Researching Technology Policy Comprehensively

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1. Perspectives for Coordination between Fields with the National Institute

When the National Institute for Land and Infrastructure Management (NILIM) was launched on April 1, 2001, I took up a position as the head of the Research Planning Department in the Public Works Research Institute, which had been re-established as an incorporated administrative agency. At the time, we were fully occupied with how to make the best use of the new organizational form of the incorporated administrative agency, and I recall that my sole impression of NILIM was its long name and that it was a research institute newly created by unifying the Public Works Research Institute, the Building Research Institute, and the Port and Airport Research Institute.

A symposium commemorating NILIM's establishment in June 2001 discussed the direction that it should aim for and what could be expected of it.[1] The debate included opinions like, "NILIM can do so many things because it is an institute bearing the 'national' banner. It will determine policy concerning technology, such as creating technical standards. When doing so, it is important that the institute takes the slightly broader perspective of determining policy for improving land and infrastructure management, rather than determining technical standards strictly, as has conventionally been done." Moreover, it was also considered necessary for NILIM to play the role of horizontally linking the three research institutes that it was formed from and to work comprehensively on broad fields, not just particular ones, in order to resolve issues we will face in the future.

In response, NILIM has created and has been working on project-based research, which is coordinated between different fields. In addition, we have established five interdepartmental organizations, such as the Disaster Prevention and Reduction Research Committee, as organizations covering multiple fields.

The three key points for generating outcomes that exhibit the connecting strengths of activities covering multiple fields were described as follows by Fujita Kōichi when he was executive director for research affairs:[2]

(1) Depict the overall view or structure of the subject, and identify issues and evaluate initiatives while clarifying the positioning of each element.
(2) Work backwards from what you want to achieve and then arrange various initiatives.
(3) Taking the horizontal axis as the major assumption for producing outcomes, ensure that the vertical axis, i.e., the technology in each field, is firmly rooted in the earth (the work site).

At present, one topic that NILIM is working on through collaboration between several fields is flood control in river basins. The table is an excerpt of materials submitted to the Research Evaluation Committee in FY2021.[3] Achieving a transformation to river basin flood control requires all kinds of relevant people to cooperate and put in efforts throughout the river basin, based on the effects of climate change, changes in social conditions, and other factors. NILIM is also conducting research and development to support the advancement of policy and its implementation in the field.

Table: NILIM's research and development on river basin flood control

	Tangible	Intangible
(1) Measures to prevent/reduce flooding as much as possible	• Establishment of levee reinforcement technology (River) (p. 20) • Support for maintaining/improving channel flow capacity (River) (p. 24) • Research on upgrading maintenance methods contributing to dam rehabilitation (River) • Research on measures against sediment and flood damage and debris flow, which have become more marked due to climate change (Sabo) (p. 28)	• Establishing techniques to draft river improvement plans consistent with runoff limitation measures (River) (p. 26) • Surveys on upgrading dam operations (River)
(2) Measures to reduce the scope of damage	• Research on techniques to evaluate, improve, and manage greenery as green infrastructure (Infrastructure Management)	• Research on establishing techniques to create flood risk information (River) (p. 25) • Research on ensuring safety of port zones against storm surge disasters (Coastal, Marine & Disaster Prevention)
(3) Measures to ameliorate damage and enable early recovery and restoration	• Research and study on making road structures more resilient against flooding and torrential rain (Road Structures) (p. 27) • Fact-finding surveys on development of disaster prevention and reduction technology for sewer drain routes (Water Quality Control) • Research on preventative renovation methods for existing stand-alone residences to reduce damage risk in the event of flood damage (Housing) (p. 21) • Research on facility design, etc. in ports based on effects of climate change (Coastal, Marine & Disaster Prevention) (p. 21)	• Development/improvement of flood damage risk lines (River) (p. 20) • Research on establishing techniques to create flood damage risk information (River) (p. 25) (repeated) • Upgrading event detection using AI on river management camera imagery (Infrastructure Management) • Development of support technology for flood prevention activities (River) (p. 29) • Development of flood visualization technology (River)

As the table shows, we have organized the measures into three perspectives in line with the perspectives of the measures and the viewpoint of what we are seeking to realize: measures to prevent or reduce flooding as much as possible; measures to reduce the scope of damage; and measures to ameliorate damage and enable early recovery and restoration. This shows that the relevant research departments are dividing and coordinating work in their efforts for the tangible technologies and intangible skills needed in order to achieve these measures.

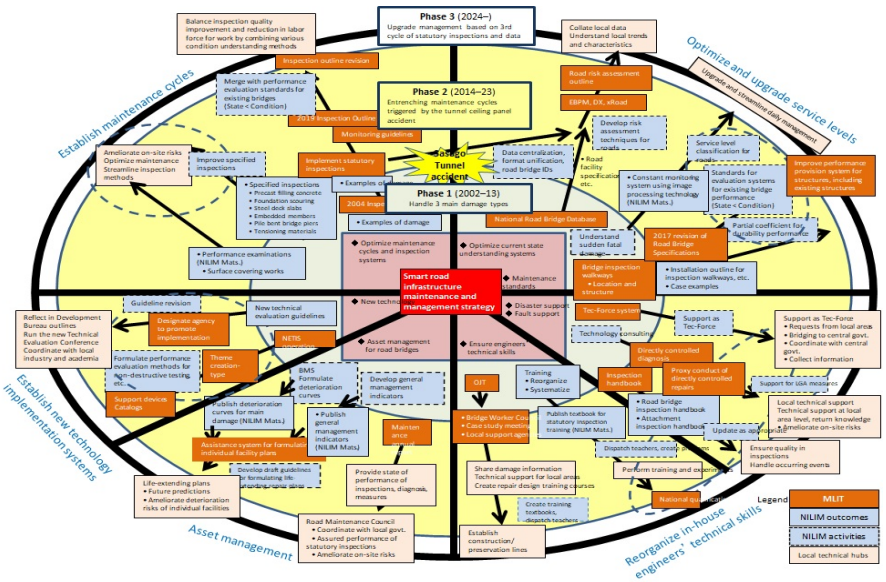


Figure: Road map to improving preservation systems in the road structures field (draft)

2. Perspectives on Technology Policy

Technical standards are important tools for resolving the issues we face or realizing what we find desirable, but they are not enough on their own. What is more, we cannot achieve these with a single technical development or specific research, and it is essential to create the technical skills to use it fully, as well as mechanisms for a variety of relevant people to participate. This requires efforts from the perspectives of many different concerned parties. This can be called technology policy.

The figure shows a road map to improve preservation systems in the road structures field (draft). It has been debated from shortly after the launch of NILIM, mainly by people in charge of bridges at NILIM but also incorporating Road Bureau officials, and this is the current version. Technology relating to structure conservation brings to mind UAV and other inspection and non-destructive testing technologies, diagnostic technologies to evaluate soundness, and repair and reinforcement technologies according to the cause of damage and its progress. These are all important technologies, but they are not enough to reach a resolution on their own, and it is necessary to work comprehensively, involving asset management to establish maintenance cycles by systematizing inspections, etc., and to rationally manage enormous structures, necessary technical development support and mechanisms to introduce that technology into the field, and more than anything else, technical abilities that enable engineers to use these fully.

For this reason, we have created six axes for resolving problems, as shown in the figure, and have worked to deepen this initiative over time axes and phases. Besides the matters under NILIM's purview, they also show initiatives of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and local technical hubs. This demonstrates NILIM's stance of being conscious of comprehensive measures to resolve issues and taking charge of the technical development that lies at their core in the first place, rather than simply engaging in research and development into technology for specific elements.

In addition to working on research from a broad perspective in collaboration with experts in various fields, NILIM is engaged in comprehensive efforts with relevant organs to implement the outcomes of the research in order to resolve social issues and realize what we are aiming for. On our pride as a national institute, we intend to be a place for researching technology policy comprehensively.

See here for detailed information

1) *Report of the National Institute for Land and Infrastructure Management Symposium*, NILIM Materials, vol. 1, Jun. 2001.
2) Fujita Kōichi, "Expanding the fruition of disaster prevention, maintenance, and environmental research by reinforcing the interweaving of horizontal and vertical axes," *NILIM Report 2014*.
3) *Report of the Research Evaluation Committee, National Institute for Land and Infrastructure Management, FY2021*, NILIM Materials, vol. 1187, Jan. 2022.

For Protecting Not Only Lives But Also Assets and Livelihoods When Flood Overwhelms Flood Control Structures

River Department

Since the limitation of the conventional measures for flood damage prevention, which combine flood control structures development and advance evacuation, has become apparent in the face of frequent heavy rainfall and flooding under climate change, a shift to flood damage prevention / reduction measures that "protect not only lives, but also assets and livelihoods when flood overwhelms flood control structures" is urgently needed, and we are conducting the necessary research.

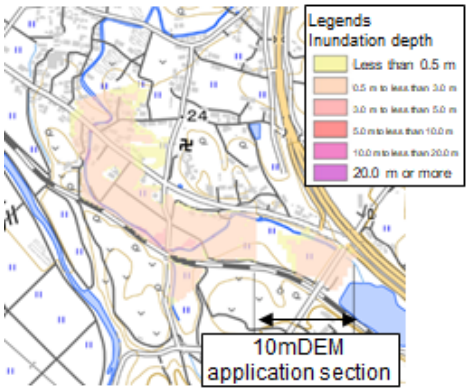
Social background and challenges

- Severe flood damage occurred frequently (July 2021 Heavy Rain in Shizuoka, etc. July 2020 Torrential Rain in Kyushu, October 2019 Typhoon in East Japan).
- Along with the steady development of flood control structures, measures to prevent / reduce damage when flood overwhelms flood control structures are important (promotion of “River Basin Disaster Resilience and Sustainability by All” is essential).
- As heavy rains and floods frequently exceed the design scale of flood control structures, flood damage prevention measures to protect lives by evacuation from flooding are reaching their limit because of difficulties for the elderly in evacuation, rebuilding livelihood after the disaster, etc.

Research contents

Support for eliminating blank areas of hazard information that are expected to be inundated in the event of flooding.

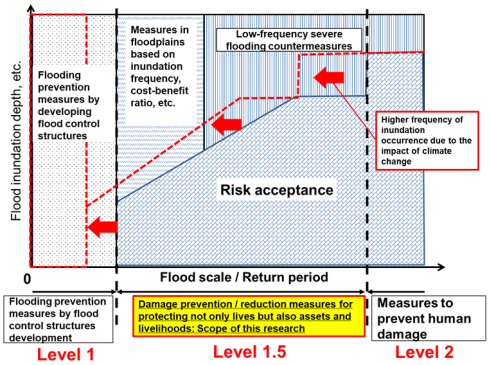
In order to study specific damage prevention / reduction measures in the event of a flood that exceeds the capacity of flood control structures, flood hazard maps (e.g., legal flood hazard area map) are necessary to show the extent and depths of inundation that is expected in the event of flooding.
However, the number and length of rivers in Japan are enormous, and it is difficult to conduct field surveys, etc. on all rivers in order to create the flood hazard maps.
Therefore, we have developed a flood hazard mapping method with using LP (aerial laser survey) data, which eliminates the need for field survey, etc., and in response to requests from the prefectural governments, we have performed the calculations necessary to create flood hazard maps for about 2,800 rivers, extending about 12,000 km, to support the prefectural governments and solve technical challenges.



Example of flood hazard mapping with using LP data

Research on methods for studying measures to prevent /reduce damage from level 1.5 flooding

Conventionally, we mainly took flood control structures measures to prevent flooding up to the design scale of flood control structures (Level 1 measures) and to save only lives at the assumed maximum scale of flooding (Level 2 measures). However, as shown in the Figure on the right, a specific study method has not yet been developed for "damage prevention / reduction measures for not only lives but also assets and livelihoods when flood overwhelms flood control structures" (tentatively called "Level 1.5 measures"), which fills the gap between the two measures.
Therefore, based on a set of flooding scenarios assumed for each area where the levee could break in the event of flooding, we are considering what are possible to avoid the "worst-case flooding scenario for the area" and are studying measures to gradually upgrade flood damage prevention / reduction measures in stages.



Damage prevention / reduction measures according to flood scale

Securing a society where not only lives but also assets and livelihoods are protected in case flood overwhelms flood control structures by implementing “River Basin Damage Resilience and Sustainability by All” in preparation for climate change.

☞See the following for related articles.
- Eliminating flood hazard information blank areas - Trial flood hazard mapping in small rivers, p. 54
- For avoiding the worst-case flood scenario - Study on damage reduction measures in case floods overwhelm flood control structures, p. 56

Development of on-site technologies for rapid recovery / reconstruction from sediment disasters and for the maintenance of a safe living environment after disasters

Sabo Department

To cope with sediment disasters, we are striving to clarify the mechanism of slope failure and develop technologies to respond to them. Research results are compiled into manuals and guidelines, while work is implemented by local governments and regional development bureaus of MLIT, etc. We also provide technical support upon request in the event of a sediment disaster, thereby contributing to rapid recovery / reconstruction of the region and the maintenance of a safe living environment.

Social background and issues

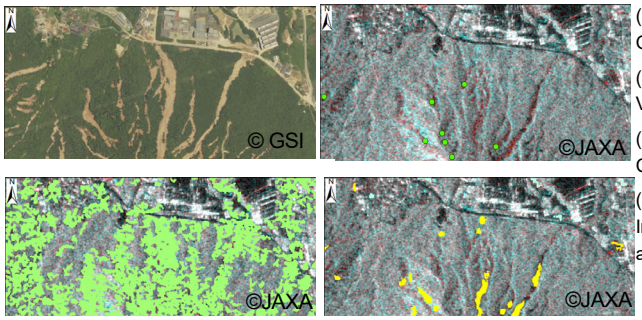
In order to carry out rapid warning / evacuation and recovery / reconstruction projects:

- (i) It is necessary to improve the technology for interpreting satellite-mounted synthetic aperture radar (SAR) images, which can acquire information over a wide area even at night or in bad weather, so that the site of sediment disaster can be identified in a short time after occurrence.
- (ii) It is necessary to develop technologies that clarify the mechanism of large-scale sediment transport caused by deep-seated landslide, etc., and to identify in advance dangerous sites where large-scale sediment transport could occur.

Research contents

Quickly grasp the sites of sediment disasters using satellite SAR images.

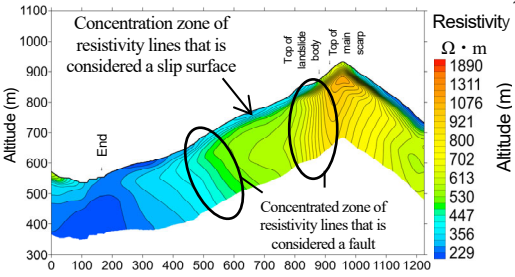
The amount of data processed by the Advanced Radar Satellite "Daichi-4" (Advanced Land Observing Satellite 4 : ALOS-4) will increase as its observation range expands, so it is necessary to streamline the process of interpreting SAR images.
Therefore, we compared the reliability in estimating the sites of sediment disaster between multiple methods that excel in processing SAR data observed over a wide area and methods based on visual interpretation.



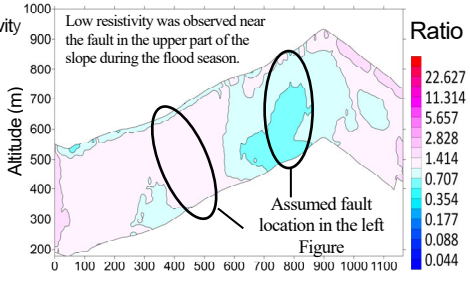
Example of estimation results for each method (Torrential rainfall in July 2018, in Higashihiroshima City)

Visualize subsurface geology and hydrology with geophysical exploration technology to identify slopes at high risk of deep-seated landslide.

The risk of deep-seated landslide can be assessed with high accuracy by identifying deformed slopes from topographic maps and aerial photographs, and by investigating the presence of slip surfaces and faults within the slope and their relationship with groundwater behavior by airborne electromagnetic survey technology using a helicopter or drone.



Resistivity ratio during dry season (November) by airborne electromagnetic survey using a helicopter



Resistivity ratios during the flood season (October) and the dry season (December) based on airborne electromagnetic survey using a drone.

Risk assessment of sediment disasters and support for rapid recovery / reconstruction from sediment disasters

Development of on-site technology and technical support to local governments and Regional Development Bureaus

☞See the following for related articles.
- Research on the advancement of sediment disaster monitoring methods using remote sensing (p. 59)
- Development of technology for identifying slopes with particularly high risk of deep-seated landslide using geophysical exploration technology (p. 147)

Rapid Technical Support for Disasters and Troubles

Road Structures Department

In order to respond to functional loss of road structures due to disasters and troubles, we rapidly dispatch experts on request from local governments and provide technical support for emergency measures, stopgap recovery efforts, etc. Here we present the state of responses and examples of major responses in FY2021.

Social background and issues

- Given that the severity of torrential rain disasters is trending upwards and structures built during the period of rapid economic growth are deteriorating with age, road-related damage and troubles occur frequently.
- We are conducting on-site investigations and providing technical advice regarding recovery on request from local governments, and in every case, we are required to respond promptly because avoiding further damage and restoring function are urgent duties.

Response state and examples

State of responses in FY2021

In FY2021, we have coordinated with the Public Works Research Institute, Road Maintenance Centers in Regional Development Bureaus, and others to dispatch experts for the road disasters and troubles in the table to the right on request from local governments and RDB.

It is apparent that many of them were caused by torrential or extended rainfall and that road structures have lost function due to a variety of damage and deformation.

If an advisory committee is established to investigate causes or for the recovery efforts, the experts participate and contribute to find solutions.

Examples of road disasters and troubles where experts were dispatched in FY2021

Outline	Dispatch location	Requesting agency
Deformation of slopes, retaining walls, etc.	Slopes, retaining walls on Nat. Hwy 107	Iwate Pref.
Bridge pier inclination due to scouring	Kawashima Ōhashi (Matsubara-Imojima Route (pref. road))	Gifu Pref.
Bridge pier sinking due to scouring	Kisegawa Ōhashi (Fuji-Shimizu Route (pref. road))	Shizuoka Pref.
Bridge damage due to sediment flow	Aizomebashi, Nat. Hwy 135	Shizuoka Pref.
Sediment runoff	2 locations, Nat. Hwy 54	Chūgoku RDB
Shoulder collapse, bridge damage due to landslide	2 locations, Nat. Hwy 19	Chūbu RDB
Sediment runoff	Ōmi Jingū ramp section, Nat. Hwy 161	Kinki RDB
Scouring of revetment, streambed	Shin-Ōtagiribashi (Shin-Kasuga Kaidō Route (municipal road))	Komagane, Nagano Pref.
Sediment runoff	Nat. Hwy 220 (upbound)	Kyūshū RDB
Deformation of tunnel mouth and slope	Zennami Tunnel, Nat. Hwy 47	Tōhoku RDB

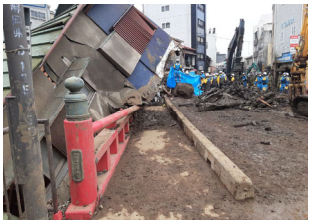
Response to damage due to heavy rainfall in July 2021

One pier of the Kisegawa Ōhashi bridge (Fuji-Shimizu Route (Shizuoka prefectural road)) had sunk more than 2 meters due to scouring from heavy rainfall in July 2021, and we provided technical support to prevent the growth of scouring and for stopgap recovery efforts.

On the Aizomebashi bridge (National Highway 135), which was affected by sediment flow occurring in the city of Atami in July 2021, we provided technical support for matters to investigate and examine with a view to prompt reopening to traffic.

With our technical support, scouring countermeasures were implemented and a temporary assembled bridge was installed at the Kisegawa Ōhashi, and the route was reopened to traffic on August 31 (https://www.pref.shizuoka.jp/kensetsu/ke-830/documents/210826kisegawa.pdf). Traffic regulations on National Highway 135, which includes Aizomebashi, were removed on July 29.

Meeting for on-site investigation and response policy for Kisegawa Ōhashi



Aizomebashi damaged by sediment flow and on-site investigation

Providing rapid, appropriate technical support to minimize the effects of disasters and troubles

☞See here for related articles
• *Technical Support for Frequently Occurring Road Disasters* (p. 32)
• ~~2)~~ *Development of Methods for Determining Disaster Potential and Preventive Measures for Bridge Washouts and Scouring* (p. 61)

For the Effective Use of the Stock of Reinforced-Concrete Apartment Buildings
--The Development of a Method of Sophisticating the Durability Evaluation and Technology to Enlarge Space--

Building Department

The transition to old towns due to the aging of buildings and residents has been advancing with the apartment building complexes developed in suburban areas during and after the rapid economic growth period. We have been conducting the development of technology to efficiently use reinforced-concrete apartment building stock and to realize the regeneration of eco-friendly housing complexes.

Social Background and Problems

- For the regeneration of eco-friendly suburban housing complexes, the reinforced-concrete apartment building stock needs to have longevity and needs to be used effectively.
- For the stock to have longevity, our task is to sophisticate the evaluation of durability and to select rational countermeasures in consideration of the local risk of cracking, water contents, and so forth, as well as carbonation.
- For the effective use of stock and to try to activate the housing complexes by encouraging child-rearing households to move in, our task is to establish the technology to realize, in consideration to the safety of the structure, the expansion of small housing spaces (to form an opening in structural walls between apartments).

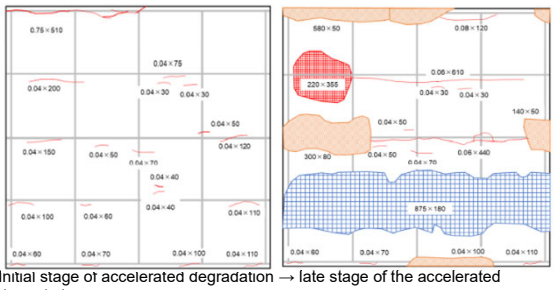
Description of the Research

For the Longevity of the Stock of Reinforced-Concrete Apartment Buildings

We have been examining methods of sophisticating the evaluation of durability and measures for enhancing the durability, to improve the longevity of the reinforced-concrete apartment building stock. We examine documents, investigate real buildings, and conduct experiments to examine and propose ① a method of evaluating the current status of degradation, including cracks, exposure of reinforcing bars, and so forth, ② a method of evaluating the resistance to degradation and the environmental degradation factor using the indices such as carbonation and water contents, and ③ a method of comprehensively evaluating the durability performance of existing reinforced-concrete parts. In addition, we also have been examining ④ a method of the rational selection of longevity countermeasures in response to the results of the evaluation of durability performance.

Description of the drawing on the right. The degradation of RC wall member was accelerated with an electrical method. As a result, we confirmed that the degradation was seen in the order of the crack in the longitudinal direction of the iron bar → the loose surface and the peeling → the peeling off. This result was reflected in the current method used to evaluate the degradation status.

: Crack
: Loose (the part causing some noise in the hammering test)
: Peeling (some peeling recognizable in the visual check, and ready to peel off easily if hammered)
: Peeled off (a concrete piece that has peeled off)

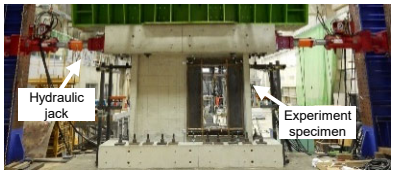


Initial stage of accelerated degradation → late stage of the accelerated degradation
An example of an RC wall member in the accelerated degradation experiment

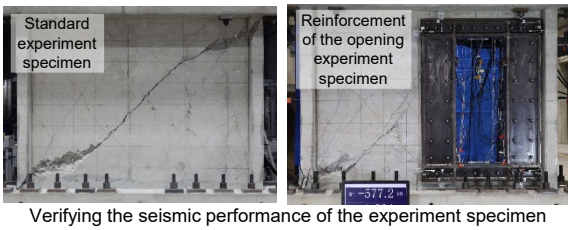
Effective Use of the Stock of Reinforced-Concrete Apartment Buildings

In order to realize the expansion of the space between apartments for the effective use of RC apartment buildings in consideration of the safety of the structure, we need to propose an evaluation method to grasp the influence from the formation of an opening over the seismic performance of the architecture, the rules to arrange the openings to minimize the degradation of the seismic performance caused by the formation of openings, and the technology to reinforcement for the recovery of the seismic performance. To solve these problems, we have been conducting analyses using the finite element method, and experiments using model specimens.

Description of the photo on the right. A new opening was formed in the RC experiment specimen simulating a structural wall between two apartments (scale reduced to two thirds). The steel skeleton was used to reinforce the surrounding part, and the horizontal load was applied for simulating seismic loading condition. In this experiment, the experiment specimen with its opening reinforced sufficiently was proved to exercise the lateral load carrying capacity equivalent to, or more than, the standard experiment specimen, which simulated the status before the new opening was formed.



A view of the loading test



Verifying the seismic performance of the experiment specimen
With a reinforced opening by the loading test

Promoting the longevity of apartment building stock and effective use by expanding space to contribute to the regeneration of the eco-friendly apartment complexes for the realization of the green society

Further Efficiency and Sophistication of Building Management Using BIM

Housing Research Department

We have participated in the "BIM Promotion Roundtable," which organizes the environment to use BIM comprehensively from the phase of building planning and design to the phase of maintenance management, to advance endeavors in cooperation of governmental bodies and private entities. In addition, we have been studying how to use BIM to make maintenance management of public rental houses more efficient.

Social Background and Problems

•The endeavors for so-called BIM have been spreading, where the building information covering the designing to the construction and maintenance management of buildings is integrated and visualized, and information is shared and used to make the business more efficient.

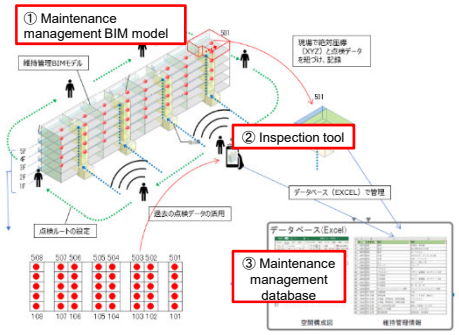
•Appropriate maintenance management and operation of a large amount of public rental house stock. Further streamlining and greater efficiency of business are wanted in response to the aging and the reduction of personnel with technical skills.

