Let's Think Flexibly!

-- In Order to Lead Changes in Society / Technology --

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1. Introduction

I appreciate those who read the Annual Report of NILIM for their understanding of and cooperation with NILIM. I hope this report would be of help.
In recent years, technologies represented by IoT and data science have rapidly progressed and, parallel to that, socio-economic activities have become more complicated and high-tech. Under such circumstances, I would like to talk about "flexible thinking" in my opening message. Flexible thinking is a topic that consistently draws my interest as an "attitude" required for engineers and researchers in the public capital/housing field.

2. How do you think?

What is "Flexible thinking"? Let me give you some examples. How do you think about the following themes?

(1) What is a digital twin in regards to maintenance?

The concept of a "digital twin" is at the core of "Society 5.0" and maintenance of social capital is often discussed as a field for which introduction is expected. We see the catchphrase of its ideal, such as "automatic perception of abnormality based on data, efficiency increase and advancement of maintenance by creating a virtual site." However, we rarely see discussions about the specific content of the technology.
What does it actually mean to detect abnormalities based on data? Roughly speaking, it might mean to "install sensors of the necessary performance in appropriate locations, consistently collect, transmit, record and accumulate abnormality data in the cloud, and detect abnormalities using AI." However, requirements should be clarified, such as sensor location and sensitivity. If AI analysis is conducted, the teaching data of abnormal behaviors will also be necessary. If asset management is developed, it will be necessary to set the deterioration curve of structures and target values of management. That is, knowledge as a structure is indispensable.
It would also be necessary to consider management of the IoT system itself, operating procedures for initial actions to take when an abnormality is detected, and the system, personnel, and skills appropriate for the virtual site.
Of course, establishment / verification of the system itself and issues concerning the hardware and systems should be addressed in parallel. However, there is no doubt that knowledge other than IoT is indispensable. Therefore, on the subject of how to use IoT as a tool, a broad view based on action and flexible thinking is required particularly for engineers and researchers who will be using it.

(2) What impact does climate change have on structures?

It is widely recognized that climate change will cause frequent natural disasters and devastating damage. So, won't other things be affected? The impact of intense heat on the labor environment of a site is well recognized. What is the impact on structures? Such indication has never been heard although I may not have learned. However, isn't there any relationship? For example, let us consider the impact on the durability of structures in a cold, snowy area. Isn't it possible that temperature could fluctuated around zero degrees and consequently increase in the risk of freezing and thawing even in areas where the temperature is normally below zero all day long in the winter, such as the mountainous areas of Hokkaido or Honshu?
New findings would be obtained by relating the knowledge that is common individually, such as global warming and freezing and thawing effect.

(3) What effect does i-Construction bring?

What is the expected effect of i-Construction ("i-Con")? Most people would say improvements in quality / work efficiency and solutions to labor shortages. However, this is how a builder sees things, and looks at construction sites in the narrowest sense. For the former, it is also important to discuss the effect of efficiency-enhanced construction management on the owner and the kind of business process / operation system desirable to the owner.
Regarding the latter, changes in work style are being reported by pioneering enterprises that adopted i-Con technology, even in part, such as very recently hired young employees operating heavy machinery or women employee who had previously been doing paperwork taking charge of data creation. These

examples suggest changes in the way young people view the construction industry as working opportunities are being created for women and inexperienced persons. Moreover, if it were possible to acquire skills in 3D data creation or IT heavy machinery operation at an industrial high school or technical college, young people would be more interested and could be put to work immediately. Development of a construction simulator for educational purposes would not be difficult, given the technologies available today. It would bring changes to job training by systematizing the skills that should be acquired for i-Con age and creating educational programs for acquiring them.
Various development ideas can be hatched by watching manifested events and being imaginative.

3. "Flexible thinking" is a sense of crisis turned inside-out.

The foregoing examples are some of the ideas I have been presenting in my daily work. Although the themes of discussion are different, what commonly underlies them all is “flexible thinking." In fact, this is a sense of crisis turned inside-out.
As I stated at the beginning, the world around us is becoming increasingly complicated and moving at an accelerating pace, all the while placing greater emphasis on performance and social implementation. Accordingly, there are not a few cases where we see the tendency of pursuing easy and fragmented results that are apparently easy to understand. This goes for science and technology in general, as well: there is an observable tendency towards superficial activities that sound good in theory. Of course, as the world of competition, skills for quick and skillful presentation will be necessary. On the other hand, there is actually a steady tendency in some data business, etc. that a highly sufficient system is created quietly to a certain extent and disseminated / implemented in society before people know it.
Under such circumstances, what value do engineers and researchers have in the housing and social capital fields? I think that these fields are characterized by physical existence including buildings, structures, rivers, and seas, real development of socioeconomic activity and citizens' lives on them, and the need of policy development and system construction for implementation.
The engineers and researchers who have been involved in these fields should have knowledge of all of this. Based on accurate technical capabilities, perceive the essence of things and see the future. Overviewing with a consistently high perspective, such as whole engineering system, social system including policies and systems, regions and land, and relationship with social life. Such idea and action are possible with flexible thinking. These might be the existence value.

4. Conclusion

In this paper, I have stated my personal opinion and some criticism. However, what is stated here is also expected of the concerned persons and readers, including the people in my organization.
I believe that, if more people in our organization practice "flexible thinking" based on proper expertise, knowledge, and experience, we can steer the engineering development towards what society truly needs and prove ourselves useful even in rapidly changing times, without being swayed by new technologies or requests. I also see pride and humility integral to flexible thought.

River Engineering for Adaptation to Climate Change

River Department

We are conducting a study to provide flood risk information, which is useful for estimation future rainfall and flood characteristics as well as flood prevention activities and evacuation guidance, in order to advance disaster prevention by river development etc. and disaster mitigation after flood occurrence, in consideration of the serious flood damage that frequently occurs recently and change in heavy rain due to climate change.

A social background and issues

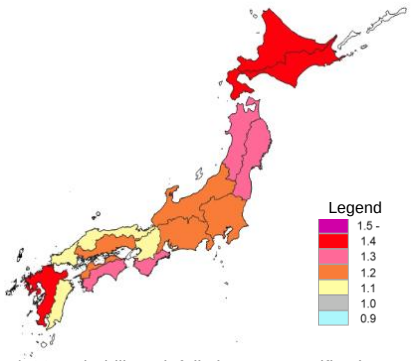
- In recent years, flood disasters with human damage frequently occur due to the frequent occurrence of heavy rain, such as Typhoon No. 19 in FY2019.
- Further, it is also necessary to consider disaster prevention / mitigation for rainstorms etc. including the impact of climate change.
- Accordingly, it is important to advance river development based on future rainfall and flood characteristics and to provide flood risk information so that local governments and residents may take actions properly to prepare for flood.

Study contents

Future changes in the target rainfall of river plan

It is pointed out that the scale of heavy rain causing river flooding frequently in recent years has been becoming large due to the impact of climate change. To address such changes in large-scale flood, it is required to reflect quantitatively future changes due to climate change in rainfall as external force, which is the target of river development and to implement river development adapted to climate change systematically and promptly. Then, Water Cycle Division of the River Department is analyzing future changes in the target precipitation of river planning using the climate forecast data based on the latest climate model.

The right Figure shows an example for calculation of the ratio of past and future precipitation ("precipitation change magnification") in a planned scale for each of the 15 areas divided across the country. Considering such future changes in rainfall as external force, river planning adapted to climate change is expected to proceed across the country.



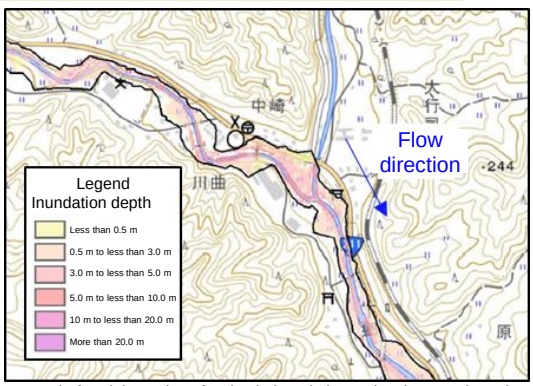
1/100 probability rainfall change magnification at the temperature rise of 4°C
(Rain area; 1,600 km², Duration of rainfall: 24 hours)

Support the creation of flood risk information based on the limited available data on small- and medium-sized rivers

For flood control measures under climate change, promotion of the damage prevention / mitigation measure in case of flood, as development of flood control facilities, is much more important.

For damage prevention / mitigation measure in case of flood, crisis management actions are important, for which flood risk information such as inundation estimation map is necessary. However, river lengthwise and cross / longitudinal leveling data etc. necessary for creation of the inundation estimation map is short due to the limited budget and personnel for small- and medium-sized rivers extending across the country, so that there is an issue of how to eliminate flood risk information vacuum areas.

Flood Disaster Prevention Division of the River Department has developed a method of creating a simple inundation estimation map based on the airborne laser survey (LP) data for eliminating such information vacuum areas and advancing the study for social implementation.



Example for trial creation of a simple inundation estimation map based on LP data

Support the creation of flood risk information necessary for crisis management actions as well as river facility development to prepare for climate change.

☞ Related articles are here.
- Changes in River Plan Target Precipitation due to Climate Change (p. 51)
- For Solution of Flood Risk Information Vacuum Areas in Small- and Medium-sized Rivers (p. 55)

Activities for Wide-Area Development of Technologies for Large-scale Sediment-related Disaster Countermeasures

Sabo Department

In the 2011 Kii Peninsula Flood Disaster, large-scale sediment collapse and movement including deep-seated landslide, shallow landslide, and debris flow occurred and caused serious damage. Sabo Department has been studying the mechanism and countermeasures for sediment disasters in cooperation with the Technnical Center for Large-scale Sediment-related Disaster Countermeasures (Nachi-Katsuura-cho, Higashi-Muro-gun, Wakayama-ken).

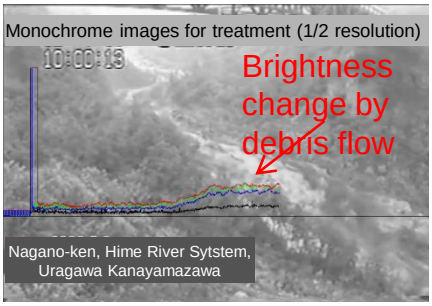
Social background and issues

- In 2011, deep-seated landslide frequently occurred in the basin of the Kumano River, Hiki River, etc. In addition, serious damage was caused by shallow landslide and debris flow to the basin of the Nachi River.
- When large-scale phenomenon of sediment collapse / movement occurs, it is necessary to detect it immediately and take emergency actions including evacuation.

Study contents

Technology for detecting large-scale sediment movement using the image analysis technology

A lot of monitoring cameras are installed, including the mountain area, by river administration offices under direct control. In order to keep on monitoring certainly for 24 hours a day without omission, automatic detection technology is essential. Improvement is also required for the technology of night-time monitoring, in which watching with eyes is difficult. Therefore, we will develop a technology to detect sediment movement automatically from the video and another technology to obtain clear images even during night time. With these technologies, we will strengthen the monitoring system and support labor saving.



Temporal change in brightness calculated from the video of Kanayamazawa

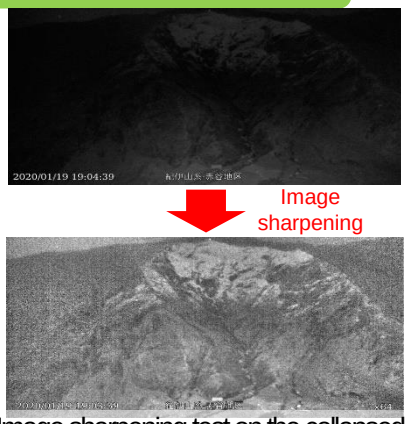
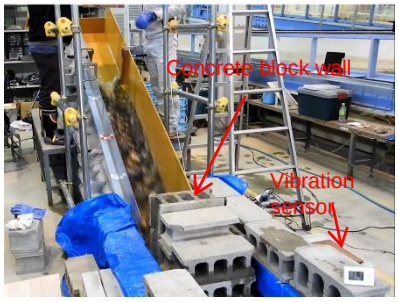


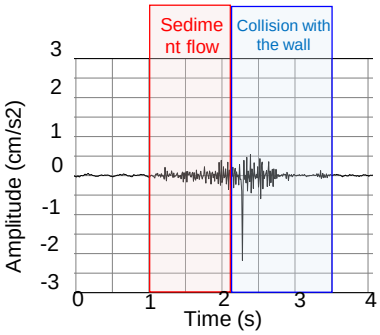
Image sharpening test on the collapsed slope in Akatani Area

Sediment movement detection technology focused on ground vibration in the event of large-scale sediment movement

In the event of large-scale sediment movement, such as deep-seated landslide, the vibration is transferred to the ground at the time of flow or collision. Measurement of this vibration with a seismograph will enable prompt estimation of the occurrence of deep-seated landslide, location of collapse, and the volume of collapsed sediment.
In the detection of vibration caused by sediment movement, focus is placed on the difference of frequency and noise from the earthquake and peripheral environment is removed with a filter. By improving this, enhance the accuracy of the sediment movement detection technology.



Vibration measurement experiment of collapsed sediment



Ground vibration generated by collision of sediment

Realize a society where prompt evacuation and guidance for residents and grasp of the site situation by administration are possible even in the event of a large-scale sediment disaster.

☞ Related articles are here. (introducing related articles of the divisions in charge)

- 2012 White paper on Land, Infrastructure and Transport in Japan, Part II, Chapter 6 (p. 212) Column "Large-scale Collapse Watching and Warning System"
- Technical Center for Large-scale Sediment-related Disaster Countermeasures https://www.kkr.mlit.go.jp/kiisankei/center/index.html

Road Traffic Management Using Big Data

Road Traffic Department

In order to realize safe, smooth, and comfortable road traffic using road networks at the maximum, we have been studying on road traffic monitoring using various big data including ETC2.0 probe information (*) and development of road traffic improvement measures.

* Information obtained through roadside units including ITS spot about the positions, time, etc. of vehicles provided with ETC2.0 compatible in-vehicle equipment, etc.

Social background and issues

- Roads should continue to play their functions to improve the wealth and quality of public life as important social infrastructure that forms national land even in social environment faced with various issues including depopulation, arrival of a super-aging society, and need for revival of local economy.
- To this end, it is required to demonstrate road functions at the maximum through the grasp of road traffic condition and development of improvement measures by using ICT (big data, AI, etc.), in which technical innovation is rapidly progressing.

Study contents

Road traffic monitoring and study for development of improvement measures

Extract various data (i.e., original-destination (OD) data, travel history data, behavior history data, speed data, traffic volume data, details of dangerous events, etc.) from video images etc. in addition to probe data including ETC2.0 probe information. By merging these basic data and existing data for analysis, establish a technique for monitoring OD traffic volume, automobile route, bottleneck points, dangerous event spot / area, and details of dangerous events at individual points. Also, organize the method of developing road traffic improvement measures in response to results of this monitoring.

Aim to use the monitoring method above also in effect analysis after application of the road traffic improvement measures.

Study for efficient / effective data collection and utilization of ETC2.0 probe information

We also study the following for maximum demonstration of road functions

○ Efficient / effective data collection using portable roadside units

In order to solve the issues closely related to communities, such as traffic congestion at an event area or tourist area and road traffic safety, study the points etc. where ETC2.0 portable roadside units should be installed, and establish survey and analysis methods, aiming for efficient / effective data collection.

○ Further utilization of ETC2.0 probe information

Study services etc. for reducing "floating cars" that are looking for a parking space by integrated use of ETC2.0 probe information and data held by private sectors.

ETC2.0 portable roadside units are smaller and lighter than existing roadside units and can be installed easily on existing poles, etc. The same type of data as obtained from existing roadside units is collectable.

Example of ETC2.0 portable roadside unit installation

Contribute to improvement in the abundance and quality of public life by the maximum demonstration of road functions and stable use of road networks.

See the following for related articles.
- Introduction of Image Recognition Type Traffic Count using AI (P. 135)
- Proposal of Effective Utilization Method for ETC2.0 Probe Information in Traffic Safety Measures (P. 61)

Development of next-generation technical standards enabling the utilization of various inspection / monitoring techniques and repair / reinforcement techniques

Road Structures Department

In response to aging of road structures and intensifying disasters, we aim to formulate technical standards for inspection, monitoring, repair, and reinforcement so that road structures can be maintained efficiently while enhancing the reliability of their safety.

Social background and issues

In response to the manifestation of deformation due to aging in road bridges, etc. in the country, requirement of periodic inspection by proximity distance observation of all components every five years was established by law in 2014.In the future, further aging and intensification of disasters are expected to proceed while periodic inspections are continually implemented, and it is required to improve the quality of periodic inspection and to be able to perform safety management timely and continually with less labor and cost.
It is also required to not only conduct inspections but enable rationalization and secure life extension.

Case of requiring improvement of the quality of periodic inspection
(For suspension bridges, it is difficult to grasp the condition of cable under covering only with proximity distance observation)

Study contents

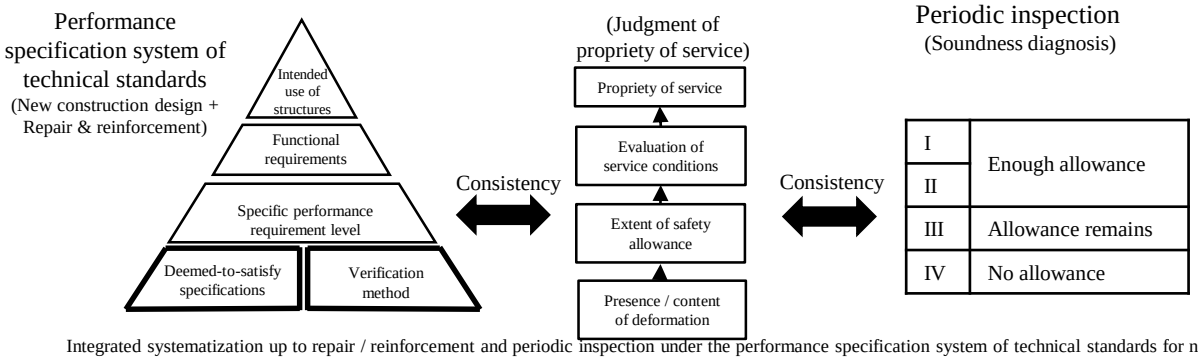
Development of performance evaluation (soundness diagnosis) method for existing structures

■ For next-generation periodic inspection.

We are studying the concept of next-generation periodic inspection procedures, such as customization of inspection methods according to characteristics of each bridge with combination of various sensing techniques, non-destructive inspection techniques, periodical replacement of components, etc. To this end, it is expected to use techniques that can evaluate external force, response, and strength as quantitatively as possible. Hence, we are also studying about systematization of performance evaluation methods concerning non-destructive inspection techniques and monitoring techniques.

■ For reasonable repair / reinforcement.

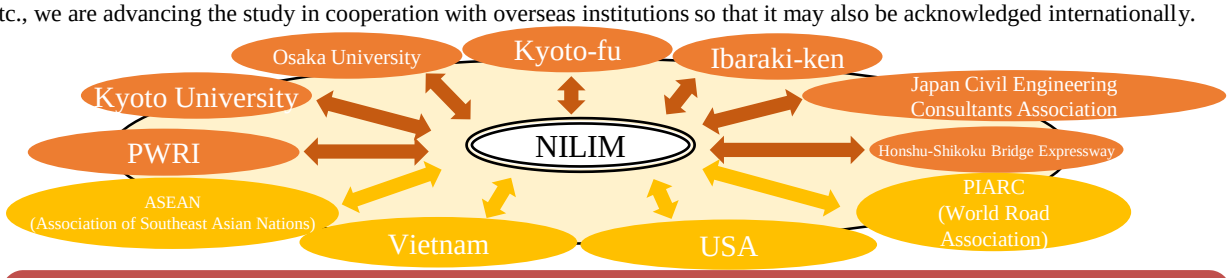
For the safety and performance of bridges, we are studying for formulation of technical standards of repair and reinforcement so that reasonable repair / reinforcement can be implemented using various materials and construction methods according to the conditions of individual bridges with utilization of the merits of the partial factor design method and limit state design method, which enable meticulous design. For instance, we are studying about load combination according to changes in the evaluation period, method of setting the partial factors of existing components and repair / reinforcement components, and systematization of performance evaluation methods for new repair / reinforcement components / construction method.



Integrated systematization up to repair / reinforcement and periodic inspection under the performance specification system of technical standards for new construction design.

Joint research system at home and abroad

Conducting the study jointly with domestic institutions that play a role in development / management of road structures, including the Japan Civil Engineering Consultants Association, in order to ensure / accelerate dissemination / implementation of study findings. In addition, for the performance evaluation method of sensing technology, repair / reinforcement construction method, etc., we are advancing the study in cooperation with overseas institutions so that it may also be acknowledged internationally.



Achieve both quality improvement of road bridge maintenance and burden reduction

Development of design and construction technologies for mixed-structure buildings that use new wooden materials

Building Department

Technologies are now under development to contribute to the establishment of design and construction technologies for mixed-structure buildings that mix wooden structures using large wooden panels, such as cross-laminated timber (CLT), and other structural types or other wooden structural types to respond to the need to promote the use of wooden materials, expand usability by effectively using the characteristics of wooden materials, shorten the construction period, and respond to the need to effectively use the designability of wooden materials.

Social background and issues

- The Basic Policy on Regional Empowerment for Japan's Growth (reached Cabinet Decision in June 2015) stipulates that the development of CLT and other wooden materials and building wooden public buildings shall be further promoted to increase the number of wooden buildings.
- The policy calls for the increased use of wooden materials, such as CLT, in mid-to-high-rise buildings. Combining wooden materials with fireproof members, such as an RC structure (= mixed wooden structure), is considered effective in increasing the use of wooden materials. Yet, actual experience in constructing such buildings or technical references are rarely available.
- To spread mixed wooden structures, it requires the development of structural design and fireproof design methods and the establishment of standard specifications for joint sections and other parts so that anyone can build such buildings. It is necessary to present standard designs and construction methods from the perspective of ensuring durability as well.

Study contents

Examination of structures, fireproofing, and durability performance needed to materialize prototypes

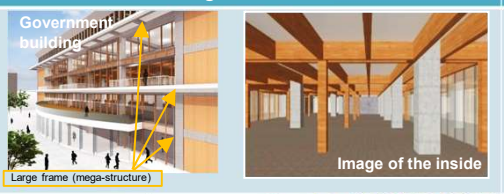
The main technological development concerning structural performance, fireproofing performance, and durability performance that are necessary to materialize the main variations (prototypes) of expected mixed-structure buildings are examined.

○ Main issues related to each type

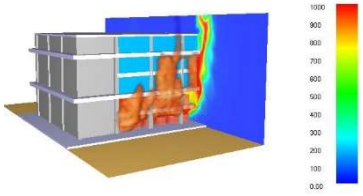
Type I: Examination of how to control fire on the upper floors

Type II: Investigation of the characteristics of mixed-structure buildings

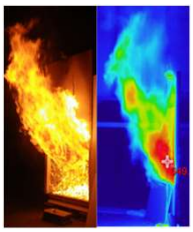
Type III: Cases when different types of wooden materials are used

Type	Image of frames	Benefits
Type I Two-layer RC structure Wooden frame is freely arranged inside the large frame		-Flexibility - Visible arrangement of wooden materials is possible on the fourth floor and up. - Fire safety section with the floor and core of the mega-structure
Type II Use wooden materials on the walls and floors of each level using RC structure and S-structure frames		- Flexibility - Realization of building higher than four floors by arranging wooden materials in visible parts of indoor spaces - Fireproof design can be relatively easily created (section at each floor)
Type III Realizes free spaces with large spans with wooden materials	Mixed construction using CLT walls + beams made of integrated woods 	- Free spatial structure - More efficient construction by reducing the number of parts to use

Partial structure test using RC framework + CLT wing walls



Examination of the risk of fire propagation during a fire in multi-story buildings



Fire in wooden section

Air blowing and water spraying test on outer walls of ventilation structure

Expansion of new demand for wooden materials and promotion of uses through highly flexible designs and construction using the proper materials in the proper places

☞Relevant articles

- Development of design and construction technologies for mixed-structure buildings that use new wooden materials (P.88)

*General Technological Development Project: A system to comprehensively and systematically implement researches through cooperation among the industry, academia, and the government under the initiative of the administration section by selecting especially urgent themes that are also applicable to a wide range of fields among important research themes related to construction technologies

Examination of the actual energy conservation performance of buildings using big data

Housing Department

Using a Web program designed to evaluate compliance with energy conservation standards, big data of the energy conservation performance of buildings were gathered on the cloud system and analyzed to identify the actual conditions. This enables the analysis of the relationship between building design specifications and energy conservation performance, which used to be unclear, with conventional investigation methods. It also enables the efficient supply of useful data to be used to propose energy conservation measures.

Social background and issues

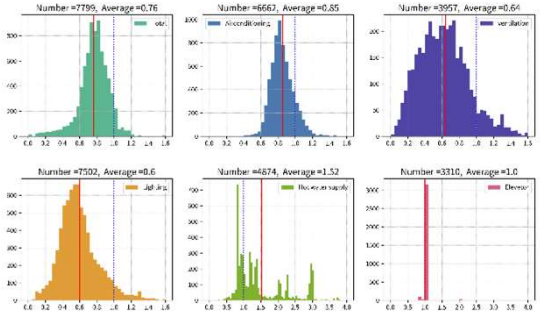
- Improving energy conservation in buildings based on the Paris Agreement is an urgent issue in the effort to mitigate global warming. It is important to identify actual energy conservation performance and to implement proper measures to realize the goal with reasonable effort.
- Competent administrations used to manually tabulate energy conservation standard evaluation results and then report them to the Ministry of Land, Infrastructure and Transport. Starting in FY 2018, this system was changed to the method that used data entered into the Web program to evaluate compliance with the energy conservation standards. (In the new system, the competent authorities report the ID numbers of applicant properties to the Ministry of Land, Infrastructure and Transport, which then uses the ID numbers to download the entered data and the evaluation results.)
- An issue in question is how the Ministry of Land, Infrastructure and Transport would analyze the gathered big data.

Study contents

Analysis of energy conservation performance evaluation result based on big data

About 16,000 cases of data evaluated for the energy conservation standard in FY 2018 through the Web program were analyzed. The distribution of the energy conservation performance of buildings (7,799 cases) submitted as the model building method in six regions of the energy conservation area category (warm areas including Kanto) is shown. The X-axis of the graph is the BEIm (BEI = building energy index) that indicates energy conservation performance. When the BEIm is 1.0 or less, it means that the standard is met.

The average BEIm of all buildings was 0.76, indicating that the buildings satisfy the standards with a relatively large margin. The average BEIm of lighting is 0.60. This is lowering the overall BEI of the building. The BEIm of ventilation and water heating varies greatly among buildings.

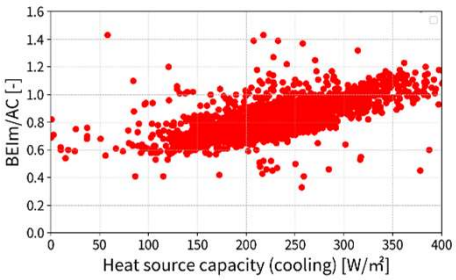


Distribution of energy conservation performance (BEIm) in six regions (warm areas including Kanto) of the energy conservation area category

Example of detailed analysis (analysis of the actual air-conditioning facility designs)

Actual conditions concerning the relationship between the facility design specifications and energy conservation performance were analyzed in detail. As an example, the relationship between the capacity of air-conditioning/heating devices (cooling/heating system) per floor area [W/m^2] and the energy conservation performance of an air conditioner (BEIm/AC) is shown.

This indicates that the capacity of the heating device is small in an energy conservation type building with small BEIm/AC that indicates the energy conservation performance of an air conditioner. This means that selecting a heating device in the proper size (capacity) would lead to energy conservation, and that its effect is reflected in the evaluation of energy conservation performance.



Relationship between the capacity of air-conditioning/heating devices (cooling/heating system) per floor area [W/m^2] and the energy conservation performance of an air conditioner (BEIm/AC)

The proposal of building energy conservation measures based on actual conditions is supported by providing proper information in a timely manner while reducing the workload of the administration.

☞Relevant articles

- Research on the facade design method to improve energy conservation performance in buildings (p. 101)

Technology to improve the living environment and mobility environment in residential areas in the suburbs

Urban Planning Department

Studies are being conducted to improve the living environment, such as the types and arrangement of living support facilities in residential areas, in the suburbs and the mobility environment, including the exploration of new styles of mobility, while the social situation is going through rapid changes, such as a declining birth rate, the aging of society, and changes in lifestyles.

Social background and issues

- After the period of rapid economic growth, many residential complex zones were planned and constructed in the suburbs of large cities and formed residential areas in the suburbs.
- Residential areas in the suburbs are becoming outdated towns as the housing and residential areas became older, the discrepancy between the single-purpose use of the land and new lifestyle needs grew, the number of vacant houses increased, and public transportation systems deteriorated.
- Meanwhile, such areas have advantages, such as higher coverage of public facilities thanks to planned development from the past and the environment containing a lot of green areas. Thus, these areas can be described as valuable social assets of cities to be maintained and passed on to future generations.

Study contents

Technology to improve the living environment in residential areas in the suburbs

Actual uses, level of satisfaction, and needs (frequency of using facilities by types, means of transportation to use to get there, satisfaction regarding location, and satisfaction regarding facilities and services) of living support facilities were identified through interviews and surveys targeting residents in the area of the facilities.

Mobile shops at the parking lots of community association buildings

Kids market at the front of vacant shops

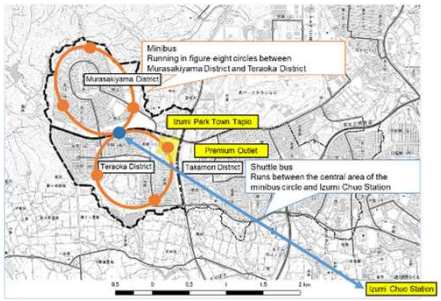
Childcare support room in community association buildings

Technology to improve the mobility environment in residential areas in the suburbs

Characteristics of new types of mobility, such as personal mobility, were organized by studying advanced examples inside and outside of Japan.

By conducting questionnaire surveys about mobility targeting the residents of residential areas in the suburbs, patterns of transportation networks that use new mobility were examined based on the questionnaire findings.

Use of new mobility



Examination of transportation network patterns

Contribute to the realization of integrated urban structures, which are sustainable even during the period of depopulation by avoiding the deterioration of residential areas that can become core areas in the suburbs

For Continuing to Product Research Results Responding to Social Demand

AMANO Kunihiko (Ph. D.), Executive Director for Research Affairs

key words: mission of NILIM, social demand, index, recognition

1. Introduction

The mission of the National Institute for Land and Infrastructure Management (NILIM) is, as stated in its Research Policy (revised in Nov. 2017), "to realize, as the sole national research institution in the field of housing and public capital , a safe, secure, active, and attractive land and society for present and future generations by using technologies as a driving force". NILIM is developing research activities in order to achieve this mission in pursuit of the maintenance and improvement of service provision to society concerning housing and public capital. This paper first describes how NILIM considers service for society concerning housing and public capital to achieve research results that lead to maintenance and improvement of the service. Then, it looks at matters necessary for conducting research at NILIM.

2. Understanding social demands with indexes

As an example of social service in the housing and public capital sector, let us discuss road traffic. Society demands that people and goods can move smoothly. If the traffic volume (needs) that embodies the movement of people and goods exceeds the traffic capacity of the supplied road, traffic congestion occurs. If both supply and demand of the whole road network could be adjusted in various ways to avoid such problems and still enable supply to reasonably meet demand, service would be adequately provided and social demand would also be met.

As described above, NILIM views social demands as needs that can be indexed, and evaluates technologies, measures, etc. (provision of service) to meet such needs with an index comparable with those needs. Then, using such indexes of supply and demand, NILIM conducts examination of response policy, which is a type of technological policy, and technological development required for execution of the policy in combination of various researches.

As the above-mentioned example suggests, introducing traffic volume as an index makes it possible to quantify needs. Furthermore, the present level of service provided can be identified by measuring the level of service that fulfills demand with the index for traffic capacity and comparing it quantitatively against demand. Then, if cost required for supply is separately calculated, it is possible to indicate the economic rationality of project, which is an act of providing service, which will lead to social agreement to determine the reasonable level of service to be provided.

Since the purpose of service provision to society concerning housing and public capital is huge, it is necessary to take actions for achievement of this purpose by forming layers each of which represents the purpose and procedures to achieve it for each service field so that achievement of procedures of a certain layer will be the purpose of the layer immediately below that layer, with the top layer constituting the huge purpose above. Normally, for individual research themes at NILIM, indexes determined in a layer of the above structure are evaluated with models obtained from theoretical analysis, statistics, simulations, physical experiments, etc. and the purpose of research is to take those models to new depths. However, many of such models are continuously examined and tend to focus on more detailed model development or improvement as research proceeds and the position of research may be lost if too much focus is placed on indexes or models directly handled in individual research themes.

In order to conduct research that corresponds to social demand, it is necessary to go deep with individual research themes and attentively position those themes in the aforementioned hierarchical structure. Moreover, though it is effective to quantify social demand with indexes or models, we should always ask ourselves whether we misinterpret such indexes or models as real when they could inherently be biased.

3. Response to changes in social demand

New issues (needs) that are not easy to address in a deteriorating economic situation, such as maintaining the level housing and public capital services in depopulated areas faced with particularly severe situations, have arisen. Unlike the conventional way, new response, such as "Compact plus Network." is needed in the circumstances where degeneracy cannot be avoided. For such issues, it is required to study in the reverse way, i.e. to request changes in social structure, considering the restriction on the service supply side.

For utilization of new technologies represented by ICT and AI, to which prompt response is required and for which knowledge is not sufficiently accumulated in NILIM, it should be studied in both needs and supply by taking social demand in advance. In the field of public capital as well, advent of an age is predicted

where services specialized even to the level of individuals using ICT is called for. If society demands real-time provision of services at the level of individuals in the field of public capital, it will be necessary to recognize needs with indexes different from existing ones and new approach will be required. Whatever form is taken in service provision, we would be urged to obtain a lot of data and establish data-driven services. In many fields, it is required to prepare for the new services in the age of Society 5.0 by clarifying the position and roles of the public sector.

4. Response to uncertainty

Many of the research themes at NILIM contain some uncertainty. The solid red line in the following conceptual drawing represents the distribution of occurrence probability of the simulated the needs indexes (external forces such as flood flow, traffic volume, and load) and the solid blue line simulates supply indexes (functions such as discharge capacity, traffic capacity, and intensity). Supposing that the index value of a supply that is met at present represents ① on the scale, a problem (flood, traffic congestion, destruction) will arise if external force exceeds ①. Taking as an example climate change, which is considered to cause an increase in flood flow, distribution of the occurrence probability of flood flow expected in the future is likely to move to the right as shown with the broken red line, but it is uncertain to what extent it will move and how the form of distribution will be. When themes entertain an external force with an inconsistent distribution of occurrence probability, as in the case of an impact assessment of climate change, the uncertainty of the external force assessment will create problems. In such fields, an attempt to reduce the uncertainty has been made by drastically increasing the amount of information through improvements in weather forecast calculation technologies, accumulation of observational data such as radar rainfall, etc.

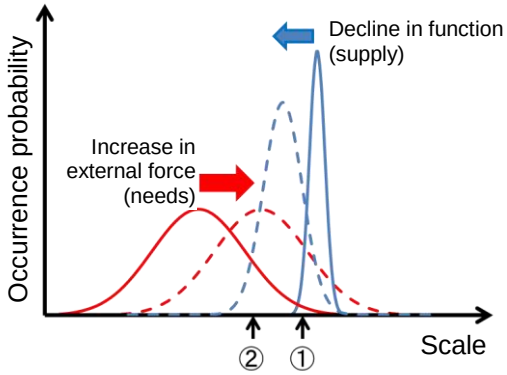


Fig.: Uncertainty in index assessment

As the solid blue line shows, the distribution of occurrence probability in the index value of function (supply) also varies. If the value of the supply index lowers and reaches ② on the scale as the distribution of the broken blue lines is due to insufficient management of facilities, it will lead to frequent problems, so it is essential to assess and maintain the functions of facilities, etc. Uncertainty can expectedly be controlled by increasing the amount of information about the functions of facilities, etc. such as acquisition of continuous monitoring data on the behavior or displacement of facilities, etc. by applying new technologies. The importance of status monitoring technology for facilities, etc. is high. Since housing and the provision of public capital have been developed to a certain extent, the importance of the response to uncertainty has been increasing from the viewpoint of risk management. Assessment based on the accumulation of accurate data is becoming more necessary than ever before, and utilization of housing and public capital data is one of the utmost important issues.

5. Conclusion

It is possible to say that many of the researches conducted at NILIM assess land, society, systems, facilities, etc. with indexes or models and study how to steer new technical policies towards social demand. Accordingly, taking individual research projects to new depths and constant reviews of the purpose and positioning of research would lead to achievement of research results that contribute to society. Let's move forward to a new frontier, without falling into inertia.

The Decade and Future of B-DASH Project

OKAMOTO Seichiro (Ph. D.), Director, Water Quality Control Department

Key words: technological demonstration, B-DASH Project, guidelines for technology introduction, top-runner approach

1. Introduction

The Breakthrough by Dynamic Approach to Sewage High Technology Project ("B-DASH Project"), launched in 2011, marked its tenth anniversary this year. Over the decade, the B-DASH Project has greatly contributed to the development and dissemination of new technologies concerning sewerage, adopting a total of 45 technologies and publishing 24 guidelines for technology introduction (as of Dec. 2019). Compared with earlier technical development projects concerning sewerage, the B-DASH Project surpasses any of them in terms of project period, budget, variety of target technologies, etc.

The Water Quality Control Department at NILIM has been overseen this project as the executive agency since the promotional system was established. This paper looks back at the trends, results and purpose of this Project over the past ten years.

2. Circumstances and aim of system establishment

As is roughly explained as follows, the B-DASH Project aims to "substantially reduce the costs of and create renewable energy in sewerage projects through the acceleration of R&D and practical use of innovative technologies, and to support overseas development of the water business by Japanese enterprises".

Since sewerage projects are not under the direct control of the central government but are, instead, initiatives promoted by local governments, it is difficult to demonstrate, disseminate, or otherwise apply new technologies when spearheaded by the central government. In the field of sewage and sludge treatment, the development of new technologies is highly anticipated, but the minimal exposure that technologies developed by private sectors receive and the lack of adequate engineering data and information for cost estimations have been cited as impediments to introduction. Because past technology development projects have run into these troubles, the B-DASH Project aims at more quickly disseminating new technologies by promoting development via pilot tests in actual-size facilitates, having the central government formulate guidelines for technology introduction, and building a development system with the cooperation of private enterprises, local governments, etc.

With respect to actual-scale demonstrations, there were advanced examples in the Advance of Japan Ultimate Membrane Bioreactor Technology Project ("A-JUMP"), which was started in 2008 for the purposes of applying Japan's world-leading membrane processing technology and know-how to sewerage and overseas development by domestic enterprises. In the B-DASH Project, technologies have been demonstrated in more fields by applying the A-JUMP model. As a side note, the author has heard that this project was named "B-DASH" because "B" comes after "A."

3. Trends of adopted themes

In the B-DASH Project, a preliminary survey was conducted into the needs and technical seeds of the project entity before public solicitation of development technologies. The recent themes for public solicitation are mainly related to the technologies classified below (see the figure), which shows the rising needs for the technologies by project entities.

