of the "cracks" in RC valley-side columns of RC sheds and PC valley-side columns of PC sheds shows that the RC valley-side columns deteriorate faster than the PC valley-side columns.



(RC shed RC valley side columns, cracks) **(PC shed PC valley side columns, cracks)**

Fig. 11: Example of state probability distribution

5. Conclusion

NILIM has prepared a collection of examples of deformation[2] as reference material for periodic inspections, as well as the analysis results of the first round of periodic inspections shown in this report. [1]. We will continue to conduct a comparative analysis of the results of the first and second rounds of periodic inspections, and to study the application of new technologies, etc., which are expected to lead to proposals for streamlining periodic inspections, etc.

☞See the following for details.

1) Technical Note of NILIM, No. 1145, "Analysis of the Periodic Inspection Results of Sheds, Large Culverts, etc. (1st round)
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1145.htm
2) Technical Note of NILIM, No. 1135, "Reference Material for Periodic Inspection of Sheds, Large Culverts, etc. (2020 Edition)"
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1133.htm

Technical Cooperation

1. Introduction

The research policy of NILIM provides, as a basic attitude, "Aim at new technical development by implementing technical cooperation and integration widely among industry, university and government," and, as preparedness for research, "Establish an efficient research system in cooperation with external organizations while recognizing our own strengths and weaknesses." The following introduces representative examples of such cooperation.

2. Examples of coordination and cooperation with related administrative bodies

NILIM carries out many research projects with project costs, etc. that lead directly to policy development in cooperation with the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Comprehensive technical development projects (comprehensive projects) and administration cost itemized budget projects are examples of particularly large-scale research subjects. Among important research subjects concerning construction technologies, comprehensive projects address particularly urgent issues with a wide target area. This research is conducted comprehensively and systematically in cooperation with industry, universities and government under the leadership of administrative departments in project planning and promotion. The administration cost itemized budget is reviewed directly by the Ministry of Finance, and is used to carry out comprehensive research leading to the creation of new policies. **Table-1** shows the subjects of comprehensive projects implemented in fiscal 2020, and **Table-2** shows research conducted using the administration cost itemized budget.

3. Examples of cooperation with the private sector, universities, etc.

In addition to joint research conducted jointly by NILIM with other organizations and contract research outsourced to NILIM by organizations already conducting the research, NILIM is also engaged in diverse other types of cooperation, which can be roughly classified as follows.

The condition of implementation of joint research and contract research in fiscal 2020 is shown in **Table-3** and the following table, respectively.

I. Research institutionalized by NILIM

(1) Joint research, (2) Contract research (research publicly offered by NILIM), (3) Contract research (publicly offered by Council), (4) Budget of other ministry or agency (PRISM)

II. Research institutionalized by other organizations

(5) Technical research association

III. Research not institutionalized but established to a certain extent

(6) Technical public offering, (7) Social experiment, (8) Workshops and study groups

IV. Research conducted by devising operation

(9) Cooperation with policy development by MLIT, (10) Cooperation with municipal projects, (11) Workshops with universities and the private sector

4. Conclusion

In addition to the above, NILIM is also engaged in various other forms of technical cooperation, such as research activities and revision of technical standards through industry-university-government cooperation as committee activities of academic societies and

Table-1 Comprehensive technical development projects implemented in fiscal 2020

Subject	Research period	Department / Center in charge
Research on construction productivity improvement with full utilization of ICT	2017-2020	Infrastructure Management
Development of design / construction techniques for mixed structure buildings using new wood material	2017-2021	Building
Research on upgrading of construction production systems using AI	2017-2020	Infrastructure Management
Development of suburban residential area revitalization techniques responding to mature society	2018-2022	Housing / Building / Urban
Technical development contributing to urban revitalization / resilience by rationalization of structural regulations related to buildings and ground	2020-2023	Building / Urban

Table-2 Research based on administration cost itemized budget implements in fiscal 2020