Description of the Research

Development of a model utilizing BIM for maintenance management of public rental houses

To create a (simple) BIM model for maintenance management on the basis of the actual situation of a business
Examining a method of using Excel as a database, linking the data with location information, and viewing and visualize these data in the BIM model (3D model).

An overview of " BIM model of maintenance management of public rental houses (draft)"
- In the maintenance management of the public rental houses, they are controlled basically in the unit of each house
- The box for collecting data with the maintenance management BIM model is the housing unit
  Information is controlled with the absolute coordination in the space of housing unit
- The BIM model is used as a vessel for the confirmation of information, visualization of data, etc. without linking the photos or forming data directly with objects

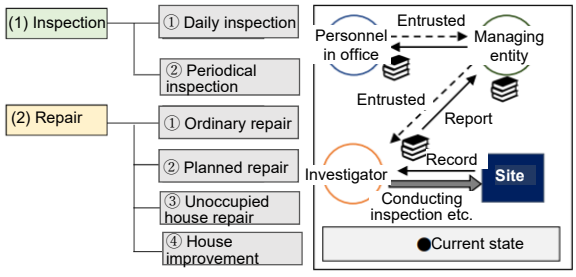


An image of using the maintenance management BIM model

Investigation of the current state of actual business in the maintenance management of public rental houses

The actual status of the inspection of rental houses (daily, periodic, legal), repairs (finance, planning, uninhabited on public houses), and so forth, the introduction of BIM and IoT technology, the records and usage of information, the investigation and analysis of the actual status of digitalization etc.

Investigating and analyzing the actual status of maintenance management
- Daily inspection etc. are performed using paper documents, with drawings etc. brought into the site.
- Inspection records and written reports are refined after the personnel return to the office.
- The report to the administrator etc. is made with paper documents, CD's, etc. (electronic files).
  ⇒ Redundant records and inputs. Risk of causing incorrect copying.



An example of the actual situation of the maintenance management of public rental houses

Creating a manual (guide) for introducing and using the maintenance management BIM model based on the actual situation of the business owner of a public rental house, in order to support the endeavors to making maintenance management more efficient

☞ Click here for relevant articles
• The development of the BIM model assuming the use of public rental house stock (p. 149)

Research on the Multi-functionalization of Transport Hubs for Effective Urban Space Use

City Research Department

We have been advancing our research on the multi-functionalization of transport hubs such as station squares and its peripheral developments for the formation of urban spaces where "you feel comfortable and want to walk." We are mainly aiming at the creation of the station squares with the function to exchange railway lines, bus lines, etc., and with rich pedestrian and greenery spaces.

Social Background and Problems

- Conventionally, at the stages of designing and planning transport hubs(station squares etc.), there used be a tendency to place importance on securing traffic space for exchanging modes of transport, including railways, buses, taxis, and privately owned cars.
- In recent years, people's activities in urban areas have diversified, and these would be seen at transport hubs as well. Hence, it will be desirable to have transport hubs that not only serve as a transfer place, but also enable their users to use environmental space such as greenery spaces, the remaining space excluded traffic space from transport hub area, for various reasons.

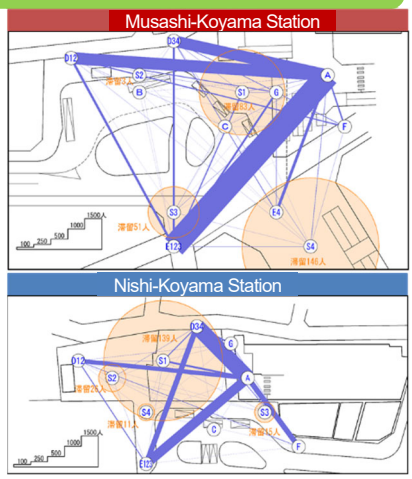
Transport hub Integrated with the Surrounding Area (Musashi-Koyama Station, Tokyo, Japan)

Description on the Research

Characteristics of the transport hub use based on on-site observation

To grasp the actual situation of transport hub usage, we observed and analyzed the number of passengers getting on and off, their flow lines and staying statuses, etc. in different hours at two sets of two station squares, with different characteristics of their railway stations, surrounding downtown areas, etc. even though they generally are comparable in the number of passengers, station square area, and environmental space area.

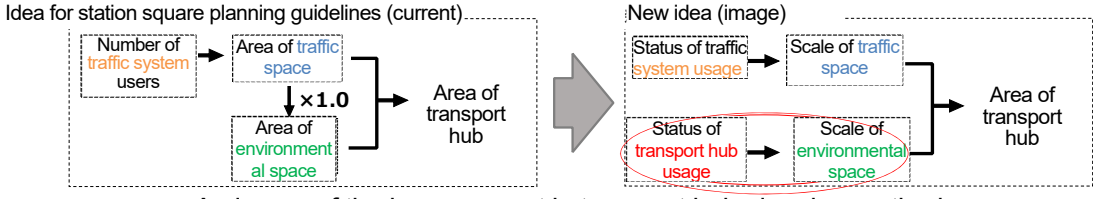
Observed Areas (Examples)				Musashi-Koyama Station	Nishi-Koyama Station
Characteristics	Number of users of the station (regular users)			Generally the same	
	Area of the station square/Area of environmental space			Generally the same	
	Characteristics of station			Express train stop	Local train stop
	Characteristics of surrounding downtown areas			Both residential and commercial	Mainly residential
Results of observation	Use of squares	The number of users		Large	Small
		Ratio of users of non-traffic systems (in daytime)	Use of squares	Frequent	No frequent
			Transitory passage	No frequent	Frequent
	Average staying time			Long	Short
	Population characteristics of users			Use by groups	Use by individuals



State of flow lines and stays of people in station

Examining the Direction for the Improvement of Transport hub Planning Methods

To be able to show ideas for planning and/or design, including the redevelopment of station squares etc. based on the social situation, urban policies, etc., including new technology, DX, and the new normal in relation to cities and traffic systems, we have been advancing the direction of improvement in planning methods according to the characteristics of a transport hub (flexible use of environmental space in terms of scale, allocation, composing elements, and time and so forth).



An image of the improvement in transport hub planning methods

Making transport hub, one of the bases of a city, multi-functional and sophisticated to contribute to the formation of an aggregated urban structure (compact + network) and of a walkable inner-town space

Multiple ecosystem services of blue carbon ecosystems

Coastal, Marine and Disaster Prevention Department

Blue carbon ecosystems, such as seagrass beds and tidal flats in coastal areas not only reduce global warming but also enrich biodiversity and human life. This research will help quantify the multiple ecosystem services and promote the conservation and restoration of blue carbon ecosystems.

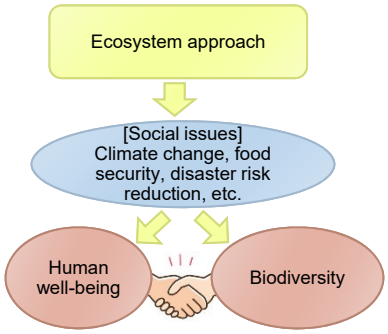
Social background and issues

- In recent years, global warming and climate change have become major environmental problems worldwide.
- There are measures to mitigate this global warming using the power of nature. Mitigation measures using the power of natural processes will benefit biodiversity and human well-being.
- In coastal areas, blue carbon using coastal ecosystems, such as seagrass beds and tidal flats is garnering attention.
- Quantitative assessment of the multiple ecosystem services of blue carbon ecosystems to support and promote conservation and restoration of blue carbon ecosystems depleted by past coastal development.

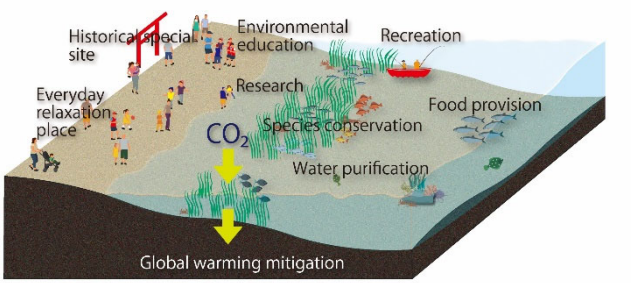
Research content

Approaches to and ecosystem services of mitigation measures using the natural processes

Benefits of solutions using the natural processes



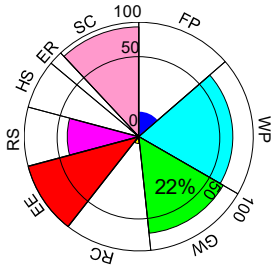
Multiple ecosystem services of blue carbon ecosystems



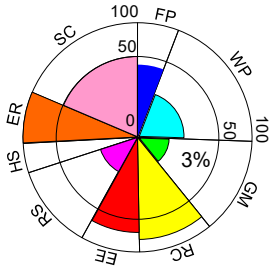
Quantifying the ecosystem services of blue carbon ecosystems

Example (pie area shows the economic value of each service)

Tidal flat: A



Tidal flat: B



- The balance of ecosystem services differs depending on the tidal flat
- The percentage of the service of mitigating global warming to the total value is 22% for tidal flat A and 3% for tidal flat B.
- Co-benefit
  Tidal flat A: 78%, Tidal flat B: 97%

Point

1. Various ecosystem services of blue carbon ecosystems were quantified.
2. In the tidal flats assessed in this study, more than 70% of the ecosystem services were values other than mitigating global warming.
3. The restoration of blue carbon ecosystems will contribute to the development of coastal areas that reduce global warming, enhance biodiversity (species conservation) and enrich people's lives (food provision, water purification, recreation, environmental education, everyday relaxation place, etc.).

Curbing global warming and creating coastal areas that enrich people's lives

Scan for related articles

- National Institute for Land and Infrastructure Management YouTube Channel:
  Blue carbon and the value of coastal environments

Efforts towards sustainable hinterland transport of containers

Port and Harbor Department

Although there are concerns about a shortage of truck drivers, we will propose measures to maintain and improve the efficiency by promoting cooperation among firms including container round use and reviewing transportation networks to/from inland areas, so that hinterland transport functions of international maritime containers can be maintained in the future.

Social background and issues

- In the majority of cases, international maritime containers are transported to/from shippers by truck, however there are concerns about the serious shortage of truck drivers and the impacts this might cause.
- There is a need to meet the Sustainable Development Goals (SDGs), including reducing carbon dioxide emissions.
- In order to improve and maintain the efficiency of transport, there is a growing trend that firms introduce cooperative activities in their logistics functions.

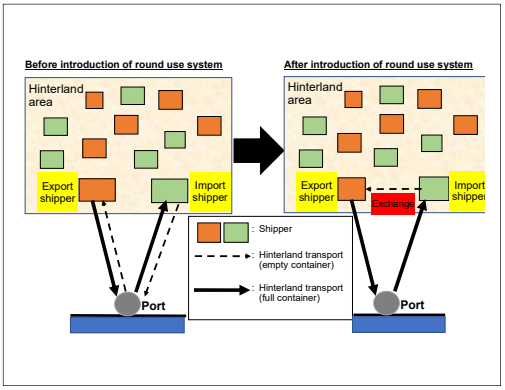
Research content

Estimating the future shortage of truck drivers and establishing efficiency targets

We will estimate the future balance between demand and supply of truck drivers involved in international container hinterland transport to assess shortages. In addition, measures to promote container round use which more and more firms are introducing will be examined, while evaluating expected improvements in transport efficiency (reduction in the number of transport to/from firms from/to ports, etc.) based on the participation rate of shippers adopting the round use system and other factors.

Based on these considerations, we will establish targets for efforts to improve the efficiency of hinterland transport systems.

Note: Container round use is a system in which shippers engaged in exporting and shippers engaged in importing match and exchange empty containers in the hinterland area in order to reduce transport to/from port areas.

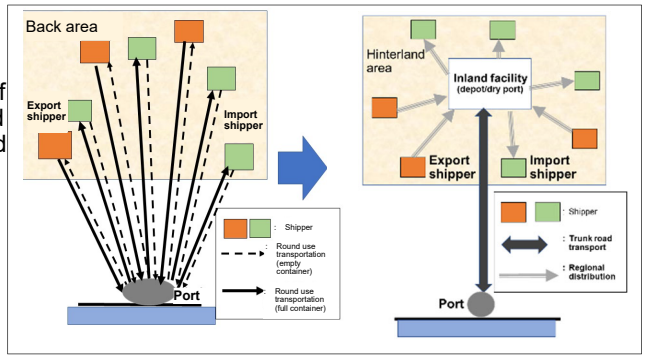


Container round use system

Proposal and evaluation of social system for hinterland transport systems

We propose a social system for sustainable hinterland transport systems through the review of transport networks between ports and hinterland areas. As a part of this measure, the introduction of inland facilities to support container round use, and the introduction of new methods such as trunk road or convoy transport will be considered. The effectiveness of the proposed systems will be evaluated based on indicators such as degree of secure of sufficient truck drivers, reduction of transport costs, reduction of transportation cycles, and reduction of environmental impacts.

At this time considerations will be given so that advantages are given to the parties involved in the hinterland transport system. Various challenges for the realization as well as measures to solve them will also be examined.



Current practice (left) and after improvements (right)

We will contribute to the realization of SDGs by proposing a "social system" in order to maintain and improve hinterland transportation systems.

Completed Recovery of Major Roads Damaged in 2016 Kumamoto Earthquake

Research Center for Infrastructure Management

NILIM established the Kumamoto Earthquake Recovery Division and provided technical support at the site of disaster recovery efforts in order to achieve the prompt recovery of roads that were severely damaged in the 2016 Kumamoto earthquake, thus contributing to the completion of recovery efforts on all roads where they were conducted as a project performed by the national government on behalf of the local government, six years after the earthquake.

Social background and issues

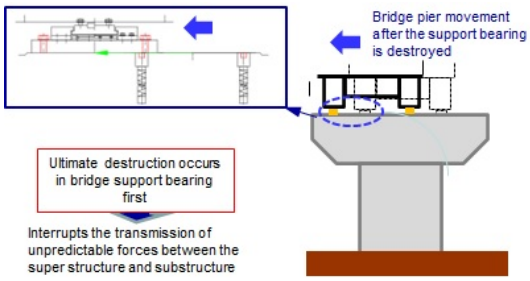
- Major roads connecting urban areas of Kumamoto and the Aso area were cut by the Kumamoto Earthquake. To ensure prompt recovery, the national government was to carry out the project for recovery of three routes managed by local government.
- Recovery of the road bridges required advanced technical support adjusted for various forms of disaster damage.
- Rather than simply recovering them to their original state, it was necessary to reduce the risk of similar disasters affecting them again.

Social background and issues

Recovery considering effects from ground deformation

Even when the ground had deformed due to slope collapse, fault displacement, etc., we gave technical advice to minimize the effects and reflected it on-site.

For the Shin-Aso Ōhashi, where the fault shifted horizontally, we proposed designs for the bridge support bearing and structural considerations that would reduce the risk of super structure falling, even if a fault shift occurred.



Design concept for a bridge support bearing that interrupts transmission of the unpredictable forces arising between the supper structure and substructure with fault deformation

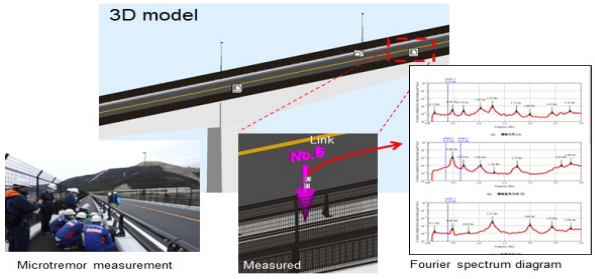
Opening ceremony for the Shin-Aso Ōhashi (March 2021)

Maintenance-minded recovery

We also took certainty and ease of maintenance into account and proposed information acquisition leveraging ICT and recording and storage using BIM/CIM.

For the Aso Chōyō Ōhashi, we proposed using a strong rigid-frame structure to create a form that was less likely to sink over the structure as a whole, even if the slope collapsed in a large earthquake.

Aso Chōyō Ōhashi after completion of recovery



Acquiring information that is useful for maintenance and recording and storing it with BIM/CIM (Shin-Aso Ōhashi)

Stimulating regions through prompt infrastructure recovery from disaster

☞See here for related articles
• Five years progress in the Kumamoto Earthquake Recovery Division – The activities of the NILIM's research division establishing at the disaster restoration site of the 2016 Kumamoto Earthquake (p. 142)

Research and Study Activities for the Realization of a Green Society

Environment Research Committee

In order to realize a green society, collaborative initiatives among various fields and entities are important, and "research and study activities" supporting these initiatives are necessary to enhance and strengthen environment-related measures.

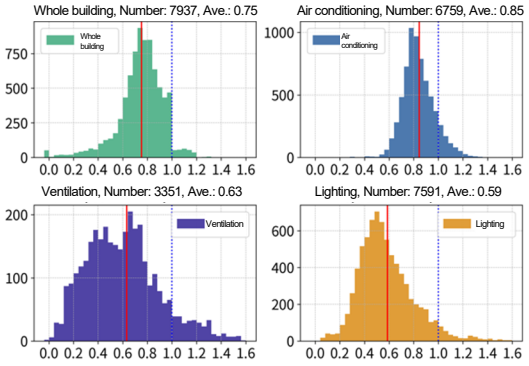
Activity introduction

- In order to contribute to the realization of a green society, including carbon neutrality by 2050 and addressing the climate crisis, the MLIT, which is strategically engaged in global warming mitigation measures and climate change adaptation measures, has compiled and published the "MLIT Green Challenge" regarding measures and projects including green technologies in the environmental field (July 2021).
- In order to strongly promote this project, the Ministry established "Headquarters for Realization and Promotion" to mobilize all available measures, and positioned these as priority projects in the MLIT Environmental Action Plan.
- To support these measures, the NILIM also strategically conducting research activities in each department and center, and the Environment Research Committee organizes and shares these activities within the NILIM.

Introduction of related research

Analyze the current status of building design specifications using energy efficiency standard application data

Under the Building Energy Efficiency Act, which was revised to further improve the energy efficiency performance of buildings (fully effective April 2021), a system obliging compliance with the energy efficiency standard is in operation In this research, a vast amount of application data through a program to confirm conformity with energy efficiency standard (web program) was collected and analyzed in the cloud to clarify the actual status of energy efficiency performance (BEIm) of buildings.
We also support the formulation of energy conservation measures by the MLIT, by analyzing the relationship between energy efficiency performance and the design specifications of the building envelope (walls, openings, roof, etc.) and equipment (air conditioning, lighting, hot water supply, solar power generation, etc.).



Distribution of energy efficiency performance (BEIm) (FY2020, Kanto Region)
(The horizontal axis is BEIm, and if it is not more than 1.0, the standard is met)

How to evaluate multi-functional green infrastructure

Green infrastructure is promoted as a solving method of various regional issues. Especially, estimate infiltration volume for rainwater runoff control is often expected a method of urban flood damage reduction.
In case of green space, it is difficult to estimate due to influence of various conditions. But it is expected to promote more functional green infrastructure by estimate infiltration volume in consideration of land cover and soil condition, etc. like overseas cases. And it can also use to setting green infrastructures layout and scale. In the case of region-wide plan such as “River Basin Disaster Resilience and Sustainability by All” estimate infiltration volume can cooperate with other infrastructure or determine the appropriate area for infiltration.

Example of green infrastructure (Machida City, Tokyo)
*Green space with consideration for rainwater storage function

☞See the following for related articles.
- Clarify the actual status of building envelope and equipment design specifications using energy efficiency standard application data (p. 152)
- How to evaluate green infrastructure having diverse functions (p. 133)

Research to Promote DX in the Infrastructure Sector

Digital Transformation of Infrastructure Systems

NILIM has established the Digital Transformation of Infrastructure Systems Research Committee and is conducting research necessary for implementing new technologies and revising the corresponding technical standards through cross-sector information exchange and collaboration, with the aim of achieving the digital transformation (DX) of the infrastructure sector as promoted by MLIT.

Activity introduction

MLIT is promoting DX in the infrastructure sector to handle radical changes in socioeconomic conditions and to utilize data and digital technology in the infrastructure sector to reform infrastructure and public services, MLIT operations, organizations, and processes, and the culture, climate, and working style in the construction industry and MLIT.

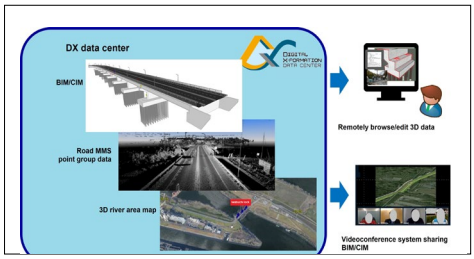
In addition to establishing the data center and experimental fields required to move forward with infrastructure sector DX, NILIM is researching and developing technologies that will be the key in promoting it. Examples of research topics in progress in various fields are presented below.

Research introduction

Building a DX data center

We are building a DX data center as a system to centrally store three-dimensional data, such as BIM/CIM and point group data, and smoothly share information between the orderer and the contractor in the construction production processes of surveying, investigation, construction, design, and maintenance.

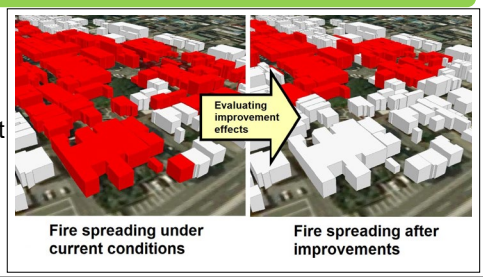
We can install BIM/CIM or other three-dimensional data software and use VDI functions to view data remotely, for example. It is also possible to provide high-capacity storage for high-speed access to and from regional development bureaus and offices.



Research on promoting the use of 3D urban modeling aimed at resolving urban issues

We are developing additional data specifications and methods to reduce data creation and updating costs for 3D urban models capable of expressing urban areas in three dimensions, including building attributes, etc., to make it possible to evaluate means to resolve disaster prevention, greening, and various other issues that cities face, while conducting highly accurate simulations.

We encourage understanding of, resident participation in, and increased administrative efficiency of policies in the urban sector, such as by using 3D urban modeling with highly versatile data to visually present the improving effects of policy measures in highly dense urban areas through fire spreading simulations.

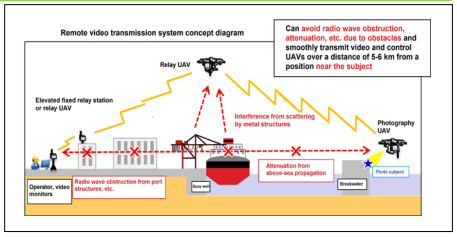


Developing efficient inspection methods for port and harbor facilities using UAVs

We are developing methods for AI to perform preprocessing to remove the sea surface, extract cracks, and carry out other tasks in place of humans in inspection data for port and harbor facilities captured by UAVs.

We are also conducting development aimed at extending the distance for real-time video transmissions using relay UAVs, accounting for environments with many obstacles, such as large ships.

This reduces the work and time required for inspection work on port and harbor facilities.



Realizing infrastructure and public services to handle structural reforms for a new social economy with frequent disasters, deteriorating infrastructure, insufficient personnel, and the post-COVID era

☞See here for related articles
- Disaster Prevention, Environmental Conservation, and Regional Stimulation in Coastal Areas (p. 40)
- Research on Urban Area Simulations Leveraging 3D Urban Modeling (p. 126)
- Development and Operation of Experimental Fields for Construction DX (p. 154)

Research of the NILIM: Past and Future

SASAKI Takashi (Ph. D. in Engineering), Executive Director for Research Affairs

Key words: 20-year History of the NILIM

1. Activities of the NILIM over the past 20 years

The National Institute for Land and Infrastructure Management (NILIM) was established on April 1, 2001, by reorganizing the Public Works Research Institute, Building Research Institute, and Port and Airport Research Institute of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). The activities conducted since then were compiled into the "20 Years' Experience -- NILIM" ("20-year History") last year.

Although priority research themes of the NILIM changed from time to time over the past 20 years, we have divided our research into three major categories based on the NILIM's essential mission of " Safe, secure, energetic and beautiful national land and society": 1) Research to strengthen the national land and protect people's lives and livelihoods, 2) Research to enhance the productivity and growth potential of society, and 3) Research to support comfortable and secure living. These categories are referred to as "Strength," "Use," and "Beauty," respectively, in the 20-year History. Based on this classification, 47 research projects have been presented along with relevant reports and technical data. **Fig. 1** shows some examples of R&D described in the 20-year History.

In compiling this 20-year History, I was involved in organizing the department's past researches as the research department director, and had ample opportunity to reflect on how we researchers have conducted our activities within the social context and policy trends of our respective eras. The R&D activities over the past 20 years have been diverse, and the activities presented are just a few of them.

In addition to the R&D described above, the 20-year History also introduces the "Technological contributions to sites" (advanced technical support for disasters and accidents, international research activities, improvement of on-site technical capabilities, collection and analysis of data, and return of data to society) and "Development of the environment supporting research" (management support for high-quality research, human resource and research environment development, and public relations activities).

This 20-year History is posted on the NILIM's website. Each research can be viewed individually, so we hope you will take a look at it, starting with the area that interests you.