- ICT/IoT utilization, AI-equipped system (13), (14), (26), (27), (30)-(32)
- Downsizing, water treatment technology for small-scale entities
  (12), (22), (25)
- Technologies for effective use of sewage resources and energy for small to medium-sized cities

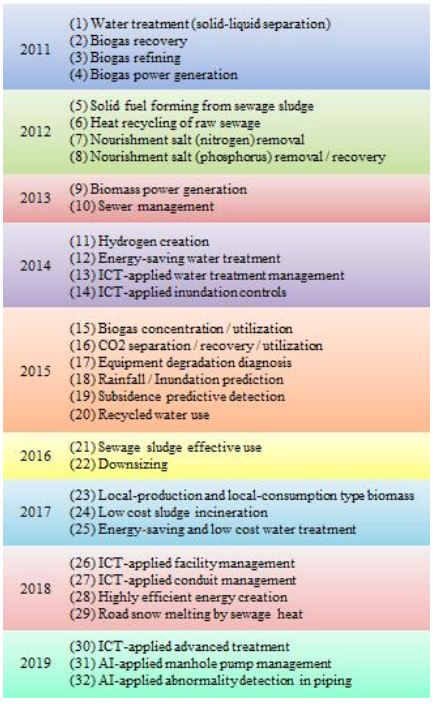


Fig. Trends of publicly-solicited themes for B-DASH

(15),(20), (21), (23), (28)

The utilization of ICT, etc. represents technical needs for supplementing human resource shortages and promoting labor-savings in all industries. In addition, technical solutions are being sought for the issues small to medium-sized cities face prior to the problems seen in large cities, including relatively weak project management systems and response to the issue of depopulation, which must be addressed in the future. The technical needs for labor-savings, downsizing, and actions by small to medium-sized cities are believed to remain at a high level, therefore the key issues at present are to develop and apply the technical seeds.

4. Top-runner approach

The technologies developed and disseminated through the B-DASH Project offer water and sludge treatment operators greater energy-efficiency than what is available with conventional technologies. For this reason, the Ministry of Land, Infrastructure and Transport (MLIT) decided to introduce a top-runner approach into sludge treatment facilities and require facilities that seek related grants for sewerage projects to achieve energy-efficiency performance above a certain level of (see the below table). This performance requirement was decided based on the results of the biogas collection technology ((2) in the above figure) and the biomass electric generation technology ((9) in the above figure) for incinerators in the B-DASH technologies. The effect of introducing this approach is expected to be great since sludge treatment facilities across the country are now entering a period of reconstruction.

Hence, the purpose of the B-DASH Project is to contribute not only to the development and dissemination of individual technologies but also the performance improvement of sewerage facilities across the country. Parallel to the B-DASH Project, NILIM continues to research these and other performance improving technologies, and consider what is coming out of the B-DASH Project as the top-runner in its field.

Table Example of the performance requirement indicators for grants

Facility name	Performance index value
Digester (Mesophilic digestion) *	Electricity consumption (per amount of decomposing organic matter) [kWh/t-VS decomposition ***] is not more than 280**.
Incinerator	Exhaust heat recovery rate is 40% or more and power consumption reduction rate is 20% or more.

* Treatment to stabilize sludge in an anoxic tank. Methane is obtained. Mesophilic digestion at a temperature of about 35 ℃is common, but thermophilic digestion is also being introduced.

** 270 or less for sewage treatment facilities with a daily sewage treatment volume of 100,000 m^3 or more.

*** Power consumption (kWh) per ton of organic matter (VS) decomposed in water, gas, etc. in the tank.

5. Future issues (Spread and promotion of developed technologies)

The future dissemination and promotion of developed technologies is important. Trends show that developed inspection and diagnosis technologies are introduced at an early stage, while advanced technologies for entire water treatment systems take time to disseminate because they can only be introduced when facilities are reconstructed. In the Water Quality Control Department at NILIM, we intend to continue cooperating with MLIT to disseminate and raise public awareness of guidelines and provide project entities with helpful information for choosing the technologies they need. In addition, this top-runner approach needs to be continued since it directly leads to the dissemination of technologies.

In the B-DASH Project, pilot tests are, in principle, conducted in an extremely short period of time (two years) though data acquisition over a longer period may in some cases lead to technical improvements and a more focused scope of application. As for the technologies demonstrated in the past, we have decided to follow up on the guidelines for technology introduction, as needed, based on the results acquired after the demonstration period through independent studies by the developer and reviews of the guidelines by a third-party committee. We expect that the transmission of more useful up-to-date information will also lead to the dissemination of the technologies.

By implementing and following up on the B-DASH Project and further disseminating and promoting the developed technologies as described above, we aim to upgrade and enhance the efficiency of domestic sewerage facilities.

☞See the following for details.

1) Outline of B-DASH Project, List of adopted technologies, guidelines for technology introduction (Website of Wastewater and Sludge Management Division, NILIM)
http://www.nilim.go.jp/lab/ecg/bdash/bdash.htm

Research and Study Supporting Disaster Prevention / Reduction in the Water Field

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

key words: climate change, disaster prevention / reduction, flood risk, maintenance

1. Introduction

In 2019, Typhoons Nos. 15 and 19 and other storms caused enormous damage across Japan. In July of the previous year, the heavy rains caused serious damage across West Japan. For the first time, the Meteorological Agency blamed this heavy rain on climate change.

With regard to climate change, the Panel on Infrastructure Development ("PID") issued a report in August 2015, titled "Interim Report on Climate Change Adaptation Measures in the Flood Disaster Field," in which it indicated that (i) infrastructure should be built to the planned scale; (ii) proper maintenance and upgrades are necessary to ensure infrastructure functions as expected and (iii) water disasters can be prevented and mitigated by ensuring the foregoing efforts, devising operating and maintenance procedures for infrastructure, promoting, as proposed, community and regional development in consideration of likely disaster risks and improving preparedness in terms of orderly evacuation, smooth emergency response, business continuity, etc.

Furthermore, in the "Flood Control Plan for Climate Change" proposed on 2019 by the Engineering Workshop on Flood Control Planning for Climate Change, a major proposal was made to "change the basis of flood control planning from the actual precipitation to the future precipitation predicted from climate change".

The "Flood Control Measures for Mitigating Large-scale Flood Hazards" -- a report issued by the PID after heavy rains hit the Kanto and Tohoku areas in September 2015 -- decried the need to make society "aware of waster disaster prevention" and indicated that local governments, local communities, residents, businesses and river administrators should be aware that "infrastructure has its limits and unpreventable large-scale flooding is bound to occur" and that non-structural measures that aid the evacuation of residents should be ensured part and parcel to structural measures for flood prevention. In response, MLIT launched a "Vision for Making Society Aware of Waster Disaster Prevention" and proposed an emergency action plan in order to realize this vision. Measures have been promoted under the plan, which has been modified because of the heavy rain disasters that occurred after the plan's inception.

As presented in the PID's proposal in August 2015, in order to prevent / reduce damage by rainstorms and other events, including the impact of climate change, it is important to develop and continually maintain various infrastructure that protects communities (e.g., river / coastal levees, dams, etc.). Systems for inspecting and assessing infrastructure are being established, but it is nonetheless important to improve the efficiency of maintenance activities for existing infrastructure with limited financial and personnel resources.

2. Disaster prevention / reduction measures for flood damage

In light of the circumstances stated above, it is necessary to make society aware of water disaster prevention and conduct studies into flood control measures from various aspects in consideration of climate change.

NILIM has proposed a new flood control framework [1)] for reducing water disasters, which promotes disaster prevention / reduction in a seamless and comprehensive manner by combining a reduction in flood frequency (disaster prevention by river development, etc.) and post-flooding damage control (disaster reduction or risk management) after predicting changes in heavy rainfall due to climate change and subsequent changes in river flow. In order to promote this approach, it is necessary to examine quantitative methods for measuring the effects of various measures on flood damage risk and uncertainty, as well as specific measures.

<Viewpoint of disaster prevention> In river development, it is important to improve river channels to ensure flow of river water, and to build levees. Specifically, we promote the study of river improvement methods to control sediment re-deposition after channel excavation and re-growth after cutting trees (See Fig. 1).

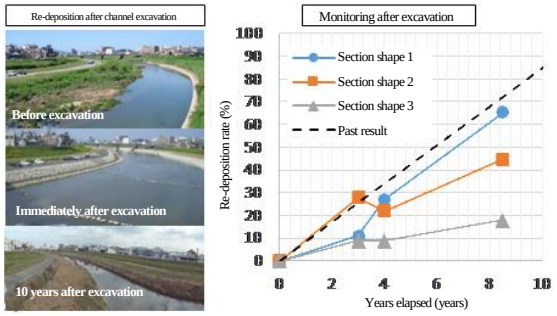


Fig. 1 Analysis on sediment re-deposition after channel excavation

In addition to levees, dams are another important piece of flood control infrastructure and, due mainly to a decrease in suitable sites for new dam construction, effective use of existing dams and dam upgrades are critical flood control measures. For this purpose, there are both non-structural and structural technologies. In the field of non-structural technologies, we are conducting a study into utilizing a dam's flood set function more effectively using precipitation forecast information. In terms of structural technologies, we are raising levees, expanding discharge gates, and addressing reservoir sedimentation with existing dams and studying methods for choosing the most appropriate technologies and supporting their application to individual dams.

<Viewpoint of disaster reduction> An ongoing study at NILIM is mapping the potential spatiotemporal variations in river water level in a flood as "Flood Damage Risk Lines" (See Fig. 2). In addition, technical development and social testing are underway for a system that predicts the occurrence of inundation by rainfall in urban areas and transmits information to local residents, etc. (see Fig. 3). For the foregoing studies, we continue to advance system development with the aim of expanding the scope of application and upgrading information in ways that provide a stronger basis for deciding on evacuations and promote effective / efficient flood prevention activities.

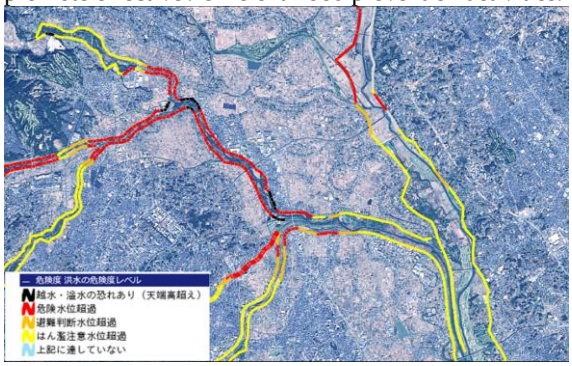


Fig.2 Example of flood risk line indications

Fig. 3 Inundation forecast system

3. Activities for infrastructure maintenance

Regarding the maintenance of river infrastructure, a study is proceeding on a new approach for detecting deformation, etc. using satellite imagery, laser survey data, etc. and is expected to enhance administration efficiency. For river channels, we are studying simple and low-cost ways to measure discharge capacity in small and medium-sized rivers, while, for levees, we are studying a method for screening locations we should inspect based on laser survey data, etc. As for dams it is generally difficult to apply deformation detection methods of other structures because dams are huge structures, but we are developing technologies to inspect the inside of the dam body in a manner suitable for the characteristics of dam materials and structures (non-destructive / semi-destructive method). In the coastal field, we are studying a method for mapping wide sections of the submarine topography along sandy beaches using satellite imagery, laser survey technology, etc. and a method for measuring coast lines efficiently and continuously (see Fig. 4).

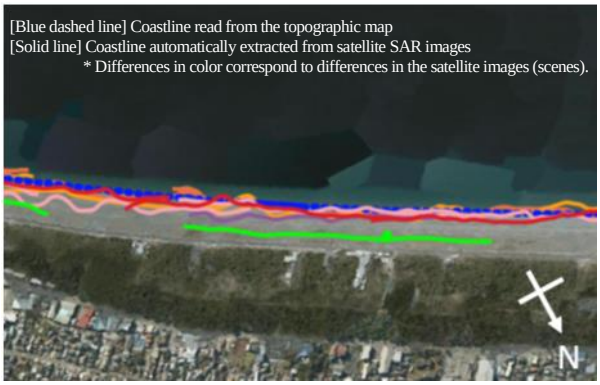


Fig. 4 Example of coastline extraction with satellite SAR images

☞See the following for details.

1) NILIM Project Report No. 56, 2017
http://www.nilim.go.jp/lab/bcg/siryou/kpr/prn0056.htm

Disaster Prevention / Mitigation for Devastating Sediment Disasters

NISHII Hiroshi, Director, Sabo Department

key words: sediment disaster, sediment / flood, technical support, human resource development

1. Introduction

In recent years, serious sediment disasters have frequently occurred in Japan, including Typhoon No. 19 (2019), July 2018 Heavy Rain, Northern Kyushu Heavy Rain (2017), Kumamoto Earthquake (2016), and Mt. Ontake Eruption (2014). There More serious sediment disasters may occur because of the impacts of climate change, etc. Given the circumstances, the Sabo Department at NILIM has been advancing studies into identifying the mechanisms of sediment disaster, status of effective infrastructure development, and non-structural measures such as warning, evacuation and monitoring systems, using data on sediment disasters across the country in order to prevent / reduce damage resulting from heavy rains, earthquakes, volcanic activity, etc.
This paper describes the main activities of the Sabo Department.

2. Study activities

In recent years, major sediment disasters and floods have caused serious damage in Japan, including Typhoon No. 19 (2019), July 2018 Heavy Rain, and Northern Kyushu Heavy Rain (2017). Furthermore, Typhoon No. 19 of 2019 and the July 2018 Heavy Rain caused widespread and simultaneous sediment disasters in the Eastern Japan and Western Japan. The following introduces part of our study activities based on those situations.

2.1 Prevention / Mitigation of damage caused by sediment / flood

In order to upgrade sediment / flood control measures, it is necessary to improve the predictive accuracy of sediment movement phenomena caused by rainfall, etc. and to advance infrastructure development based on the improved predictability.
The Sabo Department has been continuing research / studies [1)] of sediment / flood and giving technical guidance to offices across the country under its direct control when they plan sediment / flood projects, etc. In addition, results accumulated in the Sabo Department and technical findings obtained through technical guidance, etc. have been documented as Technical Notes of NILIM. [2)] The offices under direct control of the Sabo Department that are implementing sediment / flood control measures are now using an analytic method for calculating sediment movement based on river erosion control technical standards revised in March 2019 (Planning Part), in planning infrastructure construction. The Sabo Department is assisting them in technical matters.

2.2 Utilization of Synthetic Aperture Radar (SAR) images for grasping wide-area sediment disasters

In the event of a wide-area sediment disaster, in order to prevent secondary disasters and take emergency actions quickly, it is necessary to quickly grasp of the scope of the sediment disaster, because personnel deployment and the distribution of goods are important components of initial response efforts. As before, helicopters are used immediately after the occurrence of a disaster, but we now are using remote measurement technology in the form of images taken by Synthetic Aperture Radar (SAR) onboard orbiting satellites. These images are available even at night and under bad weather conditions, and utilized when taking initial action. We have been conducting a joint study with the Japan Aerospace Exploration Agency (JAXA) since FY2017 and creating a manual [3)] describing the sediment disaster interpretation research method. We also hold training events for the personnel of Regional Development Bureaus, etc. to promote use of this technology.

3. Technical support to local governments, etc. in the event of a sediment disaster

When a large-scale sediment disaster occurs, we dispatch personnel at the request of local governments, etc. to conduct onsite surveys and give technical support including advice to local governments, Regional Development Bureaus, etc. about observation methods, emergency measures, warnings and evacuations, and other critical matters from a viewpoint of preventing secondary disasters. Moreover, when recovery / restoration plans go through the required technical reviews, we provide technical expertise of the actual conditions of the sites.
Particularly, in relation to Typhoon No. 19 of October 2019, we dispatched personnel to Miyagi, Gunma, Kanagawa, and other prefectures where major sediment disasters occurred, in response to the request from local governments, and worked in cooperation with the Sediment Management Study Group of the Public Works Research Institute.
In Marumori Town, Miyagi Prefecture, where the most personnel were dispatched, we conducted sky and ground surveys from a viewpoint of preventing secondary disasters, explained survey results to the town mayor and concerned persons in the town, prefecture, and Regional Development Bureau and gave advice on emergency

measures, warnings and evacuations, and other critical matters. We intend to strengthen such support activities.

4. Implementation of the Regional Development Bureau personnel training support program

The Sediment Disasters Prevention Act was revised in 2010 to stipulate that, in the event of ash fall or river channel blockage by volcanic eruption in excess of a certain level that may produce debris flow, the central government is required to conduct an emergency survey and provide local governments with information on areas and timing where disasters are expected to occur. It is necessary to maintain / improve the technical capabilities of personnel of the Regional Development Bureau who take charge of this duty.

Accordingly, since FY2013, a sabo subsection manager from each Regional Development Bureau has concurrently served at NILIM from April to December. These persons additionally participate in NILIM's lectures, seminars, and on-site training workshops for about two-weeks per year on early detection /measurement of river channel blockage, debris flow flood simulation, watching and observation, emergency works, etc. In FY2019, a total of 9 persons from across the country partook in the program, which included on-site training in the Kii Mountains etc. To date, a total of 56 persons have completed this program. We intend to continue improving this program.

5. Activities by the Technical Center for Large-scale Sediment-related Disaster Countermeasures

In the 2011 Great Kii Peninsula Flood, deep-seated landslides, river channel blockages, and large-scale run-offs frequently occurred in Nara, Wakayama, and Mie Prefectures and caused enormous damage. In response, the Kinki Regional Development Bureau established the "Technical Center for Large-scale Sediment-related Disaster Countermeasures" in Nachikatsuura Town, Wakayama Prefecture in 2014 to promote research and development related to large-scale sediment disasters. For a while after the center was established, personnel from the Sabo Department were deployed to the center to support survey and research activities. Since 2017, a senior researcher has been stationed there to perform research activities in cooperation with the concerned organizations.

The Kii Mountains are located in an area with a steep topography and a median dislocation line running on the northern side. Sediment disasters including deep-seated landslides occur frequently in the area. In the area, we are conducting studies on the mechanisms of large-scale sediment disasters including deep-seated landslides, shallow landslides, and debris flow, as well as risk assessment methods by conducting hydraulic / hydrologic surveys, aerial electromagnetic surveys, etc. In addition, we give technical support to the local government, etc. in order to prevent secondary disasters if a sediment disaster occurs in the center's area. We intend to continue activities in cooperation with local communities.

6. Conclusion

For the Sabo Department to properly conduct research activities that lead to the prevention / mitigation of sediment disasters, it is important to accurately grasp social needs and provide specific results. Accordingly, we consider the utilization of research results, such as their reflection in various technical guidelines, in the way we conduct studies. We also use technologies available in other fields and cooperate with other organizations because advanced technologies from other fields, such as information collection technology based on SAR images, and cooperation with other organizations can advance research.

In recent years, the response to sediment disasters has required diverse action and quickness due to the effects of natural phenomena like climate change, earthquakes, volcanic eruptions, social changes like urbanization and depopulation, and administrative activities aiming at more systematic / efficient infrastructure development and improvement / reinforcement of warning and evacuation systems. In research activities for disaster prevention / mitigation, we will strive to grasp future social needs and situations in order to stay on top of things, and to pursue research activities more systematically and efficiently based on objectives and priorities. We will look at both issues that require immediate results and issues that we need to address over the long-term.

☞See the following for details.

1) e.g., Reproduction of Sediment / Flood Cases considering Fine Sediment Behaviors, p. 59
2) Technical Note of NILIM No.1048, "Guide (draft) to Study on Sabo (erosion control) Facility Arrangement as Countermeasure for Sediment Flooding / Inundation using River-bed Variation Calculation" http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1048.htm
3) Sediment Disaster Interpretation Research Method (Draft) with Synthetic Aperture Radar (SAR) Images, p. 122

Efforts of the Road Traffic Department for Road and Traffic Innovations

FUKUSHIMA Shinji, Director, Road Traffic Department

key words: ETC2.0, autonomous driving, special vehicle travel permit, people-centric road space, no utility poles

1. Introduction

Roads in Japan have greatly contributed to an improvement in the wealth and quality of life as land infrastructure in Japan. But, roads must continue to respond to rapidly progressing technological innovation, reconsiderations of the relationship between people and cars, and social needs through the pursuit of new forms of cooperation / collaboration in the road space. Given the situation, the Road Subcommittee of the Panel on Infrastructure Development prepared a proposal as a future vision of road policy, titled "Road and Transportation Innovation", in August 2017.

In addition, the Road Act was amended in March 2020 for the purpose of ensuring road traffic safety and promoting smooth and effective use of roads. Specifically, the revised act newly stipulates the "foundation of a new traffic system of special vehicles for improving the productivity of logistics", the "promotion of development of new transport nodes in cooperation with the private sector", the "establishment of pedestrian-centric road spaces for the wealth of community", and the "development of infrastructure that assists autonomous driving in the road space".

This paper introduces part of the activities of the Road Traffic Department, NILIM, in reference to the road traffic systems we should aim for in the future, the amended Road Act, etc.

2. Strengthening traffic management with full utilization of ICT, etc.

(1) Road traffic management using big data

ETC 2.0 can collect travel and behavior histories of vehicles logged by supported on-vehicle units through the roadside units installed by the road administrator. These on-vehicle units are widely mounted, totaling about 4.62 million as of the end of January 2020, and it is possible to utilize these probe data as big data. Probe data on the speed, location, etc. of vehicles equipped with ETC 2.0 can be obtained in time and space sequences regardless of types of road.

NILIM is conducting R&D activities into traffic management by grasping the situation of road traffic in real-time using ETC 2.0, road monitoring cameras, etc. For example, traffic safety measures including speed control and through-traffic access control measures are implemented on community roads by utilizing analysis results of ETC 2.0 data to identify dangerous spots, such as where abrupt slowdowns occur, etc. Furthermore, by utilizing ETC 2.0 data to additionally analyze the effect of measures, NILIM is conducting R&D into upgrading analytical methods and technical support for road administrators.

(2) Making ETC 2.0 probe data open

In order to promote open innovation via big data utilization, it is necessary to establish a mechanism for making proper data accessible, including secondary use, within the viewpoint of personal information protection. With the aim of making ETC2.0 data collected by government open and promoting its utilization, NILIM has been conducting joint research in cooperation with industry since October 2018.

3. For realization of autonomous driving

(1) Autonomous driving road tests at Michi-no-Eki (Roadside rest area, etc.)

Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has been conducting road tests of autonomous driving services at Michi-no-Eki and other central locations, with the aim of social implementation by 2020. The purpose is to ensure the flow of people and logistics, which are critical to community revitalization, by utilizing self-driving vehicles in hilly and mountainous areas affected by a super-aging population and other issues.

For the road tests, short tests of about a week and long tests of 1 to 2 months were conducted to study technical issues and business models. Regional Development Bureaus teamed up with various players to organized local oversight councils involving experts, local governments, vehicle suppliers, etc. and NILIM provided technical support.

Based on the results of these road tests, full-scale introduction just started for the first time in Japan in November 2019 at "Kamikoani," which is the Michi-no-Eki (roadside rest area) in Kamikoani-mura, Kita-Akita-gun, Akita.

(2) Development of infrastructure that assists autonomous driving in the road space

For autonomous driving to ever happen, not only vehicles but road infrastructure need to support it, including recognition of magnetic markers and other driving support infrastructure installed along roadways, which is why the Road the Act was amended.

NILIM is exploring, in cooperation with concerned

organizations, what kind of infrastructure might assist autonomous driving, such as electromagnetic induction lines and magnetic markers that were developed for the road tests at Michi-no-Eki, and how to ensure travel space for self-driving vehicles.

(3) Provision of merge support and pre-read information

Self-driving vehicle technologies that support safe driving, such as an automatic braking system, have been developed in cooperation / collaboration with and between car manufacturers, IT companies, etc. and already installed on commercial vehicles. In order to realize fully autonomous driving, information on roads is also needed, such as the traffic situation on trunk roads at expressway junctions and traffic restrictions on the road ahead, when information solely from the self-driving vehicle technologies is insufficient.

NILIM started joint technical studies with industry (first phase started in Sep. 2012; third phase started in Jan. 2018) into merger support service for expressways, providing information on lane restrictions / obstacles on the road ahead, service for providing information on toll gate open / close status, etc.

4. System for new traffic system of special vehicle

In accordance with the increase in demand for distribution by large vehicles, the burden of business operators, such as the longer time needed to complete travel permit procedures for special vehicles, (which exceed a certain limit in vehicle weight, length, etc.,) has grown and, consequently, productivity has declined.

In the last revision of the Road Act, a system was established that allows registered special vehicles to drive the road immediately and their traveling routes etc. and checks the route actually traveled, etc. through ETC2.0. NILIM is conducting system design, etc. for establishment of a new system that checks traveling route, etc.

5. Promotion of utilization of road space

(1) Reorganization of road space and establishment of people-centric road space

While the volume of vehicle traffic is decreasing on some roads because bypasses have been built, the volume of pedestrian traffic is increasing on other roads and making it necessary to construct people-centric road spaces. Accordingly, the amended Road Act established a system for designating roads for construction as popular road spaces ("Pedestrian-Friendly Roads").

NILIM has organized design methods for enhancing the effect of road space redevelopment projects and guidance on how to build consensus and promote utilization of road spaces, and has been conducting technical studies on constructing people-friendly road spaces based on the amended Road Act, etc.

(2) Promotion of no utility poles

MLIT has been systematically working to remove utility poles from the viewpoint of improving the disaster prevention capacity of roads, ensuring safe and comfortable travel spaces, developing good landscapes, and promoting tourism. However, progress is far behind major European and American cities partly because of the high costs. MLIT also intends to remove utility poles because many poles were damaged and toppled by strong winds during typhoons last year. NILIM is studying technical issues in order to introduce a low cost method of removing the utility poles and smooth build consensus amongst the relevant organizations, etc.

6. Conclusion

This paper introduced some of the activities for road and traffic innovation that are needed because of the fast pace at which the relationship of people, cars, society, and technology surrounding roads is changing, on account of Japan's super-aging society, changes in fuel and vehicle ownership as represented by ride-sharing, micro mobility, and autonomous driving technologies. In addition, the Basic Policy Group of the Road Subcommittee of the Panel on Infrastructure Development has reviewed this new relationship between people, society, and roads and launched studies into the kind of society road policy should target and possible mid- to long-term policies for realizing such a society. In response to the various changes stated above, NILIM is committed to realizing safe and smooth road traffic in a quick and flexible manner over the mid to long term.

For Realization of New Road Vision

KIMURA Yoshitomi, Director, Road Structures Department

key words: road structures, maintenance, disaster prevention / mitigation, new technology utilization

1. New road vision

In February 2020, the Basic Policy Group of the Road Subcommittee of the Panel on Infrastructure Development deliberated a proposal of a new vision [1)]. The previous road policy vision of Japan had been established in 2002. It was titled "In 2040, Road Scenery will Change -- To roads leading to people's happiness --" and provided three images of society that the road administration aimed to achieve. This paper introduces the activities for realizing such society by the Road Structures Department in 2020.

2. Roads for protecting people and livelihoods from disasters and climate change

Following the natural disasters that occurred in Japan in 2019, including the Boso Peninsula Typhoon and the East Japan Typhoon, some roads remained impassible for long periods of time, although they were designated as part of the primary highway freight network, due mainly to scouring of bridge foundations and collapsed earthworks and natural slopes (see the below photo).

In response to the intensifying and growing threat of recent disasters, the proposed vision states that "Disaster-resilient highway networks shall ensure the movement of people and goods to affected areas without stoppage and minimize the loss of human life and damage to the economy."

It is important to build a system for properly managing the risks of road structures according to the performance required of the said route.

Photo: Hounji Bridge on National Highway No. 20 where subsidence of the bridge pier occurred

NILIM focuses research on (i) improving disaster prevention capacity by advancing technical standards for new construction, (ii) devising preliminary measures for potential risk reduction and disaster mitigation of existing infrastructure, (iii) grasping the extent of damage in order to ensure system in the event of a disaster, and (iv) technologies for road sweeping, emergency recovery, disaster recurrence prevention, etc. It then aims to subsequently reflect the results of these studies in supportive measures and implementation in the field.

In studying these issues, the Road Structures Department uses its organizational abilities to link the performance of individual structures to the service level of individual routes that constitute the road network, and organize standards into specific review standards for managing the disaster prevention measures of those structures (Fig. 1). In such process, we will aim that disaster-resistant performance of roads can be reasonably "visualized" in order to propose measures to improve disaster-resistant performance of roads in an easy-to-understand manner to people.

In order to enable information-gathering activities in a disaster, NILIM promotes, in cooperation with road administrators, research and demonstrations of technologies for grasping the scale of damage and road accessibility in the event of a disaster using unmanned / manned aircraft, information on severed optical cables, and strong earthquake monitoring information.

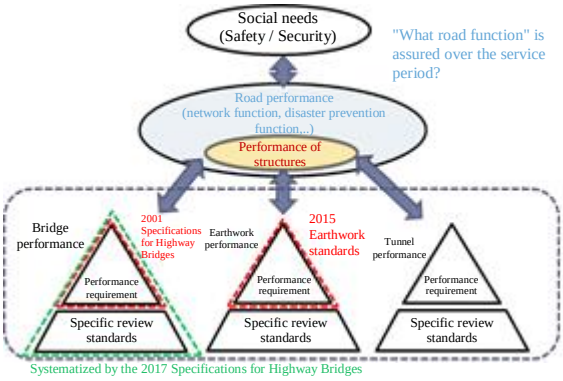


Fig. 1 Development of standards based on road performance

3. Extension of the life of road network

Due to rapid deterioration, it is necessary to systematically maintain road structures at the minimum life-cycle cost. Since FY2014, it has been required by law to inspect road structures every five years, the first round of inspections having been completed in FY2018. The second round of inspections that started in FY2019 feature a streamlined procedure that is based on the results of the first round of inspections and efficiency-enhanced through the introduction of new technologies.

As such, the proposed vision states that "Road networks shall function without interruption by introducing new technologies that enable efficient and advanced preventive maintenance."

NILIM has cooperated in the preparation of information concerning the aforementioned inspection procedure, and the introduction of new technologies. It will continue to conduct studies into ways to improve the reliability and efficiency of inspections through comparative analysis of the results of the first and second rounds of inspections, and promote research into quality assurance / improvement measures of inspections and diagnoses that should be reflected in the revision of the statutory inspection procedure for the third round of inspections, labor-saving measures, and measures for streamlining inspections under various conditions.

Because of the inspections, structures that require repair or reinforcement are also being identified. In pursuit of reasonable actions, the department continues to study the introduction of partial factor / limit state design methods into the repair / reinforcement of road bridges, as well as the survey / design method for eliminating early deterioration of pavement sections.

The department also conducts studies into common management methods for road structures by fully utilizing the results of statutory inspections and maintenance information from Regional Development Bureaus, in order to efficiently and effectively manage assets across the country.

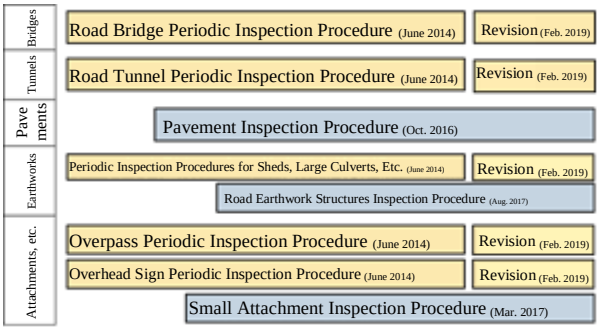


Fig. 2 Formulation of periodic inspection procedures for road structures

4. Development and utilization of new technologies

In reference to the development and utilization of new technologies as one of the challenges for advancing the foregoing road measures, the proposed vision states that "For the development and utilization of new technologies, the central government needs to promote open innovation and shift to a mindset of active utilization of new technologies."

For road bridges, the design technology standard was revised in 2017 from the allowable stress design system to the partial factor design system, and the conditions that "enable a design to adequately and meticulously realize safety, reliability and other performance requirements" were specified. The department studies ways to achieve structural goals under these conditions with new technologies such as high strength material. For technical standards of other road structures, we also organize the performance requirements systematically to ease the utilization of new technologies.

Additional, the department conducts the following in cooperation with the Road Bureau.

- Clarifying the requirements of new technologies that correspond to field needs by exchanging opinions with concerned persons in the field, industrial associations, and technical developers.
- Establishing performance evaluation criteria that can serve as an index for determining the applicability of new technologies, and performance evaluation methods.
- Addressing the utilization and revision of the "New Technology Assessment Guidelines," which organize the viewpoints and considerations for proper assessment of conformity with technical standards (performance assurance).
- Participating in the planning of various systems concerning new technologies, such as public solicitation for technologies / field demonstrations by the New Technology Information System (NETIS) (theme setting type) and Road Bureau, and technical research and development contributing to quality improvement in road policy, and technical support so that new technologies match needs and are correctly implemented.

Through the activities described above, the Road Structures Department intends to contribute to roads that lead to people's happiness.

[References]

1) Material of the 73rd meeting of the Basic Policy Group, Road Subcommittee, Panel on Infrastructure Development http://www.mlit.go.jp/policy/shingikai/s203_seisaku01.html

Construction standards and promulgation technologies that can respond to needs of the society

FUKUYAMA Hiroshi (Ph.D. in Engineering), Director, Building Department

(Keywords) Rural revitalization, environmental problem, urban redevelopment, robustness improvement, protective measures against strong wind

1. Introduction

The Building Department is working to respond to the various needs of citizens and society, which are in constant change with the movement of the world, and to realize a more reliable, safe, comfortable, and attractive architectural environment. 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 include field investigations at disaster-hit areas and the exploration of measures to take in the future, application and spread of investigation and research outcomes to society, and the provision of technical support for organizations inside and outside of Japan.

This paper introduces researches that the Building Department is now implementing or planning and their directions by keeping in mind recent hot topics, such as regional revitalization, environmental problems, urban redevelopment, and robustness improvement. This paper also discusses the direction of examining measures to respond to damage caused by massive typhoons (protective measures against strong winds) because massive typhoons have been occurring at a high frequency over the past few years.

2. Responses to regional revitalization and environmental problems

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 woods were used. To achieve these objectives, it promoted the development and the use of cross-laminated timber (CLT: thick wood panels created by layering and bonding wooden boards in alternating directions) to increase the number of wooden buildings, including the construction of wooden public buildings. A general technology development project, Development of Technologies to Install and Construct Mixed-Structure Architecture Using New Wooden Materials (2017–2021), is now underway to effectively use wooden materials, provide versatility in architecture, shorten construction periods, and realize various requests, such as responding to various needs to utilize the designability of wooden materials.

Here, a new architectural space is created by using CLT, large-scale wooden panels, and other wooden materials as structural members and combining them with RC structures and steel structures. In particular, creating a space where wooden materials are visible on the surface of the interior used to be difficult in mid-to-high-rise buildings. Yet, the project will present multipurpose design methods and bonding methods that can realize the necessary structural performance and durability by actively using the newly revised fire safety and evacuation regulations. These will be organized as three types of prototype architectural design examples, which are to be spread as general technologies (Figure).

Figure: A prototype building under consideration

3. Responses to urban redevelopment and robustness improvement

Cities in Japan are expected to be redeveloped into more compact and more robust ones. Fundamental technologies to smoothly meet these expectations are thus

essential.

The following two topics are going to be covered in the general technology development project that starts in FY 2020 titled 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 (2020–2023): 1) what to do with already installed piles that pose challenges in renewing and redeveloping architecture in cities, and 2) the robustness improvement of deteriorating residential lands and retaining walls in hilly areas.

In 1), the project includes the development of methods to verify the structural safety of ways to reinforce installed piles and the ground and the methods of using newly installed piles along with already installed ones (different types of piles) as ways to reuse piles from past buildings that become obstacles upon renewing the structures. The developed methods are then going to be put into wide use. The project also includes the development of performance evaluation methods that take into account the ground properties that tend to become soft and loose when the ground soil is refilled after removing piles in cases where piles are removed. In 2), the project includes the development of technologies to diagnose and reinforce existing residential land and retaining walls to avoid deforming or collapsing deteriorated or damaged retaining walls and the ground of residential land due to earthquakes and, consequently, degrading the safety and utility of nearby traffic and houses standing there. In the end, by applying them in society, these developments will contribute to the redevelopment and improvement in the robustness of cities.

4. Responses to massive typhoons (protective measures against strong winds)

Typhoon #15 (Faxai) that hit Chiba in September 2019 caused serious damage to the outdoor materials of buildings, such as tiled roofs and wooden roof trusses. As the strong winds and rainwater invaded indoor spaces, damaged houses lost their functions as shelters. Restoration from the damage also required massive time and costs to restore the structures. According to the General Insurance Association of Japan, the annual amount of insurance payout for damage caused by strong winds and floods in recent years has been higher than the payout for earthquake damage.[1] Given the recent trend of extreme weather events, the improvement of the robustness of architecture against strong winds is considered a pressing issue.

Our on-site investigation of damage caused by Typhoon #15 (Faxai) found that significant damage was seen in window glass, roofing materials such as tiled roofs, wooden roof trusses, exterior finishes, outdoor fittings, eave soffits, and other parts of houses and low-rise retail stores.[2] Focusing on damage (photos) to roofing materials, wooden roof trusses, and outdoor fittings (large sash),

Scattering of roofing materials　　Damage to roof trusses

Outdoor fittings of stores
Damage and collapse of large sashes

Photo: Various building damage caused by strong winds

the NILIM is going to examine the following to reduce damage to them using the supplementary budget of 2019 and other funds. By doing so, the NILIM is going to propose testing and evaluation methods and their specifications to improve performance against strong winds and spread the technologies by reflecting them in the guidelines used by the applicable industries.

1) Roofing material: Observed damage caused by factors that include roofing materials installation methods (mainly fitting and binding methods) and the causes of the damage are examined to select and establish recommended methods to be used widely. Also, the diagnosis and renovation methods used on currently installed roofing materials and the wind resistance performance ranking of roofing materials are examined to find ways to guide the industry to more robust roofing.

2) Roof trusses: Examples of the specification for roof trusses based on standard wind speed will be proposed by conducting stress experiments using test specimens that reflect the actual conditions of roof beams and roofing boards.

3) Large sashes: Stress tests and evaluation methods will be developed by identifying the actual strength at the joint sections between a large sash and the building frame to present recommended specifications.

☞For more information:

1) The General Insurance Association of Japan: Insurance payouts for natural disaster damage
https://www.sonpo.or.jp/report/statistics/disaster/index.html
(For example, the total fire insurance payout for the damage caused by the heavy rains in July, Typhoon #21, and Typhoon #24 in 2018 was 1,357.8 billion JPY in total. This was higher than the 1,283.3 billion JPY payout for the damage caused by the Great East Japan Earthquake in 2011—the largest insurance payout for earthquake damage.)

2) The National Institute for Land and Infrastructure Management - Building Research Institute: Report of on-site investigation of building damage caused by the strong winds of Typhoon #15 (Faxai) in 2019, October 24, 2019
http://www.nilim.go.jp/lab/bbg/saigai/R1/taihu15.pdf

IoT, AI, and the disaster management of houses and buildings

SANKAI Toshihiro (Ph.D), Director, Housing Department

(Keywords) IoT, AI, energy harvesting, fire evacuation, daily disaster, wide-area disaster

1. Introduction

The use of innovative systems that use IoT and AI is increasing in houses and buildings. Many new technologies are being released, especially in the field of technologies, to sophisticate and streamline building operations.[1] While the use of IoT has been increasing in the field to improve convenience and service, the use of these new technologies, however, is happening too slowly in the field of assisting people during fire evacuations and of improving the safety of the elderly and disabled on a daily basis. Progress is also slow in the field of responding to the cutoff of utilities. Therefore, this article discusses the utilization of IoT and AI in fire evacuations, daily-level disasters, and utility disruptions.