Subject	Research period	Department / Center in charge
Research on comprehensive management of sewer pipelines	2018-2020	Sewerage
Development of pre-analysis method for sediment disaster caused by large-scale earthquake	2018-2020	Sabo
Development of existing RC member evaluation techniques contributing to life extension / improvement of exterior / waterproofing membrane of building	2018-2020	Building
Establishment of visualization method for barrier-free effect according to life stages	2018-2020	Housing
Research on quantitative evaluation method for urban environment improving effect of green space, etc.	2018-2020	Urban
Research on immediate damage estimation method for port facilities in a major earthquake	2018-2020	Port and Harbor
Research on levee collapse perception / flood situation forecast for communicating information that enables quick actions for evacuation / flood prevention	2019-2020	River
Development of techniques for quickly judging the soundness of base buildings damaged by earthquake	2019-2021	Building
Research on wide-area cooperation of urban functions in a local city	2019-2021	Urban
Development of an evaluation technique for efficient utilization of environmental conservation technology in coastal area	2019-2021	Coastal, Marine and Disaster Prevention
Development of terminal congestion index contributing to improvement of punctuality of container ships	2019-2021	Port and Harbor
Research on upgrading of safety measures of civil construction considering environmental changes at the site	2020-2022	Infrastructure Management
Development of plan assessment technique for urban problem-solving to support promotion of smart cities	2020-2022	Urban
Research on quantification of effects on preventive measures for management failure of abandoned houses	2020-2022	Housing
Research on design targets for independent energy systems for continued residence after disasters	2020-2022	Housing
Development of performance index and evaluation program contributing to advanced fire-prevention performance of non-residential buildings	2020-2022	Building
Research on introduction of self-driving airport snow removal vehicles	2020-2022	Airport

associations. In the future, we intend to continue our research efforts through diverse forms of cooperation with industry, universities and government agencies.

Pattern	Name of Council, etc.	No. of cases
Research publicly offered by NILIM		3
Research publicly offered by MLIT Council		
	New Road Technical Conference	24
	River works (sediment disaster prevention) technology research and development	10
	Sewerage B-DASH	12

Table-3 Joint research conducted in fiscal 2020

Subject of joint research	Partner organization	Research period	Department / Center in charge
Research on early detection of sediment disasters using observation / monitoring data of mountainous watershed	National Institute of Advanced Industrial Science and Technology (AIST)	2016-2020	Sabo
Research on technical standards, etc. in building, housing and urban fields	Building Research Institute	2016-2021	Building / Housing / Urban
Joint research on development of sediment disaster monitoring methods using Advanced Land Observing Satellite No. 2 "Daichi No. 2"	Japan Aerospace Exploration Agency (JAXA)	2017-2021	Sabo
Joint research on technological development for practical use of next-generation cooperative ITS	29 entities and 32 organizations including automakers, electrical equipment manufacturers, related foundations and expressway companies	2017-2022	Road Traffic
Joint research on seismic performance verification experiment of mixed structure buildings using new wood material	National Research Institute for Earth Science and Disaster Resilience	2017-2021	Building
Joint research on life extension of weathering steel bridges	Public Works Research Institute (PWRI), Japan Bridge Association Inc., Japan Iron and Steel Federation, Nagaoka University of Technology, Nippon Steel Anti-corrosion Co., Ltd.	2017-2020	Road Structures
Joint research on maintenance of concrete floor slabs	PWRI, Japan Prestressed Concrete Contractors Association	2018-2021	Road Structures
Joint research on inundation forecast system in Tokyo	Waseda University	2018-2021	River
Joint research on ETC 2.0 data distribution service	ITS Technology Enhancement Association	2018-2022	Road Traffic
Joint research on upgrading steel bridge performance evaluation / restoration techniques	PWRI, Japan Bridge Association, Inc., Japan Iron and Steel Federation, Nagaoka University of Technology, Waseda University	2018-2021	Road Structures
Joint research on real-time utilization of strong motion index	National Research Institute for Earth Science and Disaster Resilience	2019-2020	Road Structures
Joint research on evaluation technology for road bridge performance	Japan Civil Engineering Consultants Association, Japan Federation of Construction Contractors, Japan Bridge Association Inc., Japan Prestressed Contractors Association	2019-2021	Road Structures
Joint research on management of special / huge bridges	Honshu-Shikoku Bridge Expressway, Kyoto University, Osaka University, PWRI, Tokyo Rope Mfg. Co., Ltd., Shinko Wire Company, Ltd.	2019-2021	Road Structures
Joint research on continual improvement of maintenance plans for existing road bridge groups	Japan Civil Engineering Consultants Association, Kyoto University, Osaka University, Kyoto-fu, Ibaraki Prefecture	2019-2021	Road Structures
Joint research on sediment / flood control technology	University of Tsukuba	2019-2021	Sabo
Joint research on integration of AIS data for Tokyo Bay and use in disaster prevention	Kanto Regional Development Bureau (MLIT)	2019-2021	Ports and Harbors
Joint development of inspection / diagnosis system for port and harbor facilities utilizing 3D / 4D data	Japan Marine Surveys Association	2019-2021	Coastal and Marine
Joint research on development of rapid emergency recovery of wastewater treatment functions after inundation damage	PWRI	2020	Sewerage