[Strength: Research to strengthen the national land and protect people's lives and living]

- ✓ Technologies for identifying and forecasting floods installed as the Flood Risk Line
- ✓ Technologies required to create Sediment Disaster Alert Information
- ✓ Development and revision of inspection guidelines required for statutory inspections of road structures
- ✓ Revision of technical standards for building structures in light of earthquake, heavy snowfall, and strong wind damage.
- ✓ Technologies, etc. introduced in standards, guidelines, etc. for airport civil engineering facilities

[Use: Research to enhance the productivity and growth potential of society]

- ✓ Technological development in the sewerage field through the B-DASH Project
- ✓ Technologies introduced in technical standards for port facilities that are being developed abroad
- ✓ ICT construction for i-Construction promotion
- ✓ Creation of various standards for BIC/CIM

[Beauty: Research to support comfortable and secure living]

- ✓ Traffic safety technology for arterial roads using ETC2.0 data
- ✓ Maintenance of various manuals, etc. related to condominium rehabilitation
- ✓ Proposal for "Wind Path" as a countermeasure to urban heat islands
- ✓ Environmental assessment method for coastal areas

Fig. 1: Examples of R&D projects described in the NILIM's 20-year History

2. Evaluation of current research activities

As introduced in the section on "Development of the environment supporting research" in the 20-year History, the research activities of the NILIM have been subject to evaluation by the Research Evaluation Committee (the "Committee") composed of external experts. In addition to an annual evaluation of individual research projects, the NILIM undergoes an "institutional evaluation" (evaluation of institutional management performance) once every five years. Since the last fiscal year was an interim year of this evaluation, we decided to review the institutional evaluation criteria (evaluation criteria) established in 2018, as shown in **Fig. 2**, in preparation for the "Institutional Evaluation" coming two years later.

To contribute to the consideration of the appropriateness and review of the evaluation criteria, we confirmed the conformity of the research activities with the evaluation criteria in some broad categories, i.e., "Examples of activities related to River Basin Disaster Resilience and Sustainability by All" and "Examples of DX-related activities in the infrastructure field." As a result, we have received opinions from the Committee about the importance of cross-disciplinary research, long-term perspective research, etc., rather than a review of the overall

structure of the evaluation criteria.
Although "River Basin Disaster Resilience and Sustainability by All" is a new policy initiative launched recently by the MLIT, the NILIM has been conducting related research for some time. Extensive activities through the Climate Change Adaptation Research Group, one of the mechanisms for cross-sectional collaboration within the NILIM, have produced research results that have contributed to "River Basin Disaster Resilience and Sustainability by All" in the past.
One such research introduced in the 20-year History (the related research as a whole has been ongoing for about 20 years) is titled "Advanced methods for identifying and forecasting floods". As a result of this research, there is now the "Flood Risk Line", but it would have been impossible to imagine the future that the practical application of today's technology would bring. However, "River Basin Disaster Resilience and Sustainability by All" in response to climate change is looked at as a paradigm shift, so, while advancing ongoing research, it is also necessary to consider new research from a long-term perspective and an expanded scope.
Research that contributes to "River Basin Disaster Resilience and Sustainability by All" is introduced here as an example, but it is necessary to consider future research activities in a timely manner, review the 20-year history of our activities and consider changes in the social environment, the opinions of the Committee (long-term perspective, collaborative activities), etc.

[I. Implementation and promotion of R&D]
(1) R&D supporting the proposal, planning and dissemination of MLIT's policies
(2) Technical support for response to disasters and accidents and upgrading of countermeasure technologies
(3) Supporting the improvement of on-site technical capabilities of local Regional Development Bureaus, etc.
(4) Collection, analysis, and management of data as the technical basis for policy proposal and planning, and return of data to society

[II Institutional management]
(5) Establishment of a management structure to support high quality research
(6) Fostering of human resources who can steer policy development from both research and administrative on-site perspectives, based on technology.
(7) Ownership and functional reinforcement of experimental facilities, etc. to support technical research and development in the housing and social infrastructure fields
(8) Effective dissemination of research results and activities

Fig. 2: Institutional Evaluation Criteria (established in 2018)

3. For the future

In moving things forward, there are "backcasting" and "forecasting," which are not new terms. Backcasting is "thinking about how the future should be and what needs to be done to achieve it," while forecasting is "thinking about building up possible improvements from what we have now and connecting them to the future." As such, backcasting is important to the greater goal of "achieving carbon neutrality in 2050," while forecasting seems realistic for individual initiatives and individual research projects. So, for example, when analyzing and forecasting the competency of current research with an eye to the future (goals), if research needs to be accelerated or expanded in inadequate areas, etc. in order to reach the goal, various types of collaboration, such as joint research and commissioned research, might be effective.
To seek research collaboration, it is important to have a good grasp of information in various fields. There are "T-shaped people" and "pi-shaped people," which might be overused terms. It is essential to have knowledge and information in multiple fields on the horizontal bar, with the core technologies on the vertical bar. In R&D, individual researchers are of course the most important, but now that the target fields are expanding greatly, I feel that it is necessary to collect information in an organized manner. In this regard, I think that initiatives such as cross-sectional organizations and theme-specific study groups for intra-office collaboration may be useful.

4. Conclusion

Regarding the provision of information on dam operations in the event of a flood, the steps of "communication," "comprehension" and "action" are considered necessary. This train of thought could also be applied to developed technologies. For example, when publicly announcing a developed technology, it is necessary not only to communicate information on the developed technology, but also to make sure people understand the information, and to think about how to encourage them to take actions (use). Even in the R&D stage, it is necessary to know well the actual site where the technology will be used, and to consider the path to action (use). The NILIM is, as a research environment, close to the target site, and we intend to continue to use this position of ours to produce the best results.

☞See the following for details.
1) 20-year History of the NILIM
http://www.nilim.go.jp/lab/bbg/20nenshi/index_20years.htm
2) River Basin Disaster Resilience and Sustainability by All
https://www.mlit.go.jp/river/kokusai/pdf/pdf21.pdf

For Realization of Carbon Neutrality Technological Development in the Sewerage Field

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Director, Water Quality Control Department

Key words: sewerage, carbon neutrality, Sewerage Technology Development Conference, B-DASH Project

1. Introduction

In Japan, in order to reduce greenhouse gas ("GHG") emissions, which is a global issue, the "Act for Partial Revision of the Act on Promotion of Measures to Cope with Global Warming" was promulgated in June 2021. The Act stipulates the establishment of basic principles to realize a decarbonized society by 2050, the setting of targets for implementing measures in action plans to be formulated by local governments, etc. In October 2021, the Cabinet approved the Action Plan for Global Warming Countermeasures, which aims to reduce GHG emissions by 46% in FY2030 (compared to FY2013).

In view of the situation above, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) established the "Subcommittee to Study the Contribution to a Decarbonized Society in the Sewerage Policy Research Committee" (Sewerage and Wastewater Management Department of the MLIT, Japan Sewage Works Association) to study the ideal state of sewerage systems, necessary measures, roadmaps, and other matters for realizing a decarbonized society. In collaboration with this initiative, the Sewerage Technology Development Conference (hosted by the Water Quality Control Department of the NILIM),[1)] consisting of members from industry, government, and academia, has been working on "Re-organizing effective technologies on sewage systems for the medium-term goal of FY2030" and "Examining technological development, etc. expected in future sewage systems in response to the long-term goal of FY2050" in the Energy Subcommittee (the "Subcommittee"), which was established to study the utilization of resources and energy inherent to sewerage systems, the development of new technologies that contribute to the optimization of sewerage systems, and measures to promote their introduction.

2. Current status of GHG emissions in the sewerage field

About 6 million tons (CO_2 equivalent) (**Fig. 1**) of GHG were emitted from the sewerage field in FY2018, which corresponds to about 0.5% of total domestic emissions[2)]. This amount is relatively high as the amount emitted by individual local governments that formulate action plans, and reportedly accounts for 35% of the total [3)]. For this reason, it is also necessary to reduce GHG emissions proactively in the sewerage field.

The majority of GHG emissions in the sewage field are indirect emissions from the use of electricity and fuel at water treatment and sludge treatment facilities, followed by dinitrogen monoxide (N_2O) emitted from the sewage sludge incineration process, and methane (CH_4) and N_2O emitted from water treatment facilities. In recent years, electricity consumption has increased slightly, and electricity consumption per volume of treated water has temporarily decreased but is again on a slight upwards trend, and the factors behind this increase need to be analyzed. N_2O emissions from the incineration process are on a downward trend due to the progress of initiatives including the replacement of furnaces with lower emission models. On the other hand, GHG emissions from water treatment facilities have remained generally flat, and, particularly with regard to N_2O, there are many unclear points as to its generation mechanism, and there are no known measures to control the emissions.

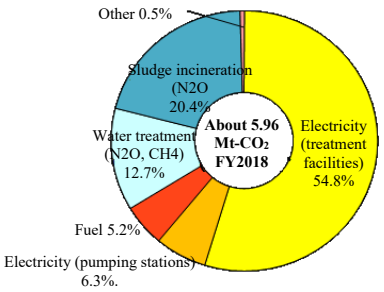


Fig. 1: GHG emissions from sewerage [2)]

3. For reduction of GHG emissions in the sewerage field

The time available to implement measures to achieve the 2030 target is limited. The main themes studied in the Subcommittee are 1) the reduction of electricity and fuel consumption in the sewage treatment process (energy saving), 2) the reduction of N_2O and other emissions from water treatment and sludge treatment facilities, and 3) the promotion of use of sewage sludge, which contains a large amount of organic matter, as an energy source (energy creation), which are all positioned in the Global Warming Action Plan as GHG emission reduction measures in the sewerage field. In addition, the "effectiveness as a system," by which the desired effect is demonstrated through the

close linkage of multiple processes between water treatment facilities and sludge treatment facilities, is also considered and evaluated.

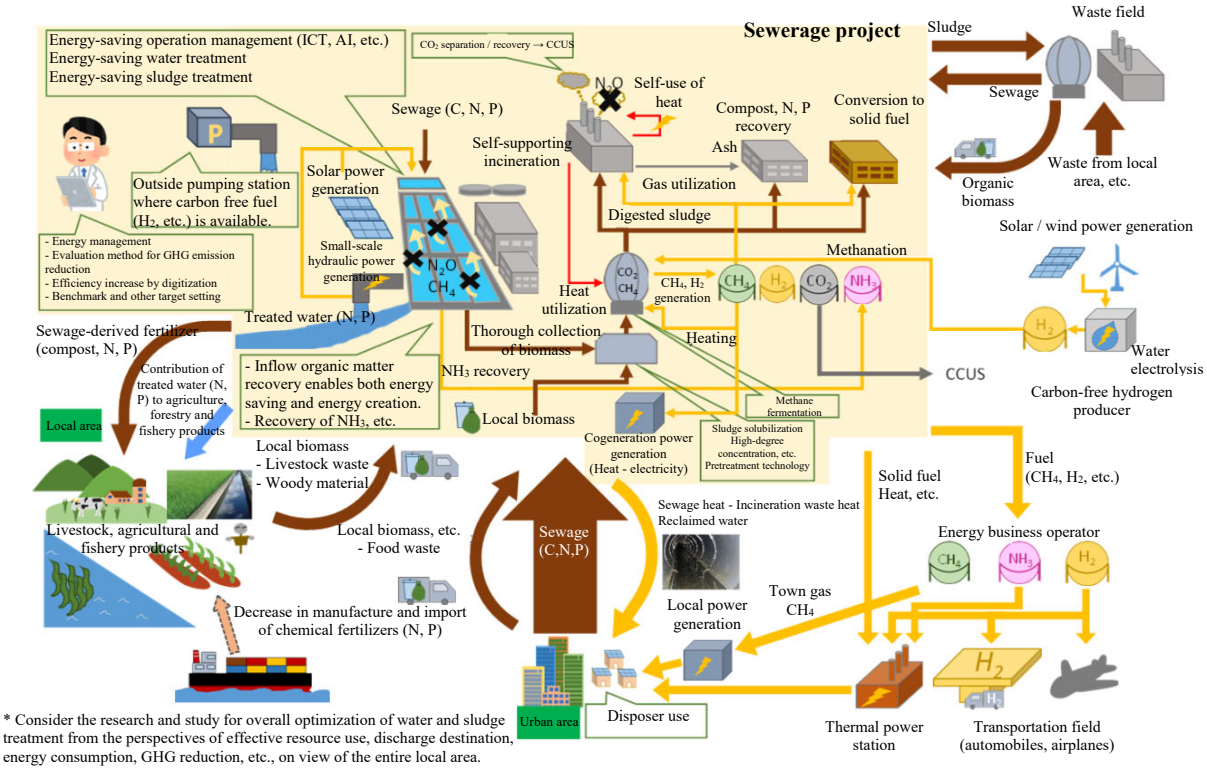
The MLIT has been supporting the introduction of technologies to solve problems in the sewerage field through the Breakthrough by Dynamic Approach in Sewage High Technology (B-DASH) Project, which began in 2011, and other projects, and has also been promoting the demonstration and dissemination of technologies related to energy conservation and generation. Discussions and considerations in the Subcommittee determined that GHG emissions could be significantly reduced through continued efforts in technological development, timely and accurate introduction of new technologies into sewerage projects, and appropriate implementation of operation and management that contribute to energy efficiency. For the realization of a decarbonized society by 2050, the need was indicated for initiatives from the perspective of the entire basin and encompassing social system, and ideas that are not bound by conventional stereotypes, including the development and proactive introduction of new technologies, the clarification of the phenomena of N_2O emissions from water treatment facilities and development of countermeasure methods, a shift of the core technical concept from sewage treatment to resource and energy recovery, and collaboration with the waste, agriculture, energy, and other fields. (**Fig. 2**).

4. Conclusion

Although sewerage administrators have a lot to work on and cannot focus solely on GHG emission reduction, GHG reduction is considered necessary to maintain a sustainable world, and we all need to work on it in cooperation with each other. I would like to take this opportunity to thank the Subcommittee members for the many ideas they gave us, and we would like to continue discussion and consideration with the understanding of many people.

☞See the following for details.

1) Sewerage Technology Development Conference: http://www.nilim.go.jp/lab/eag/gesuidougijyutsukaihatsukaigi.html
2) NILIM: The Energy Subcommittee's Report on Sewerage Technology Development, etc. for the Realization of Carbon Neutrality (Proposal) http://www.nilim.go.jp/lab/eag/pdf/20220113_2-3_houkokusyo.pdf
3) Bureau of Sewerage, Tokyo Metropolitan Government: Earth Plan 2017, p. 7, March 2017.



* Consider the research and study for overall optimization of water and sludge treatment from the perspectives of effective resource use, discharge destination, energy consumption, GHG reduction, etc., on view of the entire local area.

Fig 2: Image of technologies that contribute to carbon neutrality (from Subcommittee Document [2])

Research Initiatives for Disaster Prevention in River Basins and Coastal Areas in Preparation for Climate Change

FUKUHAMA Masaya, Director, River Department

Key words: rainfall change ratio, resilient structure, AI utilization, flood risk information, support for flood prevention activity

1. Introduction

In August 2021, the Summary for Policymakers of the Report of Working Group I on the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) was released. This Summary for Policymakers indicates that the magnitude of external forces causing water-related disasters in basins and coastal areas will increase in the future, including that (i) the certainty is high that "On a global scale, extreme precipitation in terms of daily precipitation will increase by about 7% per 1°C of global warming", and (ii) it is almost certain that "Global average sea level will continue to rise during the 21st century".

In Japan, we have suffered disasters described as "never experienced before" every year due to fronts, typhoons, etc. and it is expected that we will suffer disasters of even higher intensity and frequency in the future.

As disasters are expected to intensify in the future, the Council for Infrastructures has reported a shift to "River Basin Disaster Resilience and Sustainability by All (basin flood control)" in terms of water-related disaster countermeasures in light of climate change. Basin flood control is a multilayered approach that considers not only the catchment area and river area but also the flooded area as one basin area, and all parties involved in the basin work together on measures to (i) prevent or reduce floods as much as possible, (ii) reduce the damage target, and (iii) mitigate damage, and accelerate recovery / reconstruction.

The River Department is responsible for research on rivers and coasts, and each division publishes one article in this report. The **Figure** shows the relationship between the articles and basin flood control, and the following describes the aims, overview, and direction of the research.

2. Quantitative assessment of climate change impacts

If we do not accelerate the improvement of infrastructure such as river management facilities and coastal conservation facilities that achieve the target level of safety as soon as possible, the level of safety will relatively decrease due to the increase in external forces caused by climate change. Quantitative evaluation is needed to reflect climate change impacts in the planning of improvement.

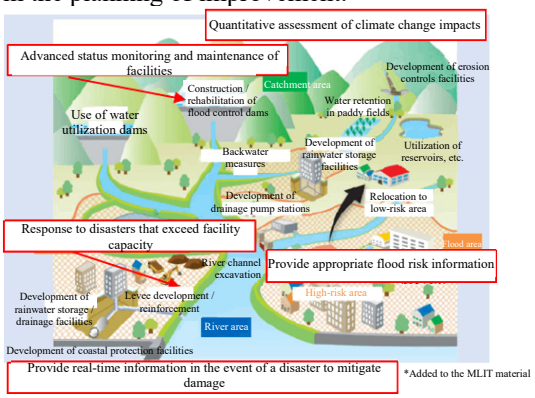


Figure: Relationship between articles and basin flood control

Therefore, the Water Cycle Division is studying future changes in rainfall to revise flood control plans that take climate change into account[1)]. For example, future rainfall change ratios are calculated for each temperature / sea surface temperature scenario according to each regional category with similar rainfall characteristics in Japan. Although results vary according to regional classification, the average rainfall change ratio for a 2°C rise in average temperature was 1.15 times in Hokkaido and 1.1 times in other regions. Other results show that average rainfall change ratios for a 4°C rise are 1.4 times in Hokkaido and northwestern Kyushu, and 1.2 times in other regions. The average rainfall change ratio for a 2°C rise is now being used in the review of river improvement basic policies. Please note that the above is based on average external forces for flood control planning. For basin flood control, it is necessary to continue to study future changes in precipitation and the spatiotemporal distribution of rainfall that exceed the average external forces.

3. Response to disasters that exceed the capacity of facilities

In the 2019 East Japan Typhoon, river levees broke in 142 locations across the country, more than 80% of

which were broken due to "overtopping" factors. In addition, Typhoon No. 21 in 2018 and other typhoons caused storm surges and high waves that recorded the highest tidal levels, etc. ever before. Such phenomena are likely to occur more frequently in the future, and levees need to have a "resilient structure" that demonstrates disaster mitigation effects, such as a levee that is less prone to breaking, and allows as much time as possible before breaking, even when water or waves overtopped the crown.
For this reason, the River Division has been studying river levee structures that are resilient and resistant to breaking even in the event of overflow due to flood [2)]. River levees are generally made of earth, and breaks occur due to a back erosion process where the back slope of the levee (the slope or bottom of the levee on the opposite side of the river) is eroded, followed by a crown failure process where the crown collapses after the entire levee back slope is eroded. By confirming these mechanisms through full-scale hydraulic model experiments, we will propose structures, such as covering the levee with anti-absorption sheets, blocks, and vegetation, as countermeasure works.

4. Advanced status monitoring and maintenance of facilities

As global warming increases the risk of flooding, it is necessary to properly manage river management facilities and coastal conservation facilities at all times so that they can perform as planned in the event of a disaster. This represents the viewpoints of status monitoring and maintenance for facilities.
In the field of dam management, dams are monitored for abnormalities in status through patrols and measurements, but depending on the data acquired, it may be difficult to determine whether or not action should be taken. For this reason, the Large-scale Hydraulic Structure Division has begun to develop dam management support technologies to improve the quality of dam maintenance through the use of AI [3)]. Specifically, we are doing research to (i) forecast changes in measurement data, such as the amount of deformation in the dam body that is periodically acquired on-site, using deep learning with a Recurrent Neural Network that detects abnormalities based on deviations from actual measurements, and (ii) detect possible structural damage to the dam body by unsupervised machine learning of features calculated from earthquake motion data observed in the dam body during an earthquake. Technologies related to DX, including AI, are expected to improve in the future, and we are conducting research in the field of maintenance as well.

5. Provision of appropriate flood risk information

Enhancing flood risk information, such as hazard maps, is important from the viewpoints of both information in the event of flood evacuation and prerequisites for community development. While progress has been made in providing flood risk information such as inundation maps for large rivers, provision of such information for small and medium-sized rivers has lagged behind. In fact, during the East Japan Typhoon in 2019, human casualties occurred in areas where flood risk information was lacking. It is also important to provide flood hazard information in a multi-phased manner, including not only large-scale rainfall, but also assumption of floods with the scale of medium and high frequency external forces, and assumption of floods in the phase of advancement in river development, such as after completion of river development.
Therefore, the Flood Disaster Prevention Division is working with the Prefectural and Regional Development Bureaus to solve technical problems and provide technical support in order to eliminate the risk information blank areas for small and medium-sized rivers, which is an urgent issue [4)]. We will also study specific methods for examining damage mitigation measures for each area in the event of flood inundation [5)].

6. Provision of real-time information upon occurrence of a disaster to minimize damage

When a flood, storm surge, or high waves are forecast to occur, it is important to improve the information on river levels, tide levels and waves, which are prerequisites for starting flood prevention and evacuation activities, as well as to organize such information. Accordingly, the Coastal Division is developing a "Storm Surge / High Waves Mitigation Support System" that forecasts in real-time the risk of flooding due to storm surge / high waves with the aim of supporting flood prevention activities during such events [6)]. This system forecasts the height of wave runup at 500 points nationwide and evaluates the inundation risk of coastal areas throughout the country in three levels, which are then colored and displayed on the map. This system's accuracy has been confirmed to a certain degree and results of forecasts are being provided to municipalities upon request on a trial basis. Based on what we learned from this trial, we are improving the forecast information to make it easier to understand and to trigger residents to take evacuation action.

☞See the following for details.

1) Research on future changes in rainfall for flood control planning considering climate change, p. 52, this report
2) Development of resilient levees that are more effective than crisis management-type structural countermeasures, P. 50, this report
3) Utilization of AI in safety management of dams - Development of dam management support technology to enhance the quality of maintenance, p. 145, this report
4) Eliminating flood hazard information blank areas - Trial flood hazard mapping in small rivers, p. 54, this report
5) For avoiding the worst-case flood scenario - Study on damage reduction measures in case floods overwhelm flood control structures, p. 56, this report
6) Development of a system to forecast flood damage from storm surge and high waves in advance - Aiming

to provide easy-to-understand information that leads to evacuation actions, P.137, this report

Promotion of Research and Technology Development to Support Sabo Engineers

TOMITA Yoko (Ph. D. in Agricultural Science), Director, Sabo Department

Keywords: grasp of environmental changes in mountain basins, UAV, synthetic aperture radar (SAR), NILIM Sabo Training

1. Mountain basin environments continue to change

Often the target of Sabo, mountain basins are continuously changing due to weather, geological conditions, and human activity. Rain, snow, earthquakes, volcanic eruptions, deforestation, and wildfires directly and indirectly cause various changes in mountain basins, including slope failure, landslide dam formation, sediment discharge, and sediment accumulation in mountain riverbeds. When such changes occur, sediment disasters may occur or may have long-term effects on our lives, such as repeated slope failures and sediment discharge due to subsequent rainfall. Therefore, it is necessary to continuously monitor changes in mountain basin environments on site and respond to such changes.

For example, the Sabo Department of the Water and Disaster Management Bureau of MLIT and the Japan Meteorological Agency jointly establish and implement a provisional standard that lowers the thresholds for the release of Sediment Disaster Alert[1] for municipalities where an upper 5 seismic intensity or higher is observed. As of the end of December 2021, 80% of the normal threshold was set as a provisional threshold for Toshima Village (Dec. 9 earthquake near the Tokara Islands), Kawaguchi City (Oct. 7 earthquake in northwestern Chiba Prefecture), and Hashikami Town (Oct. 6 earthquake off Iwate Prefecture), where a maximum seismic intensity of an upper 5 was observed. Whether to return the provisional threshold to the normal threshold will be determined after the relevant Regional Development Bureau and prefecture investigate post-earthquake rainfall, slope failure, and other conditions.

The reason for implementing the provisional threshold for Sediment Disaster Alert is as follows. Since the ground in the mountain basin is likely to be vulnerable due to seismic motion[2], the risk of sediment disasters due to expansion by rainfall of slope failure or due to the occurrence of a new slope failure,[2] is higher than before the earthquake for some time after the earthquake.

2. Greatly improve the efficiency of survey, inspection, and observation methods in mountain basins and ensure the safety of personnel

Various new technologies in recent years have enabled “faster, more accurate, and safer” surveys, inspections, and observations in steep and forested mountain basins. With support from the Regional Development Bureau and cooperation from research institutes of other fields in Tsukuba City, the Sabo Department is engaged in research and technology development for the following: emergency surveys of landslide dams and grasping of damage conditions using autonomous UAV flight,[4] identification of the locations of sediment disasters using synthetic aperture radar (SAR) images,[5] estimation of more accurate rainfall intensity using surveillance cameras already installed in mountain basins,[6] etc.

The results obtained to date have been published in Civil Engineering Journal and other academic journals, etc. and organized and issued as Technical Note of the NILIM and guidelines to the engineering officials of prefectures and Regional Development Bureaus in charge of Sabo.

3. Deliver necessary technology to Sabo engineers at the *front-line*

Two examples are introduced as follows.

3.1 Emergency surveys of natural dams and grasping of damage conditions using autonomous UAV flight[4]

As a method for acquiring clear images of collapsed slopes that are not visible from the takeoff point, the Sediment Disaster Prevention Technology Center of the Kinki Regional Development Bureau, where one senior researcher from the Sabo Planning Division is stationed along with Bureau officials, enabled investigation and inspection by autonomous flight under Level 3 flight by flying two UAVs simultaneously, which are responsible for photography and radio relay, respectively to stabilize the control and communication strength during flight (Fig. 1). With this method, it is possible to greatly improve the efficiency of surveys and inspections, and ensure the safety of personnel involved in field surveys and inspections, both in the event of a disaster and in ordinary times. The results are published as "Guidance." [4]

The Level 3 flight of UAV was the first case in the country and was covered by local and national media.

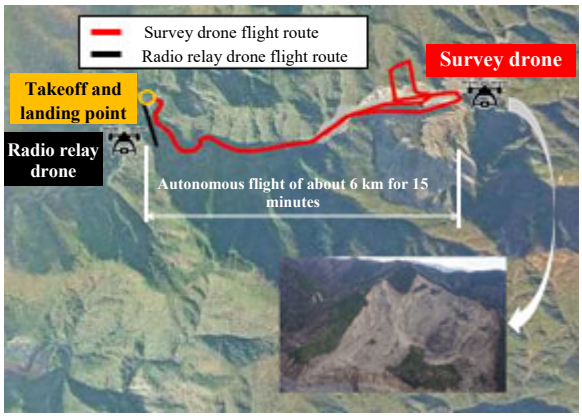


Fig. 1: UAV flight route (Kuridaira area, Totsukawa Village, Nara Prefecture)

3.2 NILIM Sabo Training

Since FY 2013, the Sabo Department has sponsored the NILIM Sabo Training for engineering officials from the Regional Development Bureaus with the aim of "promoting capacity building of engineers of Regional Development Bureaus with high competence required for surveys of sediment disasters". The members of the Sabo Department serve as lecturers to directly introduce research results and field survey methods.