2. Application of IoT and AI to assist in fire evacuations

Fire evacuation technologies (e.g. emergency lamps, fire extraction system, fire alarm system, backup power, and emergency power) that are now in use are regulated under technical standards based on the Building Standards Act that was established in 1970 after the fatal fire in the Sennichi Department Store building.

Therefore, they seem outdated compared to current technical standards. The use of new technologies, such as IoT, is thus greatly advantageous and should actively be adopted. The following are fields where the use of new technologies is expected.

1) Technologies to detect fire more quickly and accurately

⇒ Early and accurate detection of fire with the sensors of IoT devices that are used in daily scenes and the early detection of fire through AI-based image recognition technology

2) Technologies to enable proper evacuation during a fire

⇒ Technologies to assist evacuation-vulnerable people using signs, navigation (use of AR and mobile devices), and robots that enable rational evacuation (e.g. parade-like autonomous evacuation by power wheelchairs or autonomous evacuation using wearable robots)

3) Technologies to properly extinguish fires

⇒ Realization of early fire extinguishing using AI-based image recognition technology and fire-extinguishing technology using robots

In reality, however, private companies have rarely proposed or developed new technologies in this field for the following reasons. First, current industries that have the best knowledge in this field have evolved with the presumption that they must remain in compliance with current regulations, and they are not very motivated to work on new technologies. Also, knowledge of the current industries is limited within some of the technical standards that are based on regulations, and application beyond the standards is difficult to achieve.

To respond to this current situation, the Building Research Institute (BRI) is leading the research and development of IoT-based evacuation assistance technologies and technologies to assist the elderly and disabled in evacuations using robots.[2]

For evacuation assistance technology, the BRI is examining evacuation assistance within a building using AR (augmented reality) technology. This technology is expected to enable proper evacuation from building spaces where it is relatively difficult to find evacuation routes.

For the technology to assist the elderly and the disabled, the BRI is examining technologies to realize autonomous horizontal evacuation using power wheelchairs and verifying evacuation performance when mobile support technologies, such as a robot suit, are used.

3. Application of IoT for elderly and disabled support and prevention of disasters on a daily basis

The construction of barrier-free buildings has been realized by establishing regulations on the sizes of buildings (i.e. heights and widths) and the installation of handrails and elevators among other regulations. Yet, the number of people who lose their lives within houses is now more than double the number of people who die in traffic accidents. The most frequent cause of death is drowning in the bathtub, which accounts for nearly 70% of all fatalities that occur inside houses. Some speculate that heat shock is the greatest factor that leads to drowning. Nonetheless, no effective

technology is now available to prevent such deaths. Meanwhile, the use of a watchful-eye service is rapidly increasing in the field of care and nursing. Assistance technologies are rapidly being installed in the housing of people living alone. Yet, there remains a serious conflict between ensuring safety and protecting the privacy of users. AI and IoT-based technologies are attracting attention as a possible solution to such conflicts.

AI has been going through an explosive evolution since it had reached the stage where the classification of photos of cats and dogs became possible through deep learning in 2012. Meanwhile, as IoT devices have become more multifunctional with higher processing speed, a local system became able to perform AI-based image recognition. This indicates the possibility that information in the domain of privacy can be fully localized (so-called edge computing). For example, some argue that it is possible to create a system in which AI locally processes image information that a person is about to drown in a bathtub and only sends a signal to call for rescue to the outside. In the case of drowning, a rescuer who is dispatched after receiving the warning may not be able to arrive at the scene in time to save a life. Yet, a possible rescue idea is to have an airbag attached to the bottom of the bathtub, which is inflated when a drowning is detected to prevent an accident. The real question may be how far the system should go to intervene rather than what the system can do.

4. Responding to utility disruptions

The use of IoT and AI in houses and buildings may be able to generate great social benefits. Still, they are basically vulnerable to power disruptions. Energy harvesting is one of such technologies attracting attention to overcome such a vulnerability. Energy harvesting means “environmental power generation.” Various technologies are now in actual use, such as semiconductor devices that can generate power from faint vibrations, temperature changes, lights, ambient electromagnetic waves, and other phenomena, and the use of the power for operation and communication, as well as lighting systems that emit light as people step on a power-generating unit.

Cable-less IoT can be realized by using these technologies, which can overcome the vulnerability that comes from dependency on an external power supply. In addition, as discussed below, there is the possibility of compensating for the inherent nature of an emergency power supply in buildings where it is not suitable for a long-term power failure in buildings (activated simultaneously upon a power failure regardless of load condition and shuts off quickly) because the control and surveillance system and power generation system can become isolated. Details are discussed below.

(i) The system is able to maintain the necessary control and surveillance functions even when the power supply is stopped. The combination with mobile devices will also be an effective option.

(ii) Securing building functions by running an emergency power supply only when a large amount of power is needed (intermittent operation of an emergency power supply) becomes technically possible. The length of operation allowed by a certain amount of fuel has become drastically longer compared to the commonly used emergency power generator. The expectation for applicability to respond to a power failure is thus increasing.

5. Summary

The National Institute for Land and Infrastructure Management is falling behind in the field of using IoT and AI in the field of housing. Yet, the half-committed involvement of the public sector in this field where the private sector is leading technological development might distort the technologies. Careful involvement should thus be required. By observing the active development and advancement of technologies in the private sector, the public sector can find how technologies will relate to current regulations and the possible challenges because bystanders can have a bird’s eye view of the situation and the progress. Thus, being able to objectively observe the direction of the technologies was an advantage of falling behind in the game.

☞For more information:

1) *Society 5.0 Housing and Building*. Toshihiro Sankai. NILIM Report 2019. p.38, p. 39, July 2019.

2) Possibility of using sensor and robot technologies to ensure evacuation safety in a more advanced form. Koji Kagiya, Toshihiro Sankai. Compilation of Academic Lectures at the Architectural Institute of Japan Conference (Hokuriku). Fire Control pp. 369-370, September 2019.

To build sustainable cities and cities that create new value

NAKANISHI Hiroshi, Director, Urban Planning Department

(Keywords) Society 5.0, smart city, overcoming challenges, creation of values, big data

1. Policy-related challenges related to urban research

(1) Changes in policy-related challenges

Cities in Japan are transforming into mature cities after going through an era of rapid urbanization, and some of them are now transforming into deteriorating cities.

Challenges that urban policies should respond to have also shifted from controlling disorderly development to renewing and rearranging existing urban areas and then to the maintenance and management of deteriorating cities and the restoration and conservation of nature and history.

Today, the most important challenges in urban policies that various entities from various specialties must face include 1) depopulation and a super-aging society, 2) large-scale natural disasters, and 3) energy and environmental problems.

(2) New efforts using new technologies

As a way to overcome these challenges, national strategies to realize super-smart cities (Society 5.0) have been set forth to comprehensively transform the socioeconomic structure of Japan through innovation.

The development of a comfortable infrastructure and cities is one of the five strategic fields that will realize Society 5.0. Smart-city development efforts have already started by using new technologies that are already in practical use or ones to fit into society in the near future to realize sustainability by solving various issues and creating new values.

As discussed above, urban policies are one of the important elements in the national strategies. Issues that surface with the socioeconomic transformation in individual cities need to be responded to in advance through the involvement of entities in various fields. Thus, it is necessary to start full-fledged development of technologies that will enable unity and cooperation among different fields and researches on how technologies would and should affect people and cities.

2. Principle of research activities

The Urban Planning Department is conducting surveys, researches, and technological developments needed to properly and quickly plan, propose, and implement the urban policies of the Ministry of Land, Infrastructure, Transport and Tourism. The department is continuing its surveys and researches by setting the following three themes as important fields.

(i) Urban development for a society facing depopulation
(ii) Development of disaster-resilient cities
(iii) Development of low-carbon cities

The department is going to take on new challenges and keep responding to the needs of society and the administration based on socioeconomic issues and trends; national plans and the future perspective of the private sector; unexpected incidents, such as disasters and accidents; and the future perspective of technological innovations within the above framework.

In particular, the department will focus on comprehensive research and development that lead to the realization of Society 5.0 and regional revitalization, long-term fundamental researches conducted on the basis of political strategies, and academic researches founded on liberal ideas. At the same time, the department will ensure that these activities are conducted in a good balance.

It is also important to support the activities of local governments and residents as the main players in urban operations. The department will thus transmit information about the examination of research plans, research outcomes, and research activities to them. The department is also going to actively gather and transmit information through international joint researches and other activities.

3. Examples of research activities

Research activities are categorized as follows.

1) Participation in the implementation of policies at the Ministry of Land, Infrastructure, Transport and Tourism

- Preparation of the draft of technologies related to the City Planning Act, Building Standards Act, Low Carbon City Act, and other laws and regulations and the implementation of disaster surveys

2) Application of technological capabilities to the actual worksites

- Development and release of various simulation programs for advanced uses based on statistical survey data, geospatial information, building data, and other data and information
- Joint researches concerning ways to utilize traffic big

data

3) Leading new policies

- Prior surveys, researches, and technological development for the future, such as the development of compact cities, low-carbon cities, disaster-resilient cities, super-smart cities, etc.
- Development of green coverage ratio measurement methods using AI
- Development of methods to evaluate low-carbon city development by improving urban thermal environment using green areas, etc.

Focused researches and developments are introduced below.

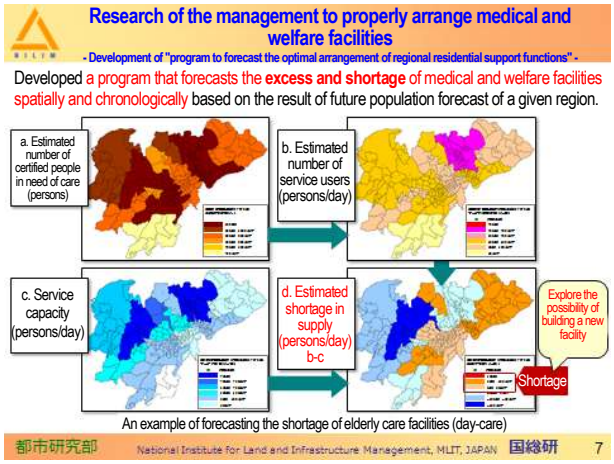
(1) The release of future population and household forecasting tools based on the unit of small areas (blocks and sections) (improved version)[1] and development of a program to forecast the optimal arrangement of regional residential support functions using the tools

The National Institute of Population and Social Security Research has been estimating future populations in individual municipalities. Meanwhile, the department developed a tool to forecast populations in individual blocks and sections within municipalities. The improved version of the tool based on the 2015 National Census was released through the Geospatial Information Center.

The program to forecast the optimal arrangement of regional residential support functions forecasts the excess and shortage of medical and welfare facilities based on the forecasted number of people certified to be in need of care, which is computed by population estimation simulations at individual blocks and sections. The objective of this program is to use the forecast to properly arrange facilities within municipalities.

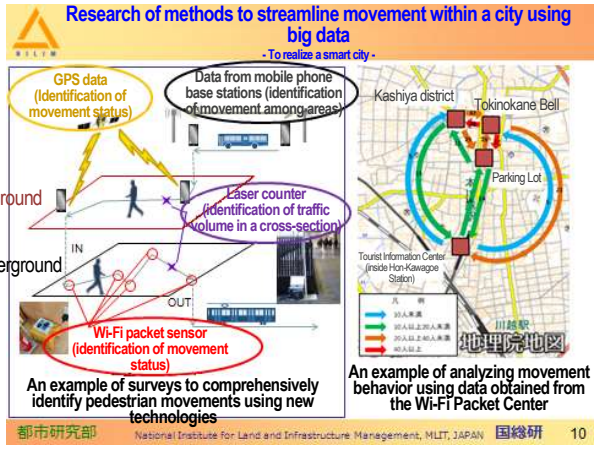
(2) Identification of movement within cities using big data

There is a need to reduce the workload required in traffic volume surveys and to provide more real-time data.



Thus, the department is trying to use big data obtained through various information and communication technologies for pedestrian traffic volume surveys.

The department is developing methods to provide accurate information that will reflect the actual traffic volumes by effectively combining different characteristics of information and communication technologies and where and how they can be used.



4. Summary

Activities related to smart cities to realize Society 5.0 are now being implemented as model projects throughout Japan.

The department is going to implement researches and the developments of evaluation methods so that new technologies, such as information and communications technologies, and new services can be used to overcome various issues and create values as a part of the efforts to promote the development of smart cities.

The department is also going to further promote the use of new technologies and real-time data and improve the accuracy of identifying various phenomena and future forecasting to help provide solutions to various challenges by improving currently used simulation tools and creating new ones.

In addition, while the necessity for open innovation has been increasing, the department is going to promote coordination and cooperation with external organizations and develop a research environment where diverse people can work successfully.

☞For more information:

1) Geospatial Information Center “Future population and household forecasting tool (improved version)” download website
https://www.geospatial.jp/ckan/dataset/cohort-v2

Activities of Research Center for Infrastructure Management and Future Perspective

SHIMIZU Akira, Director, Research Center for Infrastructure Management

key words: productivity improvement, public bidding / contracting methods, historic scenery, Kumamoto Earthquake

1. Introduction

Research at the Research Center for Infrastructure Management (the "Center") covers a wide range of fields, including estimation, public bidding and contracting methods, project evaluation, analysis of economic effect, construction work using ICT, utilization of three-dimensional data from research for maintenance, urban greening, ecosystem conservation, and landscape / historical community development, and support for recovery from the Kumamoto Earthquake. This paper introduces the main activities and future plans of the Center, which is now in its fourth year since establishment.

2. Efforts for productivity improvement

To improve productivity at construction sites, Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is working on "i-Construction" as one of the important measures, which utilizes three-dimensional data, ICT and other tools in the various stages of the construction process from research, design and construction to inspection, maintenance, and renovation.

i-Construction has also been promoted since last fiscal year under the Public/Private R&D Investment Strategic Expansion PrograM (PRISM), through which the Center is also conducting research.

(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, work progress control, etc. have been implemented in earthworks, pavement works, and dredging works. The Center has been studying ways to prepare and organize standards that would promote the introduction of the aforementioned technologies into construction sites. In fiscal 2018, the types of works were expanded to soil improvement works, slope works and ancillary structure installation works. We continue to study their expansion to other types of works and the utilization of new technologies.

(2) Introduction / Dissemination of CIM

MLIT has been using CIM models since fiscal 2012 as one of the activities for utilizing three-dimensional data. CIM (Construction Information Modeling/Management) aims to facilitate information-sharing among the persons concerned with a given project and, thereby, improve efficiency of the construction production system by introducing 3D models 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 for creating simple 3D models of existing structures as yet another application of CIM. The Center also intends to study CIM introduction for machinery and equipment.

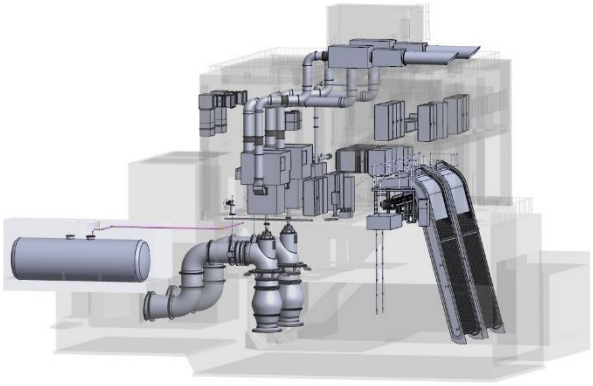


Fig. Example of CIM for machinery / equipment

(3) Infrastructure data platform

We are conducting a study into an "infrastructure data platform" for reproducing information on national land assets, such as structure data and ground data, in cyberspace. This infrastructure data platform aims to improve operational efficiency and upgrade policies and measures by collecting data obtained across the construction process from surveying and research to design, construction, and maintenance, and linking the collected data to data on economic activities such as the movement of people and goods, and natural phenomena. The Center is exploring possible links with various databases, etc.

In addition to the infrastructure data platform, the Center intends to search for ways to use data obtained from construction sites, etc.

3. Improvement in public bidding / contracting methods

Public bidding / contracting methods have been continuously improved according to the demand of the times and changes in social situations. For example,

amendments to the Act on Promoting Quality Assurance in Public Works ("Quality Assurance Act") in 2014 added quality assurance for ongoing and future public-works and development / securing of human resources on a mid- to long-term basis to the purpose of the Act, and provided a framework for introducing / utilizing various approaches to bidding / contracting. That included the technical proposal / negotiation approach, 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 process. Guidelines for this technical proposal / negotiation method were issued in 2015, and projects using this method began to appear in 2016. However, there are still few of these projects in the country and we are analyzing the effects of application, issues and potential areas of improvements in relation to the status of implementation in the construction stage. Since the technical proposal / negotiation method is applied to construction works in which the owner cannot set optimal specifications or the conditions requisite for specifications are unlikely, we will continue the study to facilitate progress of such works.

4. Promotion of practice and utilization of resident-participated biological surveys

MLIT formulated their "Biodiversity Indicators of Cities (draft)" in 2013 and "Biodiversity Indicators in Urban Areas (simple version)" in 2016. Meanwhile, local governments have been faced with the issue of how to more widely monitor the inhabitation / growth of animals and plants.

Given the circumstances, biological surveys conducted in cooperation with residents would be relatively easy for local governments to implement, since there are various precedents and this approach is considered a continuous bio-monitoring methods. Therefore, the Center is studying how to effectively implement / utilize methods of resident-participated biological surveys, with the aim of creating a technical guide for local government personnel. We intend to continue research into developing good quality communities with their own identity.

5. Support for restoration from the Kumamoto Earthquake

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 division was installed in April 2017 by stationing research personnel on the site. This division is providing prompt and detailed technical support at sites and helping to complete projects led by Regional Development Bureaus and local governments.

In August 2019, the replacement work of the Tawarayama Bridge was completed. The division is also giving advice on future management, in addition to guidance on restoration. While providing technical support for early recovery, we will continue to reflect the knowledge obtained in technical standards and study aseismatic structure etc. enabling easy functional recovery based on the same knowledge.

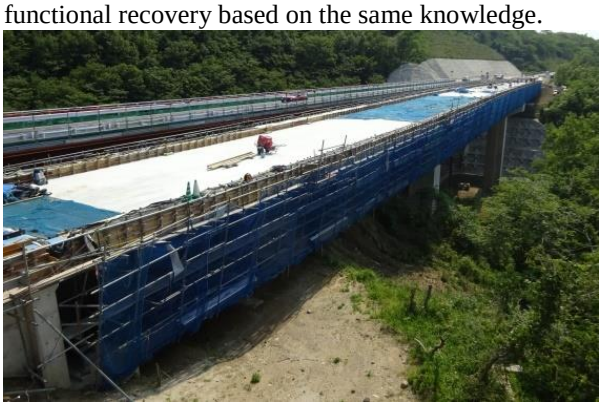


Photo: Tawarayama Bridge under restoration

6. Conclusion

As new technologies like AI and IoT emerge, we intend to use these advanced technologies and the data they obtain to improve productivity and social capital management according to site needs.

Study on Life Extension of Offshore Breakwaters and Other Offshore Facilities
--- Revision of the Coast Protection Facilities Maintenance Manual ---

(Study period: FY2019)

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key words: coast protection facilities, life extension, preventive maintenance

1. Introduction

In response to the progress of aging in the infrastructure that was intensively developed in Japan after the high-growth era, the MLIT formulated the Infrastructure Life Extension Plan (Action Plan)" in May 2014 to promote systematic maintenance, renewal, etc. of such infrastructure.

For coast protection facilities provided in Article 2 of the Coast Act, systematic maintenance, renewal, etc. have been promoted in accordance with the "Coast Protection Facilities Maintenance Manual (May 2018)" (the "present Manual"). Of the facilities defined in the present Manual, reference to other guidelines etc. are required for offshore breakwaters, submerged breakwaters, artificial leafs, piers and headlands (collectively, "offshore breakwaters etc."). We are therefore studying standard facility management procedures from a viewpoint of preventive maintenance aiming to strengthen the management of offshore breakwaters etc.

2. Status of the maintenance of offshore breakwaters etc.

Of the coast protection facilities, dikes were rapidly constructed in the rapid economic growth and the dikes that have elapsed over 50 years since the start of operation account for about 40% as of 2015. Meanwhile, there is also a concern about rapid decline of the functions for offshore breakwaters, of which development was promoted following dikes, as shown in Fig. 1.

In addition, as Fig. 2 shows, formulation of a life extension plan for offshore breakwaters etc. is behind as compared with coastal dikes etc. because of the shortage of budget and personnel, as well as shortage of know-how and no formulation of inspection and assessment procedures.

Hence, in order to promote systematic maintenance, renewal, etc. of offshore breakwaters etc., technical support is required, such as setting of inspection and soundness assessment standards.

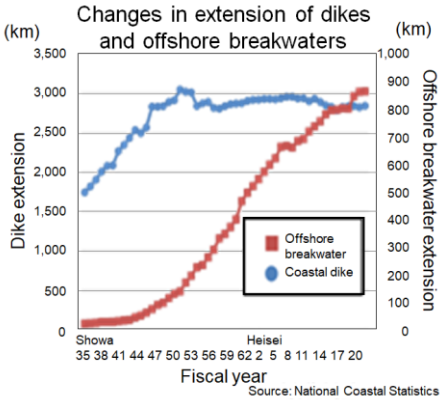

Fig. 1 Changes in extension of dikes and offshore breakwaters

Formulation of the life extension plan

Target facilities	Dike	Sluice gate, water gate, etc.	Offshore break water	Pier
Formulation rate	75 %	61 %	46 %	46 %

Reasons for non-formulation of life extension plan for offshore breakwaters etc.

Reasons	Shortage of budget	Shortage of personnel	No technical know-how	No description of inspection or assessment procedures in the manual etc.	No specific guidance from the State etc.
Ratio (%)	31	18	16	21	14

Fig. 2 Formulation of a life extension plan and reasons for non-formulation

3. Study contents

In reference to the description of dikes, revetments, etc. in the present Manual, we studied chain of deformation flow, inspection items and soundness assessment standards, collection and organization of examples for inspection procedures, countermeasure construction method, etc. and deterioration prediction line. The following describes the outline of study for each item.

(1) Study on the chain of deformation flow

In inspection and soundness assessment of facilities, it

is necessary to consider the processes of facilities such as deformation factors and form. We therefore collected 146 examples for deformation and damage across the country ("Disaster Recovery Guidelines for Protecting Beautiful Coasts (Draft)" Table A-B, etc.) and classified / organized the factors and forms to organize them into New Chain of Deformation Flow for offshore breakwaters etc. (Draft)."

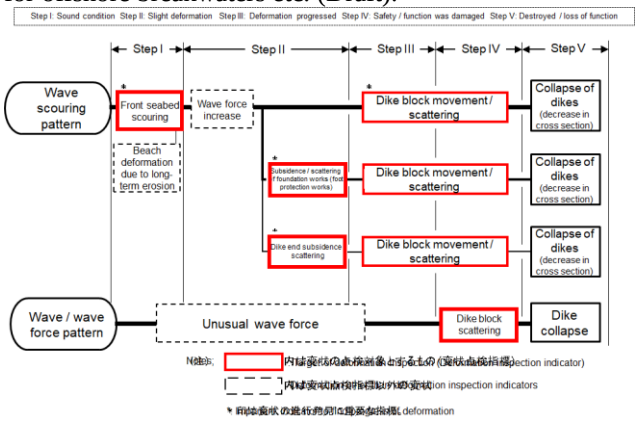

Fig. 3 Chain of deformation flow for offshore breakwaters etc. (Draft).

(2) Study on inspection items and soundness assessment standards

In studying the inspection items and soundness assessment standards above considering the aforementioned chain of deformation flow (draft), we organized the data on the inspection and soundness assessment of offshore breakwaters etc. by each coast administrator and organized inspection items and assessment standards (draft) available on the site, including identification of inspection items that "must be implemented", such as organization of deformation cases and visual inspection from land, and inspection items that "should be implemented as needed", such as submersible survey. (Figs. 4 and 5)

Unit	Implementation necessity	Deformation phenomenon / Location of inspection		Deformation level (Extent of deformation confirmed) a	b	c	d
Each facility	Certainly implement	Dike	Movement Subsidence Scattering	The cross section of the dike decreased at least one layer of blocks across the dike.	The cross section of the dike decreased across the dike. (less than one layer of blocks)	Part of the blocks moved, scattered, or subsided.	Slight or no deformation.
			Block breakage	At least one-fourth of the blocks are broken.	Broken blocks are less than one-fourth.	A few blocks are broken.	Minor or no cracks.
Each component	Implement if necessary.	Seabed ground Foot protection work	Scouring	Widely eroded and the front of the foot of rubble mound slope is scoured over 1 m. The mound etc. are affected by scouring.	Widely eroded and the front of the foot of rubble mound slope is scoured 0.5 m or more but less than 1 m.	Scoured less than 0.5 m in depth.	Slight or no deformation.
			Movement Subsidence Scattering	Flow loss, destruction, or missing.	Minor movement or subsidence.	-	Slight or no deformation.
		Dike	Movement Subsidence Scattering	The cross section of the dike decreased at least one layer of blocks across the dike.	The cross section of the dike decreased across the dike. (less than one layer of blocks) The cross section of the dike decreased at least one layer of blocks in half of the dike.	Part of the blocks moved, scattered, or subsided.	Slight or no deformation.
			Block breakage	At least one-fourth of the blocks are broken.	Broken blocks are less than one-fourth.	A few blocks are broken.	Minor or no cracks.

Fig. 4 Deformation level assessment standards for offshore breakwaters (Draft)

Inspection point	Inspection item	Item to check	Implementation	Inspection method expected
Front Seabed ground	Scouring	Whether the front is scoured	Implement if necessary.	Sounding Diving survey Underwater camera survey
Foundation work (foot protection work)	Movement Subsidence Scattering	Whether the foundation rubble, block, etc. are moved, subsided, or scattered.		
Dike	Movement Subsidence Scattering	Whether the blocks moved, subsided, or scattered.	Certainly implement	Visual inspection (land) or similar method
			Implement if necessary.	Visual inspection (on water) method Sounding Diving survey Underwater camera survey Aerial photo (UAV etc.)
	Block breakage	Whether the blocks have cracks / damage.	Certainly implement	Visual inspection (land) or similar method
			Implement if necessary.	Visual inspection (on water) method Diving survey Underwater camera survey Aerial photo (UAV etc.)

Fig. 5 Primary inspection items / procedures for offshore breakwaters (Draft)

(3) Example collection and organization for inspection methods, countermeasure construction methods, etc.

Since all or part of such facilities as offshore breakwaters etc. are submerged under the sea, it is difficult to grasp all deformations only with visual inspection from land, which is applied to dikes, revetments, etc.

We therefore collected and organized examples of inspection methods and countermeasure construction methods focused on new technologies in order to promote utilization of new technologies that replace visual inspection from land. (Fig. 6)

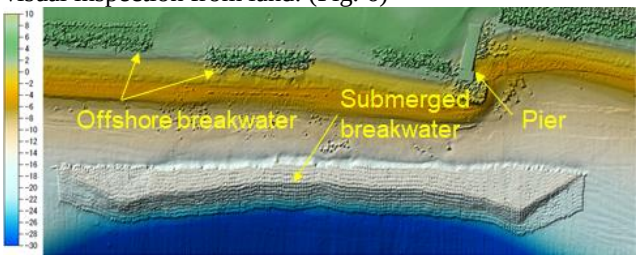

Fig. 6 Example of 3D geographic measurement with ALB and narrow multibeam

(4) Study on deterioration prediction line

For systematic maintenance and renewal, it is necessary to predict the time of deterioration and deformation in facilities and to consider repair / renewal plans for facilities.

However, in comparison with dikes, revetments, etc., which mainly suffer temporal deterioration, offshore breakwaters etc. may suffer sudden deformation caused by unusual waves, etc. since they are located off the shore line. With this taken into consideration, we are continuing the study.

4. Future schedule

We are going to reflect the results of study including the opinions of academics and coast administrators in the revision of the present Manual.

☞See the following for details.

1) Committee for Revision of the Coast Protection Facilities Maintenance Manual
http://www.mlit.go.jp/river/shinngikai_blog/kaiganhozen/index.html

Changes in River Plan Target Precipitation due to Climate Change

(Study period: FY2018-)

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key words: climate change, ensemble climate model data

1. Introduction

In recent years, we often recognize the manifestation of the impact of climate change, such as disasters caused by frequent heavy rain. According to the 5th IPCC Report, there is no room to suspect the warming of climate system and the expansion of damage by the impact of climate change may become more serious in the future. Under such circumstances, shift to river development considering climate change is urgently required.

The NILIM is studying a method of reflecting the impact of climate change in the target precipitation of river development plan. This paper introduces the results of analysis on changes in the target precipitation of river development plan, conducted using the data of long-term ensemble calculation, which is a climate forecast method appropriate for discussion of low-frequent extreme phenomena, which should be covered in river development.

2. Calculation of rainfall variation magnification

The variation magnification of rainfall caused by heavy rain under climate change is calculated by conducting DAD analysis using the rainfall data of multiple long-term ensemble climate models and calculating the ratio of probability scale precipitation based on the past experiment data (climate conditions from 1951 to 2010) and future experiments (climate conditions from 2051 to 2110). Of the output results of the area experiment that covers the regions of Japan with the resolution of approx. 20 km provided by d4PDF [1)], this paper provides the results of calculation based on two types of output scaled down to the resolution of approx. 5 km using the nonhydrostatic local climate model "NHRCM" of the Meteorological Research Institute for the past experiments and future temperature rise experiments at 2°C and 4°C.

As regions for calculating rainfall variation magnification, the country was divided into several regions. Based on the region division method used practically in the hydrologic and weather fields, the division methods of multiple regions were verified statistically and the validity of region division methods was compared. The region division methods verified were the division method of regions concerning the assumed maximum scale of rain [2)], the division method of regions modified to raise the ratio of identity based on the regional comparison hydrograph [3)], and forecast division by the Meteorological Agency and local seasonal weather forecast[4)]. As a result, from a viewpoint of the identity of the probability distribution of the maximum rainfall in divided regions, no major difference was found in the validity of region division method. For analyzing rainfall variation magnification, we chose the division method of regions concerning the assumed maximum rainfall, which is the division without any river system across the divided regions, considering that it is desirable to conduct an analysis so that rainfall events are not separated in the same river system. Fig 1 shows the division of regions selected.

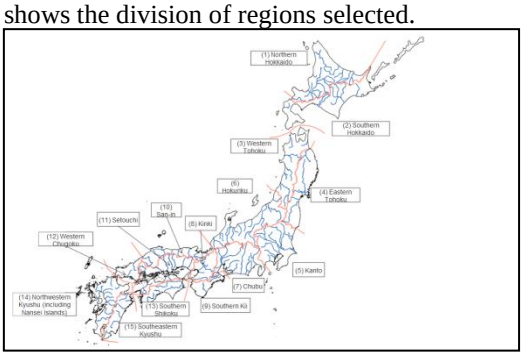

Fig. 1 Division of regions used for the study

The variation magnification of future rainfall was calculated for each region of Fig 1. The calculation procedure is shown below.

1) Organize the relationships between duration of rainfall, size of rain area, and accumulated rainfall in the duration for each year with regard to the data of both past and future experiments (DAD analysis). For the size of rain area, sample the areas where accumulated rainfall is not lower than the threshold value and that are spatially connected.

2) Create the envelope curve of the maximum accumulated rainfall based on the relationship of the accumulated rainfall for each year and the size of rain area.

3) Since the maximum envelope value of the accumulated rainfall of a certain year is equal to the annual maximum rainfall according to the size of rain area of the same year, calculate probability rainfall with Gumbel distribution using the maximum accumulated rainfall of each year for each size of rain

area.
4) Determine the rainfall variation magnification by obtaining the ratio of probability rainfall values calculated in both past and future experiments.

By conducting 2) to 4) for each duration of rainfall, it is possible to obtain the rainfall variation magnification by combining arbitrarily the size of rain area and the duration of rainfall.

3. Calculation results of rain variation magnification

As an example of the calculation results, Figures 2 and 3 provide the variation magnification of 1/100 probability rainfall for each sea surface temperature model in combination of the size of rain area (1,600 km^2) and the duration of rainfall (24 hours) with regard to the rainfall variation magnification calculated from the data of climate forecast model based on the assumed temperature rise of 2°C and 4°C in future.

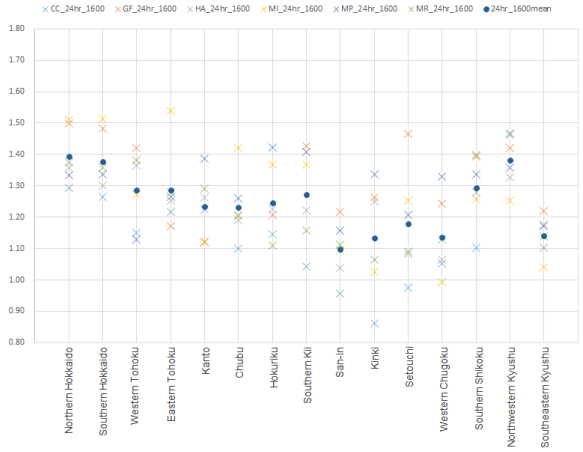

Fig. 2 Rainfall variation magnification of each sea surface temperature model for 24 hours of rainfall duration in the size of rain area of 1600 km^2 at the temperature rise of 4°C.

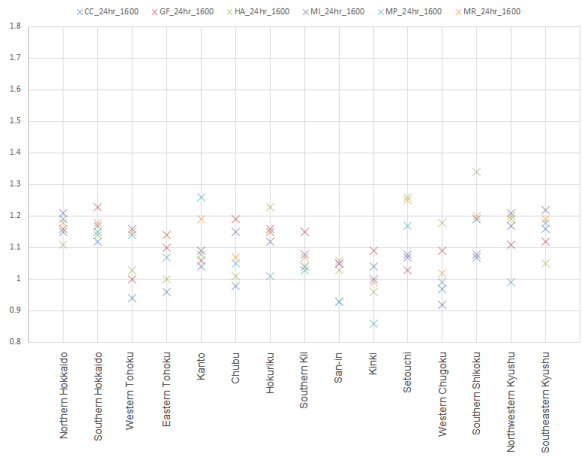

Fig. 3 Rainfall variation magnification of each sea surface temperature model for 24 hours of rainfall duration in the size of rain area of 1600 km^2 at the temperature rise of 2 °C.

At the temperature rise of 4°C, the average value of 6 sea surface temperature models in Northern Hokkaido, Southern Hokkaido, and Northwestern Kyushu regions was relatively larger than other regions. At the temperature rise of 2°C, the average value of 6 sea surface temperature models in Northern Hokkaido and Southern Hokkaido regions was relatively larger than other regions. This would be because the rate of rise in the saturation vapor pressure in Hokkaido becomes relatively large [6] and the rise of sea surface temperature is large in and around Hokkaido and Northwestern Kyushu for sea surface temperature model, since the rate of rise in air temperature becomes large as the latitude of the regions goes up. Using d4PDF, we conducted an analysis on the future variation of the river plan target rainfall and calculated the variation magnification of future rainfall considering the size of rain area and the duration of rainfall for each region. The results of this calculation are expected to be used in the study on external force setting of future river plans.

4. Future schedule

We are going to organize in detail the data on the assumed temperature rise of 2℃ in future in relation to the factor analysis of future changes.

References

1) Ensemble climate forecast database contributing to global warming countermeasures: http://www.miroc-gcm.jp/~pub/d4PDF/index.html
2) Water and Disaster Management Bureau, MLIT: "Method of setting the assumed maximum external force for preparation, etc. of inundation assumption (flood, landside water)", July 2015
3) National Institute for Land and Infrastructure Management, MLIT: A Study on Climate Change Adaptation Measures (Interim Report), Technical Note of NILIM NO. 749, Aug. 2013
4) Meteorological Agency: http://www.jma.go.jp/jma/kishou/know/kisetsu_riyou/image/png/chihou_kubun.png
5) Water and Disaster Management Bureau, MLIT: The 5th Meeting of the Engineering Workshop on Flood Control Plans considering Climate Changes, Material 5, "Proposal for flood control plan considering climate changes (Draft)," Reference data
6) Ministry of the Environment etc.: The 2018 Comprehensive Report on Observation, Forecast, and Impact Assessment of Climate Change --- Climate Change and Impacts in Japan ---, Feb. 2018

Development of Soundness Diagnosis / Monitoring Technologies for Supporting the Life Extension of Dams

(Study period: FY2017-)
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key words: dam, maintenance, inspection, non-destructive test

1. Introduction

In order to ensure proper performance of the functions of dams over the years, various inspections to keep them in good condition are very important. For this reason, in addition to the safety inspections, which consists of daily inspections by patrol and measurement, extraordinary inspections in the event of an earthquake, etc., and periodic inspections by third party, a "Comprehensive Dam Inspection", in which the dam condition is checked in detail, soundness assessment is conducted, and maintenance policy for the future is prepared in order to extend the life, has been recently implemented.

For such detailed inspections, development and dissemination of diagnostic techniques to conduct condition surveys and long-term behavior analysis of dams as objectively as possible are essential. Development of displacement monitoring techniques using satellite-based SAR and studies for the utilization of vibration monitoring, which NILIM has been conducting, are part of the activities stated above. Furthermore, attempts to grasp the condition of sites efficiently by combining drone or underwater robot technology with various measurement devices have rapidly advanced in recent years. However, there are no effective technologies for efficiently grasping the internal state of the dam body. At present, the internal state is in some cases investigated by survey boring, but there are many issues to address, such as the difficulty of grasping the area of deformation inside the dam body and work in high places, and survey costs. Hence, this paper introduces a study on the non-destructive examination method for grasping, particularly, the internal state of a dam body.

2. Development of non-destructive inspection technologies for dam body

When a crack or other deformation is found on the surface of a concrete dam body, an assessment of its impact on the body stability is needed. For such events, it is desired to establish an effective non-destructive examination method that can supplement the boring survey, which presents limitations on survey points , and grasp propagation inside the dam body.

At present, the non-destructive examination methods that have actually been used to detect cracks inside of concrete structures are limited, and one of them is the high-frequency impact elastic wave inspection method. This technique localizes the position by striking the surface of the structure with a hammer to generate elastic waves and measuring the reflected waves from the discontinuity inside the dam body and the propagation velocity. It has been used for concrete piles and used in part on a trial basis to grasp the state of horizontal construction joints, which are important for a concrete dam body to be stable. Then, in order to grasp the applicability of this method to dams, we conducted measurement tests to examine to what extent the location could be identified and the condition assessed, using large concrete test pieces with a separation plane and an actual dam body. Consequently, the location of the existing separation plane in the test piece corresponded to the reflected waves and, in the field test, measurement results generally corresponded to the locations of cracks determined by boring (Fig. 1). However, variation was found in the relationship between the state of the separation plane in the test piece (contact area ratio) and the reflected wave amplitude, and some reflected waves were also detected from the locations other than where crack were in the field test. Based on these results, we are going to summarize how to use this technology and points of attention.