Table-4 Examples of cooperation with private sector, universities, etc. implemented in fiscal 2020

Pattern	Subject	Purpose and form of cooperation	Participant	Research period	Department / Center in charge
③	Breakthrough by Dynamic Approach in Sewage High Technology Project (B-DASH Project)	Utilize local governments, private enterprises, universities, etc. for practical use of innovative techniques not yet generalized in sewerage	Joint Research Organization (universities, private enterprises, other national research centers, local governments, etc.)	2011 -	Sewerage
⑥	Project for introduction / utilization of innovative technologies for drastic improvement of productivity in construction sites	Publicly offer a project for improving productivity with new technologies such as IoT and AI by obtaining real-time data from construction sites	Consortium consisting of private enterprises, universities, etc.	2018 -	Infrastructure Management
①⑦	Examination of new services using ETC 2.0 data	In order to strengthen the mobility of communities, solicit new service proposals using ETC 2.0 data from the public. Provide ETC 2.0 data to private enterprises that made proposals for verification leading to practical use.	Private enterprises	2018-	Road Traffic

International Research Activities

1. International research activities in NILIM

NILIM promotes international research activities based on the following three pillars while deepening exchanges with institutions in other countries, centering on governmental organizations and government-affiliated research institutions, and grasping future changes in policy needs related to international activities.

(1) **Technical contribution to domestic policies:**
While concluding bilateral agreements and utilizing agreements concluded by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), NILIM forms networks with governmental organizations in other countries to collect information on advanced technologies and disasters and reflect the results in domestic policy proposals, technical standards, etc. in order to the carry out the core activities of NILIM.

(2) **Technical cooperation for developing countries, etc.**
Utilizing the knowledge and lessons learned from maintenance activities, disaster response, etc. for domestic public facilities and the results of research on more advanced disaster prevention and mitigation reflecting that knowledge, NILIM supports countermeasures, etc. for high-level technical issues confronting the local governments of developing countries, etc. from a standpoint close to that of the administrators of public facilities.

(3) **Overseas deployment of infrastructure systems:**
NILIM participates in committees involved in international standardization using its knowledge of the formulation of technical standards, manuals, etc. which support the development of important policies for issues directly confronting Japan. NILIM also prepares working drafts in some fields, and contributes to the smooth international deployment Japanese technologies through efforts to “promote international standardization of domestic standards” and “ensure consistency between domestic standards and standards in other countries,” by substantially leading discussions, etc.

2. Main international research activities in FY 2020

During the one-year period of fiscal 2020, all countries unavoidably restricted international travel as the novel coronavirus spread around the world. As a result, with some exceptions, international conferences, meetings, etc. were either canceled or postponed or changed to online meetings. Those concerned responded by conducting online meetings, and in-person meetings decreased sharply. Some meetings were originally scheduled to be held by overseas travel limited to the main person in charge, however, accompanying the change to online meetings, in some cases it was possible to hold the meetings with the participation of a larger number of persons, or to deepen the discussions by holding multiple meetings following up with the originally-scheduled meeting.

The following introduces representative examples of international research activities in FY 2020 amid the restrictions imposed in response to the spread of the coronavirus.

2.1 Start of international consortium

In the Sabo Department, following a decision at a meeting in Perugia, Italy in January 2020, deeper discussions were possible by online meetings, and as a result, an international consortium called LandAware [1)] related to landslide early warning systems was launched. Accompanying this, a platform was constructed for related research activities at an international conference scheduled for FY 2021.

2.2 Exchange of views for Japan-Netherlands joint research

In an online meeting held at the Embassy of the Kingdom of the Netherlands on November 2020, the River Department conducted an exchange of views based on the status report on Japan-Netherlands joint research being carried out at Hokkaido University, etc. concerning Japan-Netherlands joint research on flood damage risk management considering climate change, which was proposed by the Netherlands in FY 2019.