Figure 2 shows the content of this training. The officials from the Regional Development Bureaus in charge of Sabo have been participating in this program from the beginning, and the officials in charge of road disaster prevention have been participating since FY 2018. As of FY2021, 101 trainees (74 for Sabo and 27 for roads) had completed the training, and were engaging in TEC-FORCE activities, etc. in the event of a sediment disaster.

In FY2021, we took a collective approach as much as possible to hold the training while striving to prevent COVID-19 infection. In the field training, with the cooperation of the Kii Mountain Sabo Office of the Kinki Regional Development Bureau, we conducted a field survey of torrents prone to debris flow (Photo 1) and boarded the helicopter "Kinki" to confirm the scale of the deep-seated rapid landslide and landslide dams. (**Photo 2**).

In FY2022, we will continue to implement the training, while incorporating new findings obtained from the research.

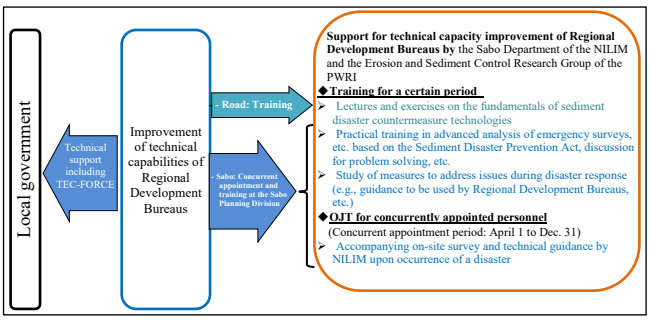


Fig. 2: Main contents of the training program for engineers responsible for advanced investigation and technical support in the event of a sediment disaster

Photo 1: Practical training on a field survey of torrents prone to debris flow

Photo 2: Confirmation of deep collapse and natural dams from helicopter

4. For rapid post-disaster recovery / reconstruction and the following maintenance of a safe living environment for the region

Sediment disasters directly affect human lives. In addition, evacuation may be prolonged if houses are damaged or infrastructure such as roads and water and sewage facilities is severely impacted. It is important not only to prevent disasters in advance, but also to rehabilitate and maintain the living environment to prevent secondary disasters.

To keep the living environment in the region safe, we will continue to conduct research and technology development on the construction and maintenance of Sabo facilities in accordance with changes in mountain basins, the development of technologies that contribute to sediment management, and the ideal form of Sediment Disaster Alert.

[References]

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2) Torii et al. (2007): Experimental Study of the Mechanism of Slope Failure Caused by Rainfall after an Earthquake, Journal of the Japan Society of Civil Engineers, C, Vol. 63, No. 1, p. 140-149
3) Tomita et al. (1996): Expansion of Collapsed Areas due to Post-earthquake Rainfall in the Rokko Mountains, Journal of the Japan Society of Erosion Control Engineering, Vol. 48, No. 6, p. 15-21
4) "Guidance for Emergency Surveys of Natural Dams and Grasping Damage Conditions Using Autonomous UAV Flight" https://www.kkr.mlit.go.jp/kiisankei/center/research3.html
5) NILIM material No.1110 "Guidance for the Interpretation of Sediment-related Disasters by Synthetic Aperture Radar (SAR) Images" http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1110.htm
6) Kanazawa et al. (2021): Estimation of Rainfall Intensity using Pixel Values of Surveillance Camera Images, Journal of the Japan Society of Erosion Control Engineering, Vol. 74, No. 3, p. 37-48

Towards the Realization of the Roles Roads Should Play

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

(Keywords) road traffic management, traffic safety, road space reconstruction, automated driving, road traffic data

1. Introduction

Japan's roads have contributed greatly to improving the affluence and quality of the lives of the citizenry as important infrastructure forming the backbone of the country. Despite a social environment that in recent years encompasses issues like a decreasing population, the arrival of a super-aged society, and the need for revitalization of local economies, roads must continue to play this role while appropriately incorporating elements such as technical innovation. In addition, from the point of view of the direction taken by mid- to long-term road policy, the roles that roads should play are being reconsidered, such as the need for roads themselves to become a place to be, rather than just a space to move people and things. The substance of these matters has been organized in the suggestion of the Road Subcommittee of the Council for Infrastructure[1)] and the proposal of the Basic Policy Group of the same Subcommittee.[2)]

This paper briefly describes representative initiatives in the Road Traffic Department in the road traffic field in particular, based on their relationship with the roles that roads should play.

2. Effective Use of Road Networks

In addition to developing the road network, serious consideration should also be given to the perspectives of stable use of the road network and maximizing the utilization of road functions. For this point of view, it is necessary to work towards achieving road traffic management that makes full use of ICT (Big Data, AI, etc.), acquires information about road traffic conditions, and introduces appropriate improvement measures to enable smart use of roads.

The Road Traffic Department is conducting research aimed at understanding road traffic conditions in real time by acquiring travel speed, distributions of originating and concentrating traffic volumes and information on routes automobiles use from ETC 2.0 probe information and other sources, in addition to traffic volumes from traffic counters and road management camera imagery. Using this information, we will work on research aimed at road traffic management, such as forecasting near-future road traffic conditions and examining methods to actively control them.

3. Realizing Traffic Safety

Further promotion of traffic safety measures in main roads, neighborhood roads and roads used by school traffic is expected to create road areas where everyone can travel in safety and comfort. For this point of view, it is necessary to effectively extract locations with a risk of accidents and to draft and implement appropriate traffic safety measures by using Big Data, in addition to traffic accident data.

The Road Traffic Department is using Big Data that includes traffic accident data and ETC 2.0 probe information to conduct research aimed at effectively extracting accident risk locations where accidents and sudden braking occur and appropriately extracting district through-routes that automobiles take using neighborhood roads in particular. In addition, for neighborhood roads, we are moving forward with research into effectively placing individual measures to control automobile travel speed and traffic passing through districts and methods of reaching consensus with a view towards implementing control measure, and we will support the roll-out of "Zone 30 Plus (traffic safety measures in neighborhood streets that appropriately combine 30 km/h zone limits, speed bumps, etc.; Fig. 1)".

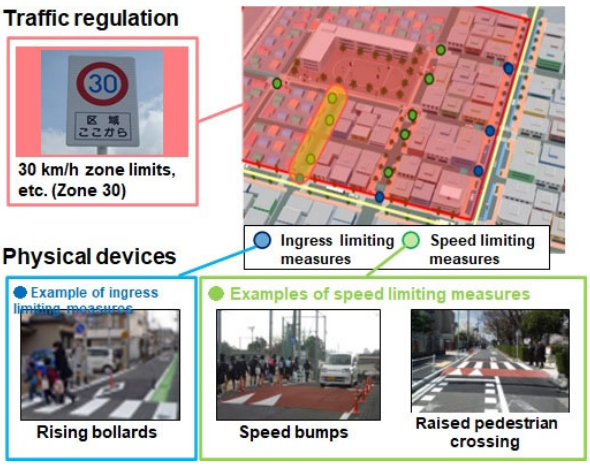

Fig. 1. Images of Zone 30 Plus (traffic safety measures in neighborhood streets)

4. Constructing Road Spaces Suited to Diverse Needs

In conjunction with bypass development, it is desirable to examine road space reconstruction over the entire road network, such as rehabilitating the road that was mainly used previously (the existing road) to make a human-focused road space, and to turn the existing road into a safe, comfortable, vibrant road space. In addition, in roads located in town centers, "curbside management" should be rolled out to allow road spaces to be used in various forms, including as drop-off/pick-up zones or open-air cafés, depending on the day of the week and time.

The Road Traffic Department is working on research aimed at achieving the reconstruction of existing roads in conjunction with bypass development and the creation of vibrant road spaces through gathering case examples and findings, examining road space formation techniques, and other methods.

5. Realizing Automated Driving

Automating and reducing the work needed for transporting people and things through automated driving is expected to realize safe, efficient road services, as well as improving productivity, contributing to the formation of local communities where life and livelihood are sustainable, and realizing sustainable economic and social activities. In addition to using expressways and other roads that form the backbone of the country, automated driving could also be used to assure transport modes in regions surrounding rest areas in semi-mountainous zones, for example, where government contact points and other services needed in day-to-day life are likely to converge.

For the automated driving technology, automatic braking based on detection information from on-board sensors and other autonomous vehicle technologies for safe driving are being developed and are in the process of being implemented in vehicles. However, with a view towards more effective automated driving, we could conceivably support appropriate vehicle control by providing automobiles with information that the roads hold to supplement situations where the information from autonomous vehicle technologies is not sufficient on its own.

The Road Traffic Department will use the public-private joint research framework to evaluate technical specifications for areas including technologies for information provision services for merge support, which we aim to realize in expressways, and self-positioning in self-driving vehicles.

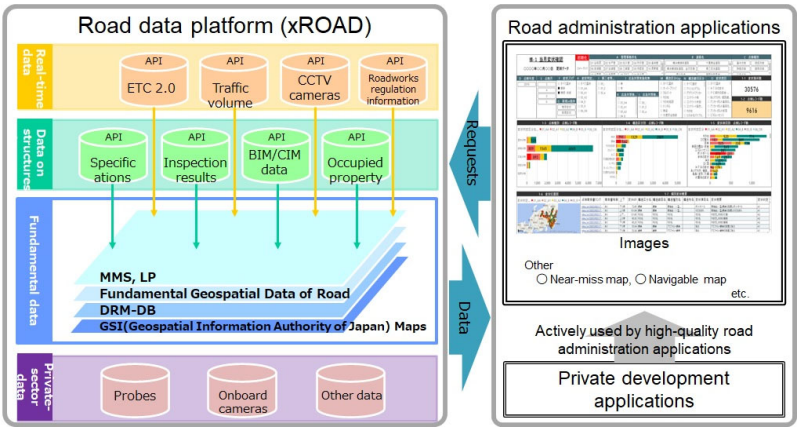

Fig. 2. Road data platform (xROAD) and its use

6. Effective Use of Road Traffic-related Data

The above discusses Road Traffic Department initiatives based on their relationships with the roles that roads should play. However, gathering road traffic-related data appropriately and using it effectively seems to be an important key in implementing these initiatives. The Road Bureau of the MLIT is building a "road data platform" (Fig. 2) that centralizes and makes available the data collected and held by road administrators and others, and is moving forward with examinations aimed at realizing such outcomes as ongoing monitoring of road traffic conditions, etc., upgrading information provision services, and data-driven management, to name but a few.

Through close coordination with the Road Bureau, the Road Traffic Department will conduct further research with a view towards building the road data platform, as well as building techniques for evidence-based policy-making that uses it.

7. Conclusion

This paper presented some of Road Traffic Department's initiatives aimed at realizing the roles that roads should play. At the Road Traffic Department, we are keen to continue the necessary research, with an appropriate understanding of the roles that roads should play.

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Technical Support for Frequently Occurring Road Disasters

FUKUDA Yukihiro, Director, Road Structures Department

(Keywords) Road structures, road disasters, disaster prevention & reduction, technical support, scouring

1. Introduction

The Fifth Priority Plan for Infrastructure Development, which was adopted by a cabinet decision in May 2021, listed "realizing a disaster prevention/mitigation-focused society" as a priority target and presented "mitigating risks for earthquakes, tsunami, and other imminent disasters" and "ensuring transportation availability during disasters" as a policy package aimed at achieving this target. The plan lists deepening infrastructure through "Full forces" as initiatives to achieve the target. Full forces refer to entity, means, and the time axis; from the perspective of concerted efforts by entities, the plan promotes measures through strengthened coordination between the national government and local governments.

The Road Structures Department offers technical support for disasters affecting roads, including those managed by local governments; below is presented a case example of recently occurring damage from torrential rain that demonstrates the disaster response (investigation of causes, stopgap recovery efforts) and the initiatives to make use of the findings obtained from it in preventing disasters from recurring.

2. Support for disaster response

Figure 1 shows NILIM's technical support and research activities in disaster response. The balloons with red writing at each item show concrete technical support provided by our department and the blue frames show our department's research activities. Dispatching experts to disaster-affected locations, establishing advisory committees as necessary, and investigating and inspecting similar locations are efforts that should be anticipated immediately after disasters occur.

(1) Support for on-site investigations and recovery efforts at disaster-affected locations

When a road disaster occurs, we dispatch experts in the bridge, tunnel, and earthworks sectors in response to requests from local government, as well as from regional development bureaus, and provide technical advice for cause investigations and emergency recovery efforts.

We dispatched experts to disaster-affected locations again in FY2021, as shown in the close-up at the beginning of this issue.[1)] When doing so, NILIM often teams up with the Public Works Research Institute to dispatch personnel, and they are accompanied by employees from the development bureau with jurisdiction.

(2) Initiatives to make use of lessons from disasters

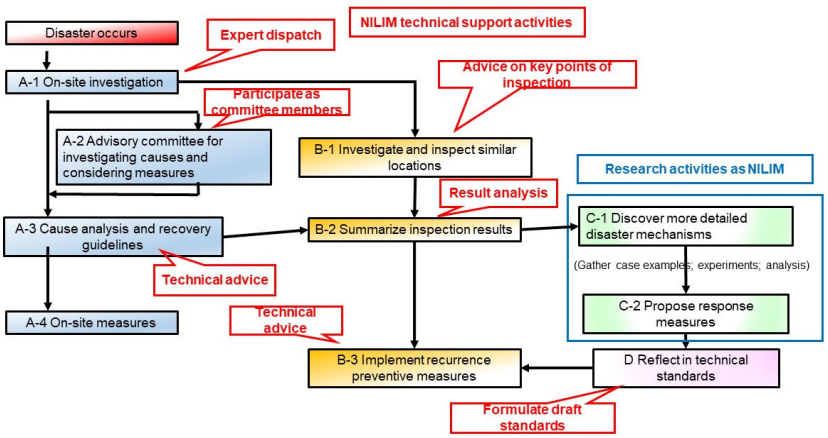


Fig. 1. NILIM's technical support and research activities in disaster response

Initiatives to investigate factors in the occurrence of disasters and to connect these to preventing further disasters are also important. For this reason, we provide technical advice aimed at investigating and inspecting locations with conditions similar to the disaster-affected location and prevent further disasters from occurring.

In addition, when a detailed analysis of the disaster mechanism is necessary, we bring it up as a research topic, propose response measures through collecting case examples of disasters and conducting simulations and experiments, and reflect these in technical standards.

(3) Examples of specific initiatives

A bridge was closed to traffic for a long time due to scouring of its foundations in the 2019 East Japan typhoon. In response, we conducted research on the topic of "extracting road bridges likely to suffer scouring damage," looking at methods of finding road bridges with a high risk of being affected by disaster and methods of increasing the options for preventive measures and reducing the risk of being affected by disaster, with the aim of proposing reasonable preventive measures against the above disaster.[2)]

While conducting the above research, we also analyzed cases of disasters from recent years and extracted points to note during inspections. In August 2021, we organized the outcomes into training materials titled "Preliminary knowledge on scouring in road bridge maintenance (draft),"[3)] so that it could be widely known among engineers involved in road bridge inspections. This document is used in training for regional development bureau and local government employees (Fig. 2).

In addition, we are also researching effective methods in locations requiring measures to control scouring. In some cases, bridge piers have sunk or collapsed near locations where streambed protection has been installed with the objective of preventing scouring on the streambed due to flowing water. Given this, to test the possibility of the flow accelerating and local scouring occurring more readily around bridge piers adjacent to streambed protection, we built a 1:30 scale model of a bridge confirmed to have suffered pier sinking and inclination due to scouring from torrential rain in July 2020. We conducted hydraulic model experiments focusing on the scope of the streambed protection installation, whether there was a ground sill, and the distance between the ground sill and the bridge, and we measured and observed water levels, flow speed, streambed height, etc. (Photo)

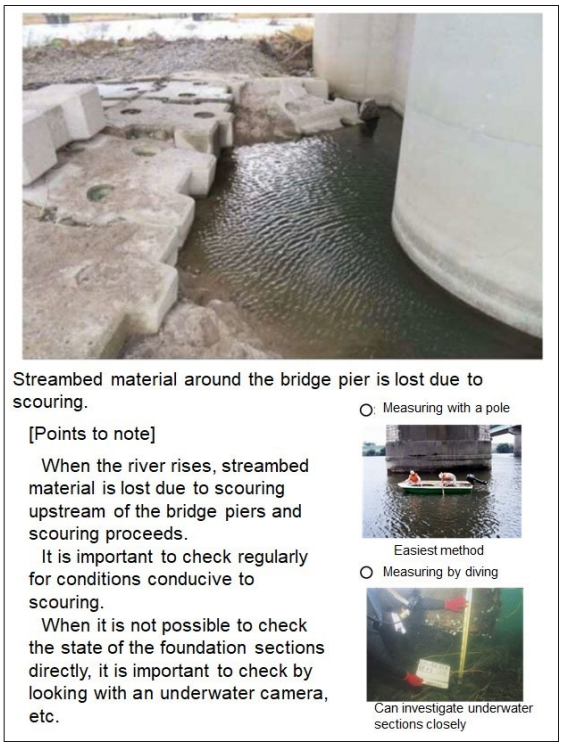


Fig. 2. Example of preliminary knowledge about scouring

Photo. Experiment on scouring around streambed protection

3. Conclusion

The Road Structures Department provides support for technical aspects of sites and policy for road disasters, such as on-site investigations, formulating recovery guidelines, recurrence prevention measures, and reflecting these in technical standards, and we hope to continue to play this role.

☞See here for detailed information

1) *Rapid Technical Support for Disasters and Faults*, p. 9 herein

2) *Development of Methods for Determining Disaster Potential and Preventive Measures for Bridge Washouts and Scouring*, p. 61 herein

3) *Preliminary knowledge on scouring in road bridge maintenance*

http://www.nilim.go.jp/lab/ubg/reference/pdf/21BR005/20210831_bridge_scour.pdf

Architectural Research to Respond to Changes in Social Needs

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

(Keywords) Social needs, architecture, green society, disaster prevention/disaster mitigation, new lifestyle

1. Introduction

Building Department has engaged in research to realize safer, more secure, and more attractive buildings that meet the increasingly diverse and sophisticated needs of society by bringing together knowledge and other expertise in the fields of structure, fire protection, materials, and equipment.

This paper introduces some representative studies from the viewpoint of “architectures that respond to changes in social needs.”

2. Research to Realize Green Society

1) Promoting the Use of Wood in Mid- to High-Rise and Large-Scale Architectures

In order to realize a green society that aims to be carbon neutral by 2050, there is a need to expand the use of wood, which is highly effective in reducing greenhouse gas emissions, in buildings. To achieve this, it is necessary to establish design methods for structures and fire-proof performance that will serve as common rules for advancing the use of wood in mid- to high-rise and large-scale architectures. For this purpose, we conducted a comprehensive project, “Development of Design and Construction Technology for Mixed Structure Architecture with the Use of New Wooden Materials,” (FY2017-2021), to facilitate the realization of mid-rise complex structure architecture by combining the wooden construction using large wooden panels with reinforced concrete construction, steel construction, other wooden structure methods, etc. In particular, we set up prototype types of structures, including a type in which a wooden frame is freely installed inside a large RC structure (Photo 1) and the wooden components are shown on the interior surface, and then we verified, with experiments, the performance levels of structure, fire resistance, durability and sound insulation required to realize each type, and developed design and construction methods.

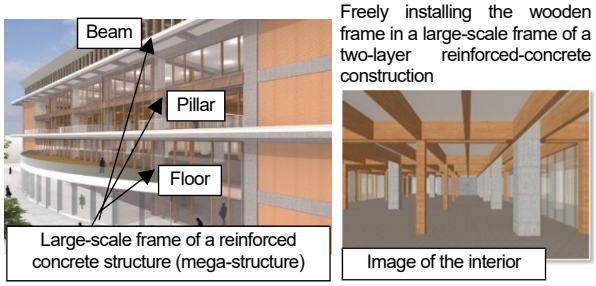


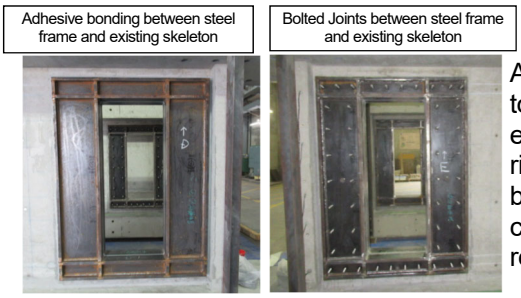
Photo 1. Example of the prototypes of frame form in mixed structure architecture

We will attempt to reflect achievements in research related to notifications in relation to the Building Standards Act, guidebooks of technological standards, etc. In addition, we will sum up the research achievements on the standard specifications of joint parts etc. and examples of the design of prototype architectures to support their proliferation as general technology. For the further promotion of the use of wood in architecture, on the other hand, we think that it is necessary to continue to cope with problems such as sophisticated structural design, fire-proof/fire-prevention design, securing durability performance, etc.

2) Promoting the Longevity and Efficient Use of Existing Reinforced Concrete Construction Housing Complexes

The degradation of housing complex aggregates, which were provided in large quantities during and after the rapid growth period, into old towns has become a social problem. In order to promote "environmentally friendly apartment complex revitalization" toward the realization of a green society, it is necessary to further extend the service life and effective utilization of existing RC housing complexes.

For this purpose, we are implementing the comprehensive project, “Development of Regeneration Technology for Suburban Housing Estates in Response to the Mature Society” (FY2018-2022). In relation to the evaluation of durability performance concerning the longevity of existing reinforced concrete housing complexes, we have been making efforts towards achieving the sophistication of evaluation methods by combining the influence of reinforcing bar corrosion etc. from local degradation risks in addition to conventional resistance to carbonation. As for housing aggregates, where the aging of the population is advancing and vacant houses are increasing, the efficient use of stock and promotion of the provision of houses is desirable to support the child-rearing generation, and also from the viewpoint of sustainability of the suburban housing estates. We are therefore developing a design method to expand space by creating openings in the structural walls between dwelling units of existing RC housing complexes, and a reinforcement technique to restore structural performance after the creation of openings (Photo 2), through experiments and other verification.



A loading test to verify and evaluate rigidity and bearing capacity after reinforcement

Photo 2. Testing of steel frame reinforcement around opening formation

3. Research for disaster prevention and disaster mitigation

1) Strengthening cities by promoting renewal of obsolete architecture

Realization of the regeneration of cities and strengthening cities by renewing obsolete architecture is an urgent problem. How we dispose of existing piles from obsolete architecture while promoting the renewal of architectures in narrow land at the center of cities etc. is one part of this problem.

For this purpose, we are implementing the comprehensive project, "Development of Technologies to Contribute to the Regeneration and Strengthening of Cities with Rational Structural Regulation Concerning Architectures and Land" (FY2020-2023). The project aims to develop (1) evaluation methods for structural safety when existing piles are reinforced and reused, (2) evaluation and design methods for structural safety when existing and new piles are used together, (3) performance evaluation methods for backfilling ground when existing piles are removed and backfilled (Photo 3), and so on through experiments and other verification, in order to enable various treatment methods for existing piles in consideration of freedom of architectural design and economic rationality.

Photo 3. Verifying the characteristics of the soil after removing existing piles

(Left) Removing existing piles (the end-cutting withdrawal method with casing)
(Right) Horizontal loading test of new piles installed on refilled land after removal

2) Resistance of roofs of existing architectures to strong wind

Typhoon 21 in 2018, Typhoon 15 in 2019, and other large-scale typhoons in recent years caused a large amount of damage to roof tiles on architectures, the roof trusses of wooden constructions, and so forth, which obstructed the continuity of residence and smooth recovery. It is anticipated that the influence from climate change may increase the damage occurring from large-scale typhoons; thus, the protection of weak portions of roofs from strong winds is an urgent task.

For this purpose, we are implementing the project, "Research on Anti-wind Examination and Technical Evaluation of the Reinforcement of Thatching Materials on Roofs of Existing Architectures" (FY2021-2023). The project aims to improve the wind resistance of roofs of existing buildings through the development of (1) wind resistance diagnosis methods to identify weak points of roofing materials, and (2) evaluation methods for reinforcement techniques according to the identified weak points and the required wind resistance performance level (from the level equivalent to the Building Standard Law to the highest level assumed to apply to disaster base buildings, etc.). Through these research efforts, we intends to induce improvements in the wind resistance of the roofs of existing buildings.

3) Sophistication of Fire-Prevention Performance of Non-residential Architectures

A fire at a physical distribution warehouse in Miyoshi Town, Saitama Prefecture, in February 2017 required a long time to extinguish, and caused a high level of economic damage including the disruption of the continuity of the business. While the sophistication of fire-prevention performance of non-residential architectures is one of our tasks, there is currently no system for evaluating fire-prevention performance of non-residential architectures and expressing it to the owner of the construction etc. in an attractive way.

For this purpose, we are implementing the project, "Development of New Performance Indices and Evaluation Programs Contributing to the Sophistication of Fire-prevention Performance of Non-residential Architectures" (FY2020-2022). The project aims to develop new indices for the comprehensive evaluation of functional continuity performance and a program for the evaluation of functional continuity performance in consideration of physical damage, recovery periods, etc. up to the level of members based on the results of the predicted characteristics of a fire inside the architecture at the time of the occurrence of the fire.

Note that, recently, there have been fires at physical distribution warehouses etc. that took a long time to extinguish and fire incidents with many victims. We think it is necessary to continuously conduct research to contribute to further measures in consideration of the problems associated with fire prevention or evacuation from existing non-residential architectures.

4. Toward New Research Triggered by the Covid-19 Pandemic

The Building Department continues to conduct research to precisely correspond to a various needs for architectures in relation to the variance and

sophistication of social needs.