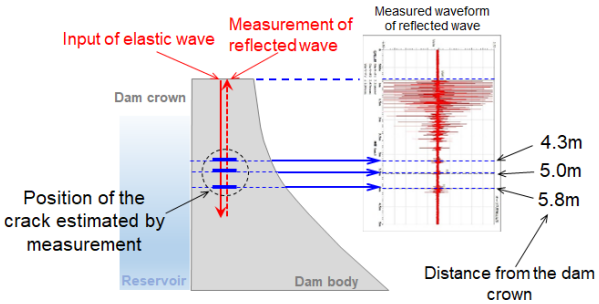

Fig.1 Crack survey of concrete dam body by high-frequency impact elastic wave inspection

In order to further advance the development of the non-destructive inspection technology, which is effective for detecting deformation inside mass concrete structures but has not been used widely at home and abroad, NILIM is simultaneously advancing technical development in cooperation with universities and other organizations that have more expertise and advanced knowledge (research funded by MLIT's River Erosion Control Technical Research Development System, Table 1).

Table 1 Contents of research and development and research institutions

Study	Contents of R & D	Research institution
(1)	Crack detection and strength distribution detection methods for concrete dams using low-frequency elastic waves	Tokyo Metropolitan University, etc.
(2)	Crack progress and assessment in the concrete dam body using the ultra-broadband SA sensor	Kyoto University, etc.
(3)	Visualization assessment technology without destruction of the crack / joint surface of the concrete dam body using remote monitoring system infrared light / elastic waves	Toyama Prefectural University, etc.

Of the projects above, Study (1) (Table 1) is investigating whether or not cracks inside the dam body can be detected from the delay in arrival time and decrease in low-frequency elastic waves, which are expected to penetrate large-scale structure such as dams (Fig. 2).

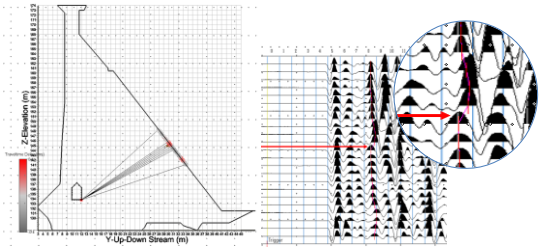

Fig. 2 Crack estimation by low-frequency elastic waves
(Observed waveform between the inside and surface of the inspection gallery, and delay)

Study (2) (Table 1) is developing technology for detecting internal deformations including cracks using a sensor that enables elastic wave observation in a wide frequency band and elastic wave tomography technology (Fig. 3), aiming to develop a method for monitoring internal conditions using Acoustic Emission (AE), which propagates a very small elastic wave inside the dam body.

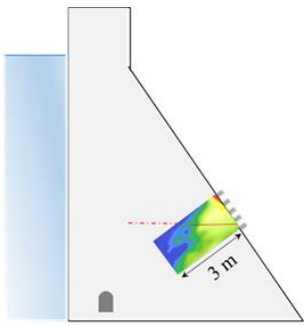

Fig. 3 Crack depth estimation by elastic wave tomography (Comparison of the results of boring survey and output)

Study (3) (Table 1) is exploring the applicability of various analysis methods (Fig. 4), where elastic waves are used for detecting cracks inside the dam body, in combination with surface condition surveys conducted with infrared light (UAV) and visible images. Estimates made from elastic wave measurements in each project are generally consistent with the results of cracks found by boring survey, so we are encouraged to continue research into the practical use of the technologies.

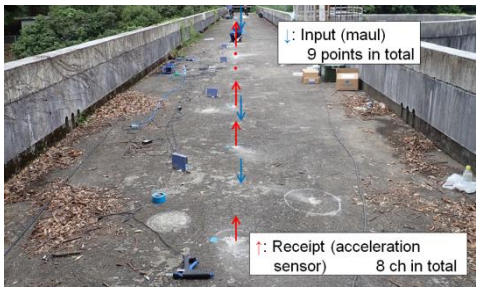

Fig. 4 Survey of cracks inside the dam body with elastic waves
(Implementation of surface wave survey)

In addition, NILIM is studying injection materials for survey to promptly grasp the depth of cracks that arise in case of a massive earthquake, etc. with focus on electric survey technology as non-destructive examination technology for fill dams. The results of field tests conducted in the past show that cracks can be detected from the difference in specific resistance from the dam body material and a material obtained by mixing electrolyte (calcium chloride water solution) with a commercial self-filler, and that the crack depth can be reproduced relatively well because the material readily fills cracks and permeates less into adjacent areas (Fig. 5).

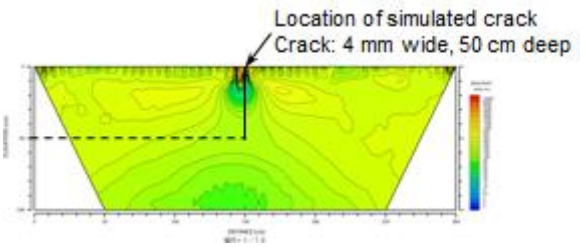

Fig. 5 Example of crack detection by electric survey (banking ground)

3. Future development

For the various survey technologies introduced in this paper, we intend to continue the study on how to apply them to dams, points of attention, etc. and summarize them in the technical data available from field inspections together with existing various survey / diagnosis techniques.

For Elimination of Flood Risk Information Vacuum Areas in Small- and Medium-sized Rivers

(Study period: FY2017-)

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River Department, Flood Disaster Prevention Division

key words; small- and medium-sized river, flood risk information, an estimated inundation map, airbornel laser survey

1. Introduction

In recent years, devastating flood disasters occurred in various places in Japan, including the July 2017 Northern Kyushu Heavy Rain, the July 2018 Western Japan Heavy Rain and the October 2019 Typhoon No. 19.

In order to respond to the frequent occurrence of large-scale heavy rain and flood including floods in excess of the design size of flood control facilities, for which the impact of climate change is indicated, it is further important to share flood risk information in society including the estimated inundation map in order to promote damage prevention / mitigation measures in case of flood, as well as promotion of the development of flood control facilities.

Hazard maps issued by local governments are used as one of the important tools for communicating flood risk information to local residents, and the estimated flood / inundation area maps, etc. prepared by the State and prefectures are used as flood risk information to be described on hazard maps. Social importance of such flood / inundation area map has been increasing as known from the mass media's reporting about the consistency of estimated and actual inundation areas.

2. Flood risk information vacuum area in small- and medium-sized rivers

Under the Flood Control Act, river administrators are required to specify estimated flood / inundation areas for some types of rivers (river required to forecast flood / river required to communicate water level). As of October 2019, a total of 2,063 rivers (preliminary value) have been specified.

However, most of the rivers administered by prefectures, totaling as long as about 110, 000 km in length, are not specified as any of the rivers stated above and river administrators are therefore not required to prepare an estimated flood / inundation area map for them. The rivers not specified as stated above are hereinafter called "other rivers." Areas along other rivers (flood risk information vacuum areas) may be misunderstood as "safe area for flood" even if the flood risk of the area is originally high and a place or route of evacuation may be designated in the area. Therefore, provision of true information is extremely important for risk communication. In the October 2019 Typhoon No. 19, devastating flood damage also occurred in the flood risk information vacuum areas of other rivers (Fig. 1, Table).

Note that as the main reason for non-provision of flood risk information including estimated inundation maps in other rivers, it is difficult with limited budget and personnel to acquire the data of longitudinal and cross sections of rivers, which is necessary to estimate inundation for target rivers of which total extension is extremely long.

3. Activities for eliminating risk information vacuum areas

Considering the limitation stated above, the Flood Disaster Prevention Division, giving top priority to the elimination of flood risk information vacuum areas, has developed a simple flood risk information preparation method [1)] using the longitudinal and cross sections of rivers based on LP (airborne laser survey) data, and is supporting the following researches and studies for field use.

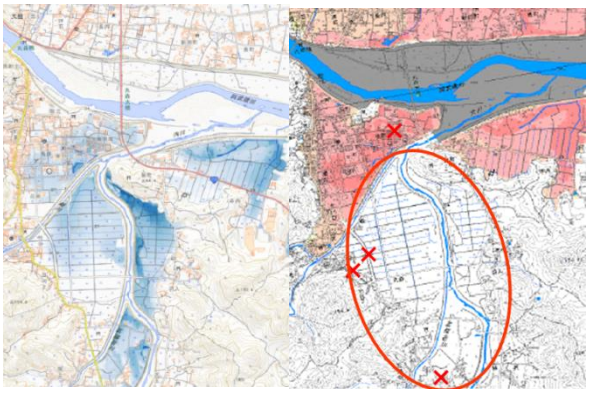

Fig.1 Events of inundation outside the estimated flood / inundation area (2019 Typhoon No. 19) (Left: Estimated Inundation Gradient Tints Map (Geospatial Information Authority of Japan) Right: Added to the Estimated Flood / Inundation Area Map (Sendai Office of River and National Highway) Red "X": Site of personal injury based on the data of Professor Ushiyama at Shizuoka University. * From the Material of the Water and Disaster Management Bureau of the MLIT [3)]

Table: List of the numbers of rivers collapsed by the 2019 Typhoon No. 19

Prefecture	The numbers of rivers collapsed	Dry riverbed of the river required to communicate water level, etc.	Other dry riverbed
Miyagi-ken	18	4	14
Fukushima-ken	23	9	14
Ibaraki-ken	4	3	1
Tochigi-ken	13	6	7
Saitama-ken	2	0	2
Niigata-ken	2	2	0
Nagano-ken	5	0	5
Total	67	24	43

*** From the Material of the Water and Disaster Management Bureau of the MLIT [3)]**

(1) Utilization by local governments when considering an evacuation plan

In order to support the examination of an evacuation plan in the risk information vacuum areas along other rivers, the NILIM is supporting the examination of an evaluation plan by local government by preparing a simple estimated inundation map (Fig. 2) on a trial basis for model rivers in two municipalities in cooperation with the Cabinet Office, Flood Risk Reduction Policy Planning Office, River Environment Division, Water and Disaster Management Bureau, MLIT, prefectures, cities, villages, etc.

In preparing the map above, we prepared it on a trial basis as shown in Fig. 2 considering the opinions in favor of an estimated inundation depth distribution map available in the event of a flood with the estimated maximum scale, rather than the overlapped map of estimated inundation areas for each flood of multiple scales, which had been prepared on a trial basis by the Flood Disaster Prevention Division up to the last fiscal year

In addition, we participate in meetings with local residents to exchange opinions with residents, local government personnel, etc. Some participants in the meetings stated that the image map of locations prone to inundation based on the past inundation events, site condition, etc. is consistent with the simple estimated inundation map, further, we confirmed that utilization of the simple map is effective to a certain extent in examination of an evacuation plan for the risk information vacuum areas of the river.

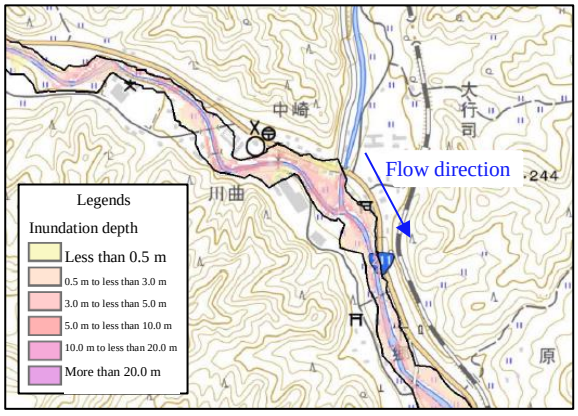

Fig. 2 Simple estimated inundation map (estimated maximum scale: Trial version)

(2) Engineering workshop on the flood damage risk assessment of small- and medium-sized rivers

In addition, for elimination of the risk information vacuum areas along rivers, "Engineering workshop on the flood damage risk assessment of small- and medium-sized rivers" 3) (Chairman: TAKEUCHI Koji, Professor of the University of Tokyo Graduate School) was established by the Water and Disaster Management Bureau of the MLIT in order to conduct technical review on the simple inundation estimation method using LP data, etc. and expand the "Guide" [2)]. In the first Engineering Workshop, held on January 7, 2020, discussion was made about the calculation conditions in simplification, etc. and academic members stated their opinions about the importance of assessment on the accuracy of calculation and phenomena including back water, and local government members stated their opinions about the high social needs for provision of estimated inundation maps of other rivers. This review is going to be continued in order to expand the Guide by June 2020.

4. Study perspectives

We intend to prepare and release in turn simple estimated inundation maps for elimination of risk information vacuum areas along small- and medium-sized rivers in coordination with prefectures and continue to study the specific utilization method of the map, etc. in the disaster prevention and city planning fields.

☞See the following for details.

1) Proposal of a simple flood risk information preparation method using aerial laser survey data for small- and medium-sized rivers, Collection of Papers on River Engineering, Vol. 25, pp. 31-36, June 2019.
2) 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 simple flood risk information preparation for small- and medium-sized rivers http://www.mlit.go.jp/river/shishin_guideline/pdf/chushou_kaninarisuku_tebiki.pdf, December 2018
3) Engineering workshop on the flood damage risk assessment of small- and medium-sized rivers, https://www.mlit.go.jp/river/shinngikai_blog/tyusyokasen/index.html, January 2020

"Techniques" for "Supporting" "Flood Prevention Activity" for Community to Take with a Unified Effort

(Study period: FY2017 to FY2019)

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key words: flood prevention activity, flood prevention group, flood damage mitigation, supporting techniques

1. Advent of an age to address floods with a unified effort

In recent years, a large scale flood exceeding the discharge capacity of river has occurred almost every year at many places in Japan and caused enormous damage to local communities including personal injuries, such as the 2016 Typhoon No. 10, July 2017 Northern Kyushu Heavy Rain, July 2018 Western Japan Heavy Rain, and October 2019 Typhoon No. 19. In the future, the frequency of a flood exceeding the discharge capacity of river is expected to increase due mainly to the impact of climate change. To address such floods, it is essential to advance comprehensively the reduction of flood frequency by active promotion of river development (disaster prevention) and damage control (disaster mitigation or risk management).
To this end, river administrators (mainly the State and prefectures), flood prevention managers (mainly municipalities), and local communities need to make a unified effort to address floods. This paper focuses on "Damage control activity for community to take with a unified effort in case of a flood ("flood prevention activity"), which is one of the leading means of damage control as stated above. In order to implement flood prevention activity effectively and reasonably and thereby mitigate flood damage, i.e. reduce the impact on local community to the extent possible, what techniques ("flood prevention activity supporting techniques) should river administrators support'?
This paper intends to propose flood prevention activity supporting techniques focused on "information."

2. Various contents of flood prevention activity

To propose flood prevention activity supporting techniques, it is requisite first of all to grasp the status of flood prevention activity. Then, in this study, we conducted hearings from a total of 12 flood prevention control groups and teams (including firefighting teams) in 3 years to grasp the status of flood prevention activity. Common matters obtained from the hearings are as follows. 1) Necessary to address water overflow from a branch river or inland water inundation before addressing a flood of major river or river levee deformation (sand bag stacking). 2) Various actions and much time and effort are required to address flood of a branch river or inland water inundation, including sand bag preparation and carrying, stacking them near the branch river / houses,

Photo 1 Hearing about the status of flood prevention activity

evacuation guidance, support of household goods protection, attention calling on the inundated road, relief activity with a boat, and drainage work. 3) Accordingly, a case could occur where it is difficult to address the risk of flood from a major river, which could cause enormous damage to the community once it occurs. In addition, there is a difference according to areas in terms of i) degree of recognizing sites prone to inundation / flood, ii) diversity of the entity of flood prevention activity (method of role sharing for various contents of flood prevention activity), and iii) substantial entity who makes a decision for implementation of floor prevention activity, and this difference seems to be related with the frequency of experiencing inundation damage or status of urbanization.

3. Flood prevention activity supporting techniques based on the status of community

From the status of flood prevention activity stated in the preceding section, flood prevention activity could be interpreted as "overall activity for preventing / mitigating damage from inundation etc. that occurred at the community in the process of increase in the risk of flood from a river due to heavy rain." **Fig. 1** represents the image of time series for this. According to this interpretation, the priority of providing information that is based on community and supports selection of the content of flood prevention activity and decision on implementation thereof would be considered high in flood prevention activity supporting techniques, such as "To what risk is this area exposed now?" "What risk will arise next in this area?"

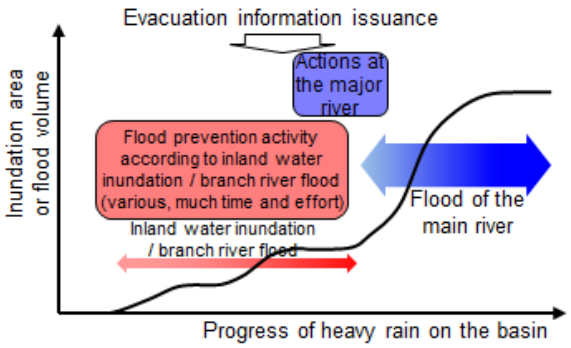

Fig. 1 Image of time series progress in local deformation and flood prevention activity required

In consideration of the above, we propose flood prevention activity supporting techniques as follows together with the method of evaluating the effects obtained from the techniques. With these techniques, it is possible to conduct, effectively and efficiently, flood prevention activity to be required in the event of flood of branch river or inland water inundation, and to secure "time to address flood from a major river that could subsequently occur and cause enormous impact once it occurs," and thereby mitigate damage to the area is strongly expected.

(1) Water level forecast information on branch and major rivers

As **Fig. 2** shows, once the water level forecast information on the sections where the risk of overtopping flood is high is provided, time to prepare flood prevention activity, time to consider arrangement of flood prevention activity personnel on the site, etc. will be secured and more effective flood prevention activity is expected from the screening of inspection points. Moreover, in the water level forecast of a major river, consideration of the extent of overflow depth on the levee would be useful for decision of whether to evacuate the field people engaged in flood prevention activity.

(2) Forecast information on inundation by flood of a branch river and inland water

As Fig. 2 shows, delay in such activities as road closure or pump drainage can be prevented by providing forecast information on flood of a branch river and inland water inundation, which frequently occurs prior to flood of a major river. It is also possible to secure the time to consider how to guide residents to the evacuation route, which contributes to evacuation in a safer situation.

(3) Status of water level in branch and major rivers

Grasp of the status of water level in not only major rivers but branch rivers will prevent the timing of switching from preparation to implementation of flood prevention activity based on the forecast information in (1) above from being lost.

(4) Risk information map focused on the relative possibility of human damage [1)]

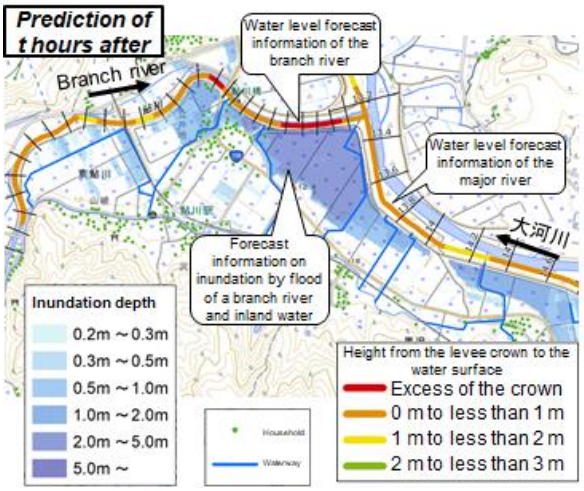

Fig.2 Image of overlapped forecast information as flood prevention activity supporting technique (forecast information on deformation in the "community")

This risk information map was created by overlapping the estimated inundation map based on flood of a major river with the estimated inundation map based on flood of a branch river / inland water. The map will enable screening of relatively high risk areas, where moving is difficult in case of evacuation and possibility of human damage is high if a major river floods. The map will also enable prior grasp of areas where evacuation guidance by door-to-door visit is preferable, which is expected to lead more effective evacuation guidance, etc.

4. Damage prevention in communities using flood prevention activity supporting techniques

In order to realize damage prevention in communities by implementing the flood prevention activity supporting techniques we have found as stated above, we intend to build the foundation of local disaster prevention activity support information by applying these supporting techniques on a trial basis to the model river basins and identifying / solving new issues through practical use.

☞See the following for details.

1) Takeuchi, Kobayashi, Itagaki: "Proposal of flood prevention activity supporting techniques focused on grasp of the status of flood prevention activity and evacuation guidance," Collection of Papers on River Engineering, Vol. 25, pp. 145-150, 2019.

Reproduction of Sediment / Flood Cases considering Fine Sediment Behaviors

(Study period: FY2013 to FY2019)
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key words: numerical computation program, sediment discharge pattern, mountainous river

1. Introduction

To prevent / mitigate sediment disasters, it is important to forecast accurately sediment movement phenomena that could occur in future. To this end, riverbed variation calculation is an effective tool. For example, in the July 2017 Kyushu Heavy Rain, a large amount of sediment was produced due to the frequent occurrence of slope failure and debris flow in the upstream of the Akatani River in the Chikugo River System (Asakura-shi, Fukuoka) and flowed down the river and caused flood and enormous damage in the downstream area. In this disaster, flow of a large amount of fine sediment is considered to have contributed to the expansion of damage. The Sabo Planning Division attempted to reproduce the riverbed variation with calculation considering the behaviors of fine sediment in the sediment flow / flood caused by the Northern Kyushu Heavy Rain.

2. Outline of the model used

Since part of the fine sediment moves in a turbulent state like water and contributes to the increase in fluid force, the model was designed to be able to consider this event. In addition, since the pattern of sediment movement (Fig. 1) changes according to riverbed slope and sediment concentration, the calculation model is designed to be able to consider flow resistance, conditional equation of exchange with the river bed of sediment (erosion / deposition speed equation), and variation by the sediment movement pattern in the equation of equilibrium concentration.

3. Result of model verification

We verified the model focused on the sediment dynamics in the Akatani River basin. We calculated two cases --- Case 1 is related to the control of the equation of erosion / deposition speed and the equation of equilibrium concentration only with riverbed slope, while Case 2 is related to the control of the same with riverbed slope and flow concentration. Fig. 2 shows the actual and calculated values of riverbed variation at each point, which was calculated with the difference analysis of LP data.

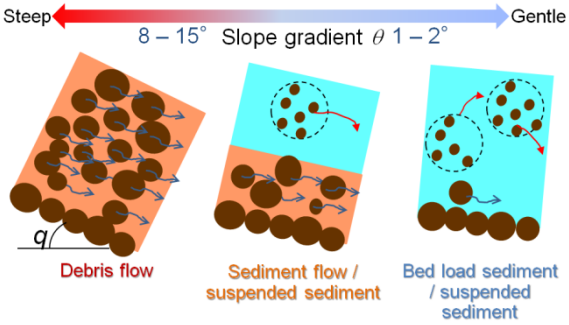

Fig.1 Image of sediment dynamics in a mountainous river

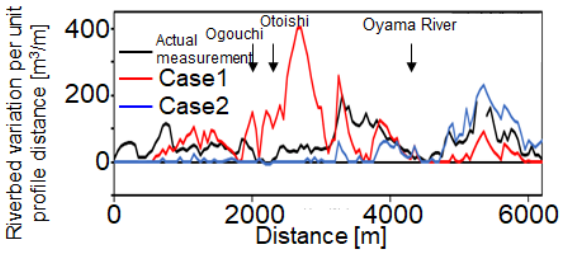

Fig. 2 Calculation result of reproduction of riverbed variation

In Case 1, abnormal deposit occurs at a point where the sediment movement pattern changes according to the calculation, while this will not happen in Case 2 and riverbed aggradation in the downstream can be reproduced close to the actual form.

4. Conclusion

It was found from the verification conducted that transition of the sediment movement pattern should be fully considered as well as the behaviors of fine sediment, to improve the accuracy of reproduction of the sediment dynamics model in mountainous rivers. For the future, we intend to verify the versatility of our findings above and improve the models for more accurate examination of the effect of sabo facilities so that the techniques can be utilized in practice.

☞See the following for details.

1) Nakamura et al. (2019): Calculation of sediment dynamics including a lot of fine sediment in a mountainous river under heavy rain, Collection of Summaries on the 2019 Japan Society of Erosion Control Engineering Research Presentation Meeting

Analysis of the Sites of Slope Collapse by Earthquake

(Study period: FY2018-)

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key words: slope collapse by earthquake, specific resistance, aerial electromagnetic survey, cap rock structure

1. Introduction

The influence of ground structure is considered at the site of a slope collapse caused by an earthquake. However, the impact of ground structure on the occurrence of slope collapse in the event of an earthquake cannot be verified since wide-area three-dimensional information on the ground structure in mountainous areas has not been sufficiently obtained. Accordingly, if a risk assessment technique that reflects the impact of ground structure in more detail were developed, the accuracy of risk assessment would be expected to increase. Therefore, we analyzed the characteristics of ground structure in slope collapse caused by earthquake by overlapping the specific resistance obtained by aerial electromagnetic survey, including the depth direction of the ground across a wide area encompassing the slope collapse caused by the 2016 Kumamoto Earthquake (Fig. 1).

2. Research contents

First, we calculated the specific resistance variation in a section 20 m deep ("depth section") by deducting, from the specific resistance at a certain depth, the specific resistance at a point 20 m deep from there for each 10 m mesh. Next, meshes were set with a center of gravity within in the collapsed site as a collapse grid. Then, we calculated the ratio of collapsed meshes according to each class of specific resistance variation (Fig. 2). As a result, the ratio of collapsed meshes was found to increase as the class of specific resistance variation became larger in the positive direction. Particularly, in relatively shallow sections, such as in the depth section of 10-30 m, the ratio of collapsed meshes sharply increased at the class where the specific resistance variation shifted from a negative value to a positive value.

In the meshes representing a positive value of specific resistance variation, specific resistance was high at shallow depths and low at deep depths, which is considered to show that the site has a ground structure similar to the cap rock structure, in which the upper layer of soft rock is covered with hard rock. In past earthquake events, many cases of collapse in a slope with the cap rock structure were reported. It is considered from the above that ground structure similar to cap rock structure exists in the site where the specific resistance variation shifts to a positive value and that a relatively larger number of slope collapses might have occurred in the earthquake event.

3. Conclusion

We intend to continue the analysis of slope collapse caused by earthquake and develop a method for predicting the occurrence of slope collapses including large scale slope collapse in the event of an imaginable earthquake.

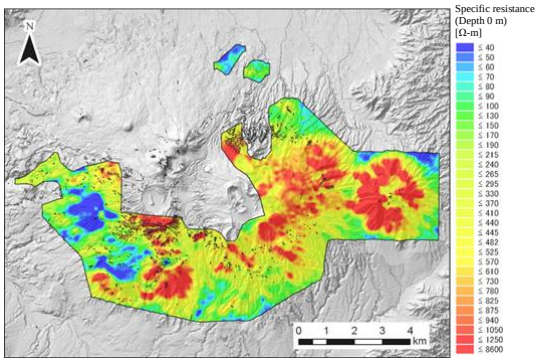

Fig. 1 Specific resistance and distribution of slope collapses caused by the 2016 Kumamoto Earthquake

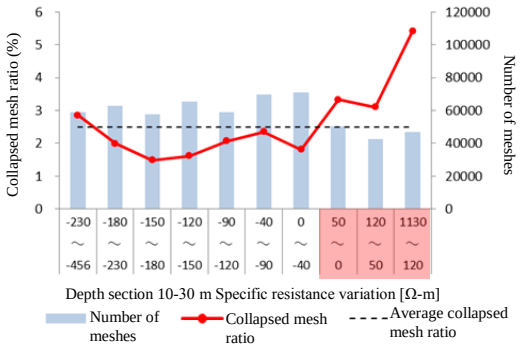

Fig. 2 Ratio of collapsed meshes by class of specific resistance variation

☞See the following for details.

1) Civil Engineering Journal, Vol.61, No.12, 2019, pp. 12-15

Proposal of Effective Utilization Method for ETC2.0 Probe Information in Traffic Safety Measures

(Study period: FY2019-)

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key words: ETC2.0 probe information, drive recorder, portable roadside unit

1. Introduction

In light of the recent successive occurrence of traffic accidents killing children or caused by senior drivers, it is urgently required to promote effective traffic safety measures.

NILIM has been studying ways to identify potentially dangerous locations using ETC2.0 probe information, which enables wide-area collection of data on the movement of vehicles (location, speed, longitudinal acceleration, etc.).

However, there is still room for further consideration in terms of both "quality" and "quantity," including efficiency and accuracy improvements to the method used to analyze ETC2.0 probe information and ensure the necessary number of data samples.

Therefore, this paper introduces a "method for determining dangerous events in ETC2.0 probe information using the results of drive recorder data analysis" and a "study for the effective utilization of a portable ETC2.0 roadside unit" as a proposal on how ETC2.0 probe information can be effectively utilized for traffic safety measures.

2. Proposal of method for determining dangerous events in ETC2.0 probe information using the results of drive recorder data analysis

NILIM has developed a method for identifying potentially dangerous locations by analyzing the sudden deceleration data of ETC2.0 probe information (e.g., longitudinal acceleration of -0.3G or below).

However, as Fig. 1 shows, the sudden deceleration data includes behaviors other than dangerous events (e.g., hard braking merely to stop in front of a red traffic light) since the sudden deceleration data is determined by simply taking deceleration behaviors showing a longitudinal acceleration not higher than a certain value. For this reason, in order to improve the accuracy of analysis, it is necessary to efficiently identify whether the sudden deceleration data of ETC2.0 probe information represents a dangerous or non-dangerous event.

Therefore, in this study, using a drive recorder ("DR") that records acceleration data, we determined whether driving behavior corresponded to a dangerous event or non-dangerous event, as Fig. 2 shows, by visually checking images ahead of the car, and checked

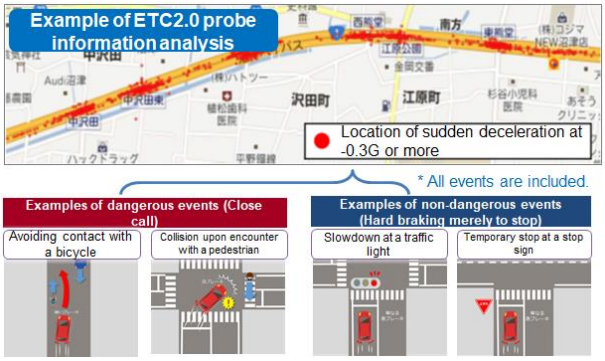

Fig. 1 Issues underlying the sudden deceleration data of ETC2.0 probe information

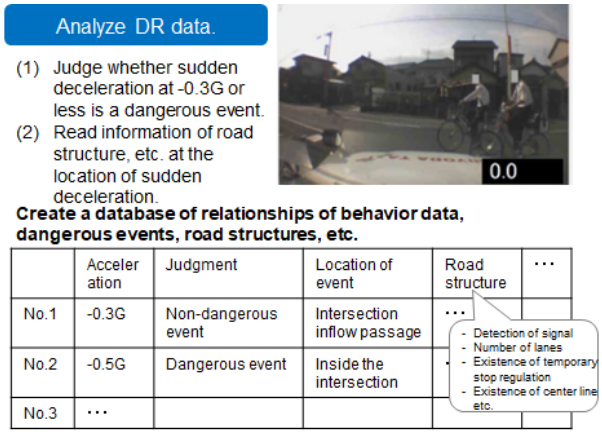

Fig. 2 Relationships between judgment of dangerous events by analysis of drive recorder data and road structures

sudden deceleration data (value of the longitudinal acceleration recorded in DR), etc. against the road structure in the event location.

Consequently, as Fig. 3 shows, it was found that a dangerous event occurred with a probability of about 90% on a non-intersection road or inside the intersection when longitudinal acceleration was not higher than -0.3G.

It was also found that non-dangerous events were included at a rate of about 70% in the intersection inflow passage. Figure 4 shows the ratio of dangerous and non-dangerous events in an intersection inflow passage by the longitudinal acceleration. It can be seen in this figure that, when longitudinal acceleration is not higher than -0.6G, about 80% of intersection

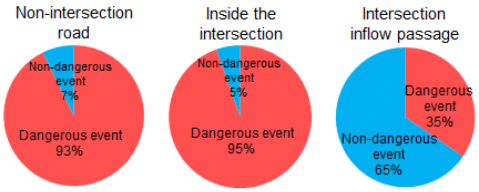

Fig. 3 Ratio of dangerous and non-dangerous events by position of sudden deceleration (when longitudinal acceleration is -0.3G or less)

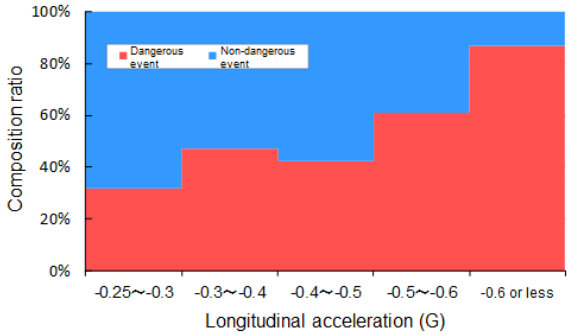

Fig. 4 Ratio of dangerous and non-dangerous events in the intersection inflow passage by longitudinal acceleration

inflow passage are recognized as dangerous events, while non-dangerous events are included at a rate of about 40 to 60 % when the range of longitudinal acceleration is in a range of -0.25G to -0.6G. Accordingly, we are going to develop a method for identifying dangerous events from road structures, such as by drawing stop lines and the number of lanes.

3. Study for effective utilization of the portable ETC2.0 roadside unit

ETC2.0 probe information data is collected when a vehicle with an exclusive in-vehicle unit passes by a roadside unit installed on expressways and national highways under the direct control. This data consists of "travel history data" in which the location of the vehicle, time, travel speed and other information are recorded, and "behavior history data" in which longitudinal acceleration, horizontal acceleration, etc. are recorded. However, according to the present arrangement of roadside units, behavior history data necessary for analysis cannot be obtained in some areas due partly to the capacity of data accumulation as the roadside units are spaced too far apart. Therefore, in this study, thinking that the necessary data could be acquired by temporarily installing portable roadside units as shown in Fig. 5, we analyzed the effect of installation in areas where portable roadside units were actually installed. Specifically, we obtained density estimation values for travel history data and behavior history data by conducting Kernel density estimation for each 50m mesh unit and calculated the "behavior history density estimation value per travel history density estimation value" with the data values obtained from the 50m

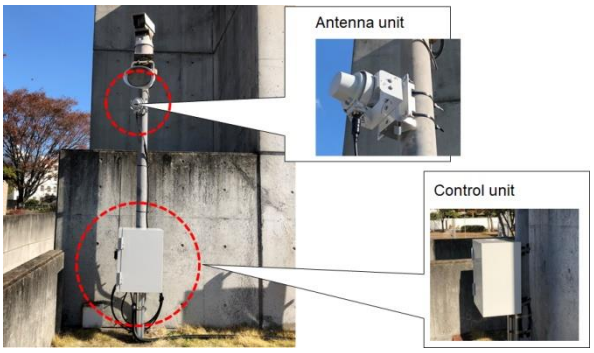

Fig. 5 Portable ETC2.0 roadside unit (Temporary installation is possible.)

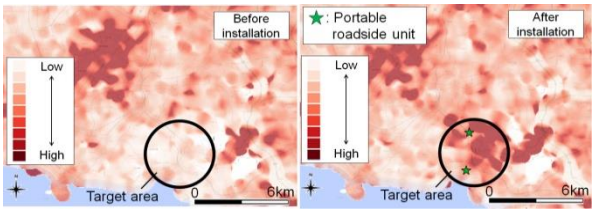

Fig. 6 Behavior history density estimation value per travel history density estimation value (Comparison before and after portable roadside unit installation)

meshes. Figure 6 provides a comparison of these values before and after unit installation. The figure shows that the ratio of behavior history density estimation value is high in the target area after installation of the portable roadside units. This means that behavior history data, which had not been obtained, could be newly obtained by installing portable roadside units. In addition, as a result of conducting such an analysis across a wide area by density estimation at the stage before installation, areas where the ratio of behavior history density estimation value was relatively low were pinpointed, which facilitated our studies of effective areas where portable roadside units should be installed. We are going to study in detail effective installation locations and methods, installation timing in order to ensure the necessary number of samples, etc.

4. Conclusion

We continue to improve our analyses of ETC2.0 probe information both in terms of "quality" and "quantity" and promote its utilization for planning and assessing traffic safety measures in the country.

☞See the following for details.
Website of the Road Safety Division
http://www.nilim.go.jp/lab/geg/index.htm

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

(Study period: FY 2019–)

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Building 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 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 the restoration processes.

This study aims to present technical materials about structures and non-structural members of buildings that are necessary for building administrators to judge whether people can enter a 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 accelerometers, is a possible option in quickly judging the robustness of a structure immediately after an earthquake without depending on experts. Yet, there are no common engineering evaluation criteria to use.

b) Technical materials 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 overcome these issues.

(i) By analyzing the structure of a building model, engineering evaluation criteria for judging the robustness of the structure using an accelerometer (Figure 2) are presented. Technical precautions are also organized for practical application.

(ii) A visual inspection guideline for non-structural members is prepared (including the evaluation of damage to 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 a building to numerically capture the properties that go through rapid changes during an earthquake. Specifically, the robustness of a structure is estimated from the level of changes in the natural period of a structure during an earthquake. In (ii), the current situation of an earthquake damage evaluation of non-structural members is organized. Then, standards for robustness judgment are prepared after conducting experiments on the evaluation of damage in suspended ceilings where knowledge and insights are in short supply.

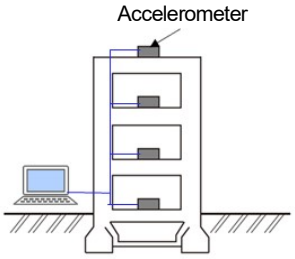

Figure 2: Practical application of the robustness judgment system in a building

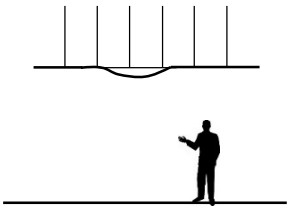

Figure 3: Damage to a suspended ceiling

3. Examinations in FY 2019

Regarding (i), the relationship between the remaining performance of an entire building estimated on the basis of damage to individual members during an earthquake and changes in the natural period are being examined by recreating seismic motion using simulations. Records of earthquakes are also being analyzed. Regarding (ii), current references about non-structural members clearly exhibiting damage from an earthquake are being gathered and organized.

Survey on Measures for Supporting / Promoting Activities for Winter Road Measures by Local Residents etc.

(Study period: FY2019-)

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key words: winter road management, snow removal, resident participation

1. Introduction

In recent years, there have been changes in the state of snowfall, with numerous cases of very strong, intensive and continuous snowfall being recorded, yet the business environment for snow removal has been increasingly handicapped by issues like depopulation, a declining birthrate and aging, and a shortage of labor and potential successors. In response to such circumstances, NILIM has been studying ways to promote resident participation in winter road measures, with the aim of establishing a system that would enable active cooperation of local residents and private-sector organizations in road snow removal. This paper reports a case study about road snow removal activities by local residents in heavy snowfall areas, measures for supporting them, etc.

2. Outline of the survey

With respect to winter road management by local residents and volunteer groups, we collected and organized a total of 55 cases (Table 1) of snow removal activities and supporting systems in 44 municipalities and 17 prefectures from past surveys, including "Examples of self-help and mutual help activities in winter road management" (MLIT, Road Bureau) and "Survey on snow removal system support for securing / training snow removal workers" (MLIT, National Spatial Planning and Regional Policy Bureau). There are many cases where the government lends small snow removal machines and tools to resident associations and neighborhood associations who mainly engage in activities so that they can remove snow.

3. Hearing survey

We conducted a hearing survey (Table 2) of persons involved in snow removal activities, sampling six communities from the surveyed cases in the preceding section, considering local characteristics and content of activities. In all the cases, residents successfully conducted snow removal activities but faced issues in continuing their activities, such as aging participants and a shortage of successors. Since circumstances of communities are various, such as difference in the state of snowfall or snow removal conditions even in the same city, or mixture of former systems before the municipal merger, it is also necessary to take measures appropriate for communities. We will continue to study ways to solve these issues and support and promote activities.