2.3 Bilateral research collaboration plan with US Federal Highway Administration (FHWA)

The Road Structures Department conducts an exchange of views called the NILIM-FHWA Conference on policies for the design, construction, operation and maintenance of road structures and trends in research and development related to technical standards with the US Federal Highway Administration (FHWA) around January of each year. but the meeting for fiscal 2020 was postponed due to the coronavirus. However, new research collaboration plans on “Health monitoring and nondestructive inspection” and “New materials” were established in August of 2020, resulting in deeper collaboration on more concrete subjects. An online meeting was

held in January 2021, leading to a shared awareness of future directions in research, etc.

2.4 Cooperation in JICA Projects / Training

NILIM receives trainees at the request of JICA. Although lectures in the laboratory, tours of experimental facilities, etc. are carried out in normal years, in fiscal 2020, the following training was provided online.

(1) Project management in social infrastructure construction and maintenance (Research Center for Infrastructure Management) (number of trainees: 20)

(2) Port development and planning (for port engineers) (Administrative Coordination Department) (number of trainees: 17)

2.5 Receipt of Foreign Intern

The Road Structures Department provided practical training for one intern, who came to Japan from Chile and is attached to the Disaster Management Program of the National Graduate Institute for Policy Studies, on the theme of "Evaluation of seismic force for bridge design based on records of earthquake observation in Chile" (period: May to August, 2020).

2.6 Cooperation in formulation of national harbor standards in Vietnam

The Port and Harbor Department conducts workshops for formulation of national standards for harbors in Vietnam in cooperation with research institutes and other organizations in Vietnam based on the "Memorandum for Cooperation in Formulation of National Technical Standards for Harbor Facilities" (signed in March 2014, renewed in June 2016), which was concluded between MLIT and the Vietnam Ministry of Transport. To date, five parts of the Vietnam national harbor standards (General provisions, Load and actions, Material conditions, Foundations / soil improvement, Construction / inspection standards) have been officially enforced by the Ministry of Science and Technology of Vietnam. Drafts of two parts of the Vietnam national harbor standards (Mooring facilities, Maintenance) are currently under examination by the Vietnamese side, and enforcement of the Vietnam national harbor standard (Maintenance) is scheduled for the near future.

The Memorandum was renewed again during fiscal 2020 (**Photo-1**). During the year, the Port and Harbor Department also held a total of three internet workshops in Japan and Vietnam on the two standards, Breakwaters and Dredging / reclamation, and the two countries jointly carried out editorial work on drafts of the Vietnam national harbor standards.

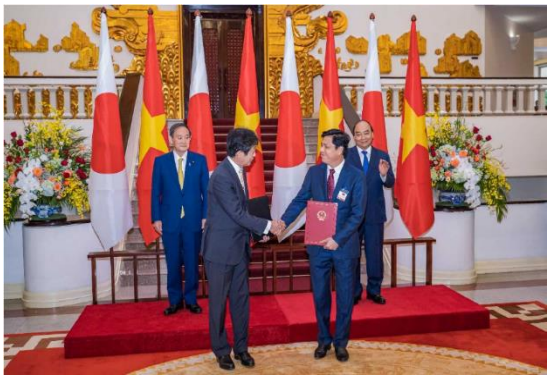


Photo-1 Scene during exchange of Memorandums (October 19, 2020)

Photo-2 Scenes of internet workshops with Vietnam

2.7 ISO-related activities

The Sewerage Department participated in a conference on rainwater management and mainly conducted online discussions of the proposed new standard "Adaptation of Climate Change Impacts" (TC224). The Building Department carried out online discussions on research and development for international standardization related to fire safety, such as implementation of round-robin tests of draft standards for evaluation of gas toxicity during fires, etc. (TC92). The Housing Department held online discussions on evaluation techniques for the energy consumption performance of air conditioning system and commissioning techniques for newly constructed buildings (TC205).

☞**For more information:**

1) LandAware website: https://www.landaware.org/

2) NILIM website: http://www.nilim.go.jp/lab/beg/foreign/kokusai/kokusaitekikatudou.htm

3) Ministry of Land, Infrastructure, Transport and Tourism (MLIT) website: https://www.mlit.go.jp/report/press/port05_hh_000177.html