We are conducting, starting in FY2022, our new comprehensive project, "Development of Technology to Evaluate the Performance of Houses and Architectures Corresponding to the Changes in the Social Environment" (FY2022-2026). The spread of novel coronavirus infection has triggered an increase in working from home, as well as the need for the home evacuation etc. at the time of a disaster. In consideration of such changes, we will develop (1) an evaluation method that is rational and easy to understand in terms of sound insulation performance and natural light permeation, (2) an evaluation method for anti-seismic performance from the viewpoint of the continuous use of houses and architectures after a large-scale earthquake, (3) an evaluation method of the continuous use of elevators after a large-scale earthquake, and so forth, leading to the propagation of high-performance the houses and architectures that may be attractive to consumers.

☞ Click here for more details

1) The website of the Architecture Research Department
http://www.nilim.go.jp/japanese/organization/kenchiku/jkenchiku.htm

Using BIM for Maintenance Management/Operation of Buildings

TAKAHASHI Satoru, Director, Housing Research Department

(Keywords) *Building production, BIM, Historical information*

1. Promoting BIM in the Field of Architecture

Endeavors for so-called BIM have been spreading, where the building information covering the planning and design to the construction and maintenance management of architectures is integrated and visualized and various entities share and use the information, in attempts to sophisticate the business efficiency and use of buildings. In Japan, at the beginning of the 21st century, endeavors for BIM started to attract the awareness of people as a new tool and/or method of design and construction following the publication of software products that were able to process the information of the structures by adding attribute information to 3D models, the introduction—by leading designers—of examples of the use of such software in architectural design, and so forth. Subsequently, the enterprises, organizations, and other entities that were advancing their leading endeavors studied the technology and service appropriate for their business, the rules for transferring information and using data, and the like, made progress in applying these tools and other practices, starting with those projects and processes in which they were able to determine to introduce them. As each enterprise etc. expanded their endeavors, for a wider range of relevant entities and processes to make use of BIM, they started to share the awareness of the necessity of the formats of the programs that were used and data defined among each specific organization or relevant entities in relation to a project, rules of operation concerning information sharing, and so forth by dividing and organizing them in “the field of competition” and “the field of cooperation.”

To solve such problems and to organize the environment of BIM usage comprehensively from the phase of planning and design of an architecture to the phase of maintenance management, the “BIM Promotion Roundtable” was founded in July 2019 as an endeavor among the government and private sector, where an extremely wide range of entities participated, including private sector associations related to each phase of Building production, the relevant divisions from the Ministry of Land, Infrastructure, Transport and Tourism, and so forth.

2. Our Aim in the Usage of BIM

At the first Architectural BIM Promotion Conference, the statuses of endeavors by each participating organization were reported. At this time, there was a conspicuous difference in the introduction and use of BIM among enterprises and organizations; thus, cooperation across fields was regarded as a problem (although there were some leading endeavors in the fields of design and construction). Therefore, in the third round of the same conference, “The Future Image and Milestones of Architecture BIM” was compiled. Its content included the tasks that should be advanced in cooperation among all entities in the field of architecture, current achievements, targets that should be organized, and so forth. (Fig-1)

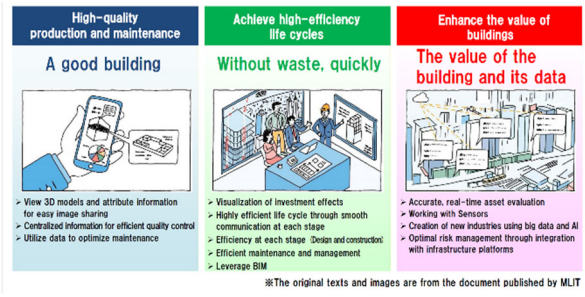


Fig-1. Future usage of architecture BIM

In the use of BIM, the portion of its conspicuous characteristics, “using 3D shapes to ‘visualize’ the building in an easy-to-understand way and thus to enhance communications and understanding” may easily attract our interest. However, the essence of BIM is “being able to add attribute information to models”; thus, the future image was depicted in providing “some value to a building and to data” as a platform for the use of information through the processes of Building production and maintenance management/operation by making use of it being a technology that “can the information through the life cycles of the buildings, which can also be linked to the IoT.”

3. Endeavors in the Collection of Information in Building production

Endeavors related to improving the rationalization and efficiency of Building production through the use of information technology have been undertaken for many years.

In development of technology related to the keywords “information collecting construction and automated construction,” industrializing construction methods that enable labor saving and man saving have been examined, where the informatization of the required performance in relation to the parts or members in architectures, and electronification to machine and manufacture members and parts at a factory, with the aim of achieving both mass-production and securing quality, were major themes. As the Internet spread, some endeavors were made in the development of “CALS/EC” technology to transfer and share the information related to design and construction by network in a fully-fledged manner, including the development and formulation of standard file formats, common codes for building production, the development and formulation of standard for CAD drawing, and so forth to transfer and share information among entities related to Building production, including the owner and the designer/constructor, the constructor and the sub-constructor/manufacturer, and so forth.

The major interest of endeavors was establishing efficient and automatic on-site construction by attempting to transfer the intention of the design between the phases of design and construction and by aiming to achieve data linkage. At this time, the viewpoint of providing data that was easy to use at the phases of maintenance management and operation and of organizing and keeping information was not conspicuous.

On the other hand, in the field of housing, the endeavors have been made in the organization and use of housing historical information (storage and accumulation of records, including how a house was built, what performance is available, and what inspections, corrections, reform, etc. have been made since its construction). Specifically, the drawings at the time of construction, documents for the confirmation of construction, inspection results, reform records, and so forth are applicable. It has been reported that the usage of housing historical information accumulated at the time of construction of a house and during maintenance management (e.g., reform) may be of value for further maintenance management and transaction of the house.

At present, it is not easy to imagine that the owners

may inherit the very BIM data that is handled in design BIM or in construction BIM as part of the housing historical information for management or other uses. Therefore, we have examined the method of using BIM data that are appropriate for current maintenance management and operation practices, using public rental apartments as elements. For the maintenance management of apartments, the outside walls, the interior decoration of each apartment, the attachments outside the apartments, and so forth are regarded as portions and parts that are involved in management. Accordingly, it is thought that extracting a 3D model of applicable portions and parts from the design BIM model and linking the inspection records etc. kept in an electronic ledger etc., as a model for the method of construction of a simplified maintenance management BIM model may be a way that the information can be used in a realistic manner. (Fig-2)

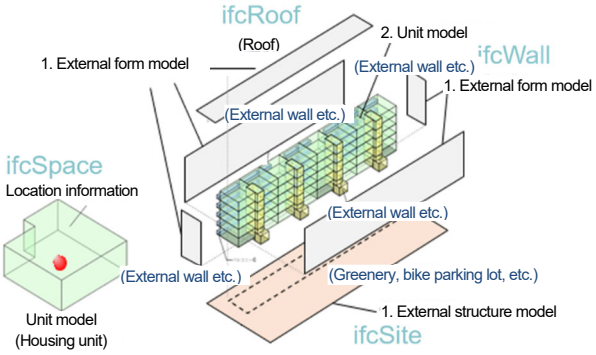


Fig-2. An example of examining the maintenance management BIM model of apartments

4. Value for Buildings and Data Alike

In our endeavors in the promotion of BIM, we have firstly been advancing the examination of standard workflows and the method of using them, mainly focusing on the phases of planning, design, and construction in new construction projects. At the beginning, we discussed it as a method of enhancing productivity, with the aim of sharing information, accelerating decision making, and reducing the unnecessary steps (e.g., by stepping back using BIM) in terms of the work processes followed by designers, constructors, etc. As our discussion went deeper, the workflow to create the maintenance management/operation BIM model for the purpose of maintenance management/operation was created, which the owner (administrator) can apply in maintaining and using the building appropriately.

Houses and architectures, by nature, produce value of use after their construction and when the activities and businesses intended for the buildings are performed. In a sustainable society, the long use of buildings is expected. Thus, it is anticipated that changes in the purpose of a building, large-scale refurbishment, and so forth may be made in the phase of maintenance management and/or operation. For the examination of changes in the planning of use a building or for the design of modifications, the realization of methods of using BIM that are able to easily confirm the information necessary for the conformity to or restriction from a building standard, the performance of the house, and the like, this should contribute to the appropriate evaluation and use of the building.

☞ Click here for more details

1) NILIM Lecture Meeting, FY2021
http://www.nilim.go.jp/lab/bbg/kouenkai/kouenkai2021/kouenkai2021.html

2) BIM Promotion Roundtable, the Ministry of Land, Infrastructure, Transport and Tourism
https://www.mlit.go.jp/jutakukentiku/kenchikuBIMsuishinkaigi.html

The Current Circumstances Surrounding Cities and the Trends of the Research

TOHYAMA Akira, Director, Urban Planning Department

(Keywords) Sustainable cities, disaster prevention, carbon neutral

1. Introduction

The cities in our country are experiencing problems such as condensed city areas that are dangerous from the viewpoint of disaster prevention and the degradation of city center areas, while depopulation, decreased births, and the aging of the population have been advancing, the awareness of the global environment has been growing, and some conspicuous changes have been ongoing in the social circumstances that we face.

Under these circumstances, natural disasters that have been gradually intensifying and occurring more frequently in recent years, the realization of a carbon neutral society in 2050, the new working styles and housing styles triggered by the coronavirus pandemic, the rapid growth of digitalization, and the like have had a great influence on urban lives and urban activities. In this background, there is a desire to implement urban policy that corresponds to the changes and diversification of people's awareness and the sense of value in relation to them.

The City Research Department, on the basis of this direction of city policies, grasps the problems onsite and the needs for technological policies and is advancing research, study, and the development of technology, aiming at the realization of excellent town building by way of the achievement of research that is reflected in national laws, ordinances, technological standards, and other policies, which is also used effectively by municipal governments.

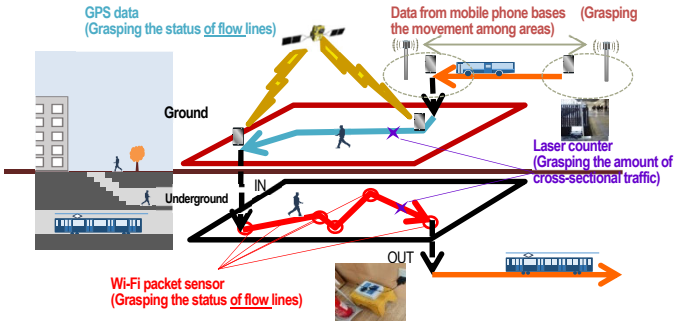
2. The Three Important Research Themes in Our City Research

(1) City Building in the Depopulating Society

For future town building in urban areas, in a background of rapid depopulation and aging, the major tasks are to realize a wholesome and comfortable living environment for seniors and for the child-rearing generation to feel secure, and to enable sustainable urban management in terms of finance and economy. Therefore, it is important to review the structure of the whole urban area, including social welfare, transportation, and other systems, with the concept of "compact plus network", medical and social welfare facilities, commercial facilities, houses, and the like being aggregated, and with residents able to access these life amenities by way of public transportation systems. Furthermore, to correspond to the decrease in the working-age population and the diversification of the social economy, it is necessary to form spaces where a variety of people can gather and communicate and to enhance the attractiveness of towns.

The NILIM, for the formation of the compact urban space where "you feel comfortable and want to walk," has been advancing the research on ① the aggregation of urban functionalities and residences and measures for promoting wide-area collaboration among cities, ②technology to enhance the living and transportation environment in suburban apartment buildings, ③ methods of regenerating public spaces in station squares and other locations as a vibrant public space, and so forth. In addition, to improve the quality of urban life with the use of digital

technology and enhance the usefulness for urban activities, we have been advancing research in relation to ④ the tools for the evaluation of planning to support municipal governments that are making endeavors in relation to smart cities, ⑤ data specifications of 3D urban models organized as the basic data of smart cities, and ⑥ methods of grasping pedestrian movement lines by analyzing the movement of terminals, such as mobile phones (Fig-1).



Using data from mobile phone bases and GPS data to grasp the long-distance movement and switching to the collection with Wi-Fi sensors when targets enter a building, underground space, or the like.

Fig-1. Continuously observing the movement lines of the people from other cities

(2) Building Disaster-resistant Cities

In recent years, the influence of climate change has been causing climate disasters to become more severe and more frequent and—in addition—the likelihood of large-scale earthquakes, such as Tokyo inland earthquakes, has been increasing; thus, there is a desire for town building that attempts to secure the safety of housing and daily lives and which is resistant to disasters.

Regarding earthquake disasters, the improvement of highly dense downtown areas—where a lot of problems lie in terms of disaster prevention—is an urgent task for securing the safety of cities. "Basic Housing and Lifestyle Plan (Nationwide Plan)" (March 2021) notes that the highly dense downtown areas that are conspicuously dangerous at the time of an earthquake with the risk of a large-scale disaster (about 2,220ha [at the end of FY2020]) should be generally resolved by FY2030 and that the completion ratio of soft measures to contribute to the enhancement of local disaster prevention abilities, in line with the aforementioned themes should be 100 percent by FY2025. Moreover, as there were many cases of the collapse or the like of retaining walls for houses in the Great East Japan Earthquake and the Kumamoto Earthquake, some of the existing housing land constructed on sloped surface are so obsolete that it makes them vulnerable to earthquakes; once an earthquake occurs, there will be some influence on the recovery of the housing land and on the rescue activities after a disaster; thus, the preparatory measures for existing retaining walls for housing before any earthquake are urgent tasks for the strengthening of cities.

The NILIM, to enhance the disaster prevention performance and safety performance of cities—including getting rid of highly dense downtowns and promoting the reinforcement in housing land—has been advancing our research in relation to ① the improvement of methods of evaluating disaster prevention performance in current highly-dense dangerous downtowns, which only evaluates the effects of hard measures, including road maintenance and rebuilding (the risk of spreading fire, difficulty in evacuation), so that it will also be able to evaluate soft measures, including measures that can be implemented by house owners or local communities, such as vibration mitigating breakers and portable pumps and ②technology to reinforce the retaining walls of existing housing land in consideration of the methods of examining the earthquake resistance of the retaining walls of housing land and the influence on the building.

(3) Building Low Carbon Emission Cities

The realization of a green society is an important political task of our country. It is necessary to understand the green society as one that widely involves a carbon-free society, a climate change adaptive society, a society in harmony with nature, and so forth. We—the NILIM—should positively contribute to the realization of this goal. In particular, the large amount of stock, including infrastructure, houses, and architectures to support various social and economic activities, which are carried out there are the foundation of a sustainable and strong green society; as city-level measures, shortening the distance of transport of people and materials as well making transport efficient by aggregating the urban functionalities and houses, promoting the use of public transportation, making operation and maintenance management of urban infrastructure more efficient using ICT and other technologies, reducing the air-conditioning load by mitigating heat island phenomena, by increasing sources of carbon dioxide absorption by maintaining and producing greenery in cities are strongly desired.

The NILIM, in addition to research contributing to the aggregation of city functionality and housing, as introduced in section 2, paragraph (1) above, has been continuing ①research to collate the results from thermal environmental simulation and the results from the human traffic line data, the population distribution by age, and so forth using GPS data to find places with a risk of overheat to enable the provision of information at an appropriate timing and, thus, to provide prioritized countermeasures, and reduce the thermal stress on people (Fig-2), ② research on the use of AI image recognition technology for the study on the green coverage rate (the rate of the green color in the visual field of men) to make it efficient for its integration into a smartphone app for anybody to be able to easily measure the amount of green color around them, which will be related to a survey on collaboration among residents and to measures for leading to the formation of awareness on the increment of greenery (photo), and so forth.

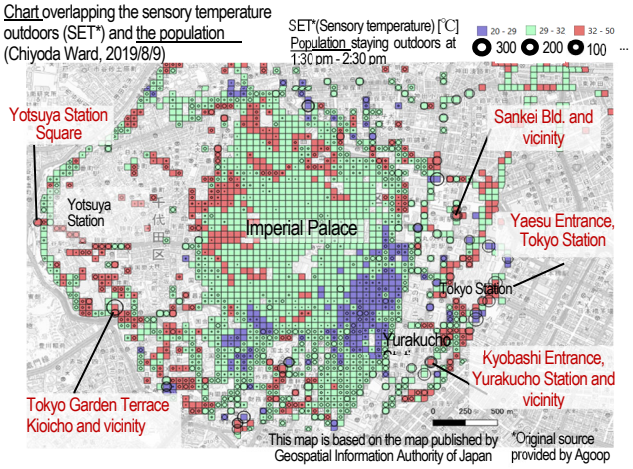


Fig-2. Objectively finding places that are is hot and where there are many people

Photo. Using a smartphone to show the green coverage rate in real time

3. Future Perspective

We want to continuously advance city research to correspond to need for the formation of sustainable cities, setting our sights on disaster prevention, greenery adaptation, the advancement of digitalization, and various residential styles and working styles for the post-coronavirus era.

Initiatives of the Research Center for Infrastructure Management Aimed at Promoting DX in the Infrastructure Sector

IWASAKI Fukuhisa, Director, Research Center for Infrastructure Management

(Keywords) DX, ICT construction, BIM/CIM, productivity improvement, working style reform

1. Introduction

The Research Center for Infrastructure Management has been conducting research for some time into i-Construction (productivity improvements on construction sites). The application of penalized maximum restrictions on overtime work in construction businesses is approaching in FY2024 and working style reforms for the construction industry cannot wait any longer. In addition, the Fifth Priority Plan for Infrastructure Development (cabinet decision, May 2021) added two new targets to previous plans' four priority targets based on recent changes in social circumstances: digital transformation (DX) in the infrastructure sector, and decarbonization of the infrastructure sector and quality-of-life improvements through multifaceted use of infrastructural spaces.

As we work towards promoting DX in the infrastructure sector, the Ministry for Land, Infrastructure, Transport and Tourism (MLIT) established the Infrastructure Sector DX Promotion Headquarters in July 2020, against the background of an increased need for responses to increasingly frequent and severe disasters and control measures for infrastructure deterioration, a serious lack of personnel in the construction industry, and the rise of COVID-19, among other factors. The promotion headquarters will promote interministerial initiatives[1)] intended to handle these radical changes in socioeconomic conditions, to utilize data and digital technology in the infrastructure sector to reform infrastructure and public services based on the needs of the citizenry, as well as reforming operations themselves, organizations, processes, and the culture, climate, and working style in the construction industry and MLIT, and to encourage public understanding of infrastructure, in addition to realizing safe, secure, and rich lifestyles (Fig. 1), and it is scheduled to formulate its action plan by the end of FY2021.

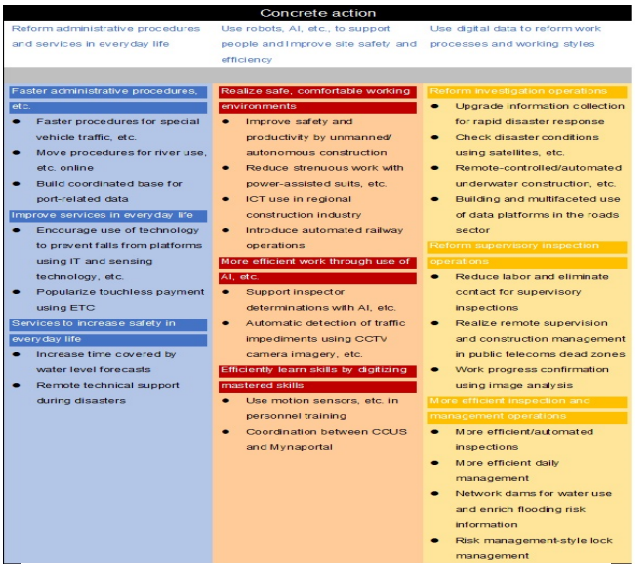


Fig. 1. Outline of DX policy in the infrastructure sector

NILIM also launched its Digital Transformation of Infrastructure Systems Research Committee in March 2021 and is promoting research and development into infrastructure sector DX. This article presents the center's main DX-related initiatives.

2. Initiatives aimed at expanding ICT construction

In moving forward with DX, it is important to have the perspective of changing how we work, rather than introducing new technologies and tools into existing workflows and merely digitizing them. To date, ICT construction has introduced aerial photographic surveying (unmanned aircraft), ground laser scanning, non-prism total stations, and other measuring technology to work sites and shifted the thinking about work process control using three-dimensional data from cross-section control (sample inspection) to plane control (total inspection). This assumes that these methods allow confirmation that they can assure similar quality to conventional inspection methods, but changing the inspection methods and items according to new technology being introduced, reducing construction management and supervisory inspection labor, and contributing to simplifying documents is expected to promote on-site productivity improvements and reform of working styles for both the

orderer and the contractor.

To expand and promote these uses of ICT construction as efforts throughout the country, we believe that it is important to give this broad-ranging industry sector a real sense of the effects of the various ICT construction tools and to have members become familiar with using the tools and put working style reforms into practice company by company.

The center began operations in June 2021 as a location for research and development on technology to support the promotion of infrastructure DX, making progress in establishing construction DX experiment fields[2] to develop and test autonomous construction technology with construction equipment using 5G communications and work progress measurement and inspection technology for structures using three-dimensional data. We have also opened it to the private sector and others as a testing and demonstration field for work progress management and new measuring technologies used in it, as well as verifying ICT construction standards, and we hope that it will lead to further technical development aimed at improved accuracy and to the spread of technology that can easily be implemented in small-scale work sites and is cheap, versatile, and effective in introduction. (Fig. 2)

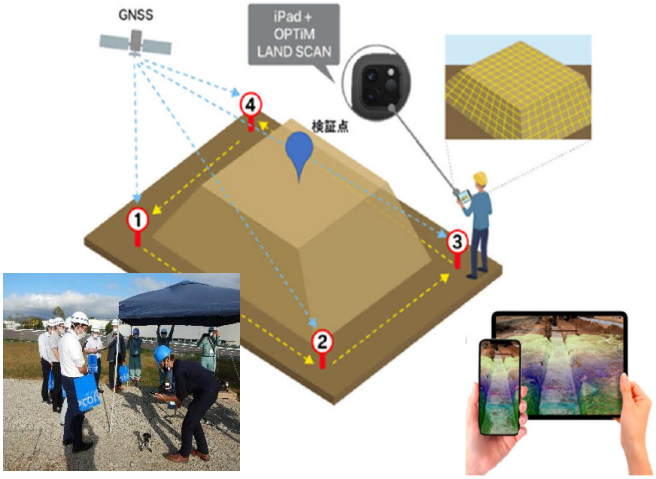


Fig. 2. Testing experiment with small-scale ICT construction technology
(Using smartphone-mounted LiDAR in work progress surveying)

3. Initiatives aimed at application of BIM/CIM principles

To promote DX in construction production processes, it is important to create an environment that is capable of using digital data across several processes, not just in specific settings, in addition to making use of digital data in various settings, and besides the further deepening of existing technology, such as BIM/CIM, the challenge is to build an environment that centrally stores digital data from many sectors, such as rivers and roads, over the several stages from investigation and design to management and allows the required data to be used at the required time. The target of applying BIM/CIM as a general rule (except in small-scale works) from FY2023 has been set, and the center has developed various standards and the like, such as the *Guidelines for creating three-dimensional modeling products (draft)*.[3]

Furthermore, to ensure smooth consultation through the centralized management of three-dimensional data, including BIM/CIM models and point group data, and sharing it between the orderer and the contractor, we are developing a DX data center as the foundation for such use and we aim to have it in operation from FY2022.

4. Conclusion

Works using ICT construction are increasing year on year, but we are not yet at the point of widespread adoption. The current reality among regional small and medium-sized enterprises in particular may be that adoption is proceeding slowly due to reasons like the initial investment cost and the difficulty in learning to use the technology. We believe it is important to ensure the spread of technology that is easily accessible to local government employees and small and medium-sized enterprises, not just MLIT employees.

Moreover, we hope that standardization will pick up pace, that productivity will further improve, and that working styles will be reformed in both orderers and contractors through on-site demonstrations using the PRISM (Public/Private R&D Investment Strategic Expansion Program) system,[4] including new technologies developed by various companies, with a view to making on-site construction management and quality control more efficient and advanced.

While social conditions grow more severe with the declining population and other factors, the progress of digital technology is remarkable and the potential for use of a variety of element technologies is spreading. MLIT has declared 2022 to be a "year to challenge ourselves," when it will resolutely work on innovations through DX, and in addition to conducting research and development with a view to reforming working styles and realizing work-life balance across the entire construction industry through the effective use of a wide range of digital technologies, we hope to continue efforts in broadcasting information that leads to the spreading of outcomes of our efforts.

☞See here for detailed information

1) List of digital transformation (DX) policies in the infrastructure sector
https://www.mlit.go.jp/common/001385990.pdf
2) *Development and Operation of Experimental Fields for Construction DX*, p. 154 herein
3) *Formulating Guidelines for Creating Three-dimensional Modeling Products for Detailed Design*, p. 105 herein
4) *Establishing Inspection Methods for Rebar Layout Using Image Measurement*, p. 103 herein

Research on Efficient Physical Asset Management of Sewers

(Research period: FY2019 to FY2021)
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Key words: sewer, physical asset management, road cave-in, deterioration

1. Introduction

The total length of sewers in Japan at the end of FY2020 was about 480,000 km. Out of this, the length of sewers older than the standard service life of 50 years was about 22,000 km (5% of the total length), and this number is expected to increase rapidly in the future to 76,000 km (16%) in 10 years and to 170,000 km (35%) in 20 years. The New Sewerage Vision Acceleration Strategy by the Sewerage and Wastewater Management Department of the MLIT in 2017 positioned the establishment of a physical asset management cycle as one of its key priorities. In order to contribute to formulation of technical policy and support for local governments in establishment of a physical asset management cycle for sewers, the Water Quality Control Department of the NILIM conducted the actual status survey on road cave-ins caused by sewers, update of the database on sewer pipe deterioration, and update of the soundness ratio prediction formula that contributes to the prediction of sewer pipe reconstruction demands, etc. In this paper, "sewer" is used as a generic term for sewer pipe (a.k.a., main pipe), manhole, lateral (pipe connecting sewer pipe and public inlet), public inlet, etc.