Table 1 Snow removal activities by residents, etc. (Preliminary survey)

Entity of activity	Resident / Neighborhood association (25), other resident organizations (community development council, community promotion association, snow removal council (6), etc.), elementary / junior high school PTA (6), student volunteer organization (9), NPO (5), municipal office (18), social welfare council (13), others (business, voluntary association (13), etc.)
Content of activity	Snow removal from community roads (33), snow disposal (13), snow removal seminar (15), snow melting (2), snow melting facility development (3), symposium / education activities (11), human resource development (9), snow removal experience tour (7), etc.
Support from administration	Lending of small snow removal equipment (8), large snow removal equipment (1), snow removal trucks (5), lending / maintenance of snow removal tools (8), coordination of snow removal volunteers (8), subsidies for snow removal service fees (3), subsidies for equipment investment (3), payment of remuneration, actual costs, etc. for snow removal activities (7), supply of snowplow fuel (2), subsidies for qualification acquisition (1)

* Figures in parentheses represent the number of cases.
Total number cases / multiple count

Table 2 Snow removal activities by residents. etc. (Hearing survey)

Survey area	Sapporo (Hokkaido), Aomori (Aomori Pref.), Hirosaki (Aomori Pref.), Takizawa (Iwate Pref.), Nagai (Yamagata Pref.), Kanazawa (Ishikawa Pref.)
Survey period	Nov. and Dec. 2019
Hearing Target organizations, etc.	City hall (road snow removal department, civic activity department / bureau, social welfare department), social welfare council, local resident organizations (resident association, neighborhood association, community development council, local community council, traffic safety association, voluntary resident organization), student volunteer organization, university's executive office, snow removal contractor (city contractor)
Issues, etc.	- Aging of activity participants - Shortage of participants against increasing demand for snow removal volunteers - Need for flexible response to the diversity of local characteristics - Solution to the feelings of inequality between communities and between residents - Need for understanding and common recognition amongst local residents

Flood Risk Assessment of Houses / Household Goods and Development of Method for Promoting Countermeasure Introduction

(Study period: FY2015 to FY2019)

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key words: flood risk assessment, building inundation, climate change adaptation measures

1. Advance the flood risk reduction measures for houses and household goods

In view of the recent impact of global warming and the occurrence of devastating flood disasters, it would be important to advance steadily flood control measures for rivers and to reduce the risk of flood disasters by taking all measures available for river basins against floods that exceed the development level. For reduction of human damage, progress of measures, including information provision and evacuation, is remarkable. The following reports the findings from the study of a flood risk reduction method by taking an approach of advancing house-specific measures and thereby reducing total damage in the community, aiming to accelerate the inundation measures for houses and household goods.

2. Coexistence of the possibility of countermeasure introduction and risk reduction effect

House-specific measures were focused on movement of household goods to a higher place, waterproof board (wall), and heightening of housing site.

Generally, when the higher the flood risk is, i.e., the more expensive houses and household goods are and the larger the possibility of inundation and water depth are, the more cost-effective benefits are expected and the higher the possibility of introducing countermeasures will be.

In addition, from a viewpoint of communities, it would be more effective to implement countermeasures preferentially in areas where the flood risk is high, many buildings with a high possibility are located, and their total amount of damage reduction (total benefit) is large.

The proposed method evaluates the possibility of introduction by cost-benefit ratio and selects the areas and buildings (housing / business type) that meet the foregoing conditions and types of house-specific measures (See Fig. 1). This method is based on the flood risk assessment of building types, and an example of the results of assessment is shown in Fig. 2. Flood risk (relationship between the recurrence interval and the amount of damage) is estimated reflecting the assets (vulnerability) and location (hazard) of each building.

3. Utilization of results

The report [1)] of this study has chapters corresponding to the stages of research, planning, and countermeasure promotion considering the convenience in practical use. The chapter of countermeasure promotion (Chapter 5) describes advanced examples at home and abroad and systems of city planning, construction, housing, etc. Utilization for countermeasure examination according to the characteristics of buildings and communities is expected.

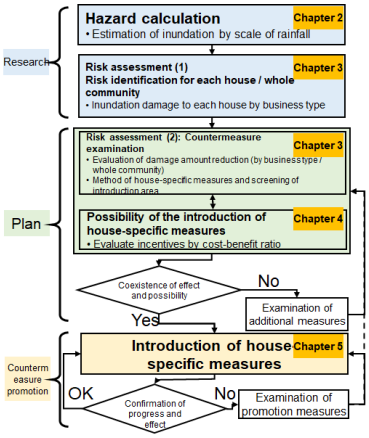

Fig. 1 Method of promoting the introduction of house-specific measures based on risk assessment

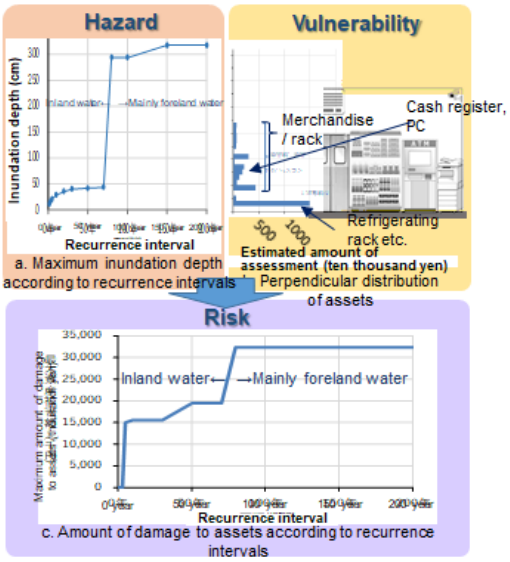

Fig. 2 Flood risk assessment by building type (an example of convenience store)

☞See the following for details.

1) Technical Note of NILIM No.1080, p. 364
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1080.htm

Report on Operation of the Technology for Real Time Collection, Summarization, and Sharing of Infrastructure Damage Information

(Study period: FY2014 to FY2019)
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key words: disaster prevention / reduction, first action response, spectrum analysis information, CCTV camera, SAR image

1. Introduction

It is not easy to quickly obtain useful information immediately after the occurrence of an earthquake. In order to build a proper first action system, grasp of damage situation is essential. For quick and accurate collection of information, NILIM has been engaging in technical development for real time collection, summarization, and sharing of infrastructure damage information using spectrum analysis information, existing CCTV cameras, and Synthetic Aperture Radar (SAR), etc. (Refer to the 2019 NILIM Report) This paper introduces the operation of the technology developed in this study with examples of disasters that occurred in FY2019.

2. Distribution of spectrum analysis information

The information analysis / decision support system [1)] developed by NILIM under the SIP will create and distribute automatically "spectrum analysis information" immediately after an earthquake.
In the past years, it took about 15 minutes from the occurrence of an earthquake to information distribution and distribution was sometimes interrupted due mainly to system failure. As of January 2020, however, stable distribution of spectrum analysis information is possible in 6 to 7 minutes after the occurrence of an earthquake as a result of the improvement of the information acquisition system through joint study with National Research Institute for Earth Science and Disaster Resilience (NIED).
Fig. 1 shows part of the spectrum analysis information distributed when an earthquake with a maximum seismic intensity 5 lower occurred at the eastern coast of Aomori-ken at 15:21 on December 19, 2019 (distributed at 15:28). It is possible to perceive the extent of damage by comparing the acceleration response spectrum and damage line at top 10 locations of the measured seismic intensity in the observation

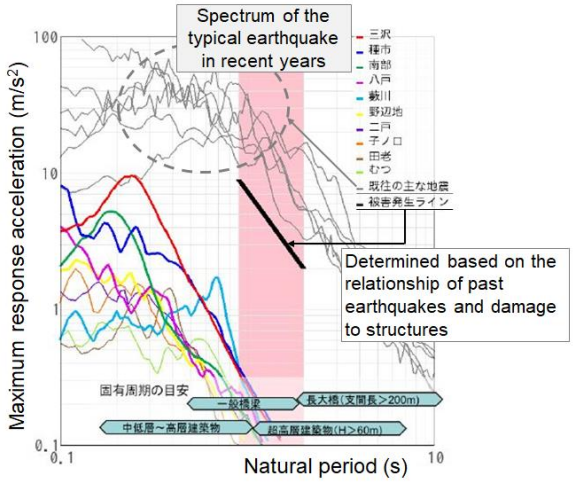

Fig. 1 Spectrum analysis information (extracted in part)

points where strong earthquake record was obtained.
In addition to **Fig. 1**, the spectrum analysis information is distributed in a 3-page PDF describing how to see the seismic intensity distribution map and damage line, characteristics of typical earthquake damages in recent years, etc.
From the current fiscal year, the spectrum analysis information is also distributed to the road management teams, etc. of Regional Development Bureaus for them to study utilization of the information to determine necessity for road inspection after an earthquake.

3. Technology for effective utilization of SAR images

We developed a system for supporting SAR image interpretation with which disaster prevention personnel can efficiently identify collapsed spots etc. using satellite SAR images. Use of satellite SAR in this system enables stable acquisition of wide-area image

Fig. 3 Panoramic image (Ex.)

information even in a situation where grasp of damage by helicopter etc. is difficult, such as bad weather or night time.

Sabo Department of NILIM implemented emergent SAR image interpretation of areas collapsed in a large scale, etc. immediately after the occurrence of heavy rain disaster or earthquake disaster in wide area, including utilization of this system on a trial basis. Immediately after the heavy rain disaster by Typhoon No. 19 in October 2019 (**Fig. 2**) and the Yamagata Offshore Earthquake in June 2019, etc., we conducted interpretation of collapsed areas with satellite SAR images before field inspection by helicopter etc. Results of this interpretation were provided to the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and the Regional Development Bureau for use in disaster response.

In addition, we held training seminars, etc. across the country for disaster prevention personnel of Regional Development Bureaus, who are expected to further use this interpretation system, so that they can conduct SAR image interpretation and learn how to utilize and operate the system, and collected opinions about improvement of operability, effectiveness, etc. by actually conducting interpretation in seminars, etc. Further, through joint study with JAXA (Japan Aerospace Exploration Agency), we studied for efficient provision of SAR images etc. in case of an emergency and jointly interrupted SAR images and verified results, etc. As a result, we created a Technical Note of NILIM describing the technical knowledge for interpretation of collapsed areas with SAR images, etc. [2)]

As stated, we are implementing the measures for the effective grasp of disasters in an emergency using satellite SAR images.

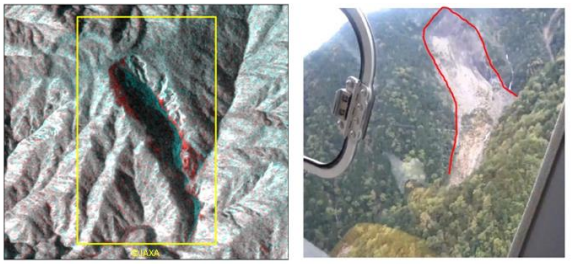

Fig. 3 Example for detecting sediment disaster in SAR image interpretation (Oct. 2019, Typhoon No. 19, etc. (Yamanashi-ken, Hayakawa-cho)

4. Test operation of CCTV cameras

The images of CCTV cameras installed by the MLIT for infrastructure management across the country are also used for grasping damage immediately after disaster occurrence. However, in order to grasp the state of damage, it is necessary to manually operate each camera, which takes much time. Then, we are developing a system equipped with the functions of (a) creating a panoramic image by turning the camera automatically and (b) detecting damage automatically from an enormous amount of image information, immediately after an earthquake, and we implement, in the current fiscal year, test operation and development for full-scale operation in next fiscal year.

(1) Test operation of the system for creating a panoramic image

The information analysis / decision support system organizes the seismic intensity data for each municipality at the occurrence of an earthquake. We are operating on a trial basis a system that detects the CCTV cameras installed in municipalities that were swung due to the seismic intensity of 4 or more and automatically creates panoramic images. From April 2019 to February 2020, an earthquake in which the seismic intensity of 4 or more, at which panoramic views were supposed to be created, was observed by CCTV camera occurred three times and panoramic images were actually created each time. As an example, **Fig. 3** shows a panoramic image created when an earthquake occurred in northern Ibaraki-ken on December 14, 2019, at 10:38.

(2) Development for full-scale operation

For full-scale operation, we are developing a full-scale operation system that includes addition of the cameras for panorama image creation, hardware reinforcement, enhancement of log management function, and addition of e-mail distribution function. Operation of this system is going to start from FY2020 for the cameras of the eight Regional Development Bureaus. We also continue to study for improving the accuracy of damage image detection using AI.

5. Conclusion

The Disaster Prevention and Reduction Research Committee is striving to further disseminate and improve the technologies introduced herein.

☞See the following for details.

1) Information analysis / decision support system
https://www.jstage.jst.go.jp/article/jdr/14/2/14_333/_article/-char/ja

2) Technical Note of NILIM No.1110
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1110.htm

Study on the Comprehensive Management for Sewer Pipelines

(Study period: FY2018-)

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key words: sewer pipeline, management cycle, inspection survey

1. Introduction

Total extension of sewer pipelines in Japan is as large as about 470,000 km, and about 3,000 cases of road subsidence occur every year due to pipe deterioration, etc. Since the personnel and budget of local governments that take charge of sewer pipeline projects are limited, it is necessary to build a proper pipeline management cycle by further increase in efficiency of pipeline inspection survey and optimization of the pipeline management cost with utilization of accumulated maintenance information etc.

The purpose of this study is to develop a method for choosing inspection survey technologies according to laying conditions, pipe types, and other conditions and thereby promote efficient inspection survey, secure the continuous function of pipeline system, and optimize maintenance cost.

2. Survey on the occurrence tendency of pipeline clogging

In considering an inspection survey plan, it is effective to determine the priority and method of inspection survey considering the occurrence tendency of risk, such as road subsidence or pipeline clogging, according to pipeline conditions. Past studies organized the occurrence tendency of road subsidence, while there are few reports on the occurrence tendency of other risks, so that we conducted a questionnaire survey to local governments with focus on pipeline clogging and organized the occurrence tendency.

The questionnaire survey researched pipeline clogging that occurred during a period from FY2015 and FY2017 due to abnormalities in the pipelines (excluding backflow and inundation caused by insufficient discharge capacity in rainy weather and pipeline clogging due to the failure of manhole pump) and received about 9,000 responses from 111 organizations.

The number of cases of clogging according to pipe types was large in concrete pipe (HP pipe), PVC pipe (VU pipe), branch pipe, and public inlet in relation to main pipe, manhole, and main pipe at the joint of main pipe and manhole, and in ceramic pipe (CP pipe) and VU pipe in relation to branch pipe at the joint of branch pipe and public inlet. For the causes of clogging, oil adhesion accounted for the largest number of about 1,600 cases in terms of main pipe, while entry of tree roots accounted for the largest number of about 2,400 cases in terms of branch pipe. In order to prevent pipeline clogging caused by external factors, such as oil adhesion, in addition to maintenance such as regular inspection and cleaning, it would also be necessary to give notification widely on proper use of sewerage service to users. For the entry of tree roots, the ratio of occurrence is greater in HP and CP pipes than VU pipe both in main and branch pipes. As a reason for this, HP and CP pipes have an opening in the joint larger than VU pipe, which may allow tree roots to enter easily. It would be therefore effective to consider the priorities of inspection taking into account pipe types and the range of growth of tree roots.

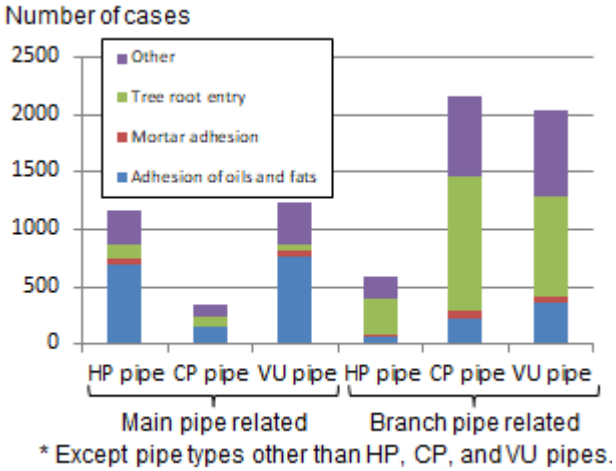

Fig. Number of cases of pipeline clogging by pipe type and cause of occurrence

3. Future activities

We intend to study the frequency and method of inspection survey according to the conditions of pipelines considering the technical development trend of inspection survey technologies that contribute to labor saving and cost reduction, as well as the knowledge so far obtained about the occurrence tendencies of abnormalities in the sewer pipelines and risk occurrence.

Development of suitable BIM model for public housing construction projects (Study period: FY 2019–)

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FUJIMOTO Hidekazu, Head, Housing Department, Housing Planning Division

(Keywords) BIM, public rental housing, maintenance and management, i-Construction

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism has been calling for the improvement of construction projects, including i-Construction activities. The Construction BIM Promotion Group was also launched in June 2019. Activities to promote the use of BIM have started in the field of construction.

The number of staff with a specialty in construction technology and management is expected to decrease in the field of public housing as well. Thus, the use of BIM during the construction, maintenance, and management phase is being considered as a new way of ensuring efficiency and quality in the design, construction, maintenance, and management procedures of a construction project and to improve the efficiency of maintenance and management.

2. Development of BIM model for public rental housing

The renewal, maintenance, and management of public rental housing, which was constructed during the period of rapid economic growth and is now facing the expiration of its service life, have become urgent issues. Thus, this study will verify the effectiveness of using BIM in improving the efficiency of the renewal, maintenance, and management of the stock of public rental housing.

To develop a BIM model that suits the public rental housing project, this study verifies the effects of using BIM and its efficacy by testing a BIM model that can be used for general purposes in the design, maintenance, and management of public rental housing based on actual rental housing construction (reconstruction) projects.

The verification is being conducted with the support of experts, the Building Research Institute, and public rental housing construction contractors. Last year, a BIM model related to a construction (reconstruction) project for public rental housing was prepared. With the model, the effects of using BIM are being examined.

Also, the examination of the possibility of using the BIM model, assuming its uses in the maintenance and management phase after construction, was also conducted.

This year, the pilot version of the BIM model that can be used in the maintenance and management phase was created by referring to the pilot BIM model to be used during the construction phase that was created last year. The effect of using the BIM is now being examined through a hearing with public rental housing administrators. (See Figure: Outline of the study.)

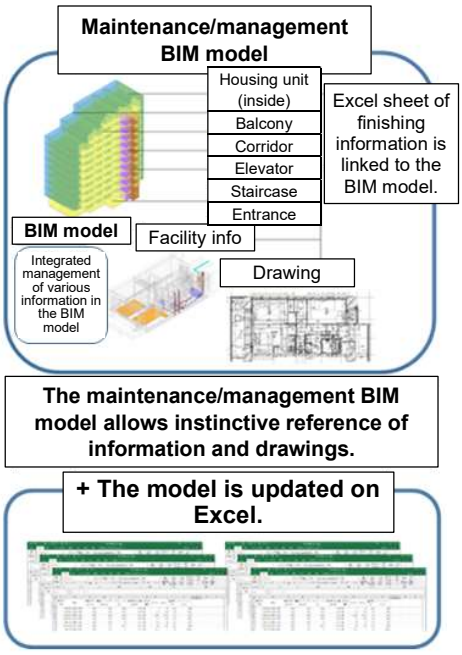

Figure: Outline of the study

3. Future direction

Using findings from this study, the draft of a guideline for the production and use of the BIM model that is suitable for public housing construction projects is going to be prepared.

☞For more information:
1) Housing Stock Management Division webpage
http://www.nilim.go.jp/lab/ieg/index.htm

A Study on Target Types of Work, Applicable Technologies, etc. for Works Using ICT

(Study period: FY2016-)

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HATASAKO Yuta, Research Engineer ,
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key words: construction productivity, construction phase, i-Construction

1. Introduction

In order to accomplish the measures for "Full utilization of ICT" in i-Construction, the Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") is conducting construction works using ICT in the projects under its direct control in accordance with the "Implementation policy for promoting full utilization of ICT."

In order to promote further dissemination of construction works using ICT, NILIM is studying for expansion of target types of works and applicable technologies and improvement of applicability to on-site work. Meanwhile, in order to reflect promptly technologies for construction, measurement, etc. held by private enterprises etc. in work progress control, etc., NILIM is also studying technical confirmation, verification, etc. required for procedures / standardization as the State in the "Private Sector Standards Proposal System," which the MLIT started in fiscal 2019.

This paper introduces the outline of the measures mentioned above.

2. Outline of study

(1) Expansion of target types of works and applicable technologies in works using ICT

Triggered by construction works using ICT, etc. which started in earthworks from fiscal 2016, dissemination and development of construction machines have been progressing in recent years, which are provided with the technology (machine guidance) of supporting operation of the construction machines by calculating differences from design values (3D design data) based on the position / construction information of the construction machine and providing the result data to the operator, or with the technology (machine control) of automatically controlling the machine on real time according to design values (3D design data).

Meanwhile, in accordance with the improvement in performance of the equipment used for measurement of work progress etc., it is also possible to apply ICT to various types of works including dredging and slope works, of which measurement conditions, accuracy requirements, etc. are different. In addition, for the software for formatting results of work progress measurement as well, a system that enables timely response according to the expansion of types of works using ICT, etc. is being established.

NILIM determines targets for the expansion of application range of works using ICT by collecting such information as stated above from private organizations etc. and considering the factors of productivity improvement, shortening of the construction period, applicability of existing technologies, etc., in cooperation with the MLIT, and is studying, as examination for expansion, on-site measurement (comparison with conventional management), grasp of the effect of productivity improvement through hearings, etc. NILIM is going to continue further expansion of application range with similar process (see **Fig. 1**)

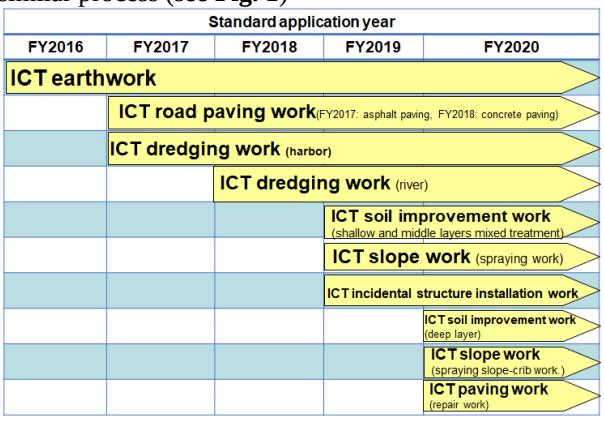

Fig. 1 Road map for expanding the types of works using ICT

(2) Follow-up after expansion of types / application of works using ICT

NILIM collects and analyzes measurement data for both the "new work progress control method" and "work progress control method by the conventional method" (work progress control in control sections) with respect to the types of works for which the

standards for work progress control in works using ICT were organized or revised in the past years, and conducts a hearing from the owners and contractors in each construction site to collect information about productivity improvement, etc.
Based on the results of the study above, we organize them as to whether "the new work progress control method" is superior or inferior to "the conventional method" in productivity improvement, utilization for maintenance, performance of completed construction, etc. and, based on the results, organize the issues of the work progress control in each type of work and consider the draft of measures to address the issues.
NILIM continually implements the measures referred to above and reflects results in the revision, etc. of standards, if necessary.

(3) Support of planning standards for work progress control, etc. based on proposals from private sectors, etc.

Since fiscal 2019, NILIM has been soliciting proposals for standards from private sectors, etc. as a "measure for preparing standards in cooperation of industry, academia and government." Proposals for standards are received according to the following three categories, and solicitation started in September 2019. (Refer to Fig. 2)

(1) Proposal for utilization of new ICT (new technology)
- Standards that enable the use of new ICT in an existing type of work using ICT
- Standards that enable the use of new ICT in a new type of work

(2) Proposal for expanding the existing target of ICT utilization (application expansion)
- Standards that enable the use of existing ICT technology in a new type of work

(3) Proposal for improvement (kaizen) of existing standards (improvement).
- Standards for improving existing standards for efficient use of ICT

For this solicitation, a total of 22 proposals were presented from the industrial organizations (Some of them are outlined in Table 1). Based on these proposals, we are going to conduct a hearing from individual proposers and verify the effectiveness and validity of a proposals, if necessary, in cooperation of the MLIT and NILIM.
Based on results of verification, we are going to prepare procedures in fiscal 2019 for the proposals that passed verification etc.

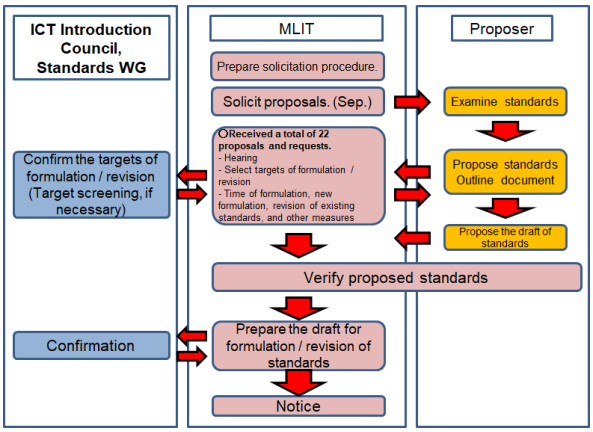

Fig. 2 System of standards preparation based on proposals from private sectors, etc.

Table 1 Outline of proposals from private sectors, etc. (relating to standards)

	Applicable ICT	Type of work etc.	Category	Outline of proposal
Commencement survey / Work progress / completed work measurement.	Aerial photogrammetry using UAV	Earthwork	Improvement	- Mitigate installation at orienting point (utilization of RTK-loaded UAV and GNSS-loaded orienting point) - Reduction by using GNSS-loaded orienting point in UAV photo measurement. - Evaluate the performance of camera lens to mitigate the lap rate of vertical / horizontal crossing.
		Paving work	Application expansion	- UAV photogrammetry technology is available for paving work
	Ground-installed laser scanner	Tunnel	Application expansion	- Measurement density, etc. according to measurement targets in application of the laser scanner to tunnel work
	Land mobile laser scanner	Earthwork	Improvement	- The work progress control procedure for earthwork that enables application of the laser measurement system loaded into heavy equipment.
		Pavement repair	Application expansion	-Availability of TLS, non-prism TS (Total Station), and MMS considered in paving work (repair work).
	Land mobile stereo photogrammetry	Earthwork	Improvement	- Response to the technology of completed civil engineering work management by creating point groups from the video data of smart phones, etc.
	Optical distance measurement such as TS	Structure (tunnel)	Application expansion	- Expand the application of three-dimensional coordinates measured with TS etc. to measurement of all structures.
	History of the construction equipment positions for construction machines (completed work / work progress measurement)	Earthwork (earth cut)	Improvement	- Use the "construction history data" of the working device (edge of blade) of ICT construction machines as work progress control data.
		Earthwork (banking)		- Use the operation track data (operation history data) of the vibrating roller used for shape adjustment as the final work progress data of road body / bed.
	History of the construction equipment positions for construction machines (three-dimensional measurement)	Earthwork	Application expansion	- Measure some points using the three-dimensional coordinates of the working device (edge of blade) and expand application to work progress control, etc.
Quality control	Image analysis	Grade of aggregate	New technology	- Quality control by image grain size monitoring. - When quality variation is detected, check the grain size by conducting a grain size test. - Quality control according to quality variation
Field management / standard values	- Aerial photographic surveying using UAV, etc. - Ground-installed laser scanner, etc.	Earthwork (cobble / boulder)	Application expansion	- Newly define standard values for the ground mixed with cobbles / boulders in the work progress control standards of earthwork excavation (field control).
	History of the construction equipment positions for construction machines (completed work / work progress measurement)	Earthwork (underwater)	Improvement	- Select no lower design limit in the work progress control standards for excavation works under water.

3. Study schedule

Based on the findings obtained up to this fiscal year, in the following years, we are going to further expand the applicable types of works and continue the measures by conducting follow-up so that standards further contribute to productivity improvement, etc.

Empirical Study and Guideline Formulation on the B-DASH Project concerning Energy Saving / Creation Technologies in Sewage Treatment / Sludge Treatment

(Study period: FY2015-)
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YAMAMOTO Akihiro, Researcher, AWATA Takanori (Ph. D.), Researcher,
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Water Quality Control Department, Wastewater and Sludge Management Division

key words: effective use of sewerage resources, effective use of existing stock, biogas, fuel cell

1. Introduction

Sewerage is essential social capital and, as a response to climate change and tightening supplies of resources / energy, it is imperative that mankind tap the potential of all available resources including the use of sewage sludge for energy, in addition to implementing measures to conserve energy.
To respond to such social demand, new technologies are being developed, but they are less used in practice and many sewerage service providers are cautious about introducing them. For this reason, MLIT launched the "Breakthrough by Dynamic Approach in Sewage High Technology" (B-DASH Project) in fiscal 2011, and the Water Quality Control Department at NILIM has been serving as the steering agency of this test project. The purpose of this project is to demonstrate excellent and innovative technologies, formulate guidelines for introducing them, and disseminate them in order to reduce costs of sewerage service, create renewable energy and pursue other noble causes. Of the guidelines for technology introduction newly formulated in this fiscal year, this paper reports three guidelines concerning energy saving / creation and one for which a new test project started this fiscal year.

2. Outline of the guidelines

Guidelines were formulated for each technology based on the results of empirical studies and opinions of local governments, and evaluated by experts. The structure of the proposed guidelines is as follows. (**Table 1**)

Table 1. Structure of proposed guidelines

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

3. Outline of demonstrated technology, etc.

The following sections (1) to (3) give an overview of the newly formulated guidelines, while section (4) introduces the test project that newly started.

(1) Technology for utilization of local supply energy for local consumption by high-efficiency digestion system
A test project was conducted in order to verify stable operation of the digester, the increase in gas generation and other technical matters concerning a high-efficiency digestion system that combined the utilization of unused biomass generated from small-scale treatment facilities, etc., a non-powered digester stirring device, a sludge solubilization device that increases biogas generation, and an efficient fuel cell using biogas. This technology is expected to improve the energy self-sufficiency ratio of sewage treatment facilities and reduce the treatment cost by concentrated treatment of sludge. (**Fig. 1**)

(2) Power generation type sludge combustion technology for greenhouse gas reduction
We conducted demonstrations in order to verify power generation and the NOx / N_2O emissions reduction effect of the foregoing system in combination with the high-efficiency power generation technology that utilizes unused waste heat from the sludge incinerator, and local stirring air blowing technology that simultaneously reduces NOx / N_2O emissions and is applicable to existing fluidized bed type sludge incinerators. Introduction of this technology is expected to improve power self-sufficiency rate and

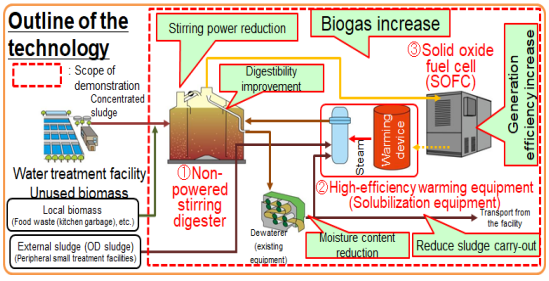

Fig. 1. Outline of the technology

greatly reduce greenhouse gas emissions in sewage facilities. (**Fig. 2**)

(3) Technology for practical collection and use of methane by way of a refiner and occlusion container
In order to conduct stable gas purification and power generation throughout the year, we conducted demonstrations of power generation technology fueled by surplus biogas that is generated, purified, and stored into occlusion containers at multiple small- to medium-sized sewage treatment facilities, and then transported by vehicles for concentration in one location. Introduction of this technology is expected to promote the effective use of sewage-derived energy in small- to medium-sized sewage treatment facilities, a reduction in maintenance cost by energy creation, and other benefits (**Fig. 3**).

(4) Advanced treatment technology by ICT-AI control of single-chamber nitrification and denitrification process
We conducted a test project at the Machida City Naruse Clean Center using treatment technology for achieving water quality equivalent to advanced treatment by controlling air content according to the fluctuation in reaction tank inflow load with ICT / AI, and for reducing power consumption by automatically computing / controlling fan discharge pressure according to air content. Introduction of this technology is expected to decrease construction cost compared with advanced treatment, realize energy-savings, and reduce the maintenance burden of administrators, and thereby promote advanced treatment. (**Fig. 4**)

4. Utilization of findings and future development
NILIM formulated the guidelines based on the results of the test project and gave a presentation at the Pacifico Yokohama Conference Center in August 2019 to introduce the guidelines to local governments, sewerage related companies, etc., which was attended by more than 100 persons. Note that a facility for demonstrating the advanced treatment technology by ICT / AI control of the single-chamber nitrification and denitrification process was completed in January 2020 and started operation.
We intend to continue demonstrating new technologies and disseminate innovative technologies through the introduction of guidelines, etc.

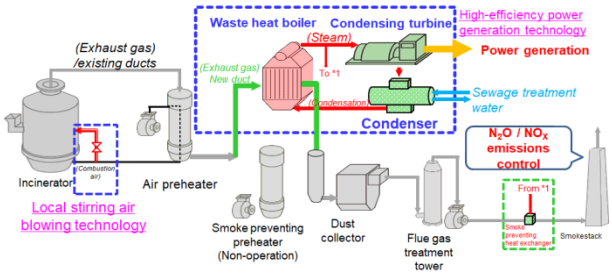

Fig. 2. Outline of the technology

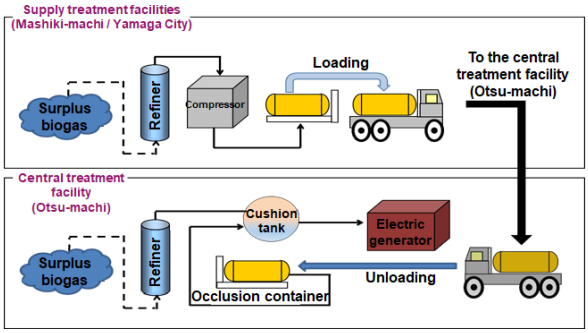

Fig. 3. Outline of the technology

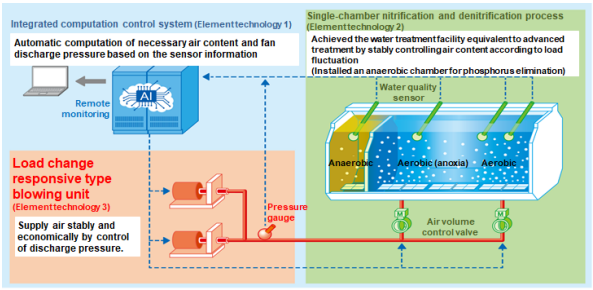

Fig. 4. Outline of the technology

☞**See the following for details.**
[Reference] Guidelines posted:
http://www.nilim.go.jp/lab/ecg/bdash/bdash.htm

Issues and Measures for Smooth Traveling of Autonomous Driving Cars in Hilly and Mountainous Area

(Study period: FY2017 to FY2019)

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key words: Michi-no-Eki, autonomous driving, demonstration experiment

1. Introduction

In the Second Term / Autonomous Driving (system and service expansion) of the Cabinet Office Cross-ministerial Strategic Innovation Promotion Program (SIP), the Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") has been conducting demonstration experiments since FY2017 aiming for social implementation of autonomous driving service based on "Michi-no-Eki," etc. in order to secure the flow of people and goods in hilly and mountainous area, where the aging of people is growing. In fiscal 2017, the demonstration experiment was conducted at 13 locations in the country and then at additional 5 locations, so that the experiment was conducted at a total of 18 locations in the country.

2. Analysis for smooth autonomous driving

Provision of the autonomous driving vehicles to be used in the demonstration experiment was solicited from the public and four vehicles were chosen (Fig. 1 shows an example). These vehicles travel on the preset locus. When there is an obstacle on the road, such as a parked car, the vehicle detects it with a sensor and automatically stops or a person in the vehicle operates the steering wheel to avoid the obstacle, etc. Reducing the latter operation, called "manual intervention etc." will lead to realization of smooth autonomous driving. For this reason, NILIM analyzed the factors of manual intervention etc. and drafted countermeasures. This paper outlines them. Please refer to Reference 1 for details.

In analyzing manual intervention etc., we grasped the time, place, and factors of manual intervention etc. from the daily driving report, hearings from drivers, and checking with the images obtained from in-vehicle drive recorders.

"Vehicle to infrastructure cooperation type" technology
Travel on the fixed route by detecting magnetic force from the electromagnetic induction lines laid underground.

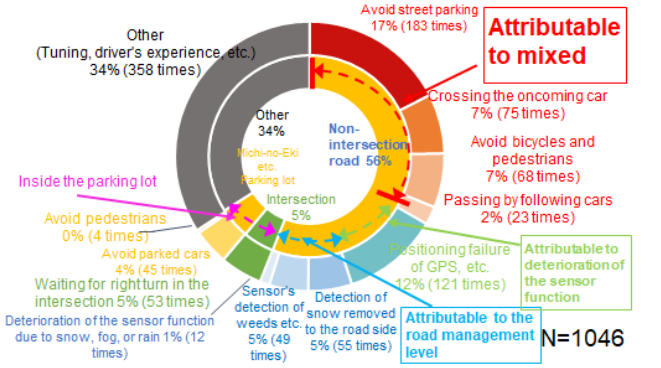
Capacity: 6 persons

Speed: about 12 km/h in autonomous driving
20 km/h in manual driving

Fig. 1 Example of the vehicle used for the experiment (cart type)

3. Results of analysis of manual intervention etc.

The following describes the situations of manual intervention etc. observed in 13 experiments conducted in fiscal 2017. Fig. 2 shows the breakdown of events where autonomous driving was interrupted by manual intervention etc. during traveling in the experiment.



* Results of the traveling distance of 1740 km except events such as an opening ceremony

Fig. 2 Situations of manual intervention etc.

According to Fig. 2, causes of manual intervention etc. are roughly classified into mixed traffic, deterioration of the sensor function, and level of road management. [1)]

The most common cause of manual intervention etc. was to avoid parked cars on the traveling road, as shown in Fig. 3.

Fig. 3 Cars parked on the traveling road.

There are also cases where the vehicle stops traveling when the vehicle sensor detects, as an obstacle, planting on the residential land along the road growing over the road or the road width narrowed by snow removal to the road side, and the person in the vehicle avoids such obstacles by manual driving (Fig. 4). This would suggest the necessity of securing proper road width and proper management level for smooth operation of autonomous driving.

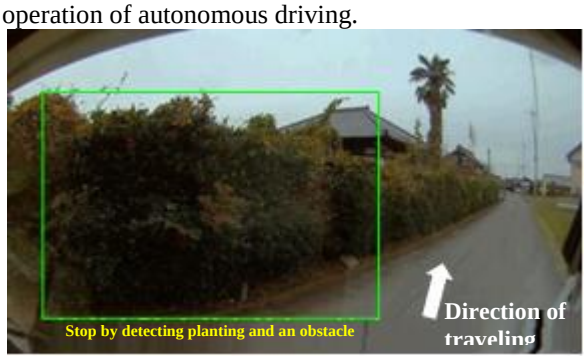


Fig. 4 Detection of planting as an obstacle

4. Drafting of countermeasures for decreasing manual intervention etc.

In the light of such situation of manual intervention etc., the following measures are considered necessary for smooth travelling of autonomous driving cars. [1)]

(1) Secure travelling space and set escape area.
(2) Improve the level of road management.
(3) Support the infrastructure of accident spot identification.