2. Grasping the actual status of road cave-ins caused by sewers

Since FY2006, the NILIM has conducted a survey on the occurrence of road cave-ins, etc. of local governments every year, in order to grasp the actual status of sewer deterioration, etc. on a macro level and to use survey results as a basis for research and policy making. In FY2020, there were about 2,750 cases of road cave-ins caused by sewers nationwide, and the number of cases has been decreasing in recent years (**Fig. 1**). As for the causative part of sewers, about 50% of all cases were caused by lateral (**Fig.2**). In terms of pipe type, concrete pipes account for about 60% of the road cave-ins caused by sewer pipe, while clay pipes account for about 70% of the road cave-ins caused by lateral. The downward trend in the number of road cave-in cases suggests that local governments have been encouraged to properly repair and reconstruct sewers through measures such as maintenance standards by FY2015 amendment to the Sewerage Act and the national subsidy program of physical asset management established in FY2016. However, it is necessary to continue to accumulate data, analyze the effects of measures, and consider measures that should be emphasized in the future.

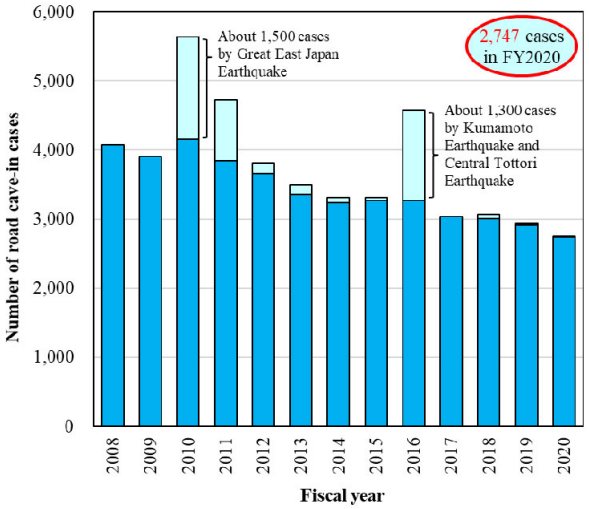
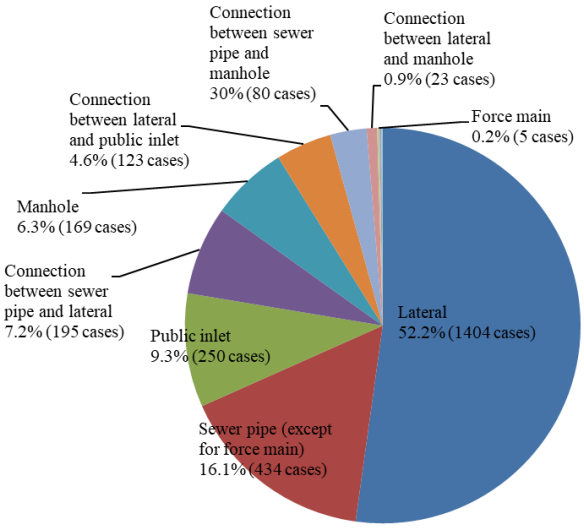


Fig. 1: Number of road cave-in cases by year



Note: Exclusive of 57 cases where causative parts or exact cave-in locations are unknown

Fig. 2: Number and ratio of road cave-in cases by causative part (FY2020)

3. Update of the Deterioration Database

The NILIM has compiled a database of some of the results of the survey on the inside of sewers collected from local governments (e.g., type of local government, elapsed year, pipe type, pipe diameter, installation conditions, deterioration and urgency assessment results) and has made it available to the public as "the Sewer Pipe Deterioration Database" ("the Deterioration Database"). The Deterioration Database Ver. 3, updated in June 2021, added data of about 60,000 spans to Ver. 2, released in 2017. As a result, data of about 310,000 spans of 60 local governments, has been registered. The registered data cover sewers with a total length of about 8,700 km, which is about 1.8% of 480,000 km of sewer pipes nationwide. The Deterioration Database has been used as supplementary data by local governments that have little accumulated inspection data in considering inspection priority areas and reconstruction demand forecasts.

4. Update of the Soundness Ratio Prediction Formula

In order to support local governments in formulating physical asset management plans, etc., the NILIM has made "the Sewer Pipe Soundness Ratio Prediction Formula" ("the Soundness Ratio Prediction Formula") available to the public since 2013. In June 2021, the Soundness Ratio Prediction Formula was updated. The Soundness Ratio Prediction Formula 2021 was calculated based on the inspection results of sewer pipes collected from local governments. The result data cover about 460,000 spans, of which about 310,000 are reinforced concrete (RC) pipes, 110,000 are clay pipes, and 20,000 are polyvinyl chloride (PVC) pipes. The Soundness Ratio Prediction Formula is a tool that can grasp the soundness ratio of sewers over time on a macro level, introduced in various guidelines, and is used as an indispensable tool for physical asset management practices by local governments.

The Soundness Ratio Prediction Formula is drawn as a graph with elapsed years as the explanatory variable on the horizontal axis and with the soundness ratio as the explained variable on the vertical axis. It represents the situation where the soundness ratio (percentage of sewers of high soundness) decreases as years pass. For example, from the graph of the Soundness Ratio Prediction Formula 2021 of RC pipes shown in **Fig. 3**, it is predicted that, for the overall 50 year old RC pipes, about 20% has no deterioration, while about 30% is in minor deterioration (Urgency III), about 40% is in moderate deterioration (Urgency II), and about 10% is in serious deterioration (Urgency I).

Classification	Description	
Urgency I	Serious deterioration	Prompt measures are required.
Urgency II	Moderate deterioration	Simple measures can postpone necessary measures less than five years.
Urgency III	Minor deterioration	Simple measures can postpone necessary measures five years or more.
No deterioration	Sound	No special measures are required.

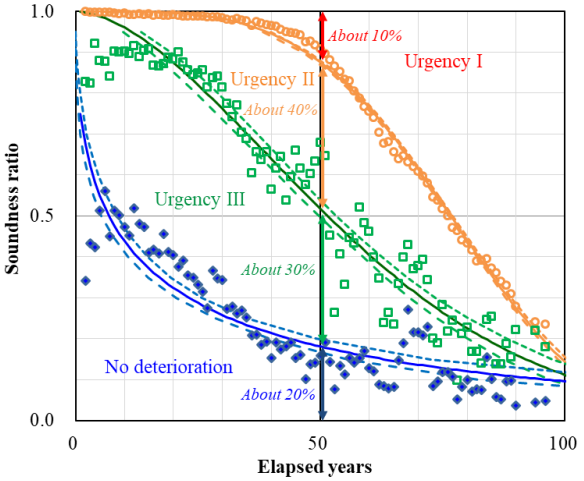


Fig 3: Graph of Soundness Ratio Prediction Formula 2021 (Example of RC pipe)

The Soundness Ratio Prediction Formula can predict medium- to long-term reconstruction demand on a macro level based on information on pipe types and elapsed years. On the other hand, even if the elapsed years are the same, there are variations in the deterioration status, which indicates it is important to grasp the deterioration status of individual sewers through inspections in a systematic manner.

5. Conclusion

The NILIM will continue to contribute to the establishment of a physical asset management cycle for sewers through grasping the actual status of road cave-ins caused by sewers, updating the Deterioration Database, and improving the Soundness Ratio Prediction Formula. In particular, the NILIM plan to analyze the deterioration trend of sewers and explore the Soundness Ratio Prediction Formula of PVC pipes, which are widely installed in small and medium-sized local governments.

☞ **See the following for details.**

1) Length of sewer pipes installed
https://www.mlit.go.jp/mizukokudo/sewerage/crd_sewerage_tk_000135.html
2) Sewer Pipe Deterioration Database 2021
http://www.nilim.go.jp/lab/ebg/rekka-db.html
3) Sewer Pipe Soundness Ratio Prediction Formula 2021
http://www.nilim.go.jp/lab/ebg/deterioration_rate_prediction_formula_2021.pdf

Development of Resilient Levees That Are More Effective Than Crisis Management-type Structural Countermeasures

(Research period: FY2019 to FY2021)

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Keywords: water overtopping, resilient levee, crisis management-type structural countermeasures

1. Introduction

As an initiative to strengthen levees against overtopping, measures to cover the surface of levees with sheets or blocks (called "Armored Levee" or "Frontier Levee") were implemented on a trial basis from around 1988 to 2003, but due to maintenance and management issues and high costs, these measures were not developed throughout the country.

Then, after the flooding in Joso caused by the torrential rains in the Kanto and Tohoku regions in 2015, under a basic understanding that "there is a limit to the capacity of facilities and that a major flood that cannot be prevented by facilities will surely occur," crisis management-type structural countermeasures have been introduced to delay the progress of levee erosion and collapse by adding asphalt pavement to the levee crown and block covering on the back slope toe in the sections where the river channel and levees have not been developed, despite the high risk of flooding, from the perspective of upstream/downstream balance, etc.

Then, the 2019 Eastern Japan Typhoon caused serious inundation damage, which indicated the need for "resilient river levees" that are more effective than crisis management-type structural countermeasures to mitigate damage caused by overtopping[1].

Accordingly, the NILIM started to develop technologies for "resilient river levees" and plans to prepare guidance for studying the structure of resilient levees by organizing the findings to date and the results of the experiments described below.

2. Consideration of resilient structure

(1) Circumstances of development

In the 2019 Eastern Japan Typhoon, water overtopped at one of the sites where crisis management-type structural countermeasures were constructed. While the countermeasures were considered effective since the levee was not broken, erosion occurred on the back slope that was not covered with blocks (**Photo 1**), and the need for slope protection was recognized once again.

Photo 1: An example of back slope erosion at a site where crisis management-type structural countermeasures were used (left bank of 6.2 kp of the Toki River in the Arakawa River system)

(2) Proposal for a resilient structure based on existing knowledge

After organizing the existing knowledge of armored levees, frontier levees, and crisis management-type structural countermeasures, we determined a resilient structure would be more effective and reasonably priced. Specifically, in addition to the slope toe and crown, the slope was also protected, and the slope protection work consisted of anti-absorption sheets held with blocks or soil cover.

(3) Issues in study of structure and response

1) Evaluation of hydrodynamic forces acting on blocks placed on the slope

To study the stability of blocks against overflow, it is necessary to understand the hydrodynamic force acting on the blocks due to the overflowing water. However, there was an issue in that it is difficult to evaluate the hydrodynamic force acting on the blocks because the water flowing over the back slope is different from the flow of water on the river surface where the blocks are usually installed, and is a shallow flow with a complex flow due to the protrusions of the blocks. Therefore, an experiment was conducted by changing the shape of the protrusions of the blocks to directly measure the hydrodynamic force acting on the blocks by the overflowing water using a force-measuring device and a force gauge (**Photo 2**).

The results showed that when the height of the block protrusion is relatively high compared to the block

thickness, the force tends to be greater than the hydrodynamic force acting in deep water flows such as those at the river surface, which, as information, served us in evaluating the stability of the block against overflow water.

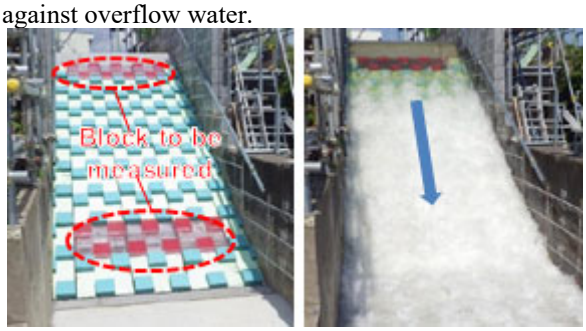

Photo 2: Experiment of hydrodynamic force measurement

2) Evaluation of pull-out resistance of sheets

When the back slope is long, it is difficult to cover the slope from the shoulder to toe with a single anti-absorption sheet, so a sheet seam is formed in the middle of the slope. Since these seams are weak areas and there is a concern that the sheets may shift or rise, we are considering inserting the sheets into the levee to hold them strongly. In examining the stability of sheets, since the pull-out resistance of the sheets was unknown, we conducted an experiment to directly measure the pull-out resistance (**Figure, Photo 3**). As a result, we found a relationship between the vertical load and the pull-out resistance of the sheet inserted into the levee, and obtained knowledge for determining the length of insertion of the sheet into the levee.

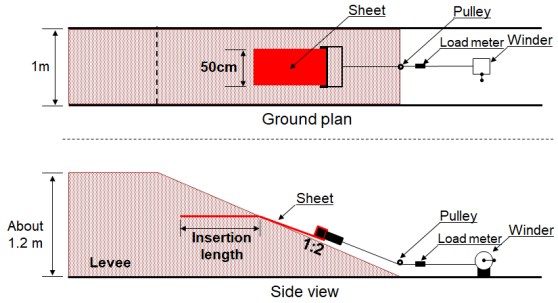

Figure: Outline of the experimental model for measuring pull-out resistance

Photo 3: Pull-out resistance measurement experiment

3) Protruding shape of slope block and water splashing at the slope toe

The slope toe protection works must prevent scouring of the slope toe due to overtopping water. Depending on the shape of the block protrusion on the slope protection works, overtopping water may splash and jump over the slope toe protection works, causing water flow to directly hit the landside, which may impair the scour suppression effect of the slope toe protection works. Therefore, we conducted an experiment to confirm how water splashes when blocks with high protrusions of the soil covering type are used (**Photo 4**).

As a result, we obtained knowledge regarding the necessary width of the top edge in slope toe protection works based on the way water splashes.

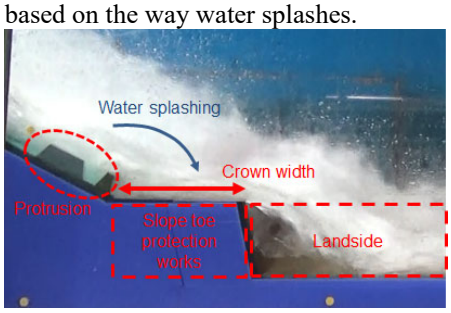

Photo 4: Experiment to confirm how water splashes

3. Future development

Considering the uncertainty of levee soil and variation of construction, it is necessary to continue to study a structure that is more effective through field testing and levee model overtopping experiments. The findings will be reflected as appropriate in a guidance to be prepared in the future.

☞See the following for details.

1) Water and Disaster Management Bureau, MLIT: Technical Workshop on River Levees Based on the Damage Caused by the 2019 Typhoon No. 19, 2020.
https://www.mlit.go.jp/river/shinngikai_blog/gijutsu_kentoukai/index.html

Research on Future Changes in Rainfall for Flood Control Planning Considering Climate Change

(Study period: FY2016-)

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Key words: climate change, ensemble climate prediction data, rainfall change ratio

1. Introduction

As heavy rains are becoming more frequent and more severe due to climate change, it is required that a shift to flood control planning that adapts to climate change . In recent years, an ensemble climate prediction database, in which perturbations are applied to the boundary conditions of climate models to perform a large number of calculations, has been developed. And, with this database, it is possible to evaluate extreme events such as heavy rains in the future probabilistically. For this reason, the NILIM is conducting research on future changes in rainfall by analyzing ensemble climate prediction data from the perspective of developing flood control planning methods that take climate change into account. The following outlines this research.

2. Calculation of rainfall change ratio

In a flood control plan, the river flow rate targeted in development is determined by analyzing runoff at a rainfall equivalent to the target annual exceedance probability (1/100 to 1/200 for Class A rivers) by probability statistical analysis based on past rainfall records. The calculation of the ratio of rainfall between future and past climate ("rainfall change ratio") plays an important role in setting river improvement goals for flood control plans that take climate change into account.

Therefore, the NILIM calculated rainfall change ratios using the "Social Implementation Program for Climate Change Adaptation Technology" (SI-CAT) of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the ensemble climate prediction database developed by the Hokkaido University with 5 km resolution.

The following is the procedure for calculating the rainfall change ratio.

1) Japan was divided into 15 regions, considering the possibility that rainfall change ratios may differ from region to region.

2) Among the ensemble climate prediction data, the relationship between accumulated rainfall, rainfall area, and rainfall duration was organized for each year for the data of "past experiments" (corresponding to climate change from 1981 to 2010) and "future experiments" (corresponding to a point in time when the global average temperature rises 2°C or 4°C above the data of the pre-industrialization level [mid-18th century]). The number of years of data varies depending on the type of database used, but is mainly 360 years of past experiments (30 years * 12 perturbations) and 360 years of future experiments (30 years * 6 SST [sea surface temperature] patterns * 2 perturbations).

"6 SST patterns" refer to the six SST patterns (denoted CC, GF, HA, MI, MP, and MR in **Fig. 1**) selected by avoiding them from becoming similar, based on a cluster analysis of 28 models calculated using the RCP8.5 scenario, etc. among the coupled atmosphere-ocean models submitted to the Fifth Coupled Model Intercomparison Project (CMIP5) of the Global Climate Research Program.

3) We conducted a statistical analysis of the maximum annual accumulated rainfall corresponding to the rainfall area and duration obtained in 2) above, and calculated the ratio between the future and past experiments for the rainfall with a 1/100 annual exceedance probability. In organizing the data above, the average values were calculated for a total of nine patterns, including three rainfall area patterns (400, 1600, 3600 km^2) and three rainfall duration patterns (12, 24, 48 hours), assuming a large river basin. **Fig. 1** shows the rainfall change ratios for each of the 6 SST patterns in the case of a 2°C rise. Although there were variations among the regions, the average value for the 15 regions was 1.10 times. For Hokkaido, all values for

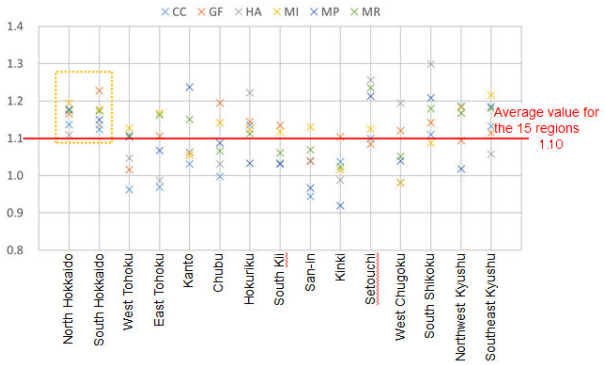

Fig. 1: Rainfall change ratio for each SST (at 2°C increase)

each SST pattern were higher than the national average. In addition, we studied the case of a 4°C rise, the case of small rainfall area, the case of short rainfall duration (between 3 and 12 hours), etc. and reported the results to the "Technical Committee on Flood Control Plans considering Climate Changes," ("Committee") established by the MLIT. As a result, in the Committee's Proposal [1], which was revised in April 2021, rainfall change ratios for flood control planning that take climate change into account, were presented based on the results of studies conducted by the NILIM (**Table**).

In response to this proposal, in the basic improvement policy for the Shingu river system, Gokase river system, and Kuma river system, the design flood was revised based on a rainfall change ratio of 1.1.

Table: Rainfall change ratio (Committee's Proposal) [1]

Region category	2 ℃ rise	4 ℃ rise	
			Short time
North Hokkaido, South Hokkaido	1.15	1.4	1.5
Northwest Kyushu	1.1	1.4	1.5
Other (including Okinawa)	1.1	1.2	1.3

3. Study of future changes in the spatiotemporal distribution of rainfall

Even if the accumulated rainfall within a given rainfall duration is the same, cases of short-term concentrated rainfall or locally concentrated rainfall can be assumed, and in some cases, there is a concern that the river flow rate will be larger than the hyetographs experienced in the past. If future changes in such spatiotemporal distribution of rainfall can be grasped, it will be possible to establish cases of spatiotemporal distribution of rainfall that should be considered when formulating a river improvement plan for each river, and it is expected that candidate target flow rates (ranges) for improvement can be estimated based on these cases. However, in order to quantify future changes in this spatiotemporal distribution of rainfall, an appropriate indicator is needed.

Accordingly, the NILIM applies "Gini's coefficient" (an indicator of income inequality where income inequality is smaller when the Gini coefficient is closer to 0 and larger when it is closer to 1), as a method for quantitatively grasping future changes in the spatiotemporal distribution of rainfall, and conducting activities to grasp changes in the spatiotemporal distribution of rainfall in the past and in the future using the indicator of time concentrated rainfall (closer to 0, equal rainfall; closer to 1, short-term concentrated rainfall) and the indicator of space concentrated rainfall (closer to 0, equal rainfall; closer to 1, locally concentrated rainfall).

Fig. 2 is an example of time concentration of rainfall that shows that the time concentration of rainfall, which was previously determined by the shape of the hyetograph, can now be quantified as a value between 0 and 1. A comparative analysis of the ensemble climate prediction data is currently underway to compare the past climate with the future climate using the said indicators.

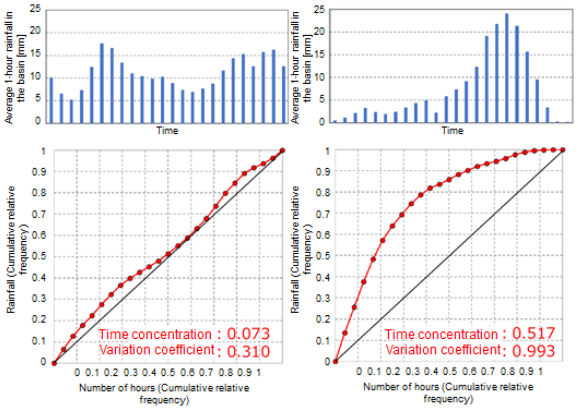

Fig. 2: Example for calculation of time concentrated rainfall
(Area within red and black lines *2 is time concentration.)

4. Future schedule

From FY2022 to FY2023, we plan to "research and develop runoff analysis and flood flow analysis technologies for estimating the flood control effect of runoff control measures" as an commissioned study by "Public Offering for Research and Development of River and Sabo Technology"[2]. In this research, it is expected to develop a model that can accurately analyze changes in the amount of runoff due to changes in the spatiotemporal distribution of rainfall and the effects of runoff control measures such as rain water storage by using rice paddies. Moreover, we intend to reflect such a model together with the results of this research in the technical data for planning river improvement projects that consider climate change.

☞See the following for details.

1) MLIT: Proposal for Flood Control Planning Based on Climate Change, April 2021.
2) MLIT: Public Offering for Research and Development of River and Sabo Technology
https://www.mlit.go.jp/river/gijutsu/kenkyu.html

Eliminating flood hazard information blank areas - Trial flood hazard mapping in small rivers

(Research period: FY2017-)
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Keywords: River Basin Disaster Resilience and Sustainability by All, flood hazard mapping, LP data

1. Introduction

Torrential rains and floods are frequent and cause serious flood damage in many parts of the country every year. In order to prevent flood disaster, it is necessary to steadily develop flood control structures and, for floods exceeding the design scale of flood control structures, it is necessary to take measures to prevent / reduce damage as much as possible by devising land use, etc. in the floodplain (areas outside rivers where farmlands, towns, etc. are located). For this purpose, it is important to promote River Basin Disaster Resilience and Sustainability by All, in which various stakeholders in the basin collaborate to prevent / reduce damage throughout the basin.

In the promotion of River Basin Disaster Resilience and Sustainability by All, the flood hazard map showing the extent of possible inundation due to flooding plays an important role. In the 2021 revision of the Flood Fighting Act, one of the laws related to River Basin Disaster Resilience and Sustainability by All, rivers that meet the criteria specified by the MLIT (rivers flowing through the areas that include targets of protection such as houses) were added to the scope of designation of statutory flood hazard areas as those that should be warned of disasters due to flooding, in addition to the statutory Flood Forecast Rivers and Flood Water Level Informing Rivers required to communicate flood water levels. As a result, the target number of rivers for which statutory flood hazard areas should be designated by FY2025 has increased from about 2,000 rivers nationwide before the revision to 17,000 rivers. In order to achieve this target, the challenge is how to create flood hazard maps for the vast number and length of small rivers (Class A and Class B rivers other than the statutory Flood Forecast Rivers and Flood Water Level Informing Rivers) for which river channel data and flood flow data, etc., which are necessary for flood hazard mapping, have not yet been developed. Therefore, we have provided "Guidance for Flood Hazard Mapping in Small Rivers" (2020, Flood Risk Reduction Policy Planning Office, River Environment Division, Water and Disaster Management Bureau, MLIT and Flood Disaster Prevention Division, River Department, NILIM), which presents a method for flood hazard mapping in small rivers with using LP (aerial laser survey) data (**Fig. 1**), and conducted trial calculations (**Fig. 2**) by the NILIM and others for rivers requested by the prefecture in order to contribute to the solution of technical challenges, etc.

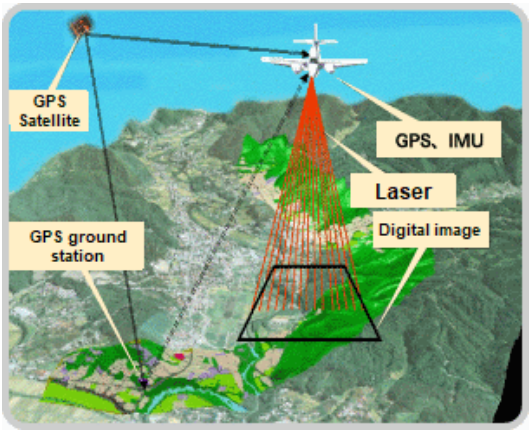

Fig. 1: Aerial laser survey

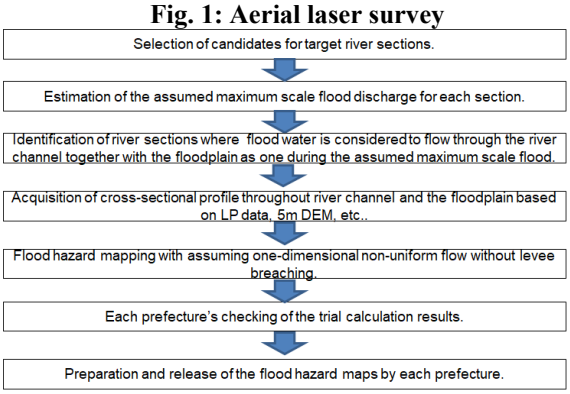

Fig. 2: NILIM trial calculation procedure

2. Identification of river sections

In response to requests from prefectures to the national government (MLIT) for trial calculations, we identified about 8,000 rivers (about 40,000 km in length) as candidate river sections for trial calculations by the national government based on the perspectives of availability of LP data stored by the Geospatial Information Authority (GSI) of Japan, early elimination of flood hazard information blank areas, etc. (Reference: The total number of Class A and B rivers in Japan is about 21,000, with a total length of about 120,000 km. In addition, there are about 14,000 locally designated rivers, extending about 20,000 km (as of 2021)). The basin areas of these river sections

were set based on the existing database or estimated based on GSI digital elevation model, and the assumed maximum scale flood discharge was calculated using a rational formula for each river section divided based on the confluences of Class A river or Class B river. We set the assumed rainfall duration with using the Krahen formula, and assumed the maximum rainfall intensity based on the "Method for Setting Assumed Maximum External Forces for Flood Hazard Mapping (fluvial flood and, pluvial flood)" (2015, Water and Disaster Management Bureau, MLIT), except when the prefecture's own setting is required. The runoff coefficient was finally set uniformly at 0.9 for both mountainous and plain areas, considering geological characteristics, etc. as well as the efficiency of the work.