For example, for "(1) Secure travelling space," it is necessary to devise control of parking on the road, complete separation from the pedestrian flow line, etc. Fig. 5 shows an image of the measure using road marking. Additionally, it is necessary to make an escape space for autonomous driving cars so that following ordinary vehicles can smoothly pass by the autonomous driving car.

Fig. 5 Example of securing the travelling space

For "(2) Improve the level of road management," for the impact of planting on the residential land along the road or snow removal to the road side, it would be necessary to set up a road management level considering autonomous driving and set up a traveling position considering the time of snow removal or snowfall, in cooperation with local community. Particularly for snow removal, cooperation of residents along the road is indispensable since expense is required.

5. Conclusion

Based on results of this analysis and drafting of countermeasures by NILIM, an interim report of the workshop on road space responding to autonomous driving was prepared. [2)] In addition, in Kami-Koani-mura, a project for social implementation of autonomous driving service is progressing. We will continue to provide technical support for expansion of social implementation.

☞See the following for details.

1) The 60th Conference of the Committee of Infrastructure Planning and Management, No.7172 Analysis of issues and measures for autonomous driving in hilly and mountainous area through demonstration experiment
2) Interim report of the workshop on road space responding to autonomous driving https://www.mlit.go.jp/road/ir/ir-council/road_space/pdf/chu-matome.pdf

Possibility of improving the comfort of already constructed houses while residents are living there (Study period: FY 2018–)

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(Keywords) Already constructed housing, comfort of living, renovation, housing performance

1. Introduction

Houses constructed many years ago were built based on lower standards of sound insulation performance, energy conservation performance, and barrier-free performance. Also, the layout and facilities tend to be outdated. From the viewpoint of effectively using housing stock, it is necessary to renovate the structure to improve the level of comfort so that people in the various generations can live comfortably in the house. The improvement in the level of comfort of housing stock is effective in redeveloping residential areas in the suburbs, which have become aged, because it can encourage younger generations to move in. Meanwhile, an important point is to be able to execute the renovation while residents are living there[*1] This is important from the perspective of consensus building in condominiums and the difficulty in finding temporary rental housing.

2. Required standards for specifications, performances, and renovation of already constructed housing

Targeting residential complexes, changes (trends) in specifications and performances based on the year of construction were organized, and specifications and performances of already constructed housing, which becomes the base of renovation, were identified. In addition, the needs of households with the intention to move to residential areas in the suburbs were identified through online surveys. The main specifications and performances that need to be improved in already constructed housing and the standard levels to be satisfied were set.

3. Reality of renovation while residents are living there and its possibilities

The study organized the challenges and possibilities based on the relationship among the reality of executing the renovation while residents are living there to improve safety, such as earthquake resistance, building barrier-free designs that are in high demand among young families with small children and elderly households, the thermal environment, the specification and performance level of already constructed housing, and the standards required for the renovation.

The possibility of implementing the renovation while residents are living there was examined by organizing the points that require precautions, such as the installation of an elevator on the balcony side of a mid-rise housing building with a staircase, minimization of the number of residents to relocate temporarily by the unit of each floor, expansion of living spaces by combining two small units into one, conditions of construction to improve insulation performance using exterior insulation and double sashes, and construction plans. The actual conditions of noise and vibrations caused by chipping and drilling on the building frames and their effects on residents were also examined.

*1 This article covers renovations that can be made without requiring all residents to relocate altogether during the construction period, renovations that can be made without requiring contractors to enter inside the housing, renovations that can be made while residents other than the ones in the housing to be renovated are still living there, and renovations that minimize the period during which residents of the housing under renovation have to stay in temporary housing.

Photo 1: Installation of an elevator between two buildings (public rental housing)

Photo 2: Improved insulation performance using exterior insulation + double sashes (private condominium)

Photo 3: Expansion of living space by combining two units into one (public rental housing)

Research on the facade design method to improve energy conservation performance in buildings

(Study period: FY 2017–2019)

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(Keywords) Energy conservation, facade, thermal environment, optical environment

1. Facade design to improve energy conservation in buildings

To realize advanced energy conservation in buildings, it is important to use the design of the facade (the exterior section of a building, such as the outer walls, windows, and roofs), which is the upstream step in the building design process, to reduce the loads on building facilities, such as the loads on air conditioners. Thus, this research examines how various types of facades affect the reduction of energy consumption in air conditioning and lighting facilities. The objective of this research is to develop design methods to improve energy conservation performance using the facade.

2. Examination of technical material to design energy conservation type facade

This research is conducted based on the flow shown in the table. This year, which is the final year of this study, technical material is examined to prepare the proposal for the guidelines for designing the energy conservation type facade. The technical material is the result of an annual simulation that measured the differences among major types of façades using software known for the evaluation of energy conservation and the indoor environment. The software used to measure the air conditioning load is EnergyPlus, and the lighting load is Radiance. Using the result, energy conservation performance, which can be used as a reference when designing a common office building, precautions in the actual design, and the concept of maintaining the thermal and optical environment are organized. Figure 1 and Figure 2 are part of the technical material based on an office in a large building. In the case of a large room that is long in the direction of depth, the load for cooling dominates the annual air-conditioning load, which is the most emphasized aspect of the design, and the effect of different types of façades is extremely small. Yet, the effect of using daylight with different types of façades, depending on the direction, becomes large in reducing the lighting load. Meanwhile, the façade design becomes more effective in mid-size buildings. This is because the depth of a room becomes shorter, and the effect of the façade in reducing the lighting load becomes relatively large compared to the air-conditioning load. This is also described in the drawings in the material.

Table: Research flow of the entire research period

FY 2017	Reconstruction of the method to evaluate the performances of individual facade types and preparation of indexes and standards for the indoor environment
FY 2018	Development of the method to evaluate the energy conservation performance based on the combined effects of the facade on air conditioning and lighting
FY 2019	Preparation of the facade design method to improve both the energy conservation performance and the indoor environment

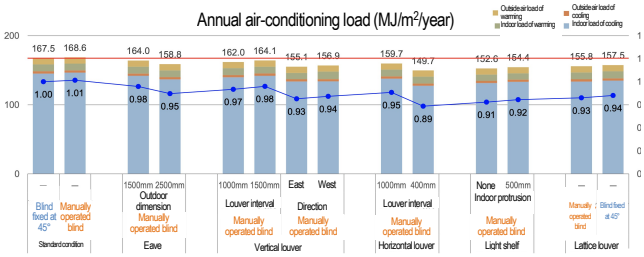

Figure 1: Annual load on air conditioning based on differences in facades

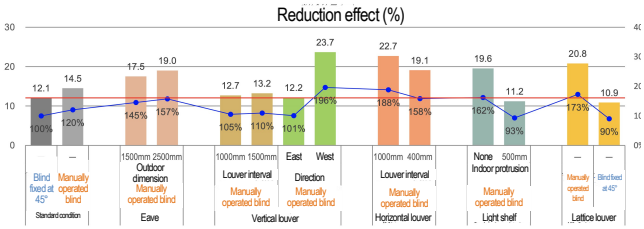

Figure 2: Effect of reducing the annual lighting load based on differences in facades

3. Future prospects

Technical materials will be organized and issued as an energy conservation design guideline using more graphical figures for better understanding among designers.

Development of technology for analysis and evaluation of urban structures based on diversifying daily support functions (Study period: FY 2017–2019)

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(Keywords) compact city, integrated city structure, factors for selecting an area to live, DID, evaluation index

1. Background and objective of study

Cities are facing rapid changes associated with depopulation and the super-aging of society while the administrations are being limited by tight budgets. Thus, it is an urgent issue for Japan to improve the sustainability and productivity of cities. To promote the shift of cities to an integrated city structure (compact city) that will improve sustainability and productivity, the Act on Special Measures concerning Urban Reconstruction revised in May 2014 stipulated the specification of urban function induction areas and residence induction areas to introduce a location optimization planning system to facilitate urban integration. Systems and frameworks are thus being reinforced to accelerate the development of compact cities.

Cities around Japan that are in need of becoming compact cities exhibit various urban and regional characteristics associated with different population sizes, urban development processes, and other backgrounds. Thus, the direction of compact city development also comes with variations depending on the characteristics. It is therefore necessary to examine the evaluation methods that enable the selection of a proper urban structure based on the characteristics of individual cities and the distribution of essential facilities that provide the necessary daily support functions.

2. Densely inhabited district (DID) data analysis

The relationship between a densely inhabited district (DID) and population density etc. was analyzed using data from 2005 to 2015 to quantitatively identify actual conditions of compact city development. In the section below, an increase by 5% or more is described as an "increase," a change within ±5% is "unchanged," and a decrease by 5% or more is a "decrease."

- Among all 912 cities, 241 (26.4%) of them exhibited an increase in DID areas, while 582 cities (63.8%) remained unchanged, and 89 cities (9.8%) decreased.
- Among cities where DID areas increased, DID population density increased in 33 cities, remained unchanged in 142 cities, and decreased in 66 cities (Figure 1). It is highly likely that urban sprawl and "sponge" city formation are occurring in cities where the DID area increased and the DID population density decreased.
- Among cities where the DID area decreased, the DID population density increased in 14 cities, remained unchanged in 30 cities, and decreased in 45 cities (Figure 2). In cities where the DID area decreased and the DID population density increased, it is considered that the population is becoming denser, and urban structures are becoming more integrated.

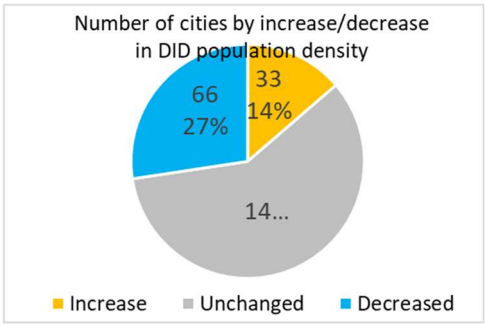

Figure 1: (Increased DID area) Number of cities by increase/decrease of DID population density

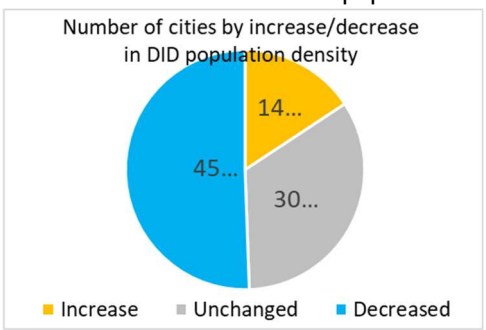

Figure 2: (Decreased DID area) Number of cities by increase/decrease of DID population density

3. Investigation of factors for selecting an area to live

To identify factors that form urban structures, a questionnaire was conducted with people who were

considering relocation to find out their residential conditions, factors for selecting an area to live, and other aspects. The outline of the survey was as follows.

<Outline of questionnaire survey>

Subject: Householders or the spouse of a householder in Fuchu City, Tokyo, and Kanazawa City, Ishikawa

Survey method: Web survey

Number of responses: 500 each from Fuchu City and Kanazawa City

Survey period: January to February 2019

The result of the survey in Kanazawa City indicated that 47.6% selected Area 1 - a central area of a region - as a desirable place to move to when there was no restriction (Figure 3). Compared to areas of current residence (Figure 4), the ratio was nearly three times the current conditions. High land and housing prices were the greatest factor in preventing residents from living in areas they liked (Figure 5), followed by inconvenience of the commute and shopping conditions. This finding indicated that many people wanted to live in a central area, but high real estate prices were preventing them from doing so.

The survey also asked whether they knew about the compact city policy. Those who responded that they knew about it accounted for 16.8%, and 55.6% of them responded they "did not know about it at all," indicating the low recognition of the compact city policy.

4. Organization of urban structure evaluation indexes

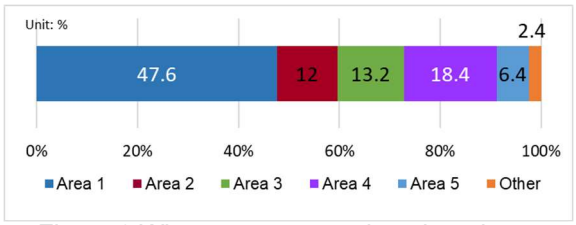

Figure-3 Where to move to when there is no restriction in selecting an area to live

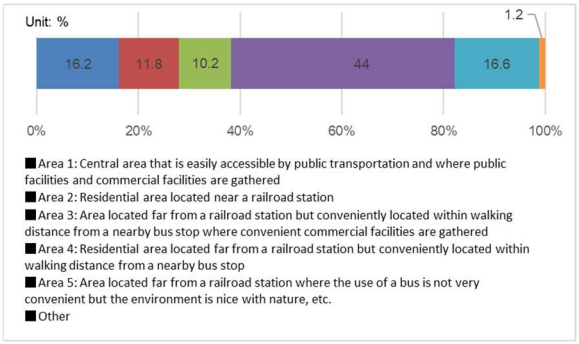

Figure 4: Current locations of residence

Twenty-five studies were reviewed to organize indexes used in the current urban structure evaluations. As a result, indexes were categorized as follows: i) indexes (such as DID) that used population density within an area larger than a certain size; ii) indexes indicating accessibility to urban functions and hub-like functions of transportation facilities (i.e. population coverage from a certain distance from a facility); iii) indexes indicating the convenience of daily support facilities (i.e. population coverage by such facilities); and iv) indexes that considered the shapes of cities (e.g., standard distance, indicating the distribution of densely populated areas).

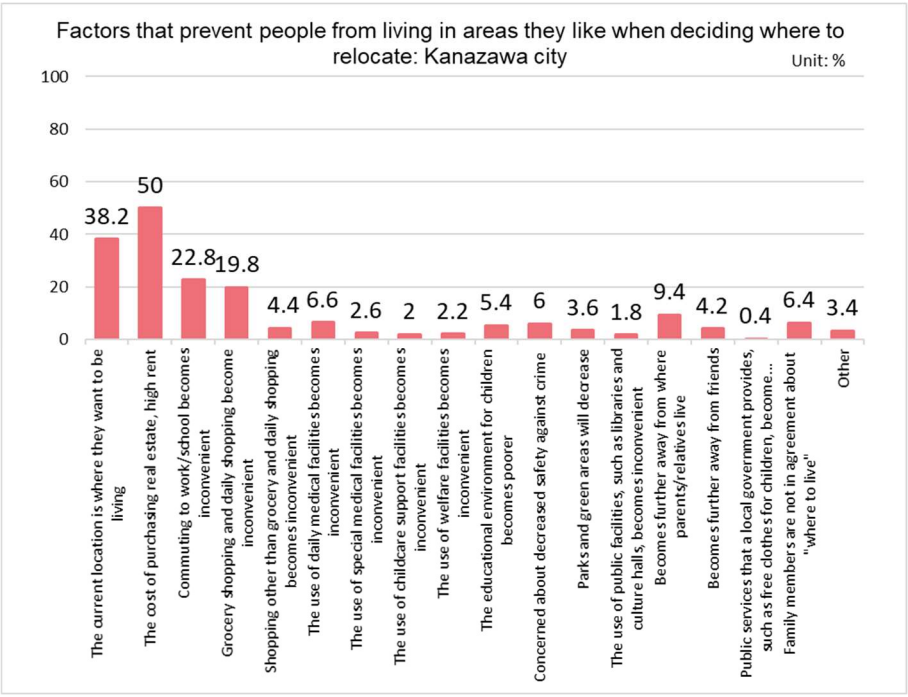

Figure 5: Factors that prevent people from living in areas they like

5. Future activities

Simple and concise urban structure evaluation methods are being developed, and their practicalities are now being examined.

Development of technologies to measure the green coverage ratio using AI

(Study period: FY 2018–2020)

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KATSUMATA Wataru (Ph.D. in Engineering), Head, Urban Planning Division

(Keywords) city, green coverage ratio, artificial intelligence

1. Research of methods for quantitative evaluation of the effect of greening to improve the urban environment

The NILIM is conducting research in the methods for quantitative evaluations of the effect of greening in improving the urban environment[1] to develop methods for quantitative measurements and evaluations of green areas in cities and to build technological knowledge to effectively utilize the various functions of green areas for use in urban planning. This article introduces the technology to measure the green coverage ratio using AI that is now under development in this research project.

2. Advancement of green coverage ratio survey by AI

This research aims to reduce the workload and cost of green coverage ratio surveys by automating the process of extracting green areas from images using the image recognition technology of artificial intelligence (AI). This research is also examining methods to improve the awareness of the private sector toward greening and spread green areas on private land by creating a smartphone application of this technology and develop mechanisms where local governments and residents together conduct green coverage surveys.

3. Utilization of image recognition through deep learning

In the early 2010s, deep learning enabled a breakthrough in the limits of conventional neural networks, which led to rapid progress in AI research. Image recognition through deep learning includes semantic segmentation. This is a technology that can classify items, such as buildings, cars, the sky, and pavement, in the image of cities captured by cameras mounted on cars by capturing the outline of individual classes, for example (Figure 1). Classes categorized here are determined by training data used for AI learning. Many training datasets are now released for AI researches to accelerate the development of more advanced neural network models.

The training datasets of urban images often include the class of vegetation as one of the class categories. AI models that have learned using this class will enable the identification of green areas, such as trees and lawns, in images. This research first created an AI model for identifying vegetation using the AI model, SegNet[2] and the dataset, CamVid[3] developed and released by Cambridge University. Then, their effectiveness was examined by computing the green coverage ratio (the ratio of green areas in one image) and comparing it with conventional survey methods.[4,5] The research also confirmed that the accuracy of identifying vegetation could be improved by using a more advanced neural network model and the AI model that conducted learning using datasets. Meanwhile, the study found that some trees were difficult to identify using the datasets released for AI researches. Possible causes include training methods, such as over-training, while the effect of the types of trees included in the dataset of images of cities outside of Japan also seemed great. To improve the accuracy of recognition by AI, it is important that the contents of the training datasets used for training AI match the purpose of using the AI.

Thinking that using images of cities captured for the past green coverage ratio surveys for AI training would be a suitable learning method for the green coverage ratio survey, this research decided to perform AI learning using images of cities in Japan with the cooperation of local governments.

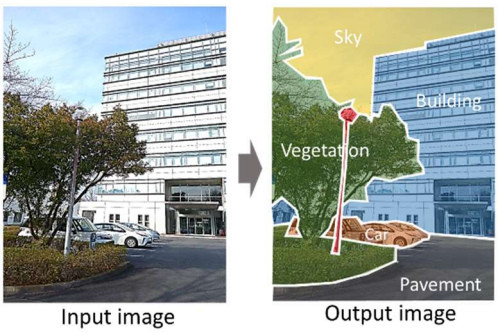

Figure 1: Semantic segmentation

4. Development of smartphone application

The smartphone has been expanding the possibility of urban sensing as multifunction sensors that are available in many parts of cities as many people are carrying smartphones with them. In addition, the System on a Chip (SoC) embedded in the latest smartphones contain AI chips for photo and audio assistance functions. Thus,

the AI processing capacity of these smartphones is quite advanced. This research focused on these characteristics and created a pilot version of the smartphone application containing the trained AI model (Photo 1).

Photo 1: Smartphone application

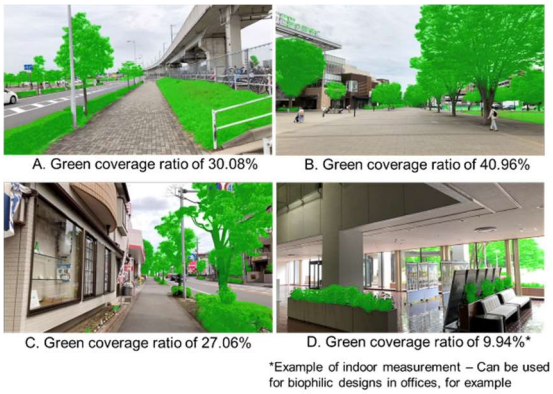

Figure 2: Example of measuring green coverage ratio using smartphone

This application can quickly and easily measure the green coverage ratio whenever and wherever just by holding up a smartphone (Figure 2). When the conditions of green areas are shown quantitatively, slight differences in the amount of green become visible. For example, when continuously watching the front from the passenger seat of a car through this application, a user can notice differences in the range of green coverage ratios of trees along different roads even when the measurement is conducted by holding the smartphone with the hand, which tends to be unstable (Figure 3).

5. For the use of this technology for future green coverage ratio surveys

A green coverage ratio survey needs to be conducted by clearly defining the green coverage ratio, such as how images are to be captured. Future research activities are going to cover the development of measuring methods based on the characteristics of smartphones and methods for evaluating the environment with visible green areas, which correspond to the green coverage ratio, as well as

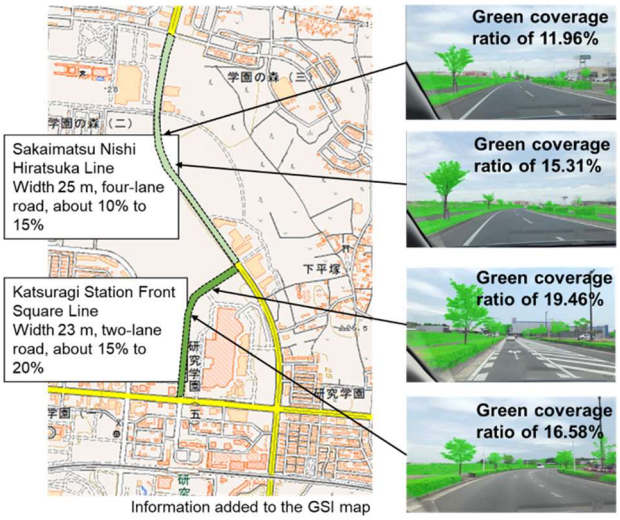

Figure 3: Differences in the green coverage ratio on different roads

the exploration of ways to increase public awareness toward greening, such as surveys conducted through the cooperation of residents (Figure 4).

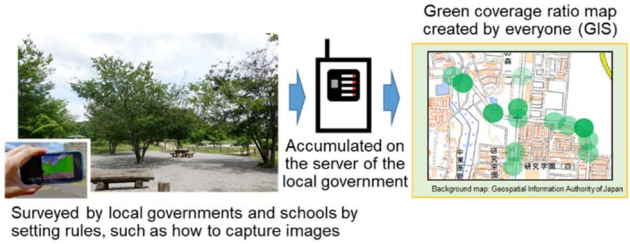

Figure 4: An image of the green coverage ratio survey with the cooperation of residents

The smartphone application for the green coverage ratio survey is going to be released in FY 2020.

☞For more information:

1) NILIM press release: Rough estimate of NILIM budget for FY 2018. p. 6 http://www.nilim.go.jp/lab/bcg/kisya/journal/kisya20170829.pdf
2) Segnet http://mi.eng.cam.ac.uk/projects/segnet/
3) CamVid http://mi.eng.cam.ac.uk/research/projects/VideoRec/CamVid
4) The Architectural Institute of Japan - Compilation of Academic Lectures in the FY 2019 Conference Environmental Engineering I. pp. 739-740 DVD-ROM
5) The FY 2019 Environmental Research Facility Interaction Seminar - Proceedings of Posters pp. 27-28 http://kankyorenrakukai.org/seminar_01/pdf/yousisyu.pdf

Emergent Survey on the Disasters by the 2019 Boso Peninsula Typhoon, East Japan Typhoon, etc.

Emergency Survey Team consisting of National Institute for Land and Infrastructure Management, Public Works Research Institute, Building Research Institute, and Port and Airport Research Institute of National Institute of Maritime, Port and Aviation Technology

key words: disaster emergency survey, typhoon damage

1. Introduction

Immediately after the occurrence of disasters by the 2019 Boso Peninsula Typhoon, East Japan Typhoon, etc., National Institute for Land and Infrastructure Management ("NILIM"), Public Works Research Institute ("PWRI"), Building Research Institute ("BRI"), and Port and Airport Research Institute ("PARI") of National Institute of Maritime, Port and Aviation Technology (National Research and Development Agency), in cooperation with each other, participated in the field activities in each site as experts and members of the Technical Emergency Control Force (TEC-FORCE) of the Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") and organized a voluntary survey team and dispatched their personnel to disaster sites.

This paper reports as a quick bulletin the outline of damage, etc. caused by the 2019 Boso Peninsula Typhoon, East Japan Typhoon, etc. based on the emergency field survey by classifying the disasters by facility etc. Note that numerical values etc. reported in this paper include those as of the survey.

2. Damage confirmed by the emergency survey

2.1 Damage to sewerage facilities

Sewerage facilities suffered serious damage from the inundation and sediment disasters caused by the 2019 East Japan Typhoon, etc.

The function of sewage treatment also stopped at 16 treatment facilities, including Fukushima Abukuma River Upstream Northeast Prefecture Treatment Center and Nagano Chikuma River Downstream Treatment Facility. Of these facilities, as of the end of February 2020, 13 facilities resumed normal operation and 3 facilities are operating with simple treatment.

As for pumping stations, a total of 28 facilities in 6 prefectures including Miyagi, Fukushima, and Nagano stopped operation due to inundation damage. Of these facilities, as of the end of February 2020, 19 facilities resumed normal operation, 9 facilities are taking emergency measures, and 8 facilities secured part of the drainage capacity.

Damage also occurred at a total of 100 spots in the pipeline facilities of 2 prefectures, 13 cities, 6 towns, and 1 association and 104 spots in manhole pumps in 28 cities, 13 towns, and 2 villages, in the region from Tohoku to Kanto.

(1) Fukushima Abukuma River Upstream Northeast Prefecture Treatment Center

The Northeast Prefecture Treatment Center is a treatment facility with the treatment capacity of 87,800 m3/day, covering Fukushima-shi, Date-shi, Kunimi-cho, and Koori-machi. Due to the heavy rain by the 2019 East Japan Typhoon and subsequent failure of the levee of the Taki River, flowing through Kunimi-cho, Fukushima-ken, the whole treatment facility submerged and lost the treatment function due to equipment failure. After suffering the damage, the facility, through the operation with disinfection treatment, is considering measures for phased water quality improvement in view of a long period up to the full recovery. Note that the NILIM dispatched experts to the site on October 23, 2019 and January 10, 2020 to grasp the status of temporary measures and gave technical advice on emergency measures.

(2) Treatment facility in the Nagano-ken Chikuma River Basin Sewage Downstream Treatment Area

Treatment facility in the Chikuma River Basin Downstream Treatment Area has the treatment capacity of 69,000 m3/day, covering the treatment area of Northern Nagano-shi, Suzaka-shi, Obuse-machi, and Takayama-mura. Located near the JR East Japan Nagano Shinkansen Rolling Stock Center, the facility on the whole submerged due to the levee failure of the Chikuma River and its function stopped (Photo 1).

Photo 1 Disaster in the treatment facility of the Chikuma River Basin Downstream Treatment Area
Photo source: Nagano-ken

After suffering the disaster and subsiding of the inundation, the facility resumed acceptance of sewage from October 19 and started disinfection operation. Then, after installing a temporary pump, the facility started operation with simple treatment (precipitation + disinfection).
For the future, the facility has been preparing for restoration, including restart of simple biological treatment in turn for each system.

(3) Damage to pipeline facilities

As for damage to pipeline facilities, in addition to the damage in wide area and increase in the number of cases, events of spill and scouring in the inundated area and elevation phenomenon, which had been rarely observed in the past events of inundation, were also outstanding and types of damage were various, so that the NILIM is organizing damage types based on the damage information from the MLIT and striving to grasp the characteristics of damage to pipelines by the heavy rain of the 2019 East Japan Typhoon.

(4) Summary

If a sewage treatment plant suffers destructive damage due to inundation etc., it is necessary to recover the function as early as possible but recovery of electric / machine equipment will take a long time. It is therefore required to advance restoration work to improve water quality in stages, while securing the minimum treatment function of the facility.
In addition, hydraulic phenomena of pipeline facilities in the event of heavy rain, such as back run of foreland water and impact pressure of water / air, are not clarified and it is therefore difficult to take countermeasures, so that solution of the phenomena is urgently required.

2.2 Damage to river management facilities

The 2019 East Japan Typhoon caused wide-area damage to river management facilities, including the levee failure in Miyagi-ken, Fukushima-ken, Ibaraki-ken, Tochigi-ken, Saitama-ken, Niigata-ken, and Nagano-ken. NILIM's River Department and PWRI's Geology / Ground Research Group, Hydraulic Engineering Research Group, and Cold Region Hydrosphere Group conducted a field survey in cooperation with the MLIT, Regional Development Bureau, and prefectures including participation in the Levee Survey Committee for the purpose of investigating the causes of damage and studying restoration methods. A total of 68 persons from 19 teams engaged in the survey to investigate the damage caused by the 2019 East Japan Typhoon, the low pressure generated subsequently on October 25, and Typhoon No. 21. The following introduces part of the survey.
Note that NILIM's River Department and PWRI's Water Environment Research Group, as of March 19, 2020, following the emergency damage survey, dispatched 14 teams of advisors of Nature-oriented River Management, which aims to promote further effective / efficient promotion of nature-oriented river development, in response to the request of the Regional Development Bureau and prefectures to support the restoration of affected areas.

(1) Tohoku Region

In the Tohoku Region, as the first Levee Survey Committee, we conducted a survey on October 16 about the collapsed area in the direct control section at 98.6 kp on the left bank of the Abukuma River and at 20.9 kp on the left bank of the Yoshida River in the Naruse River System. In the Abukuma River, collapse occurred in the section of about 50 m, where a sluice gate is located. Redevelopment of the levee site was proceeding in the emergency restoration work at the time of the survey and there were a slope inside the levee that seems a levee slope toe and a sign board that had probably been installed at the top end / top of slope and tilted toward the river side.
In the Yoshida River, a levee failure occurred in the section of about 100 m, located on the downstream side where the levee normal line turned toward the river side (Photo 2). In the back of the river side slope at the foot of the berm where the slope pavement is installed, a pool dug where the basic ground is deeply dug was formed and its ground surface was comprised of sediment that includes fine grained soil. Note that the CCTV video depicting the flooding at this point caught the flood flowing over the crest.

Photo 2 Collapse at 20.9 kp on the left bank of the Yoshida River in the Naruse River System (Oct. 16)

In addition, in the individual survey conducted on October 22, collapse of the river side slope was found at 8.4 kp on the left side of the Naruse River. The slope collapsed about 30 m in length and the collapsed sediment seemed to have fallen down to the major bed. The emergency recovery work was going on when the field survey was conducted and the collapsed sediment was already removed completely by heavy equipment working on the slope. The collapsed sediment was relatively thick, about 2 m, and there was an open crack on the slope extending over 200 m in the upstream of the collapsed section.

(2) Kanto Region

In the river levees under direct control of the Kanto Regional Development Bureau, levee failure occurred

at 3 spots in the Oppe River and Toki River, branch rivers of the Ara River, and 3 spots in the Naka River, and 3 spots in the Kuji River.
The Levee Survey Committee, organized by the Kanto Regional Development Bureau, conducted a field survey on October 17 about the 3 collapsed spots in the Ara River System and on October 18 about the 3 collapsed spots in the Naka River and Kuji River (Photo 3), respectively.
On all the sites of these 9 spots, a cofferdam was being installed in the emergency recovery work. In all the collapsed spots, trace of overtopping, far exceeding the design water level of the levee, was confirmed.

Photo 3 Collapse at 28.6 kp on the right bank of Naka River (Oct. 18)

(3) Hokuriku Region

At 58 kp on the left bank of the Chikuma River, the levee collapsed about 70 m in length and an area of about 9.5 km2 including Oaza Hoyasu and Oaza Akanuma, Nagano-shi, was inundated. The Levee Survey Committee, organized by the Hokuriku Regional Development Bureau, conducted a field survey on October 15 about the spots of collapse, etc. in the Chikuma River. At the spot of collapse, there remains part of the levee in which a large pool dug by flood stream was formed toward the inside of the levee, from which the violent flood flow at the time of collapse could be presumed. At 104 kp on the left bank of the Chikuma River, the levee was lost and the left bank side of the Chikuma River Bride, across the same spot, on the Besho Line of Uedadentetsu was scoured and the bridge girder fell because the abutment was washed away (Photo 4). The riverbed slope is steep, about 1/200, on the same spot and the erosion force acting on the riverbank is large in the section.
In addition, in the individual survey conducted on October 26, the spot where levee revetments were damaged and the bridge across the riversides fell was confirmed, although the measures for water colliding front, including installation of groyne, had been progressing in the area of Tomi-shi Umino site to Tanaka site, located in immediately upstream of the direct control section since it is located in the outer bank of the bend.

Photo 4 Levee collapse at 104 kp on the left bank of the Chikuma River Situation of damage (Oct. 15)

In addition, in the individual survey conducted on October 30, collapse of the land side slope was found at 57 kp on the left side of the Chikuma River. The thickness of collapsed soil was thin, about 0.5 m, which means the collapse of only the surface part. It was, however, characteristic that the collapsed soil on the whole greatly moved to the ground inside the levee. The case of large movement of collapsed soil was found at multiple spots including the case of Naruse River.

2.3 Sediment disaster

(1) Outline of sediment disaster

The heavy rain of the 2019 East Japan Typhoon caused a total of 952 sediment disasters in Tokyo and 19 prefectures and the dead and missing persons totaled 17 (The MLIT's Survey as of Dec.24). Particularly, in Miyagi-ken, 254 sediment disasters occurred (Photo 5).

Photo 5 Frequent slope collapse and debris flow (Igu-gun, Miyagi) Mawarigura Area, Marumori-machi, Oct. 17)

Particularly, in Marumori-machi, Igu-gun, Miyagi, debris flow and surface failure occurred almost simultaneously and the riverbed rise and channel clogging resulting from runoff of a large amount of sediment also caused damage by sediment / flood inundation. As a factor of such damage, the rainfall, totaling 607.5 mm with the 60-minute maximum precipitation of 80.5 mm (Oct. 12, 19:30 to 20:30) is mentioned (AMeDAS: Hippo Observatory). In

particular, the 12-hour rainfall (517.5 mm), observed by the Observatory, was over two times the existing maximum rainfall. As another factor, the distribution of granites and granodiorites in the affected area is considered, which are also distributed in the areas of sediment / flood inundation caused by the 2018 West Japan Heavy Rain Disaster and the 2017 North Kyushu Heavy Rain Disaster.
As an activity of TEC-FORCE, etc., NILIM and PWRI have conducted helicopter and field surveys immediately after disaster occurrence in Miyagi, Gunma, Iwate, Fukushima, Kanagawa, and Chiba and gave technical advice, etc. concerning emergency measures and warning / evacuation against further rainfall.

(2) Results of the survey on the Uchi River basin (Marumori-machi, Igu-gun, Miyagi-ken)

The Uchi River is a right-bank tributary in the downstream of the Abukuma River and has the basin area of 105.84 km2. Regarding geology, granites and granodiorites are partially distributed in the upstream area but basalts and metamorphic rock are generally distributed. The Uchi River is divided into 3 rivers just upstream of the joint with the Abukuma River, which are called Uchi River, Gofukuya River, and Shin River in the order from east. According to the airborne survey, riverbed and bank erosion and small slope failure frequently occurred in the midstream of each tributary area and there were also slopes in some areas where many collapses occurred dendritically. The collapses are considered mainly shallow landslide.
In the flat ground area at the valley exit of each of the three branch rivers, the original river channel was clogged by sediment in each area and occurrence of flood damage was also confirmed. The damage was most outstanding in the Gofukuya River, where the original channel was completely clogged at the time of the field survey and the flow channel changed in some sections (Photo 6). Sediment begins to deposit remarkably at the valley exit of the Gofukuya River. The riverbed of the section valley bottom plain, extending about 700 m, rose. In the flat ground, the area of sediment deposit spread across the Prefectural Road No. 45 in the direction of the right bank of the original channel, which shows the occurrence of flood. The deposited sediment includes few large stones and seems to be sediment of granite origin mainly consisting of sand. Flow of driftwood was also confirmed.
In the midstream of the Gofukuya River, bank erosion or bank collapse occurred in most of the section where there are no bare rocks. In the Usudaira flat ground area (about 3 km from the Uchi River junction), the river channel was mostly clogged with sediment, which is considered to show the occurrence of sediment / flood inundation.

Photo 6 Occurrence of sediment / flood inundation in the Gofukuya River (Oct. 17)

Debris flow also occurred on the back slope in the left bank of the community and caused damage.

2.4 Damage that affected road performance

(1) Outline of damage

The 2019 East Japan Typhoon caused damage affecting the road performance of road facilities in wide area. Fully blocked sections were 17 routes of the expressways, 63 sections in National Highways under the State's direct control, about 160 sections in National Highways under the control of prefectures, etc., and about 900 sections in prefectural roads, etc. In addition, some trunk roads have been affected for a long period, which has caused a major disruption to the traffic network.
NILIM and PWRI dispatched personnel based on requests from road administrators etc. to provide technical support. The following describes the damage to the Hounji Bridge, Unnojuku Bridge, and National Highway No. 138 and support activities.

(2) Damage to road bridge

In the Hounji Bridge of the National Highway No. 20 (Otsuki-shi, Yamanashi), two bridge piers that were supported by the spread foundation subsided and tilted and the road was blocked due mainly to the subsidence of the girders that were supported by these piers.

Photo 7 Giving technical advice (Oct. 21)

We conducted a field survey on October 21 upon request from the Kanto Regional Development Bureau and gave technical advice on the status assessment and emergency restoration method of the bridge after the damage (Photo 7).
The Unnojuku Bridge (Tomi-shi, Nagano), located on

the Shiratori Jinja Line of the municipal road, is a two-span continuous girder bridge crossing over the railroad of Shinano Railway. Because the revetment and levee were eroded by rise of water in the Chikuma River, A2 abutment fell down and the ground on the side of the spread foundation of P1 pier was washed away. In response to the request of Nagano-ken for technical support in such status of damage, we conducted a field survey on October 17 and gave technical advice on emergency recovery, etc.

(3) Road damage by slope failure

On the National Highway No. 138, a natural slope at Hakone-machi, Kanagawa, collapsed about 180 m upward the road (oblique distance along the slope) and the traffic of the section including this spot was blocked. In response to the request from Kanagawa-ken, we conducted a field survey on October 26 and gave technical advice on the mechanism of slope failure and emergency recovery of the road (Photo 8).

Photo 8 Field survey on National Highway No. 138, Hakone-machi. (Oct. 26)

2.5 Damage to buildings etc.

NILIM and BRI conducted a field survey in order to grasp the damage to buildings etc. in Chiba-ken and the Tokyo island area by the strong wind of the 2019 Boso Peninsula Typhoon and to buildings etc. in Ichihara-shi, Chiba, by the tornado by the 2019 East Japan Typhoon.

(1) Damage by the 2019 Boso Peninsula Typhoon

(1) Damage in Ichihara-shi, Futtsu-shi, Kyonan-machi, Minami-Boso-shi, and Tateyama-shi, Chiba

In the Ichihara City Hall, a total of 24 glass panels were broken in the 2nd Government Building and the City Council Building and, water leakage occurred at several spots in the indoor ceiling, etc. In the 2nd Government Building, 3 glass panes at the south entrance were broken and the wind blew into the Office Building and caused the damage of breakage to the glass on the north side.

As for types of damage to houses, there were breakage of windowpanes, come-off of roof tiles and other roofing, scattering of wooden roof truss (Photo 9), partial come-off, scattering, etc. of exterior wall finishing material (lath mortar, etc.). Of the above, relatively major damage was selectively caused to those comparatively aged, those located along the coast, those of which component parts considerably deteriorated or suffered termite damage, etc.

Photo 9 Scattering of the roof truss of a wooden house (Sep. 12)

Next, as types of damage to low-rise stores, there were come-off / fall of fittings and exterior walls facing outside, come-off / scattering of eaves ceiling and exterior wall finishing material, scattering of wooden roof truss, etc. There was also a case where it is considered that the eaves ceiling came off and strong wind blew in and damage expanded to the indoor ceiling finishing material.

(2) Damage to Kozushima-mura and Niijima-mura in the Tokyo Oshima Branch Office

Scattering of exterior wall material and roofing material was confirmed with houses, stores, warehouses, etc. Affected buildings include wooden ones, RC and CB structure, and masonry construction with wooden roof. In addition, some windowpanes and art works were broken in the art museum of Niijima-mura.

(2) Damage by the tornado related to the 2019 East Japan Typhoon

As damage to houses, two cases where the upper structure fell down or scattered were confirmed. In both cases, the house aged more than 50 years. As damage other than collapse of super structure, etc., there were damage to the openings and exterior walls, scattering of wooden roof truss, come-off / scattering of tiles, deformation of the fittings facing outside, etc. (Photo 10) There was also a case of damage expansion where the fittings of storm shutters, etc. were damaged by collision of flying objects and the wind blew into the room, although the storm shutters were closed to prepare for approach of the 2019 East Japan Typhoon.

Photo 10 Damage to the roof, openings, etc. of a house (Oct. 15)

2.6 Damage to harbor facilities

NILIM and PARI conducted a field survey on the damage by the 2019 Boso Peninsula Typhoon to the Yokohama Port Honmoku Futo district and Kanazawa district (Fukuura and Sachiura). Both districts are considered to have suffered damage from the high waves. The following describes the situation of damage in each district.

(1) Yokohama Port Honmoku Futo district

The superstructure of the east side revetments in the Yokohama Port Honmoku Futo district collapsed intermittently about 200 m in length. Since all the superstructures collapsed to the inland side, high waves are considered to be the cause (Photo 11). In addition, the container terminal was inundated and part of the fence collapsed. According to the trace of inundation, the inundation depth at the container terminal seemed to have been about 1m.

Photo 11 East side revetments in the Honmoku Futo district (Sep. 14)

(2) Yokohama Port Kanazawa district (Fukuura and Sachiura)

East side revetments of Fukuura and Sachiura in the Yokohama Port Kanazawa district suffered damage, and the superstructure of the revetments collapsed intermittently about 600 m in Fukuura and about 230 m Sachiura. In some area, subsidence of the revetments was also confirmed. Since all the superstructures collapsed to the inland side, high waves are considered to be the cause.

In the back of revetments of Fukuura and Sachiura is an industrial complex, where many plants etc. are located, and the whole area of these industrial complexes were flooded. According to the trace, it seems that sea water flew into the back a maximum of 800 m away from the revetments and that the inundation depth was a maximum of about 2 m near the revetments of Fukuura (Photo 12).

Photo 12 Back of the Fukuura revetments in the Kanazawa district (Sep. 12)

3. Postscript

Disasters caused by the 2019 Boso Peninsula Typhoon are characterized by wide-area damage to buildings, etc. by storm and to facilities by fallen trees, flying objects, etc. Further, the disaster by the 2019 East Japan Typhoon was such an extremely extraordinary and devastating disaster that it was designated as a "specific extraordinary disaster." The Typhoon caused enormous damage to the life and business in the affected areas as well as a large number of victims because water / sediment disaster and wind damage including house collapse occurred simultaneously and frequently in wide area and traffic and life line were widely blocked.

We are going to grasp the actual status of damage and solve technical issues in order to contribute to the restoration of affected facilities and the improvement of safety against disasters by typhoons together with the institutions concerned.

Acknowledgement

In conducting the emergency survey and completing the survey report, we owe much gratitude to the great cooperation extended by the people of the organizations and affected buildings concerned in spite of their busy schedule for disaster response, including MLIT, Tohoku, Kanto, and Hokuriku Regional Development Bureaus, Iwate-ken, Miyagi-ken, Fukushima-ken, Ibaraki-ken, Tochigi-ken, Gunma-ken, Saitama-ken, Chiba-ken, Kanagawa-ken, Niigata-ken, Yamanashi-ken, Nagano-ken, Yokohama-shi, and Ichihara-shi. We sincerely appreciate their cooperation.

Creation of the Guide to Interpretation of Sediment Disasters with Synthetic Aperture Radar (SAR) images

(Research period: FY2017 to FY2019)

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Sabo Department, Sabo Risk-Management Division

key words: Synthetic Aperture Radar (SAR) image, sediment disaster research, image interpretation, disaster response

1. Implementation of joint research

The Sabo Risk-Management Division has been conducting a joint research on development of a sediment disaster monitoring method using Advanced Land Observing Satellite No. 2 "Daichi No. 2" with Japan Aerospace Exploration Agency (JAXA) since FY2017. This research devised a method of identifying promptly the position and area of sediment disaster using the images of Synthetic Aperture Radar ("SAR") observed by "Daichi No. 2." In addition, this method was applied to actual disaster response in the July 2017 Northern Kyushu Heavy Rain and the 2018 Hokkaido Eastern Iburi Earthquake, both of which occurred during the period of this research, and the effectiveness and issues of the joint research were clarified. Based on the research results above, we decided to create a manual describing the sediment disaster interpretation research method using SAR images, aiming for practical use in disaster response by Regional Development Bureaus etc.

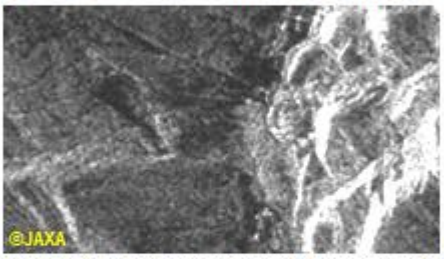
2. Features of the research method

Since the launch of Daichi No. 2 (2014), a large amount of archive images of various sites across Japan has been accumulated. This research enabled intuitive and easy interpretation with eyes using those images, which will not require advanced interpretation technique with single polarized wave SAR images, by visualizing changes before and after the disaster.

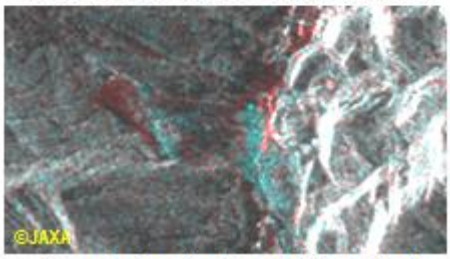
As the Figure shows, the conventional sediment disaster research using SAR images required the interpretation of geographical changes and reservoir area formation due to slope failure with shade of the image (Fig., middle: Technical Note of NILIM No.760). However, this method can indicate changes in the site with color, which enables quick provision of information in taking initial actions to address disasters (Fig. bottom).

This method has also been applied to many large-scale disasters, which are frequent in recent years. Information on the accuracy and characteristics of interpretation, time required for actions, etc. concerning this method, which was obtained from actual use in disaster response, will serve as important data when Regional Development Bureaus etc. consider about practical use of this method. We intend to organize various conditions as well as information on the operation of this method, including difference of characteristics due to the relationship between the Satellite and slope direction, and provide results as a guideline introducing examples for realization of quick and correct initial actions.

Oblique photo of slope collapse
(July 2017 Northern Kyushu Heavy Rain, Hita-shi, Oita)



Interpretation with a single polarized wave SAR image (Technical Note of NILIM No. 760)



Result of application of this method

Fig. Results of visibility improvement by application of this method

3. Preparation of the guideline

The result of this joint study was issued as "Guide to Interpretation of Sediment Disasters with Synthetic Aperture Radar (SAR) Images," Technical Note of NILIM No. 1110.

☞**See the following for details.**

1) Technical Note of NILIM No.1110
2) Civil Engineering Journal, Vol.61, No.12, 2019, pp. 16-19

Development of technologies to renovate facilities to ensure the health and safety of evacuees at evacuation shelters (Study period: FY 2017–2019)

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(Keyword) Evacuation shelter, health, safety, building facility

1. Introduction

Methods to improve the living environment in evacuation shelters need to be developed to prevent mental and health problems and to ensure the safety of evacuees after they experience a massive earthquake followed by a prolonged stay in evacuation shelters. When evacuation shelters are to be installed, individual situations, such as regional characteristics, need to be taken into consideration. Yet, current evacuation shelter guidelines do not necessarily provide sufficient information concerning specific ways to construct and renovate evacuation shelters.

Research and development to counteract this issue has been continuing since FY 2017. This article introduces the outline of the study, the contents to be examined this fiscal year, the direction of drafting a manual to protect health and safety in evacuation shelters, and future prospects.

2. Outline of the study

The purpose of this study is to show specific methods and renovation technologies to provide acceptable toilet and sanitary environments, privacy, and performances related to noise, temperature, and light as the living environment at evacuation shelters.

Three levels of target standards for the living environment, a level that is similar to daily life, a level that is about the same as past evacuation shelters, and a minimum level that will at least prevent serious health problems were organized using the gathered information about technologies for disaster response facilities by taking into consideration the availability of facilities at schools, which are often used as evacuation shelters, as well as the advantages and disadvantages of individual facilities. The study also organized precautions related to capacity, cost, and operation of individual facilities needed to provide shelter functions to satisfy the applicable standards. In organizing the data, the time schedule for the infrastructure and external support are set as shown in Figure 1. The study also considered the range of locations, such as schools, which are used as shelters as shown in Figure 2.

3. Future prospects

The findings will be organized to prepare a draft of a manual for protecting health and safety at evacuation shelters. The draft of the manual will be prepared so that it will become useful by conducting hearings with the officials assigned to evacuation shelters by the local governments. The draft will be released on the website and other media.

When the contents of the drafted manual are reflected in the disaster management manuals of local governments, it is expected to reduce physical and mental health problems while evacuees are staying at the evacuation shelters.

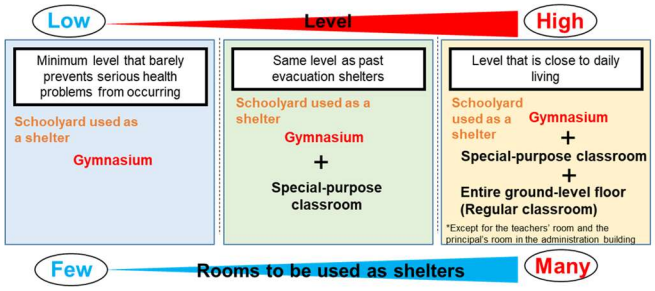

Figure 2: Examination of places, such as schools to be used as shelters depending on evacuation shelter function availability level

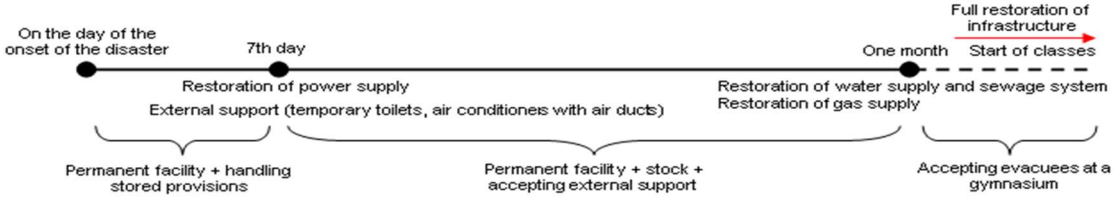

Figure 1: Time schedule of infrastructure and external support

Development of Technology for Detecting Damage by Earthquake from CCTV Camera Images Using AI

(Study period: FY2019)

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key words: AI, CCTV camera, damage grasping, image processing

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") has installed more than 20,000 CCTV (Closed Circuit Television) cameras across the country in order to administer roads and rivers and has been also using them to collect information on the state of damage after occurrence of an earthquake.
In using those cameras, there is an issue, particularly in the event of a major earthquake, that it is a heavy burden for the personnel who address disasters to watch images of a lot of CCTV cameras set in wide area and quickly check whether any damage is on the screen.
In order to solve this issue, NILIM developed a technology ("difference detection") of detecting "variation" that may be damage as a difference from the images before and after earthquakes from FY2014 to FY2018.
Meanwhile, it is found from the study up to now that difference detection has an issue of falsely detecting rain, snow, etc. on the screen as "variation" that may be damage depending on season or weather (Fig. 1).
Then, we studied in the current fiscal year a technology of reducing false detection of difference using AI (Artificial Intelligence).

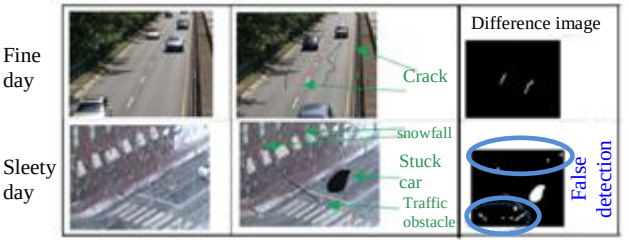

Fig. 1 Example of false detection caused by bad weather

2. Selection of AI algorithm

We studied about a method of conducting image processing with AI before conducting difference detection to reduce false detection in the subsequent difference detection. Since it is difficult to prepare a lot of damage images as teacher data, two algorithms were compared and examined in this study as AI algorithm; "Semantic Segmentation" and "Generative Adversarial Networks ("GAN"), both of which do not require damage images for teacher data.

"Semantic Segmentation" is used to create annotation images to detect "Which section does the input image indicate" using a model in which data created by adding information of such sections as "road" or "river" (hereinafter, "annotation") to images showing a normal state is machine-learned as teacher data.
Fig. 2 shows examples of image in a normal state and annotation image used for teacher data.

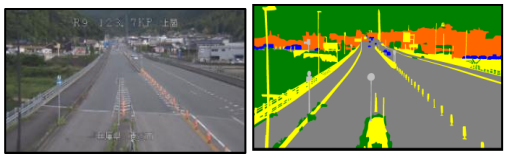

Fig. 2 CCTV camera image in a normal state (left) and annotation image (right)

"GAN" is an algorithm that converts an image similar to a horse, for example, into an image showing characteristics of horses when an image of a zebra is input to the model in which only horse images are machine-learned (Fig. 3). [1)] With application of this algorithm, it may be possible to create an image showing as if the state before suffering damage, where only the state of damage disappeared, leaving the season and weather in a normal state, when damage images are input to a model in which images of various seasons and weathers in a normal state are machine-learned. We attempted to detect only the state of damage by detecting differences between images thus created and input images.

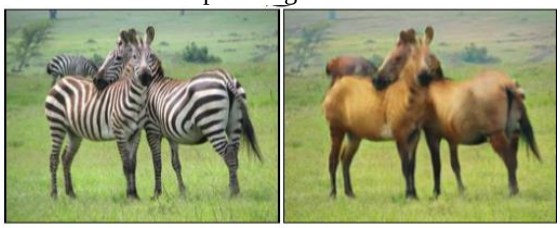

Fig. 3 Example of image generation by GAN Input image (left), Output image (right)

For Semantic Segmentation and GAN, we used a small volume of teacher data (110 images for Semantic Segmentation and 790 images for GAN). Semantic Segmentation showed a tendency of

providing stable annotation images, while images created by GAN were unstable unless a model is created for each CCTV camera. Therefore, we selected Semantic Segmentation for this study and created models and evaluated accuracy.

3. Model building and accuracy evaluation results for Semantic Segmentation

We prepared 500 annotation images to be used as teacher data from still pictures of CCTV cameras for monitoring roads, rivers and wide-area. Of the 500 images, 350 images were used for learning, 75 images, for verification of learning, and 75 images, for testing. For the model that finished learning [3] with an existing data set [2], we built a model (the "Model") that finished deep learning using 350 annotation images for learning and evaluated accuracy of the Model. Fig. 4 shows examples of annotation images created by the Model and Fig. 5 shows the results of accuracy evaluation. Note that an evaluation index called "IoU" for object detection in image recognition was used for accuracy evaluation. IoU is expressed with the following formula (1).

$$\text{IoU} = \frac{\textit{Intersection}}{\textit{Union}} \quad \text{-- (1)}$$

Intersection: A section where the correct answer image is overlapped with the generated image in the same area.
Union: A section occupied with an area of either the correct answer image or the generated image.

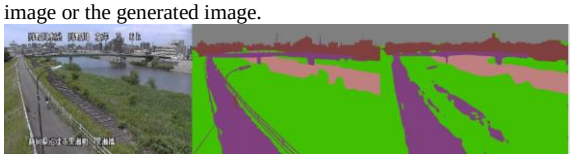

Fig. 4 CCTV camera image in a normal state (left), correct answer annotation image (middle), generated annotation image (right)

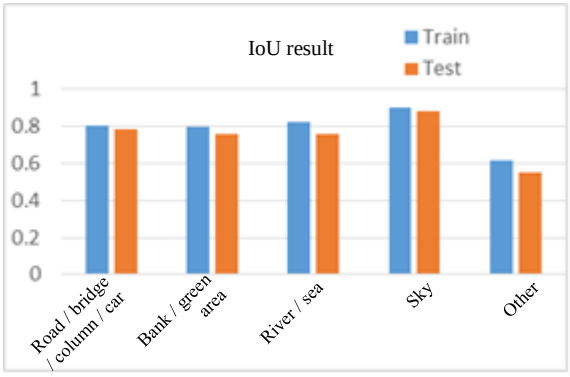

Fig. 5 Results of evaluation by IoU of the built model
Train: Evaluation result of the data for model building
Test: Evaluation result of the data for testing

Various IoUs released for Semantic Segmentation are between 0.8 and 0.9 at maximum. [4] Therefore, in a situation where the volume of learning data is limited to 350 images, results of the accuracy verification for the Model are considered generally reasonable.

4. Technology for reducing false detections using the Model

With the technology for reducing false detections using the Model, it is possible to identify the section where the detected vulnerable area is located because of the automatic generation of annotation images that recognize image sections as preliminary processing of difference detection. By examining the characteristics of damage images in the section, detection of damage points with less false detection is expected.

5. Conclusion

We are going to improve the technology for reducing false detection by verifying its effect using images of snowfall and rainfall and implement measures for supporting disaster response.

☞See the following for details.

1)https://arxiv.org/pdf/1703.10593.pdf
2)http://host.robots.ox.ac.uk/pascal/VOC/
3)https://towardsdatascience.com/deeplabv3-c5c749322ffa
4)https://paperswithcode.com/sota/semantic-segmentation-on-pascal-voc-2012

A Study for Early Restoration of the Road Bridge Damaged by the Earthquake

(Study period: FY2017-)

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key words: Kumamoto Earthquake, a road bridge, recovery

1. Introduction

Kumamoto Earthquake Recovery Division has been providing advanced technical support on the disaster sites for recovery from the damage by the Kumamoto Earthquake and striving for early recovery in close cooperation with the Kumamoto Reconstruction Project Office of Kyushu Regional Development Bureau, which is responsible for the restoration project.
In implementation of the road bridge restoration project, it is necessary to resume the service as early as possible by the bridge that secured both structural safety and smooth road function. In restoration, since the restoration work repairs the bridges that were partially damaged or deformed, it is necessary to demonstrate the effect of repair considering various uncertainties, which are not found in new bridges. Further, from the viewpoints of inspection and diagnosis in maintenance stage after the restoration work or acceleration and reliability improvement of the study in cause investigation when a problem occurs, it is important to collect and properly record / retain information in the process of restoration work for contribution to utilization in the following stage of maintenance.
In order to contribute to early recovery of road bridges damaged by earthquake, this paper reports, focused on the steel bridge damaged by the Kumamoto Earthquake, method of recovery work and verification of the effect of repair, as well as information that contributes to grasping the state of the bridge, etc. if a major earthquake occurs again during the bridge resumes service after recovery and the method of recording and retaining such information.

2. Repair of a steel bridge leaving the damaged spot and verification of repair effect with monitoring

As the damage to the Okirihata Bridge, a steel 5-span continuous non-composite curved plate girder bridge, 265 m in length, the top structure moved on the whole in the direction outside the curve and part of the main girder collapsed. It is particularly characteristic that the damage to the main girder occurred at points other than the supporting point. Above all, relatively major damage, including out-of-plane deformation, occurred to two main girders (G1 girder, G2 girder) outside the curve between P1 and P2.
As a measure to address major damage that occurred

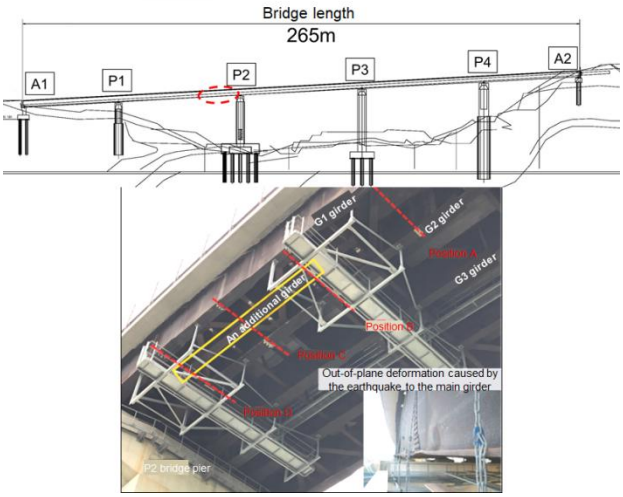

Fig. 1 Additional girder installed in restoration of the Okirihata Bridge

to the main girder at a point other than the supporting point, it is generally considered to remove or reconstruct the whole main girder or damaged part. In this paper, however, a main girder ("additional girder") cross-sectional rigidity enough to supplement the load bearing capacity of the main girder, which was lowered by the damage, was installed (Fig. 1), while strategically leaving the greatly damaged main girder, considering mainly that at least the load bearing capacity enough to support the weight of floor slab etc. is kept since no damage or deformation is increasing after the earthquake and that there is uncertainty in the extent of effect of the stress remaining in the component on other components when the main girder is removed.
In such repair work where a girder is added leaving the damaged parts, there are some uncertainties that are not found in new construction, such as diagnosis of residual stress, and it is important to secure the reliability of diagnosis on the state of components. Then, in this study, we verified whether the additional girder shows the tendency of sharing load as expected in design by monitoring stress variations from changes in the strain during jack-down after the girder was added.
Considering that the actual state the damaged part is between the state of functioning as the state of not

functioning as a resistance cross section, we compared results of two analyses for monitoring results --- one is where the damaged part also functions as a resistance cross section (not damaged) and the other is where it does not function (damaged). As Fig. 2 shows, it was found from the results of comparison that the additional girder is functioning as a resistance cross section expected in the design since the measured values of stress variations were between the values of two analyses in an expected range.

3. Utilization of BIM/CIM models in maintenance

In the bridge of which restoration work was completed, there remain some uncertainties that are difficult to consider in the phase of repair design or construction for restoration, such as decline in load bearing capacity due to temporal variation of the repair effect. For such uncertainties, it is effective to properly identify the damage caused by the earthquake to components, repair method for the damage, and information to be needed in securing the durable performance of the relevant repair method from the information to be obtained in the restoration work and record and retain the obtained data so that mutual relationship of data is made clear.

Then, we studied, focused on the Okirihata Bridge, for which repair work was implemented as stated above, what information should be kept and in what form considering utilization in future maintenance, and then visualized data obtained by utilization of CIM in a three-dimensional form.

First, based on the existing two-dimensional structural general drawing, we created a three-dimensional model of the whole structure with detailed degree of 300 [1)], which accurately represents the outer shape.

Next, we created a model for additional components, including additional girder, additional cross frame, and remaining temporary cross girder, installed when supporting the bent (Fig. 3). Note that additional components are indicated with colors so that difference from existing components is easily recognized.

In contrast, for the spots where damage to the main girder is left behind, the positions of such spots were only marked and, as attribute information of such marking, a link was set to the photograph showing the state of damage. This is because we considered that it is reasonable to confirm the three-dimensional shape of damage with eyes and it is unnecessary to create a model. In addition, only positions were indicated for the joint of girders and a link was set for details to the PDF of the relevant drawing as attribute information. This is because we considered that it is effective to create a model for joint positions to grasp the state of components but it is unnecessary to create a model for bolt shapes.

Further, for the hollow P2 bridge pier with a perforated crack, we filled concrete into the base of the hollow part and added up the thickness and piles,

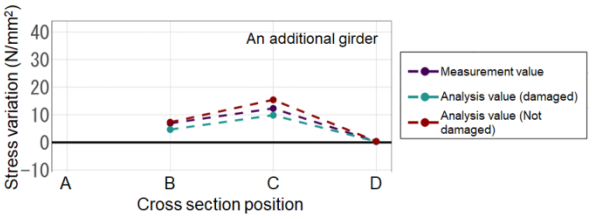

Fig. 2 Stress variation in jack-down of the additional girder

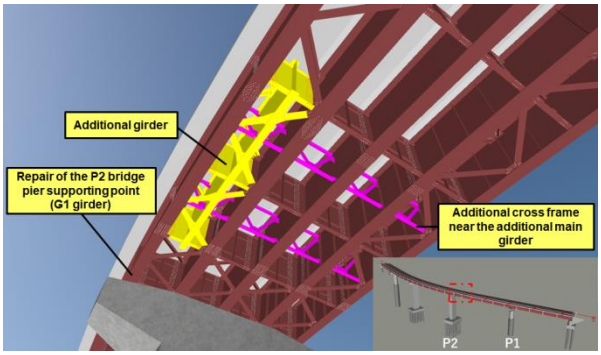

Fig. 3 Three-dimensional model of the Okirihata Bridge (near the additional girder)

and created a three-dimensional model for to visualize the positions where perforated cracks occurred and the range of filling concrete because they will be invisible upon completion of the restoration work. For the width, depth, etc. of cracks, the data was kept only as attribute information.

As stated, we are classifying information into those for which recording and retention after visualizing with a three-dimensional model considering utilization in future maintenance and into those for which recording and retention as attribute information are reasonable.

4. Future prospects

In fiscal 2019, the third year of agency under the State's direct authorization, the Tawarayama Tunnel route of the prefectural road was fully opened. [2)] We continue to address the restoration of the Great Aso Bridge on National highway No. 325 and the existing road on National highway No. 57.

☞See the following for details.

1) Ministry of Land, Infrastructure, Transport and Tourism (MLIT): CIM Introduction Guideline (Draft), Part 5: Road Bridge, May 2019
http://www.mlit.go.jp/tec/it/pdf/guide05.pdf
2) Civil Engineering Journal, Vol. 61, No. 11, pp.48-49, 2019

Research of pedestrian flow observation method using Wi-Fi packet sensor

(Study period: FY 2018–)

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(Keywords) Pedestrian flow rate, pedestrian flow, pedestrian movement observation, Wi-Fi, central area of a city

1. Introduction

To create comfortable spaces in the central areas of cities so that people will feel like walking, the spatial structure of roads and roadside facilities is reevaluated, and the utilization of urban facilities is being examined with the cooperation of organizations and groups related to roadside spaces. When conducting these activities, it becomes important to propose plans based on data, such as traffic volume and the conditions of flow and to evaluate the outcomes of conducting the activities. New methods that use data from mobile phone base stations, data from images captured by mobile phone cameras, and GPS data have attracted attention over the past few years as methods of observing pedestrian movement. This study focuses on Wi-Fi packet sensors that can relatively easily obtain data at low cost and verifies the usability of such sensors.

2. Outline of Wi-Fi packet sensor

Terminal devices, such as mobile phones with Wi-Fi functions, emit radio waves (probe request) to connect to routers etc. The probe request contains information, such as the ID of the terminal device. Sensors can identify the movement of pedestrians carrying the device by obtaining this information.

3. Application of Wi-Fi packet sensor

In this study, sensors were used in the central part of Kawagoe City, an area crowded with tourists, and pedestrian movement was identified. The flow of pedestrians moving around various areas can be identified by using ID information obtained from sensors. Figure 1 shows one of the examples. At the same time, the number of people remaining within a section divided by two sensors can also be identified. The data of people remaining within an area are compared with the data of actually measured values by conducting manual traffic counting by actual persons. As a result, the study found a certain correlation between the two, although some differences were seen depending on the locations of the observation. Meanwhile, the study found large differences in the magnification ratio (ratio compared to actually measured values) depending on the location and time zone. (Figure 2) A possible cause was that the sensor installation environment may have affected the outcome.

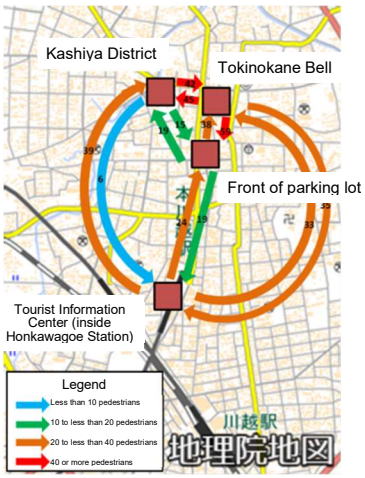

Figure 1: Movement status

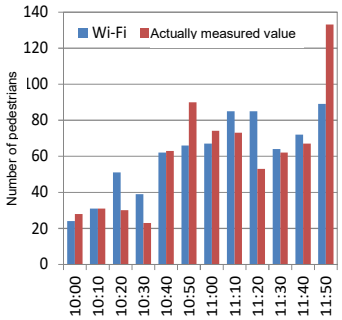

Figure 2: Comparison with actually measured values

4. Future studies

One of the great characteristics of Wi-Fi packet sensors is that they can identify pedestrian flows in underground spaces and inside buildings. Cities have many facilities, such as underground passages, that pedestrians use. Thus, Wi-Fi sensors are expected to be usable in many locations. Future observations will include ones in underground passages to focus on identifying the unique characteristics of underground spaces.

Research on Systems for Promoting New Technology Introduction in Singapore

(Research period: FY2018 to FY2019)
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key words:　Singapore, i-Construction, productivity improvement

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") is promoting i-Construction to improve labor productivity in work on construction sites using new technologies and advance quality control, etc. In order to introduce such new technologies to construction sites, it is required to take actions according to technologies in terms of systems, such as revision of technical standards, and support to enterprises.

There are some overseas examples where the country is already addressing productivity improvement by introducing new technologies etc. or promoting labor saving on construction sites. Of such countries, Singapore is particularly addressing productivity improvement in construction sites by introducing actively BIM (Building Information Modeling) and new technologies under the government's initiative. Then, we conducted a hearing, in addition to bibliographic survey, about the construction industry of Singapore from the BCA（Building and Construction Authority), which is responsible for construction administration of Singapore, and from Japanese enterprises receiving building and construction orders in Singapore. Then, we organized the results in terms of measures taken in the phases of (1) Employment of skilled workers (who engage in direct operation of construction), (2) Introduction of new technologies, and (3) Receipt of orders for construction work.

2. Measures in the construction industry of Singapore

(1) Employment of skilled workers and technical improvement

Construction sites in Singapore are characteristic in that skilled workers are mostly foreigners. Their working force had supported the high-growth era of Singapore, but the Singapore government is now advancing the measures to reduce foreign workers since the country has already entered the age of economic maturity.

In February 2010, the Economic Strategy Council, which is an inter-departmental organization across the Singapore government's ministries and agencies, proposed that excessive dependence on foreign workers should be avoided because it will inhibit enterprises from making investments for productivity improvement. Following this proposal, measures to maintain and improve the productivity of construction sites have been implemented by actively promoting the introduction of new technologies. Accordingly, management of the number of skilled workers would be closely related to measures for productivity improvement in Singapore.

According to the hearing from enterprises and BCA's employees, there is no limitation in employing domestic workers for construction sites in Singapore, but domestic workers rarely work on construction sites. As a result, foreign skilled workers will be employed and they need to obtain a work visa for employment. Work visas are distributed to the contractor of construction work in the number determined according to the size of construction site. Since the number of work visas to be issued is decreasing year by year, construction contractors are increasingly required to introduce new technologies, etc. in order to perform construction work with such a limited number of workers.

As a base for calculating the number of work visas to be issued, there is a daily construction report to be submitted to the MOM (Ministry of Manpower), a government organization. In public works, use of biometric authentication is required in order to control access to construction sites (Fig.), and “the number of

Fig.: Construction site access control by biometric authentication

workers employed in the work for construction of one square meter area on the site” is calculated based on the monthly number of skilled workers who accessed the site, which is recorded in the daily report, and the

area actually constructed. Based on such data of past works, the number of work visas to be issued for subsequent works is determined.
In addition, measures for obtaining a high quality workforce have been implemented in Singapore. BCA has opened a technical center in the surrounding countries for skilled workers there who aim to be employed in Singapore in order to support them in acquiring qualifications and skills. BCA also encourages foreign workers in Singapore to acquire further qualifications and skills by conducting training etc. at its facility called "BCA Academy."
Further, BCA recommends employment of multi-skilled workers to enterprises by reducing the tax to be imposed on employment of skilled workers with multiple qualifications ("multi-skilled workers") rather than skilled workers with a single qualification ("single skilled worker").
According to the hearing from enterprises, employment of multi-skilled workers is also advantageous to them because it is expected to shorten the construction period by reducing the waiting time of skilled workers on construction sites.

(2) Measures for promoting new technology introduction

1) Sand box

As a method of considering introduction of new technologies, there is a technique called "sand box." This method allows a technology that is not yet standardized to be used in the proposed site on a trial basis and has been more actively used in Singapore than in Japan. Results of trial use, including success or failure, are accumulated in the government and fed back to subsequent construction works.
Implementation of this method in an early cycle is considered to be promoting the introduction of new technologies in Singapore.

2) Design / construction evaluation by Score System

Singapore has a system of Buildable Design Score (B-Score), which digitizes and evaluates the ease of construction, etc. in designing buildings, and a system of Constructability Score (C-Score), which digitizes and evaluates the constructability in construction work. To these Scores, points are added according to adoption of technologies designated by BCA, such as measures for improving constructability and considerations for technologies, equipment, and safety. As this Score becomes higher, building design is evaluated safer and easier and constructability of the site is evaluated higher.
In addition, required minimum points have been determined according to the size of construction site and types of buildings (school, commercial facility, etc.) and required points need to be satisfied under the responsibility of designer for B-Score and builder for C-Score.
Further, since each Score is used as evaluation items in bidding for construction work to be described below, the contractors are supposed to actively adopt new technologies etc.

Table: Distribution of evaluation by PQM system

	Building	Civil engineering
Price	30～50 %	40～60 %
Productivity	10 %	10 %
Quality	60～40 %	50～30 %

3) From PCa to PPVC

In Singapore, PCa (precast concrete) technology is normally used. In recent years, BCA has been actively recommending the use of the building method called "PPVC (Prefabricated Prefinished Volumetric Construction)," which builds up prefabricated units completed up to interior at a certain level. With adoption of this method, the technology is expected to greatly reduce the construction period and improve safety due mainly to decrease in work at dangerous spots.

(3) Evaluation system in construction bidding

In Singapore, contractors are decided based on the results of total evaluation in bidding for construction work, and it is characteristic that the evaluation items include "Productivity" in addition to "Price" and "Quality" (see Table). In this item of productivity, results of past construction works indicated with the index calculated based on the aforementioned Scores, introduction of technologies such as BIM by the enterprise, and measures for workforce development (education) are evaluated.

3. Conclusion

With the findings obtained from this research, we are going to contribute to promotion of i-Construction in Japan by organizing and studying information in other countries.

Promotion of Global Warming Countermeasures in Sewerage

(Study period: FY2017 to FY2019)

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key words: sewerage, global warming, nitrous oxide

1. Introduction

As global warming countermeasures, the NILIM has been studying actual emissions and the grasp of emission factors concerning nitrous oxide (N_2O), one of the greenhouse gases ("GHG") emitted from sewerage. This paper describes the results of survey on actual emissions.

2. Survey of N_2O emissions in sewage treatment facilities

It is known that N_2O, a strong greenhouse gas, is generated as by-product or intermediate product in the biological treatment process of sewage treatment facilities. We have surveyed N_2O generation in various sewage treatment facilities and accumulated data. As the result, it was observed that N_2O emissions greatly differ according to treatment methods and that N_2O emissions are larger than other treatment methods in the aerobic tank of conventional activated sludge process.[1)] In the survey of last fiscal year, N_2O emissions were examined every 4 hours in the autumn and winter with regard to the pseudo-anaerobic-aerobic activated sludge process. As a result, the difference of N_2O emissions in the autumn and winter was confirmed.[2)] For this fiscal year, sampling surveys were conducted in the spring and summer in the same treatment facility as in the last fiscal year in consideration of the results of last year.

The Figures show the results of measurement of each form of nitrogen concentration and dissolved organic concentration (DOC) at the time of sampling. Removal of the dissolved organic is achieved throughout the year. Meanwhile, in the nitrification process of "ammonia → nitrous acid → nitric acid," there was residual ammonia in the winter and ammonia form was mostly seen in the spring. In the summer, oxidation of ammonia proceeded, but incompletely, and accumulation of nitrous acid was observed.

From the results of N_2O concentration measurement conducted at the time of sampling, N_2O generation per treatment quantity in the autumn, winter, spring, and summer was 54, 38, 101 and 11977 mg-N_2O/m^3, respectively. Accumulation of nitrous acid in the summer is one of the factors of the increase in N_2O generation and the cause of nitrous acid accumulation would be attributable to the failure of reaching the microbial flora appropriate for nitrification at the beginning of nitrification.

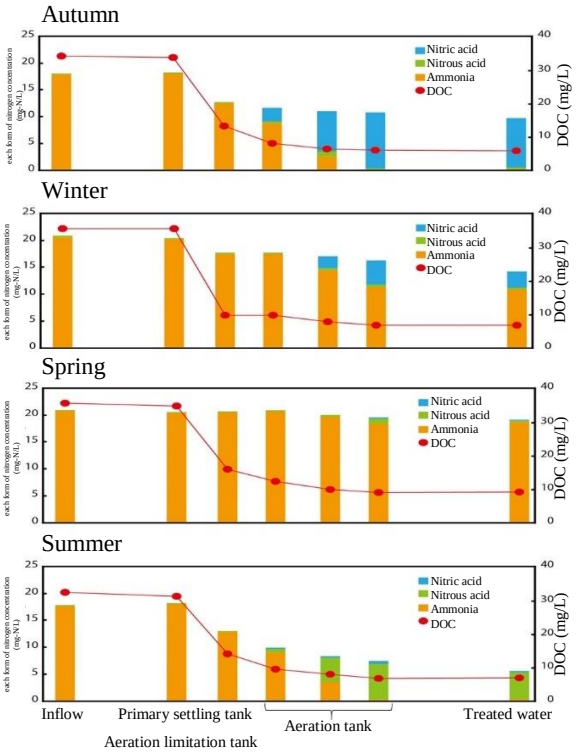

Figure: Each form of nitrogen concentration and dissolved organic concentration

3. Future development

We intend to verify the reproducibility of the cycle of annual changes in microbial flora by obtaining further data, clarify the conditions for retaining microbial flora appropriate for N_2O generation control from the relationship between the microbe involved in nitrification in the reaction tank and the amount of N_2O generation, and thereby propose an operating method with N_2O generation control.

☞Reference material is here.

1) NILIM Report 2018
2) NILIM Report 2019
http://www.nilim.go.jp/lab/bcg/siryou/report.html

Introduction of Image Recognition Type Traffic Count using AI

(Study period: FY2018-)
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Road Traffic Department, Road Division

key words: traffic survey, AI, CCTV

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") is studying a constant observation system with full utilization of ICT, aiming to shift from the conventional Road Traffic Census to be conducted every five years to a new road traffic survey system to be conducted regardless of whether at ordinary times or at the time of disaster.

As one of the efforts for establishment of such a constant observation system, NILIM conducted a study for practical use of traffic count by image recognition using Artificial intelligence (AI) ("AI traffic count") (Fig. 1) based on the images of monitoring cameras (CCTV) for road management, which enable use of existing equipment and are expected to be applied to observation of pedestrians etc. other than vehicles, and created the equipment specifications of the observation system (draft).