Based on the calculated water level with the above flood discharge and topographical characteristics, etc., the trial calculation by the NILIM was focused on the river section (**Fig. 3**) where flood water is considered to flow through the river channel together with the floodplain as one during the assumed maximum scale flood. An efficient calculation method based on LP data has already been developed for this type of sections, and about 2,800 rivers in 26 prefectures across the country, extending about 12,000 km, were identified.

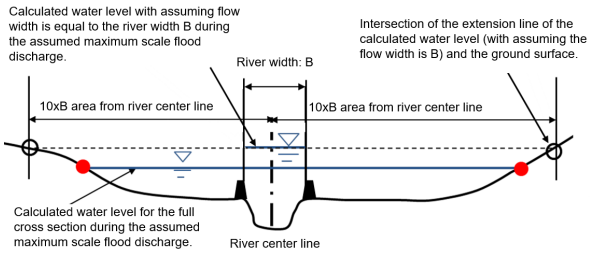

Fig. 3: Conceptual cross section of flood flowing through river channel together with floodplain as one

3. Acquisition of cross sections on the area throughout river channel and floodplain and flood hazard mapping

Based on existing LP data and a digital elevation model (5m DEM in principle, 10m DEM if not available) obtained from GSI, we obtained cross-sections at approx. 100m intervals in the direction of the flood flow. Figure 4 shows an example of cross-section acquisition. On the left side of the Figure is the road embankment, which may stop the spread of flood water in the crossing direction. If there is an opening in the embankment (e.g., box culvert), flood water may pass through it, but the opening cannot be read from the LP data, and field survey is required.

Figure 5 shows an example of flood hazrd mapping with using LP data. In the Figure, 10m DEM was used because 5m DEM was not available for the floodplain in the right section, and the section was clearly indicated when providing the trial calculation result to the prefectures because the resolution of the flood hazard mapping is different.

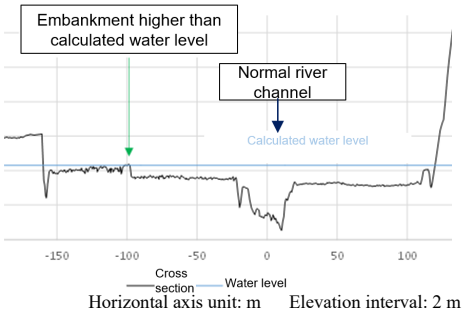

Fig. 4: Example of obtaining the cross-sectional profile

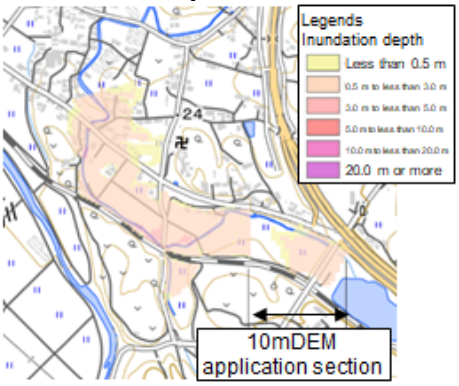

Fig. 5: Example of flood hazard mapping with using LP data

4. Conclusion

For the tentative version of the results of trial calculation by the national government, we inquired of the prefectures whether there were clearly unreasonable points in the results in a limited time, and checked and made corrections to the extent possible if there was any matter indicated. We would like to thank the relevant prefectural officials for their cooperation in checking the results of trial calculation. In order to eliminate flood hazard information blank areas in small rivers, in addition to flooding pattern in which the flood flows through river channel together with floodplain as one, it is also necessary to create flood hazard maps of river sections that are considered to cause spread-type or storage-type flooding. We are going to continue the research and development.

☞See the following for details.

1) Guidance for Flood Hazard Mapping in Small Rivers
https://www.mlit.go.jp/river/shinngikai_blog/tyusyokasen/pdf/manual.pdf

For Avoiding the Worst-Case Flooding Scenario
--- Study on damage reduction measures in case floods overwhelm flood control structures ---

(Research period: FY2021 to FY2023)
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Flood Disaster Prevention Division, River Department

Key words: River Basin Disaster Resilience and Sustainability by All, flood damage reduction, flooding scenarios

1. Introduction

In recent years, due to the impact of climate change, large-scale floods that exceed the design scale of flood control structures have frequently occurred and caused severe flood damage throughout Japan. Accordingly, the Water and Disaster Management Bureau of the MLIT is promoting "River Basin Disaster Resilience and Sustainability by All," a sustainable flood damage prevention / reduction measure that is carried out on a basin-wide basis with the cooperation of all stakeholders throughout the river basin.

Conventionally, measures to prevent flooding through the development of flood control structures such as levees and dams (Level 1 measures) and measures to protect lives by evacuation and other means from the assumed maximum scale flood (Level 2 measures) have been mainly implemented (**Fig. 1**). However, in light of the fact that the boundary lines in **Figure 1** are expected to shift to the left (to the red dashed lines) due to climate change, "flood damage prevention / reduction measures that protect not only lives but also assets and livelihoods" ("Level 1.5 measures") that fill the gap between the two measures will become even more important in addition to the above measures. This research aims to develop a specific method for studying Level 1.5 measures, which are not yet established, and a method for evaluating the effectiveness of the measures.

2. Specific examples

As examples of Level 1.5 measures, **Figure 2** shows an example of overtopping sections installed on existing riverine levees in the Saga Plain (Nokoshi), and **Figure 3** shows a conceptual diagram of the U.S. Army Corps of Engineers ECB No. 2019-8, "Managed Overtopping of Levee Systems". The former is a traditional flood damage reduction method that has been documented since the Edo era, in which a certain amount of flood flow or more is allowed to overflow to prevent damage to irrigation facilities downstream, etc. The latter is designed to ensure evacuation time for the community and to achieve cost reduction and acceleration of the restoration of levees, etc. by providing longitudinal elevation differences in the height of riverine levees to allow flood water to overflow from a section where damage from flooding is considered relatively small in the event of a flood that exceeds the design scale of the levee system.

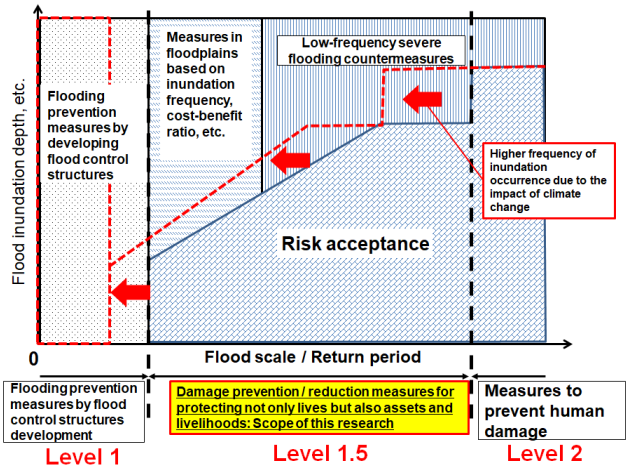
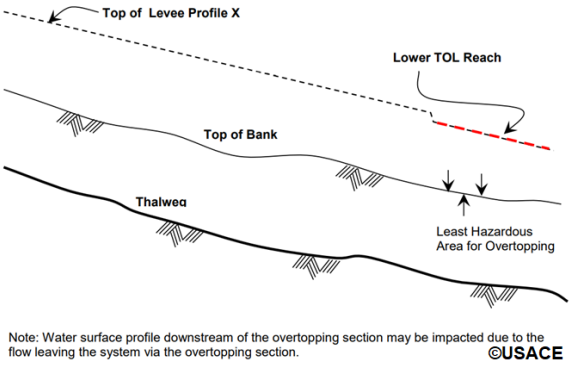


Fig. 1; Damage prevention / reduction measures according to flood scale

Prepared from materials of Kyushu Regional Development Bureau, MLIT

Fig. 2: Nokoshi, letting overflow for damage reduction



Note: Water surface profile downstream of the overtopping section may be impacted due to the flow leaving the system via the overtopping section. ©USACE

Fig. 3 Conceptual diagram of managed overtopping in the U.S. Army Corps of Engineers levee system

As of the 2019 survey, there were no sites where this method was actually implemented.

3. Study of level 1.5 measures based on flooding scenarios

For studying Level 1.5 measures, measures to avoid the worst-case flooding scenario for the area were selected as the subject of research. The reason for selection was that these measures should be studied first from the perspective of avoiding fatal damage in the area. **Figure 4** shows a conceptual diagram of studying the worst-case flooding scenario. In a series of levee sections where the safety factor is considered the same, the levee can breach at any point in the event of a flood exceeding the design scale, but the flooding damage is different according to the locations of levee breach, e.g., the damage is particularly severe when hospitals and city halls are flooded. In this research, the worst-case flooding scenario was identified from a set of possible flooding scenarios based on land use and distribution of residences, etc., and measures to avoid this scenario were examined (**Fig. 5**).

4. Interim report on test application

We selected a test application area based on the level of interest of local governments in flood countermeasures, and collected necessary materials and data from relevant organizations. The flooding analysis model was designed to calculate both pluvial flooding (flooding caused by rainfall due to insufficient drainage capacity in urban areas, etc.) and fluvial flooding (flooding caused by increased river discharge due to rainfall in mountainous areas upstream of rivers). The area of the site was approx. 20 km^2 with a mesh size of approx. 25 m.

Three flooding scenarios were prepared and compared for the levee breach flooding in the main river section (about 6 km in length). The target floods were set by expanding a well-known recent flood to the design scale. The assumed levee breach points were determined to be where the volume of flooding water is the largest (i.e., smallest flow capacity corresponding to the bottom height of the possible levee break) in each of the three sections divided from the 6km segment at the interval of about 2 km. Among these flooding scenarios (**Fig. 6**), the upstream levee breach scenario is considered to be the flooding scenario that should be avoided with top priority because it causes more serious damage, such as flooding of the city hall. We will continue to study the criteria for determining the worst-case flooding scenario, as well as branch river flooding and pluvial flooding.

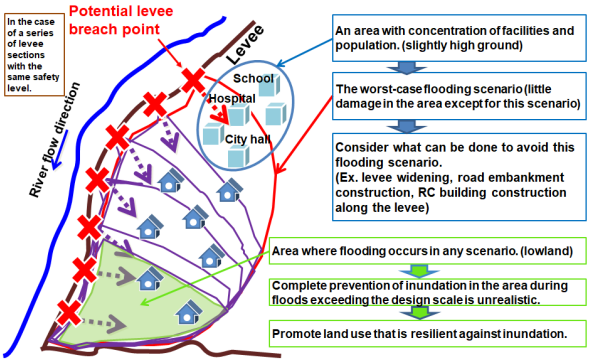


Fig. 4: Image of study on worst-case flooding scenario

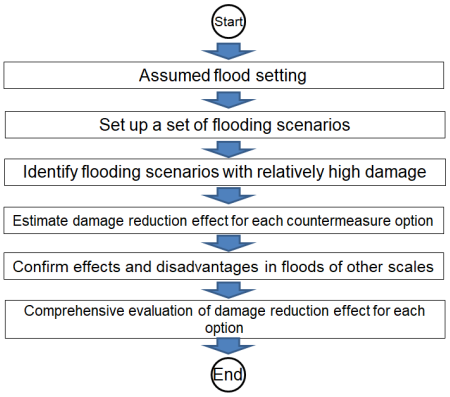


Fig. 5: Steps for studying countermeasures based on a set of flooding scenarios

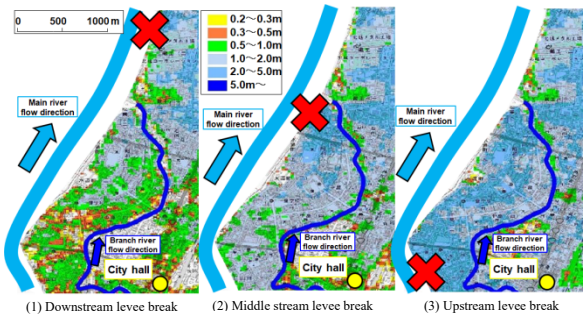


Fig. 6: Results of trial calculation of inundation depth distribution for each flooding scenario

5. Conclusion

We plan to study specific measures to avoid the worst-case scenario, evaluate their effectiveness, and develop easy-to-understand methods of presenting the analysis results, etc., which are necessary to build consensus in the community.

☞See the following for related information.

1) Research on evaluation methods for flood damage reduction effects by flood damage reduction measures for consensus building necessary to promote River Basin Disaster Resilience and Sustainability by All https://grips.repo.nii.ac.jp/?action=pages_view_main&active_action=repository_view_main_item_detail&item_id=1850&item_no=1&page_id=13&block_id=24

Development of Methods for Determining Disaster Potential and Preventive Measures for Bridge Washouts and Scouring

(Research period: FY2019–FY2020)

Bridges and Structures Division, Road Structures Department

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Senior Researcher SASADA Yukihisa Researcher IHARA Takehiro

(Keywords) road bridges, bridge foundation scouring, bridge superstructure washouts

1. Introduction

In recent years, many road bridges have suffered damage due to torrential rains. For example, a bridge was closed to traffic for a long time due to scouring of its foundations in Typhoon Hagibis in 2019, and road bridges over the Kuma River suffered washout damage in several locations from the torrential rain in July 2020. To ensure that road continue to function during disasters, it is necessary to gain information on road bridges most at risk of scouring and washout damage and to move forward with measures from the perspectives of both tangible and intangible elements.

Thus, this study firstly examined methods of identifying road bridges at greatest risk of scouring and washout damage due to flooding. In particular, it examined the potential for road bridges suffering damage from scouring and washout to connect this to the development of design and control methods, by performing factor analyses that accounting for mechanical processes based on action and resistance in the same way as the check formulas for performance in design standards, rather than being limited to statistical factor analysis. Next, it examined methods of improving the original location of bridges at greatest risk of washout so that the risk of disaster could be reduced without completely rebuilding the bridges.

2. Examining methods to evaluate disaster risk due to scouring

In relation to the mechanical process of scouring, we accounted for the dead load of the superstructure and the pressure of the flowing water as acting forces, as shown in figure 1. The hydrodynamic pressure was calculated assuming a flow velocity (V_{cr}) of 5 m/s from past measured cases of flow velocity in rivers in flood. As resistance, we accounted for the bearing power of the foundations. We allowed for the bearing power of the foundations to decrease as scouring proceeded. With these conditions, we worked backwards to calculate the flow velocity V_r when the bridge pier foundations reach their maximum strength, allowing for the effects of scouring.

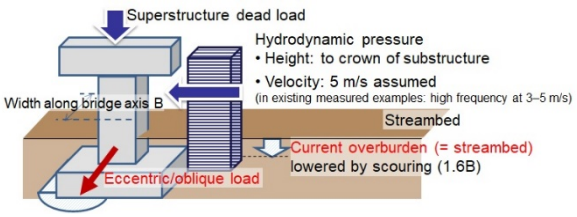

Fig. 1. Forces assumed when scouring occurs

Calculating the safety pertaining to scouring damage to be V_r/V_{cr}, we considered there to be a risk of disaster if the safety fell below 1 and calculated the scouring depth where the safety fell

below 1 for each foundation form for 12 bridge piers with different foundation forms and ground conditions. We obtained calculation results suggesting that in the case of direct foundations, damage may occur when scouring reaches a depth of at least 1 m from the upper surface of the foundations. In the case of pile and caisson foundations, we obtained calculation results suggesting that damage may occur when scouring reaches a depth of at least half the length of the foundations.

These calculation results are based on various assumptions. We therefore investigated the overburden thickness and foundation depth before the disaster in the foundations of several road bridges that did or did not suffer damage in past flooding events. As a result, the bridges that actually suffered damage all met the conditions for damage obtained from the calculation results. Among the bridges that did not suffer damage, we observed some that did not meet the conditions for damage obtained from the calculation results, as well as some that did. The above suggests that the conditions for damage obtained from the calculation results are capable of assessing the potential for damage, erring on the side of safety.

3. Examining methods to evaluate disaster risk due to washout

In relation to the mechanical process for superstructure washout, we considered that the forces acting on the guard fence (railing), bridge shoe, and piers and the forces resisting them would be as in figure 2, and assumed that we would be able to gradually increase the flow velocity and develop explanations by computing the locations where the safety rate would first fall below 1 and the flow velocity at the time. This assumption was proposed based on the results of an analysis previously conducted by the Bridges and Structures Division on damage factors for road bridges due to tsunamis.1)

To verify the validity of the assumed model, we applied it to 20 bridges in the Kuma River catchment, where several bridges were washed out in the torrential rain in July 2020. As a result, we confirmed through calculations that in bridges where the superstructure was washed out, the shoe tended to be damaged before the piers collapsed or the guard fence was destroyed, for instance. In addition, the presence or absence of washouts matched the actual cases of damage.

Although this differed from the actual flood damage, we then assumed that all the bridges were inundated and converted the force acting on the shoes into lateral seismic coefficients to compare them with the design lateral seismic coefficients.

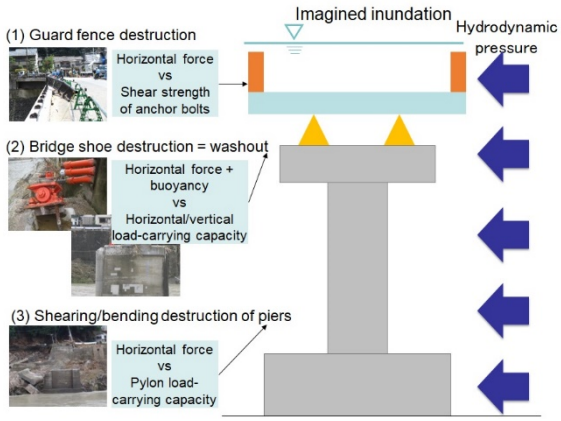

Fig. 2. Action and resistance of hydrodynamic pressure on bridge parts

We then used the flow velocity calculated backwards from the force of action calculated to wash out the bridge to find the design lateral seismic coefficients as converted from the force acting on the shoes for the case assuming that the bridge did not have a guard fence as well. The results of these calculations are shown in figure 3. As earthquake-resistant designs in past allowable

stress methods have often expected the lateral seismic coefficient to be about 0.2, we have marked the figure with a red line at 0.2. We have also indicated whether each bridge actually washed out or not. The calculation results suggest that the shoes of the bridges that actually washed out may have experienced forces greater than the forces probably imagined in earthquake-resistant design. Moreover, we found that when we assume that guard fences were absent, the force acting on the shoes may lower to about the level considered in past earthquake-resistant design. In other words, introducing innovations in strengthening the shoes and in the structure of the guard fences through future technical development may reduce the potential for damage.

4. Conclusion

As an outcome of this research, we intend to submit the method of identifying bridges at greatest risk of scouring and washout to the Road Technology Subcommittee and proceed with examinations for creating a standard from it as a risk evaluation method or the like.

☞See here for detailed information

1) Concepts for Tsunami-Resistant Design Criteria for Coastal Bridges
https://www.pwri.go.jp/eng/ujnr/tc/g/pdf/29/29-6-1_shirato.pdf

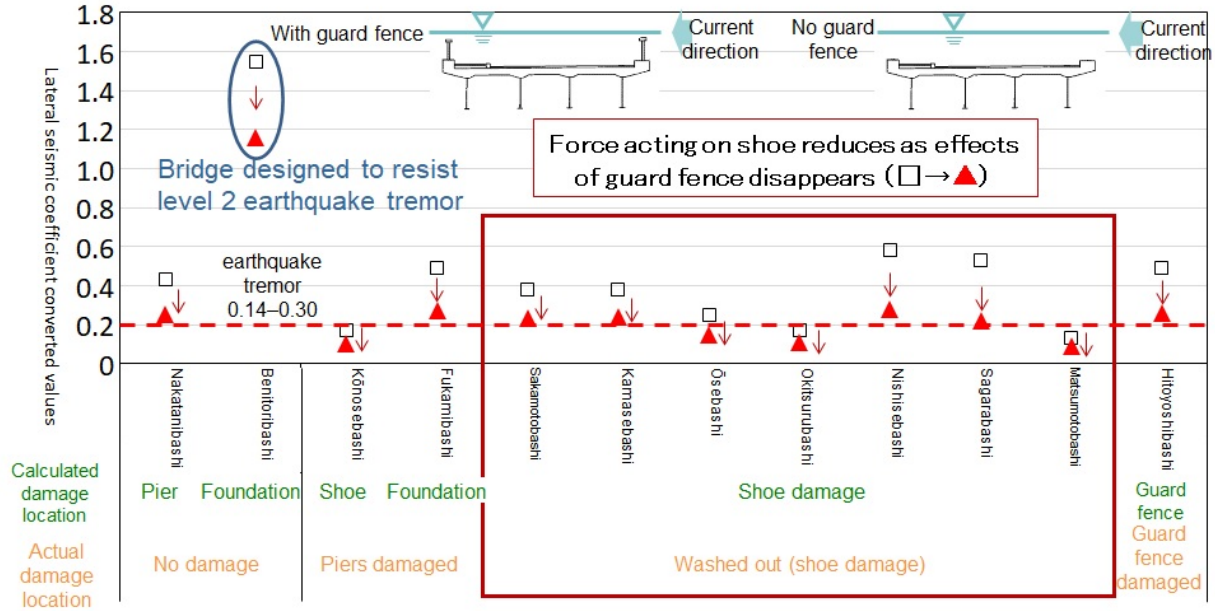

Fig. 3. Changes to acting lateral seismic coefficients depending on the presence of guard fences

Development of Earthquake Resistance Check Methods for Large Box Culverts

(Research period: FY2019–FY2021)

Foundation, Tunnel, and Substructures Division, Road Structures Department

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(Keywords) large box culverts, earthquake resistance check, response displacement method

1. Introduction

Revisions to technical standards for road and earthworks structures are being considered from the perspective of giving concrete detail to the required performance and the check methods. As part of this, NILIM is considering earthquake resistance check methods for large box culverts, which are not clearly described in the current guidelines, etc.

This article proposes an analysis model used in earthquake resistance checks for large box culverts, which fall outside the scope of the current guidelines, through previous experiments and reproduction analysis of disaster case examples, and also checks earthquake resistance under various conditions using the analysis model and presents the results of an assessment of its validity. This consideration was conducted in collaboration with the Public Works Research Institute (PWRI).

2. Comparative analysis with experiment results

To compute the response values in the event of an earthquake, we used the response displacement method, which is a static analysis method. When modeling the culvert body and surrounding ground, we let the body be a linear beam element and adopted a model that added joint elements between the body and ground spring elements so that we could appropriately replicate slipping and peeling phenomena between the culvert and the surrounding ground.

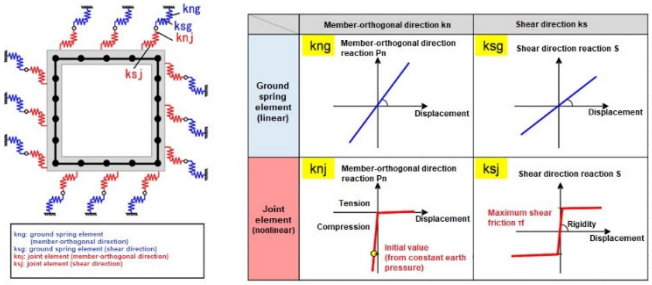


Fig. 1. Outline of body and ground modeling

Using the above analytical model, we conducted a comparative analysis with the results of two existing centrifugal model experiments shown in table 1. Given the importance of setting a maximum value for the circumferential shear on the body in creating an accurate analysis model, we changed the circumferential shear for both conditions over three cases, organized the section forces, displacements, etc. occurring in the body, and compared them to the experimental values (table 2).

Figure 2 shows the results of comparing the maximum bending moment in the experiment and the analysis for each culvert member in examination case 3 of condition 2.

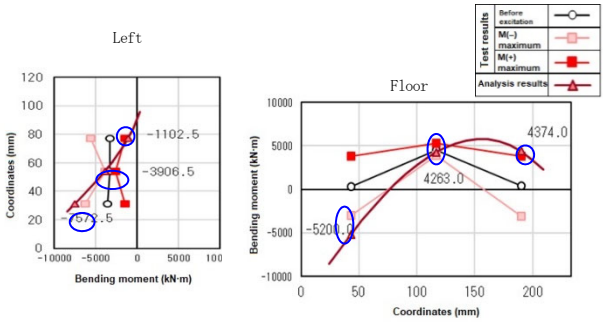
Examination case 3 was set up according to the maximum circumferential shear on a caisson foundation, which has resistance between the concrete and the ground, as with culverts, and the results show a maximum bending moment approximately aligned with that obtained for the body in the experiment (blue circles in fig. 2). Moreover, the results in condition 2, which had a smaller overburden, were similar.