Introduction of AI traffic count is expected to increase the constant observation sections of national highways under direct control, which account for about 20% of all highways and where only traffic counters ("TC") are used for observation, to about 50% at maximum.

This paper reports results of the hearing about AI traffic counting technology, results of observation accuracy verification using sample images, and equipment specifications (draft).

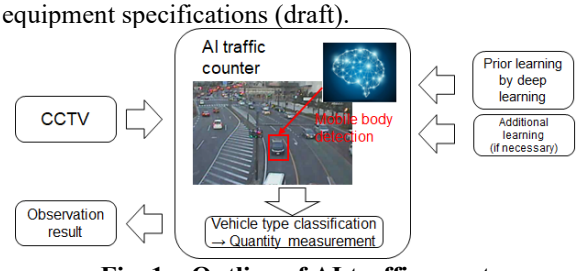

Fig. 1 Outline of AI traffic count

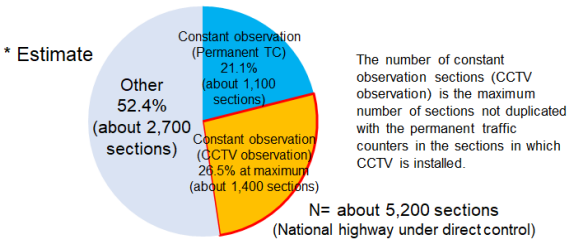

Fig. 2 Improvement of the constant observation cover ratio (national highways under direct control)

2. Results of the hearing about AI traffic counting technology

In order to create equipment specifications (draft) of AI traffic counter, we conducted a hearing survey from nine domestic private companies engaged in technical development of AI image recognition about technical requirements, including the number of lanes that can be observed, and performance requirements, including observation accuracy. Table 1 outlines the survey results.

It was found from the hearing that types of vehicles (large / small) and pedestrians can be generally observed with the present technology but that there are still issues in observation of two-wheel vehicles (bicycle, motorcycle). As response to the question of observation accuracy, they answered that it is possible to secure the accuracy in the daytime but difficult in the dark time zones including evening and night.

Other answers referred to the necessity of additional learning for each camera in order to secure the accuracy and to the effect of flare (image whitened by headlight) and occlusion (target vehicle cannot be identified due to overlap of vehicles).

Table 1 Results of the hearing about AI traffic counting technology (9 companies)

Item		Results of response
Number of lanes that can be observed		4 lanes or more: 7/9 companies
Vehicle type classification		2 types (small / large): 8/9 companies
Observation of pedestrians		Possible: 7/9 companies
Observation of two-wheel vehicles		Possible to observe / identify: 5/9 companies
Observation accuracy (Answer in the hearing / After additional learning	Daytime	Possible to secure the accuracy of 90% or more: 8/9 companies
	Night (with road illumination)	Possible to secure the accuracy of 90% or more: 6/9 companies
	Night (No road illumination)	Possible to secure the accuracy of 80% or more: 1/9 companies
AI additional learning for each image		Not required: 3/9 companies (including no provision of additional learning function)
Matters affecting accuracy		Flare due to direct projection of light to the camera lens - Shielding of measurement objects due to occlusion

3. Results of observation accuracy verification with sample images

We conducted AI observation to verify the accuracy of observation using sample images of CCTV and the technologies of 6 companies out of the hearing

respondents (Photo 1). The sample videos were taken for a total of 8 hours at two points, 4-hour time zone for each. Video images include those taken in a situation where securing the accuracy is difficult, including flare by headlight.

Fig. 3 shows the results of observation accuracy verification for all types of vehicles (conducted by 6 companies) and for only large vehicles (conducted by 4 companies). Note that additional learning was conducted for companies C and F out of the 6 companies using other images at sample points. As compared with the detection rate of all the types of vehicles, observation accuracy error in each time zone of morning and afternoon was within ±10% in 5 out of 6 companies at point 1 and in 4 out of 6 companies at point 2, which shows that sufficient accuracy was obtained from a high percentage of the companies.

On the other hand, securing the accuracy was difficult in each time zone of evening and night, resulting in a low ratio --- 3 out of 6 companies at point 1 and 2 out of 6 companies at point 2. Additionally, improvement in observation accuracy was found after learning in two companies for which additional learning was conducted.

Photo 1 Example of AI traffic counting technology

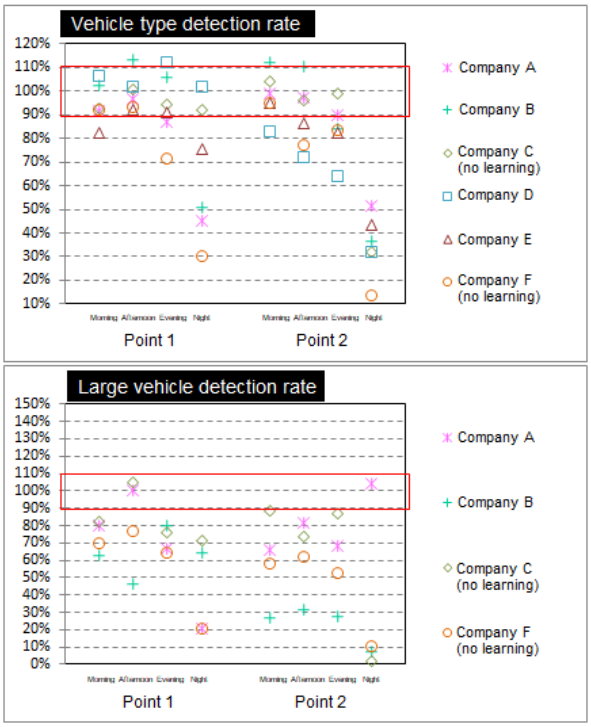

Fig. 3 Observation accuracy with sample image

For the observation accuracy of only large vehicles, observation accuracy was mostly not secured in all the companies, but improvement in accuracy was found by additional learning.

4. Equipment specifications of AI traffic counter

Table 2 shows the equipment specifications of observation device (draft) for AI traffic count, created based on the hearing results and the verification results of observation accuracy with sample images.

Table 2 Outline of the equipment specifications (draft) of AI traffic counter

Item	Specifications
Number of target lanes	4 lanes or less
Observation accuracy	Car traffic according to inbound and outbound lanes is within ±10% in the daytime (7:00-16:00
Vehicle type classification	Small car, large car (bus, truck), pedestrian, bicycle, motorcycle (No accuracy is required)

The number of lanes for observation was limited to four lanes or less. For observation accuracy, we chose to secure the observation accuracy only the daytime from 7:00 to 16:00 because it was found difficult to secure the accuracy in evening and night time zones from the results of hearing and verification. For vehicle types, we chose to obtain the observation accuracy of ±10% only for the traffic of all the vehicle types because difficulty of identifying large vehicles was expected from the verification results. However, instead of seeking accuracy, we determined as specifications that classification of small vehicles, large vehicles (bus, truck), bicycles, and motorcycles is possible, expecting for utilization in the future.

5. Conclusion

In this study, we organized the status of AI traffic count and issues in introduction, and created equipment specifications (draft). Based on these specifications, each Regional Development Bureau is advancing the introduction of AI traffic counter.

As future challenges, we need to improve the accuracy for time zones of evening and night as well as classification of vehicle types, for which securing the accuracy is difficult, and consider an approach with correction.

☞See the following for details.

1) Equipment specifications (draft) of the image recognition type traffic counter (June 2019)
http://www.mlit.go.jp/tec/it/denki/kikisiyou/touitusiyou_18gazoutorakanR0106.pdf

Development of Strong Motion Monitoring System

(Study period: FY2017 to FY2019)
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key words: seismic behavior observation, wireless communication, MEMS accelerometer

1. Introduction

NILIM has been observing seismic behavior since 1958 for the purpose of rationalizing / upgrading seismic design standards and analyzing seismic behavior for civil engineering structures. Conventionally, about three spots per structure have been observed for the reason of cost, etc. In addition, the validity of seismic design method has been comprehensively verified in light of the state of damage in the event of an earthquake based on the analysis of seismic behavior of structures with the observation record obtained. However, assuming development of new structure forms, etc., it would be necessary to grasp accurately the damping characteristic of each component, etc. and the relationship with the behavior of the whole structure. Accordingly, multiple spots need to be observed for each structure.

In recent years, in response to the development of small and inexpensive measuring devices, such as MEMS (Micro Electro Mechanical Systems) accelerometer, and advancement of wireless communication technology, it is expected to be able to observe a single structure at multiple spots and at low cost. For such new technologies, however, verification in terms of practical use was insufficient, such as communication technology for use in the outdoors and securing of power supply. Although the seismic behavior of structures is widely observed, there are not so many cases where MEMS accelerometer or wireless communication technology is used outdoors. Hence, NILIM has verified the applicability of such new technologies and constructing a system ("Strong Motion Monitoring System") that is able to observe easily the behavior of the whole system of structure by observing multiple spots of a single structure using new technologies.

2. Outline of the observation system

Fig. 1 shows the outline of Strong Motion Monitoring System. The record of observation with the accelerometer installed on the bridge is collected into the on-site receiver in wireless communication as real-time continuous record, and transmitted from the receiver to the server of the monitoring system. In the server, the behavior of bridge, etc. is calculated with the obtained record, and the results of calculation can be confirmed by accessing the server from the office PC.

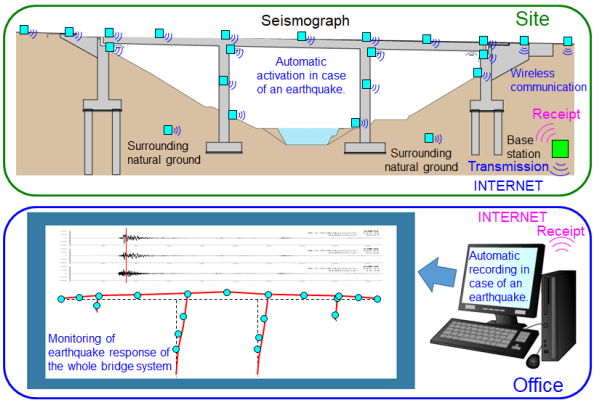

Fig.1 Outline of the Strong Motion Monitoring System

In order to verify the usefulness of the Strong Motion Monitoring System, NILIM installed an MEMS accelerometer on a trial basis on an elevated bridge in Ibaraki-ken.

Since the Strong Motion Monitoring System established in this study can collect observation record in wireless communication, it is not necessary to design or install cables, etc. Further, the sensor is smaller and can be installed with a magnet or adhesive using the inspection passage, which will make installation work easier. Each accelerometer that constitutes the Strong Motion Monitoring System is powered by a battery, and it is easy to secure electricity in the outdoors.

3. Performance verification

The following was confirmed as the result of installing an MEMS accelerometer on the bridge and conducting verification based on the record obtained through wireless communication for which FM communication module is used, from which long-distance communication with power saving is expected.

- As a result of installing multiple accelerometers on the bridge and comparing the observed earthquake records, the records obtained from the main girder lower flange, bridge pier / bridge seat, and the footing top face had different characteristics respectively, and the complex behavior of each part of the bridge in case of an earthquake was confirmed.
- The MEMS accelerometer showed a shape of spectrum that is almost the same as the record of the seismograph (servo seismograph) that has been conventionally used for observation (Fig. 2), so that it

was confirmed that observation with MEMS accelerometer is equivalent to the conventional

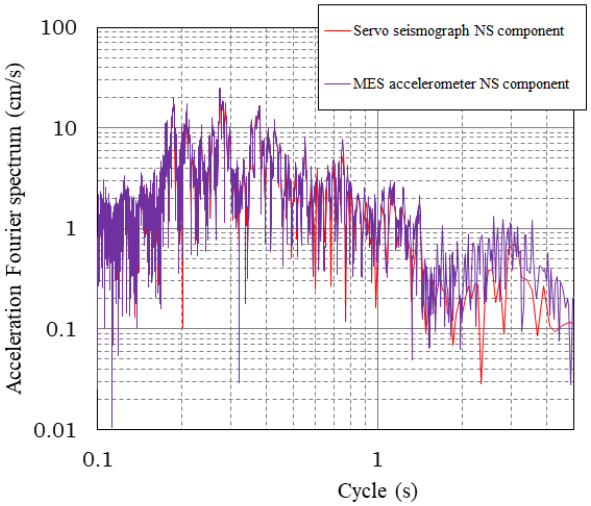

Fig. 2 Comparison of servo seismograph and MEMS accelerometer

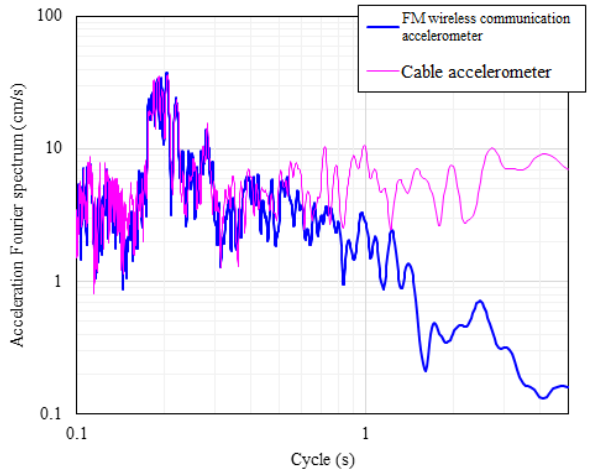

Fig. 3 Comparison of observation records by wireless communication and cable communication

observation.

- The observation record by FM wireless com munication included some inaccurate data in a longer cycle due to data compression in transmission, but the characteristics necessary for observation of the seismic behavior of bridge, including peak value, were the same (Fig. 3). The peak value was almost equivalent even in a longer cycle after improvement of the data compression.
- We confirmed that observation record can be transmitted even when at least 100 m away by changing the communication module of FM wireless communication to Sub-GHz zone. In addition, the distance of wireless communication was shortened by adding the function of transmitting and receiving observation record in wireless transmission to each accelerometer and relaying transmission using them, without transmitting observation record from each accelerometer to the receiver. As the result, stability of communication improved.

Fig. 4 shows the configuration diagram of the Strong Motion Monitoring System built in this study. Fig. 5

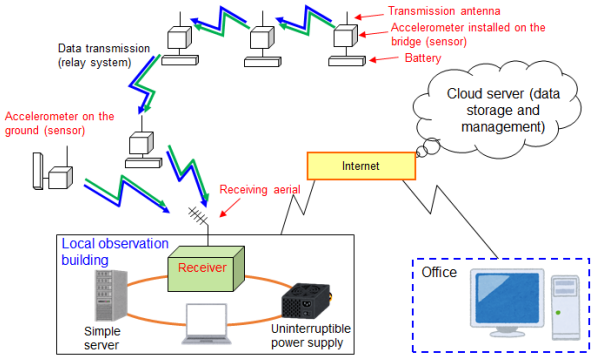

Fig. 4 Strong Motion Monitoring System Configuration Diagram

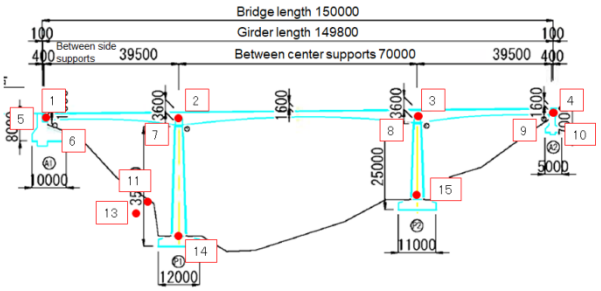

Fig. 5 Example of Strong Motion Monitoring System installation

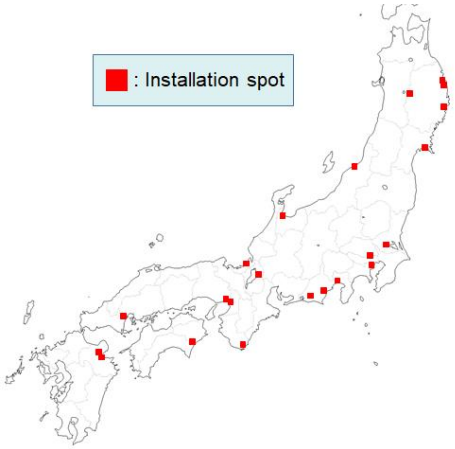

Fig. 6 Installation points (Tohoku to Kyushu Regions)

shows an example of installation of the Strong Motion Monitoring System. In fiscal 2019, Strong Motion Monitoring Systems were installed on some bridges in area from the Tohoku to Kyushu Regions as shown in Fig. 6.

4. Future schedule

We intend to analyze of the seismic behavior record of various types of bridges in the country to be obtained from the Strong Motion Monitoring System and verify the seismic behavior of bridges. In addition to Strong Motion Monitoring, we are also going to verify the "immediate damage detection function," which detects the state of damage from observation results in the event of a strong earthquake or damage.

Improvement of future population and household forecast tool by reflecting user needs and future outlook

(Study period: FY 2019–)

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Urban Planning Department, Urban Development Division

(Keywords) Future population and household, forecast tool, user needs, improvement, compact city development

1. Introduction

In January 2017, the NILIM released a future population and household forecast tool (hereinafter "the tool") that could forecast the number in a population by five-year age groups and genders and the number of households by unit of individual blocks and sections while conventional tools were only able to forecast the population and households in units of municipalities.[1] Many people are now using the tool. This tool has gone through improvements to reflect user needs. As a result of the improvement, Version 2 (2015 National Census Edition) was released in July 2018 with improvements, such as the latest population forecast function based on the 2015 National Census.[2-3] This article introduces the details of the main improvements implemented in FY 2019, the usage status, and the future outlook.

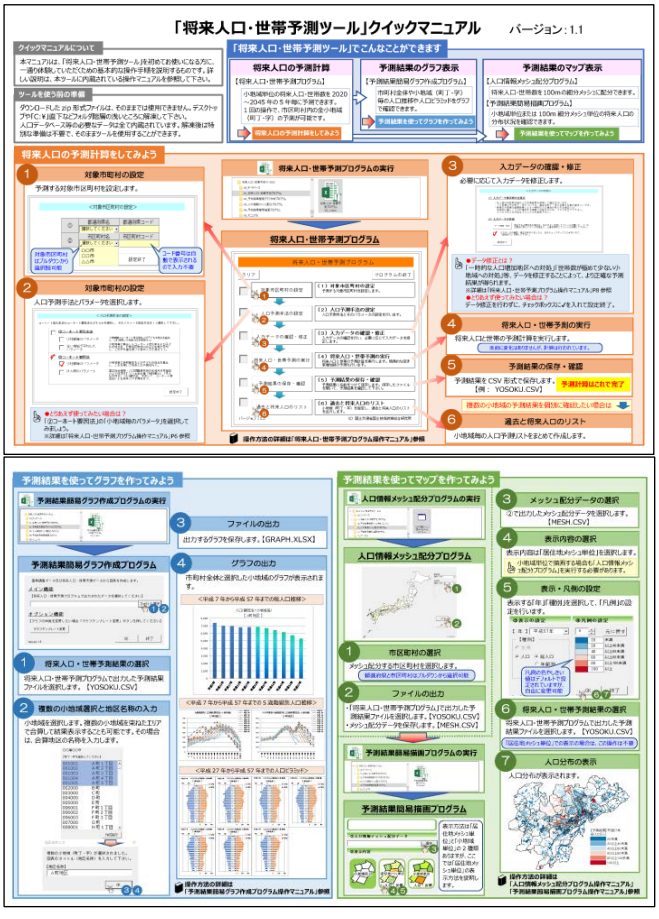

Figure 1: Quick Manual for Future Population and Household Forecast Tool

2. Main improvements to this tool conducted in FY 2019

1) Preparation of quick manual (August 2019)

This tool consists of the following programs: the future population and household forecast program - the main function that performs forecast computations and sub-functions that perform the mesh arrangement of forecasts and display graphs and maps, including the simplified forecast graphing program, the population information mesh arrangement program, and the simplified forecast drawing program. Manuals providing detailed guides to the operation procedures are available for individual programs. Still, many users have commented that reading multiple manuals was such a burden for first-time users. Thus, the *Quick Manual for Future Production and Forecast Tool* was created and released. The *Quick Manual* describes the basic operation procedures so that first-time users can quickly have hands-on experience with the tool.[3] This two-page, A3 size *Quick Manual* describes the flow from setting the target municipality and forecast computation to outputting the forecast as graphs and maps using images of operation screens so that users can visually and instinctively understand the procedure (Figure 1).

2) Addition of the number of households forecast computation function (October 2019)

Many users have requested the addition of the number of households forecast computation function. At the time when Version 2 was released, however, the improvement could not be made because the data on the headship rate by gender of the householder, five-year age group, and family category based on the 2015 National Census by the National Institute of Population and Social Security

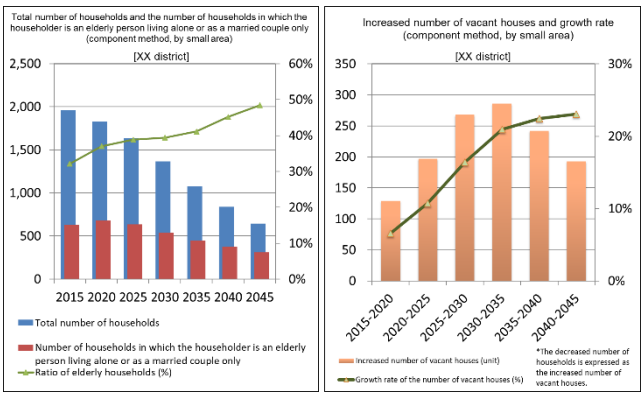

Figure 2: Image of the output of the number of household forecast as a graph

Research were not yet available.

Now that the data are available, an improvement was made to add a function to forecast and compute the number of household, etc. (Figure 2).

3. The tool usage status

According to the data provided by the Geospatial Information Center that released this tool, the total number of accesses to this tool was about 4,000 per month, and the total number of downloads has been about 200 to 400 per month. Immediately after the release of Version 2 in August 2018, the accesses reached about 19,000 per month and downloads about 1,200 per month (Figures 3 and 4). The profile of download users is as follows: private businesses (54.6%) - mainly urban planning consulting firms; municipalities (17.0%); and universities and colleges of technology (11.4%) (Figure 5).

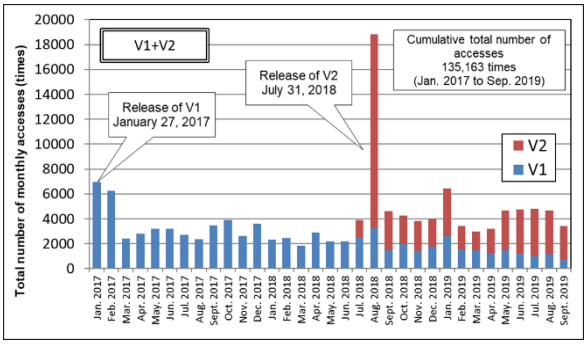

Figure 3: Total number of accesses (created based on data provided by Geospatial Information Center)

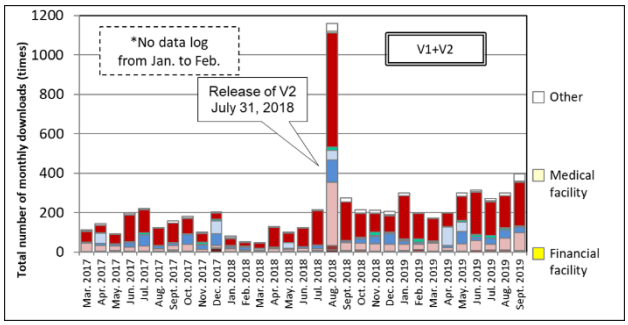

Figure 4: Total number of downloads by user type (created based on data provided by the Geospatial Information Center)

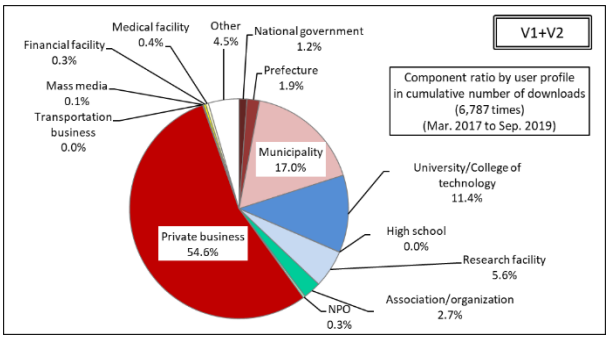

Figure 5: Cumulative total number of downloads by user type (created based on data provided by the Geospatial Information Center)

According to comments received from users, they seem to be using the tool mainly for the examination of urban spatial planning, such as optimal location planning and regional public transportation network planning, as well as to forecast demands in the field of welfare, medical care, education, and crime control.

4. Future prospects

This tool is going to go through continuous improvements based on user needs. Also, other tools, such as a forecast program to support proper allocation of medical care and welfare facilities[4] (Figure 6), which is interlinked with the forecast computation outcome of this tool to support the proper allocation management of medical care and welfare facilities, will be released when they become available for social applications.

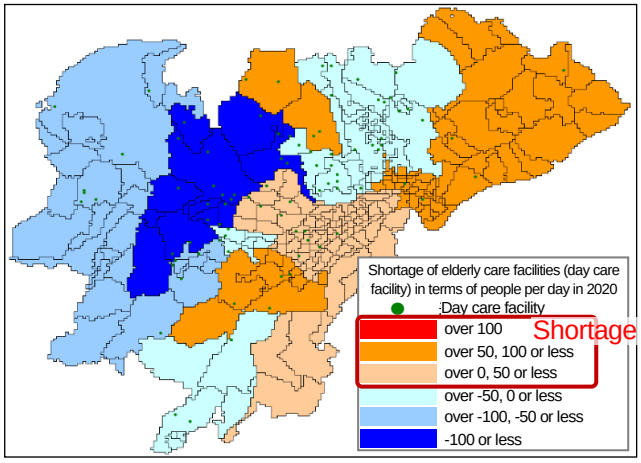

Figure 6: Example of forecasting the shortage of elderly care facilities (day care facility) using the forecast program to support the proper allocation of regional residence support functions

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☞For more information:

1) NILIM Press Release “Development of a district-level future population forecast tool - To promote compact city development by forecasting the future of a city”
http://www.nilim.go.jp/lab/bcg/kisya/journal/kisya20170127-2.pdf

2) NILIM Press Release “Future population forecasting based on the latest national census is now possible - The improved version of district-level future population forecast tool-”
http://www.nilim.go.jp/lab/bcg/kisya/journal/kisya20180731.pdf

3) Geospatial Information Center “Future population and household forecast tool V. 2 (2015 National Census edition” download webpage)
https://www.geospatial.jp/ckan/dataset/cohort-v2

4) Project Research Report of NILIM #62: “Development of strategic stock management technology for regional safety and stability functions” -Edition IV Development of method for forecasting the amount of regional residential support functions needed in a region in the future and to forecast proper allocation of these facilities
http://www.nilim.go.jp/lab/bcg/siryou/kpr/prn0062.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 own strengths and weaknesses." Some examples of such cooperation are introduced as follows.

2. Examples of coordination / cooperation with administrative organs concerned

NILIM conducts many researches with project cost budget etc. that directly lead to policy development in cooperation with the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), etc. As examples that constitute a particularly large-scale research subject, there are comprehensive technical development project (comprehensive project) and administration cost itemized budget. Of the important research subjects concerning construction technologies, comprehensive projects address particularly urgent subjects covering wide target areas and conduct researches comprehensively and systematically in cooperation of industry, university and government under the leadership of administration departments in promoting projects. Administration cost itemized budget is directly assessed by the Ministry of Finance and is used to conduct comprehensive researches that lead to creation of new policies. **Table 1** shows the subjects of comprehensive projects implemented in fiscal 2019 and **Table 2** shows researches conducted using the administration cost itemized budget.

3. Examples of cooperation with private sectors, universities, etc.

Various cooperations are implemented, which are generally classified into the following types, including joint research, conducted by NILIM jointly with other organizations, and contract research, outsourced by NILIM to other organizations that have already engaged in the research. Joint researches and contract researches conducted in fiscal 2019 are listed in **Table 3** and the following table, respectively. **Table 4** shows typical examples of cooperation with private sectors, universities, etc. including the researches above.

I. Researches established as a system in NILIM
(1) Joint research, (2) Contract research (research publicly offered by laboratory),
(3) Contract research (research publicly offered by council),
(4) Budget of other ministry / agency (PRISM)

Ⅱ. Researches established as a system in other organizations
(5) Technical research association

II. Researches not established as a system but established to a certain extent
(6) Technical public offering, (7) Social experiment,
(8) Workshop / study group

IV. Research conducted by devising operation
(9) Cooperation with policy development by the Ministry,
(10) Cooperation with municipal projects, (11) Workshop with university / private sector

4. Conclusion

In addition to the above, there are also examples of working for research activities and revision of technical standards in industry-university-government cooperation as committee activity of academic societies and associations. We intend to continue researches while developing various technical cooperation among industry, university, and government.

Pattern	Name of the council, etc.	Number of cases
Research publicly offered by laboratory		2
Research publicly offered by the Ministry's council		
	New Road Technical Conference	22
	River works technology research and development	11
	Sewerage B-DASH	16

Table 1. Comprehensive technical development projects implemented in fiscal 2019

Subject	Research period	Department / center in charge
Technical development contributing to utilization of existing buildings by streamlining fire prevention / evacuation rules, etc.	2016-2019	Building / Urban
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

Table 2. Researches based on the administration cost itemized budget implemented in fiscal 2019

Subject	Research period	Department / center in charge
Research on flood prevention activity supporting technology	2017-2019	River
Development of equipment improvement technologies for securing the health and safety of disaster victims in shelters	2017-2019	Building
Research on facade design methods aiming to improve energy consumption performance in buildings	2017-2019	Housing
Development of urban structure analysis / evaluation techniques considering diversifying life support functions	2017-2019	Urban
Development of diagnostic techniques of trafficability in case of earthquake / fire	2017-2019	Urban
Research on prompt inspection / restoration methods for airport pavement in earthquake disaster	2017-2019	Airport
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 buildings	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 methods for port facilities in a major earthquake	2018-2020	Port and harbor
Research on 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 the environmental conservation technology in coastal area	2019-2021	Coastal, Marine and Disaster Prevention
Development of terminal congestion index contributing to improvement of the punctuality of container ships	2019-2021	Port and harbor

Table 3. Joint researches conducted in fiscal 2019

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	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	2017-2021	Sabo
Joint research on technological development for practical use of the next-generation Cooperative ITS	29 entities and 32 organizations including automakers, electrical equipment manufacturers, related foundations, and expressway companies	2017-2020	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 utilization of AIS data for port maintenance / use	Service Center of Port Engineering (SCOPE)	2017-2019	Port and harbor
Joint research on utilization of construction management record obtained in seismic restoration of bridges for maintenance	Japan Bridge Association Inc., Japan Prestressed Concrete Contractors Association	2017-2019	Infrastructure management
Joint research on life extension of weather proof 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.	2017-2019	Road Structures
Joint research on maintenance of concrete floor slab bridges	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	2018-2020	Road Traffic
Joint research on upgrading steel bridge performed 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 accuracy upgrading of the liquefaction damage estimation method for infrastructure facilities	PWRI	2018-2019	Planning, Sewerage, Road Structures
Joint research on real-time data 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 Concrete Contractors Association	2019-2020	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 the continual improvement of maintenance plans for existing road bridge groups	Japan Civil Engineering Consultants Association, Kyoto University, Osaka University, Kyoto-fu, Ibaraki-ken	2019-2021	Road Structures
Joint research on sediment / flood control technology	University of Tsukuba	2019-2021	Sabo

Table 4. Example of cooperation with private sectors, universities, etc. implemented in fiscal 2019

Pattern	Subject	Purpose and form of cooperation	Participants	Research period	Department / center in charge
(3)	Breakthrough by Dynamic Approach in Sewage High Technology Project (B-DASH Project)	Utilize local governments, private enterprises, a universities, etc. for practical use of innovative techniques that are not 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 site	Publicly offer a project for improving productivity with new technologies such as IoT and AI by obtaining real-time digital data from construction sites.	Consortium consisting of private enterprises, universities, etc. (33 entities)	2018-	Infrastructure management
(8)	Local Road Economic Strategy Workshop and local workshops	- Discuss issues specific to regions and utilize needs of administration and wisdom of university. - Match with administrative needs to promote innovation of road policy.	University, MLIT, Regional Development Bureau	2015-	Road Traffic
(9)	Cooperation with local governments that implement area measures in research on traffic safety measures for community roads	Technical cooperation in effective implementation of traffic safety measures (local government: Implement measures, NILIM: analysis, technical consultation, etc.)	Yokohama-shi, Hamamatsu-shi, Kurume-shi	2016-	Road Traffic
(10)	Cooperation with local governments in research on grasping road traffic situation	- NILIM conducts transportation analysis etc., and local government (road administrator) conducts the project and consultation with organizations concerned to solve issues in proper sharing of roles.	Ibaraki-ken	2013-	Road Traffic
(1) (7)	Examination of new services using ETC2.0 data	- In order to strengthen the mobility of communities, solicit new service proposals using ETC2.0 data from the public. Provide ETC2.0 data to private enterprises that made a proposal for verification leading to practical use.	Private enterprises	2018-	Road Traffic

International Research Activities

1 International research activities in the NILIM

The NILIM is promoting international research activities based on the following three pillars.

(1) Technical contribution to domestic policies:

The NILIM forms networks with overseas governmental organizations to collect information on the examples of advanced technologies and disasters and reflect the results in proposing domestic policies, developing technical standards, etc. in order to carry out its fundamental activities.

(2) Technical cooperation for developing countries:

Using the knowledge and lessons learned from maintenance activities, disaster response, etc. for domestic public facilities and results of researches reflecting them, the NILIM supports local governments of developing countries in the countermeasures etc. for high-level technical issues they are faced with.

(3) Overseas deployment of infrastructure systems:

Using the knowledge learned from the formulation of technical standards, manuals, etc. that support important policy development in Japan, the NILIM addresses "promotion of the international standardization of domestic technical standards" and "ensuring the consistency between domestic and overseas standards" to contribute to the smooth overseas development of domestic technologies.

2 Main international research activities in FY2019

Representative cases are introduced as follows from the international research activities implemented in FY2019 based on the three pillars stated in 1 above.

2.1 Conclusion of a research cooperation memorandum with the Bundesinstitut fuer Bau-, Stadt- und. Raumforschung (BBSR) in Germany

Three organizations, BBSR in Germany, Building Research Institute, and NILIM, signed a memorandum for research cooperation in the fields of building, housing, and city on April 10, 2019. (Photo 1). The following themes are planned for cooperation.

(1) Energy saving in houses and non-housing buildings (including improvements)
(2) City planning and housing policy
(3) Utilization of BIM in building-related operations and procedures
(4) Prefabricated houses and industrialized houses

Photo 1 Execution

2.2 Release of English version PR video and exhibition at CECAR8

The NILIM's promotion video in English version was created for overseas researches, engineers, etc. (Photo 2). The video mainly introduces themes of the NILIM's overseas activities including joint researches with overseas research institutes and support of response to natural disasters in addition to the outline of NILIM. The video was published at the exhibition booth of the Civil Engineering Conference in the Asian Region (CECAR8), held in Tokyo in April 2019 and then released on the English website of the NILIM.

Photo 2 Promotion video

2.3 Conclusion of a memorandum with the Vietnam Road Authority

A memorandum was signed between the Directorate for Roads of Vietnam (DRVN） and the NILIM concerning a joint research on road bridges. This joint research aims to maximize the research results of both countries by sharing information and damage examples concerning the design, construction, and maintenance of road bridges in Japan and Vietnam. Under this memorandum, the NILIM is going to hold the Japan-Vietnam Bridge Workshop from FY2020 for the issues common to Japan and Vietnam.

2.4 Disaster Risk Reduction Training Program for Latin America and the Caribbean with Chile

The NILIM provided technical cooperation as follows to JICA's project "Disaster Risk Reduction Training Program for Latin America and the Caribbean" [2], commonly called "KIZUNA Project."
In the training seminar of "Technical capability reinforcement for public infrastructure (Quake-resistance standards for bridges)," held in August 2019, the NILIM gave a lecture about tsunami damage to bridges and countermeasures in Japan as well as results of analysis on the causes of the upper structure runoff. The NILIM also introduced Japan's knowledge about the resistance of bridges against earthquakes and tsunami to the personnel of Chilean Ministry of Public Works (MOP).

Photo 3 Lecture in the MOP-KIZUNA training seminar

In the MOP-KIZUNA training seminar on "Earthquake risk management of buildings," held in November 2019, the NILIM gave a lecture about formulation of technical standards based on the past earthquake damage and future technical trends, structural design method of buildings for evacuation from tsunami, various seismic retrofit technologies, and examples for application of seismic retrofit using seismic isolation / control technologies (Photo 3).

2.5 Short-term dispatch of experts to the Sri Lanka Project for Capacity Strengthening on Development of Warning and Evacuation Measures for Landslide Risk Reduction in Sri Lanka

In response to JICA's request for technical cooperation, the NILIM provided technical cooperation for the landslide warning / evacuation measures in Sri Lanka from October to November 2019. The NILIM conducted a hearing about the present situation from the central government agencies related to information issuance including Disaster Control Department and Weather Bureau, local government agencies, local residents of model sites, etc. Then, the NILIM made a discussion with the National Building Research Organization (NBRO), which controls sediment disaster countermeasures, about issues concerning warning rainfall standards in Sri Lanka, and gave advice on improvement measures.

2.6 Cooperation in formulation of national harbor standards in Vietnam

The NILIM provides cooperation under the "Memorandum for Cooperation in Formulation of National Technical Standards for Harbor Facilities (renewed on June 2017), which was signed in March 2014 between the MLIT and the Vietnam Ministry of Transport. Discussion for standard formulation has been made mainly in the workshop held between both countries. To date, the Ministry of Science and Technology of Vietnam officially enforced four parts of Vietnam national harbor standards (General provisions, Load and action, Material conditions, Construction / inspection standards), and the Vietnam Ministry of Transport, one part of the Ministerial standards (Breakwaters). In addition, the draft of two parts of the Vietnam National Harbor Standards (Foundation, Soil improvement) is under examination on the Vietnam side and is going to be enforced around the summer of 2020. In fiscal 2019, the remaining two standards (Mooring facilities, Maintenance) have been studied and editorial operation has been conducted jointly by both countries through the workshop held 6 times in total in Japan and Vietnam.

2.7 Reflection of research results in ISO by Building Environment Division

Part of the results of the research titled "Development of evaluation method of energy reduction effect by automatic control technology of building equipment, (2016-2018)" an itemized issue that has been implemented by the Building Environment Division, was issued as ISO 19455-1 in November 2019 and thus reflected in an international standard.[3]

2.8 Research presentation in the annual conference of the International Commission on Large Dams (ICOLD)

In the symposium of the 87th annual conference of the International Commission on Large Dams [4] in June 2019, the NILIM made an oral presentation about results of the research on seismic performance review of dams, titled "Effect of the fracture energy of dam concrete on the crack progress analysis of a concrete dam." Further, the NILIM attended the "Committee on Seismic Aspects of Dam Design" as a member and presented the proposal for amendment and addition to the new bulletin "Interpretation of earthquake record in dams" to be issued by the same Committee based on the results of analyzing earthquake observation records in Japan.

☞**See the following for details.**

1) Website of the NILIM "International Activities"
http://www.nilim.go.jp/lab/beg/foreign/kokusai/kokusaitekikatudou.htm
2) Website of the JICA https://www.jica.go.jp/project/chile/002/index.html
3) Website of the ISO https://www.iso.org/standard/70970.html
4) Website of the 87th Annual Conference of the International Commission on Large Dams
http://www.icold-cigb2019.ca/