Table 1. Conditions for centrifugal model experiments

Conditions	Banking materials	Internal cross-section breadth (m)	No. of series	Overburden thickness (m)	Examination case no.
1	Fine-grained soil	14 m	1 series	0.5 m	3 cases
2	Fine-grained soil	14 m	1 series	10 m	3 cases

Table 2. Examination cases

Examination cases	Max. circumferential shear force (top slab/side walls)	Max. circumferential shear force (bottom slab)	Notes
1	$c + \sigma\tan\varphi$	$c + \sigma\tan\varphi$	*1: Set under 2012 retaining wall work guidelines *2: 2012 Road Bridge Specifications (max. circumferential friction force of caisson foundation)
2	$\sigma\tan(2/3\varphi)$ [*1]	$\sigma\tan(2/3\varphi)$ [*1]	
3	$0.5\,(c + \sigma\tan\varphi)$ [*2]	$\sigma\tan(2/3\varphi)$ [*1]	



* Positive values indicate bending in the direction of internal tension,
○ Places where experimental and analysis

Fig. 2. Bending moment diagram (condition 2: examination case 3)

3. Comparative analysis with actual earthquake-affected culverts

Using the analysis model evaluated in section 2, we conducted an analysis of actual structures affected by earthquakes and compared the analysis with the actual damage to verify the validity of the proposed analysis model. Here, we set the maximum shear friction around the body as in examination case 3 in table 2.

(1) Case where damage occurred (Southern Hyogo Earthquake (1995): Daikai Station[1])

The damage to Daikai Station is as shown in figure 3; the damage to the central pillars was characteristic and the upper floor slabs collapsed due to shear destruction or compression failure of most of the central pillars in sections where the damage was most severe. In the trial calculation results (fig. 4), the shear check was out around the center pillars and broadly reproduced the actual damage.

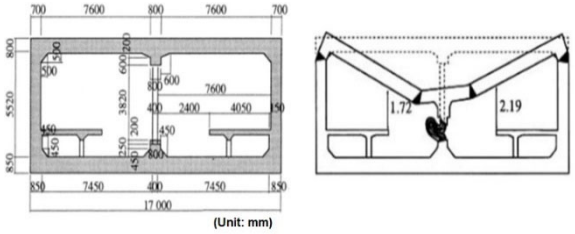


Fig. 3. Cross-section of Daikai Station (before and after disaster)

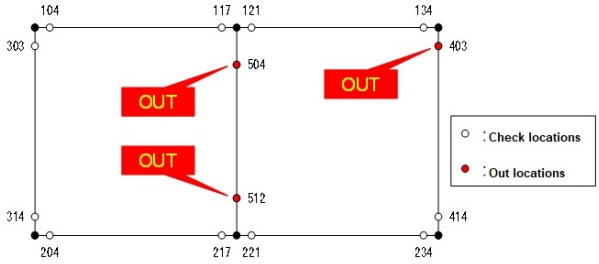


Fig. 4. Daikai Station analysis results (shear resistance check)

(2) Case where no damage occurred (Kumamoto Earthquake (2016): culverts crossing the Kyushu Expressway[2])

In the culverts crossing the Kyushu Expressway, no noticeable damage to the body has been confirmed, other than joints spreading. In the trial calculation results, all check items were satisfied and the results reproduced the outcome of no actual damage.

4. Comparison with conventional design methods

We conducted an earthquake resistance evaluation of large culverts under various conditions with cross-section designs under stationary load, which has conventionally been performed as a design method for culverts, using the analysis method considered in sections 2 and 3. The examination cases are as shown in table 3 and were conducted with level 2 earthquake tremors of types I and II.

In the bending check results, the generated curvature did not reach the yield curvature in any case, and the allowable values for drift angle established based on previous research outcomes[3] were satisfied.

On the other hand, in the shear check, while it was necessary to expect shear reinforcement roughly

equivalent to erection bars in some culverts exceeding the scope of application of the conventional form, we confirmed that changes to member width would not occur.

Table 3. Examination cases

Internal breadth	Internal height	Overburden thickness	Member thickness	Ground condition	Notes
6.5 m	5.0 m	0.5 m	Thin	Class I ground to class III ground	Conventional culvert
			Thick	Class II ground	
		1.5 m	Thin	Class II ground	
			Thick	Class II ground	
6.5 m	6.0 m	0.5 m	Thin	Class I ground to class III ground	Culvert exceeding scope of application of conventional culverts
			Thick	Class II ground	
		1.5 m	Thin	Class II ground	
			Thick	Class II ground	
8.0 m	6.0 m	0.5 m	Thin	Class I ground to class III ground	
			Thick	Class II ground	
14.0 m	6.0 m	0.5 m	Thin	Class I ground to class III ground	

5. Summary

Through this study, we conducted a reproduction analysis of centrifugal model experiment results and actual case examples and proposed an analysis method for earthquake resistance checking for large box culverts. This proposal succeeded in accurately demonstrating a standard method for earthquake resistance checking for large box culverts, which had not been demonstrated previously.

Based on the results obtained here, we intend to investigate methods to reflect the earthquake resistance checking method for large box culverts in technical standards for road and earthworks structures in future.

References

1) "Damage to Daikai Subway Station of Kobe Rapid Transit System and Estimation of Its Reason during the 1995 Hyogoken-Nanbu Earthquake." *Proceedings of the Japan Society of Civil Engineers*, no. 537, 1996.
2) "Damage analysis of box culvert locations in the Kumamoto Earthquake." *54th Proceedings of the 54th Conference of the Japanese Geotechnical Society*, 2019.
3) "Evaluation of Seismic Limit State of Single-Cell Box Culverts for Roads." *Journal of Japan Society of Civil Engineers, Ser. A1 (Structural Engineering & Earthquake Engineering)*, vol. 71, 2015.

☞See here for detailed information

"Development of a Seismic Verification Method for Large Box Culverts." *Civil Engineering Journal*, vol. 63, 2021.

Examination of the Effect of Removal of Existing Piles on Geotechnical Properties

(Period of research: FY2020 - FY2023)

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(Keywords) *Existing piles, Geotechnical properties, structural regulation*

1. Introduction

Approximately half of the non-residential buildings in Japan were constructed more than 30 years ago. While there are high expectations for the renewal of cities, in order to promote the renewal of buildings corresponding to a variety of needs, the reorganization of the rational structural regulation in response to issues related to existing piles is desired. The purpose of this research project is to develop methods for the safe and rational use of construction site that includes existing piles. In FY2021, we conducted the following research, analyses, and other examinations.

2. Overview of Our Technological Development

(1) Research for Grasping the Changes in the Physical Property of the Ground Following the Demolition of a Building

To accumulate examples of the verification of the changes in the geotechnical property in cases where several piles are removed, on sites where existing piles that used to be in actual use (cast-in-place piles) were removed and reinstalled, soil investigations were conducted before, during, and after the removal. Specifically, a standard penetration test, an electric cone penetration test, and other tests were conducted to compare and verify the changes in the geotechnical property before and after the removal of existing piles. In addition, during removal (photo), the specifications of the piles and the condition of various managements were investigated, and concrete core samples etc. were obtained.

(2) Analysis of the Structure of the Building Based on the Assumed Use, and the Usage of Existing Piles

We set up a detailed structural analysis model for the buildings that use existing piles, and conducted a time history response analysis under an earthquake. We set up analytical cases in consideration of the existence/non-existence of eccentricity and the structural property of footing beam in addition to the vertical spring coefficient and the performance of the piles (Table 1). We grasped the degree of influence on the load effect of footing beam, the vertical displacement of the pile tops, and the horizontal displacement of the upper structure from the specified conditions of the existing piles etc., and then extracted remarks for the structural design.

Photo. How the piles were removed on our investigation site

Table 1. Cases that we examined

Case	Existing pile		[3] Characteristics of upper structure		Remarks
	[1] Perpendicular spring *1	[2] Pile *2	(1) Base beam on existing pile side *2	(2) Eccentricity	
1	1 time	Coping with ultra-scarce earthquake vibration	Coping with ultra-scarce earthquake vibration	None	Basic base
2	3 times				Load history of existing pile
3	1 times	Proof force lower than new ones			Pile performance of existing pile
4	3 times				Compared with 5, 6
5				Center of gravity of existing pile	Eccentricity of upper structure
6				Center of gravity of newly installed pile	
7			Proof force lower than newly installed side	None	Compared with 8, 9
8				Center of gravity of existing pile	Base beam proof force reduced and eccentricity of upper structure
9				Center of gravity of newly installed pile	

*1. 1 time for newly constructed piles.
*2. The footing beam on newly constructed piles and newly constructed pile sides to correspond to earthquake vibration that occurs extremely rarely

3. Plans for Our Next steps

We continue to collaborate with the relevant departments and bureaus of the Ministry of Land, Infrastructure, Transport and Tourism, the Building Research Institute, other experts, and other relevant associations (associations in the industrial fields related to building foundation and/or soil), and are planning to advance our technological development.

Measures against Strong Wind on Roofs of Existing Buildings - Research on Wind Resistance Diagnosis and Reinforcement Method Evaluation of Roofing Materials

(Period of research: FY2021 - FY2023)

Structural Standards Division, Building Department

KIKITSU Hitomitsu Head (Ph.D.Environmental Studies)

(Keywords) existing buildings, roofing materials, measures against strong wind

1. Introduction

This research, on the basis of the actual situation of damage by strong wind in recent years, proposes a method for the evaluation of wind-resistant reinforcing technology adopted at the time of the development, correction, and/or modification of the method for examining the wind-resistant performance of existing roofing materials. Further, our purpose is to organize the manuals related to the diagnosis of wind-resistant performance and/or the reinforcement of existing buildings and to spread them to contribute to the guidance of the appropriate diagnosis of wind-resistant performance and reinforcement, the promotion of renovation of existing buildings.

2. Overview of Our Technological Development

(1) Development of a Wind-resistant Performance Diagnosis to Specify the Risk of Damage to Roofing Materials

We have examined the framework to specify the locations that are supposed to be a trigger of damage from strong wind and specified the factors for each type of roofing material and a method for examining wind-resistant performance that can lead to the secure reinforcement of vulnerable roofing materials. During the examination, as a relevant existing method of analysis, we investigated the guideline for the diagnosis of the earthquake resistance performance of non-structural members in existing buildings, the framework of the guidelines for the repair of roofs contributing to measures against typhoons.

(2) Examining the Method of Evaluation of Wind-resistant Reinforcement Technology to Realize Strong Roofing Materials

We examined the ideas for the level of wind-resistant performance and the evaluation of wind-resistant performance reinforcing technology that should be a base for cases in which the reinforcement of roofing materials is required to be resistant to strong wind.

① Level of Wind-resistant Performance

In order to correspond to the needs for performance that is much higher than the requirements in the Building Standard Law (disaster-recovery base buildings etc.), we have examined several levels of wind-resistant performance corresponding to the assumed wind force levels.

② Method of Evaluating the Technology to Reinforce Wind-resistant Performance Based on the Load Tests

Three methods are applied as general methods of repair and/or modification: partial repair, overall correction with layered thatching, and comprehensive thatching correction. We interviewed the relevant associations to understand the actual situation of what is mentioned above for each of the

repair or correction methods, including metal sheet thatching, bent board thatching, covering slate thatching, and roof tile thatching. In addition, as a case study of layered roof thatching modification (covering construction method), we compared and verified the difference in the resistance force before and after modification by conducting a wind-resistant pressure performance test of the metal board thatching (Photo-1) and a tensile loading test of the joining section of bent board thatching (Photo-2).

Photo-1. An example of conducting a wind-proof pressure performance test on metal board thatching

Photo-2. An example of conducting a tensile load test on the joining part of bent board thatching.

3. Plans for Our Next steps

We will continue to collaborate with the relevant departments and bureaus of the Ministry of Land, Infrastructure, Transport and Tourism, the Building Research Institute, each of the relevant associations concerning roofing materials, and so forth, and are planning to advance the technological development to contribute to the wind-resistant measures for existing buildings.

Development of New Performance Indices and Evaluation Programs Contributing to the Sophistication of Fire-prevention Performance of Non-residential Architectures

(Period of research: FY2020 - FY2022)

Fire Standards Division, Building Department

OKEMOTO Keisuka, IWAMI Tatsuya, SUZUKI Junichi, MINAKAMI Tensei

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(Keywords) non-residential architectures, fire-prevention performance, function-maintaining performance, performance evaluation index

1. Introduction

In the current research, we have been advancing the composition of the framework for the evaluation of function-maintaining performance after fire damage in a non-residential architecture. In this paper, we report on the results of the research and analysis of time-transitional changes of the functionality rate of architectures from the infliction of fire damage, through the repair, rebuilding, and other handling processes, and up to their recovery based on the press materials etc.

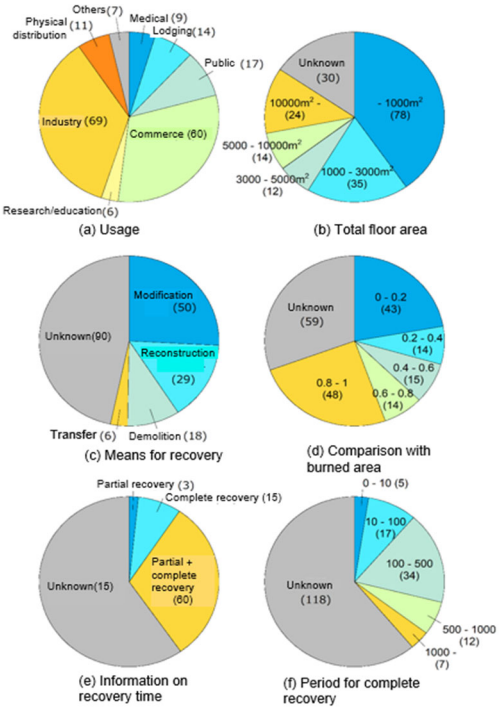


Fig-1. Examples of recovery from fire damage stored in the database

2. Database of Case Studies on Recovery from Fire

For the analysis of fire damage to architectures and the subsequent recovery processes, we used the press materials etc. issued in the 20 years from 2000 to 2019 to construct a case study database. There were 193 damaged buildings for which we were able to collect information on recovery from fire from press materials etc. Fig-1 shows a breakdown of the information. When we focus on (a), Usage, there was much information related to commercial facilities used by a large number of unspecified people or relatively large factories or warehouses. On the other hand, there was no information on houses or office buildings, which would be likely to have limited users. As for (e), the recovery period, there were a limited number of case studies that specified the specific period; there were 78 cases that specified either the period for partial recovery or complete recovery. Among them, we were able to confirm that some step-by-step recovery processes were implemented after partial recovery in 60 cases that were fully recovered.

3. Overview of the Probability Model

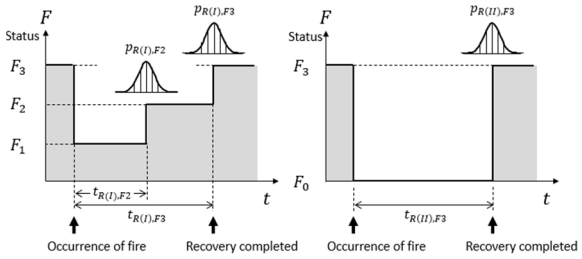
Based on the results of an investigation on case studies of recovery from fire, we classified the the spatial and functional statuses of architectures in the recovery process into four statuses: F_0, F_1, F_2, F_3 (Table-1). The actual recovery processes could be further classified

in detail; however, further classification was impossible due to the limitations of the information that we were able to collect from press materials etc. Furthermore, the handling of a damaged architecture was able to be largely classified into the case where it was partially corrected, it was reconstructed after demolition, and it was not reconstructed after demolition. Among them, cases in which buildings were not reconstructed after demolition were outside of the scope of the interest of our research; therefore, we regarded the remaining two cases as representative recovery scenarios.

Fig-2 names the cases of correction and reconstruction as Scenarios I and II, respectively, and shows a schematic illustration of the processes to the recovery of functionality rate after the fire in each of these scenarios. According to these scenarios, we conducted an evaluation—in terms of probability—of the recovery period to each space and functionality status t_R (in Scenario I, functionality status F_2 had the recovery period $t_{R(I),F2}$. In the same manner, F_3 had the recovery period $t_{R(I),F3}$; in Scenario II, F_3 had the recovery period $t_{R(II),F3}$).

Table-1. Classification of the space and functionality of architectures that experience fire damage

Status	Space	Functionality	Functionality rate
F_0	Not accessible anywhere	All stopped	0
F_1	Damaged part not accessible	Functionality of the damaged part at a halt	$\frac{A_{fl}-A_b}{A_{fl}}$
F_2		Functionality of the damaged part replaced by some other part	$\frac{A_{fl}-\alpha\cdot A_b}{A_{fl}}$
F_3	No restriction	No restriction	1



(a) Scenario I (modification), (b) Scenario II (reconstruction)

Fig-2. Step-by-step processes for the recovery of damaged architectures

4. Recovery Period

A large number of steps are required for the recovery of architectures that have experienced fire damage, including "investigation of the fire," "cleaning and/or (partial) demolition," "fund raising," "contracts with design and/or construction companies," "basic and/or construction design," "application for conformation of construction," "construction," and so forth. To understand the period of recovery to the status of each space and/or functionality t_R (days), it is necessary to clarify each of the periods required for each recovery process. However, there is great uncertainty in relation to the period required for each process because it is influenced by the specific condition of the owner, the social status on each occasion, and other factors. However, even under these circumstances, changes to the "construction" process, which is situated in the final phase of the recovery process, may be relatively small changes, and it is conceivable that it will cover a significant portion of the recovery period t_R.Thus, we regard the "construction" period, $t_{R,ref}$, as the standard time, and divide each recovery period t_R by $t_{R,ref}$ to acquire the time of normalization t_R^*; thus, we use a log normal distribution function to regress the relation with the recovery rate p_R.

$$p_R = \Phi\left(\frac{\ln(t_R^*)-\lambda}{\xi}\right) \quad (1)$$

Here, Φ is a standard normal distribution function,

and λ and ξ are the average and standard deviation of $\ln(t_R^*)$, respectively. As for the "construction" period, $t_{R,ref}$ (days), we used the report on the statistical survey on the commencement of construction to acquire the following regression equation.

$$t_{R,ref} = \begin{cases} 53.0A_{flr}^{0.250} & (RCconstruction) \\ 36.5A_{flr}^{0.229} & (Sconstruction) \\ 44.4A_{flr}^{0.209} & (\text{Wooden frame}) \end{cases} \text{(days)} \quad (2)$$

Fig-2 and Table-2 show the results of the regression in the case studies in the database using equation (1). As for the number of the case studies that we were able to use for regression N=30 for $t_{R(I),F2}$, 35 for $t_{R(I),F3}$, and N=22 for $t_{R(II),F3}$. In either step, the regression of the data was, in general, excellent. The average of $t_{R(I),F2}$, $t_{R(I),F3}$, and $t_{R(II),F3}$ were, with respect to the standard time $t_{R,ref}$, 0.282 times, 1.12 times, and 3.38 times, respectively. The required time was shorter in this order.

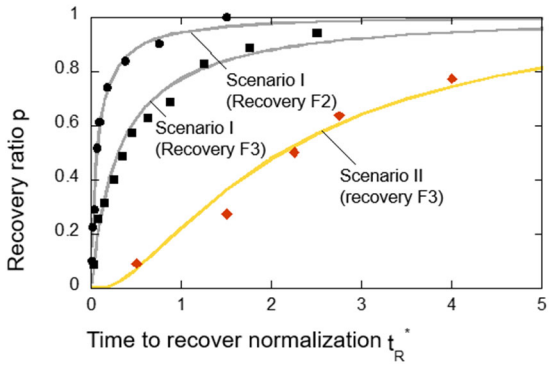


Fig-3. Recovery time to normalization and the recovery rate

Table-2. Results of the regression of the recovery rate curve

Scenario	Status	N	μ	σ	λ	ξ
I	Recovery F2	30	0.282	1.28	−2.81	1.75
	Recovery F3	35	1.12	4.13	−1.23	1.64
II	Recovery F3	22	3.38	4.26	0.743	0.975

5. Conclusion

In the probability model composed in this research, the recovery rate p_R under the conditions of the two scenarios—modification and reconstruction—was evaluated with the recovery rate curve based on the normalization time t_R^*. As a result, we have become able to use a relatively simple procedure to follow the recovery processes of architectures that have experienced fire damage.

Development of technology to support judging the robustness of local government buildings immediately after an earthquake

(Research period: FY 2019–2021)
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(Keywords) Core building, robustness, judgment criteria

1. Introduction

Government buildings often become core bases 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 them (Figure 1), which slowed down restoration processes.

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

Figure 1: Robustness is unclear immediately after an earthquake

2. Contents of the study

This study aimed 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 building structure immediately after an earthquake without depending on experts. However, there are no common engineering evaluation criteria to use.

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

The following studies were implemented to address these issues.

(i) Present engineering criteria for structural robustness evaluation with accelerometers (Figure 2) based on structural analysis of building models. Organize technical precautions for practical applications.

(ii) Develop visual inspection guidelines for non-structural members (including evaluation of damage to suspended ceiling materials [Figure 3]).

In (i), standards were prepared for judging the robustness of a structure by using acceleration sensors installed in the structure to numerically capture properties that go through rapid changes during an earthquake (Figure 4). Specifically, the robustness of a structure was estimated based on the level of changes in the natural period of the structure during an earthquake. In (ii), current situations of earthquake damage evaluations of

non-structural members were organized. Standards for robustness judgment were then prepared after conducting experiments on the evaluation of damage to suspended ceilings, for which there is a shortage of knowledge and insight.

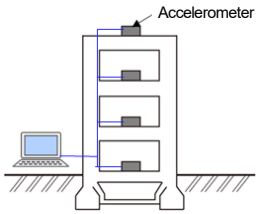

Figure 2: Practical application of a robustness judgment system in a building

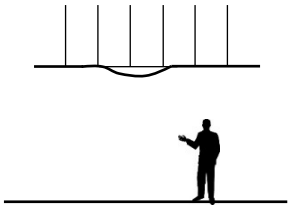

Figure 3: Damage to a suspended ceiling

Examples of subjects examined

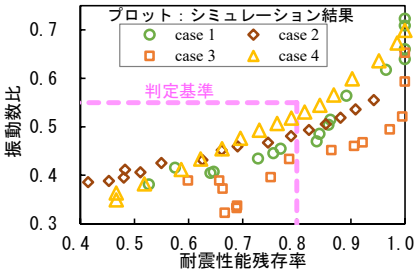

Figure 4: Robustness judgment criteria for structures

The publication of "Collection of Cases on Carefully Crafted Improvement in Densely Built-Up Areas"

(Research period: FY 2016–2020)
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(Keywords) Densely built-up areas, development, collection of cases

1. Introduction

In August 2021, NILIM published "Collection of Cases on Carefully Crafted Improvement in Densely Built-up Areas" (hereinafter referred to as the "Collection of Cases"), which describes 55 cases of improvement mainly in inside a block of areas (so-called "anko" parts), utilizing hard and soft methods such as regulatory guidance and local disaster prevention efforts in appropriate cases in response to obstacles to improvement such as poor road access and complicated rights relations of property in densely built-up areas.[1),2)] This paper presents the background, purpose, and overview of the publication of this book.

2. Background and purpose of the publication of the Collection of Cases

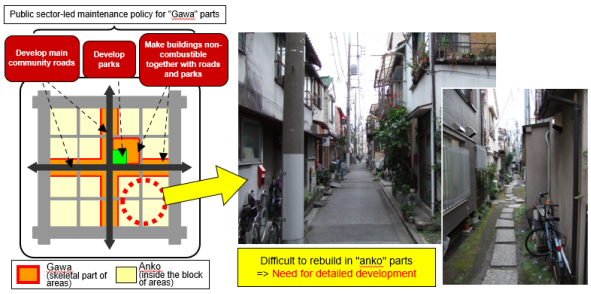

Figure 1: "Gawa" and "anko" of densely built-up area

"The basic plans for housing for people (National plan)," approved by the Cabinet in March 2021, set a target of eliminating most of the "densely built-up areas that will be extremely dangerous in the event of an earthquake, etc. (dangerous densely built-up areas)," which were approximately 2,200ha in size at the end of FY 2020, by the end of FY 2030.

There are various factors that hinder the improvement of densely built-up areas, such as narrow sites, sites with poor road access, complicated rights relations such as land leases and house leases, and the aging of landowners. In addition, local governments, which are the main parties responsible for the improvement of densely built-up areas, are under severe workforce and financial constraints. Under these circumstances, in addition to conventional public investment-type improvement of the skeletal parts of densely built-up areas (so-called "gawa" parts), such as the development of roads and parks of a certain scale, and joint rebuilding, in order to improve "anko" parts, where improvement has not progressed well with accumulated disadvantaged lots, it is also considered effective to perform carefully crafted improvement by using regulatory guidance methods and by making use of the vitality of the private sector.

Therefore, by focusing mainly on "anko" parts, NILIM conducted a survey of carefully crafted tangible and intangible improvement conducted by local governments and private companies addressing various physical and socioeconomic hindrances to improvement and compiled them to create the Collection of Cases.

3. Overview of the Collection of Cases

The structure of the Collection of Cases is shown in Figure 2. In Chapter 1, as an introduction to the Collection of Cases, the necessity of carefully crafted improvement in densely built-up areas, especially in "anko" parts, is described, and the "Hindrance to the improvement of densely built-up areas" and "Improvement methods for densely built-up areas," which were focused on when NILIM collected and organized the cases introduced in the Collection of Cases, are outlined (Figure 3). Chapter 2 presents the format of case reports (listed items) as a way of using the Collection of Cases and describes three methods of case searching from the standpoints of (1) “Hindrance to the improvement of densely built-up areas," (2) "Improvement methods for densely built-up areas," and (3) a combination of (1) and (2).

Chapter 3 contains a total of 55 cases with detailed case reports, each described in several pages in A4 vertical format (Figure 4). Chapter 4 extracts the information in the case reports (detailed) and summarizes them, with each described in one A4 horizontal page (summary) for a total of 55 cases (Figure 5). Each case report provides not only a summary of efforts but also the background, history, devised ideas, success factors, applicability to other areas, project cost, and other information that may be of interest to those in charge of the improvement of densely built-up

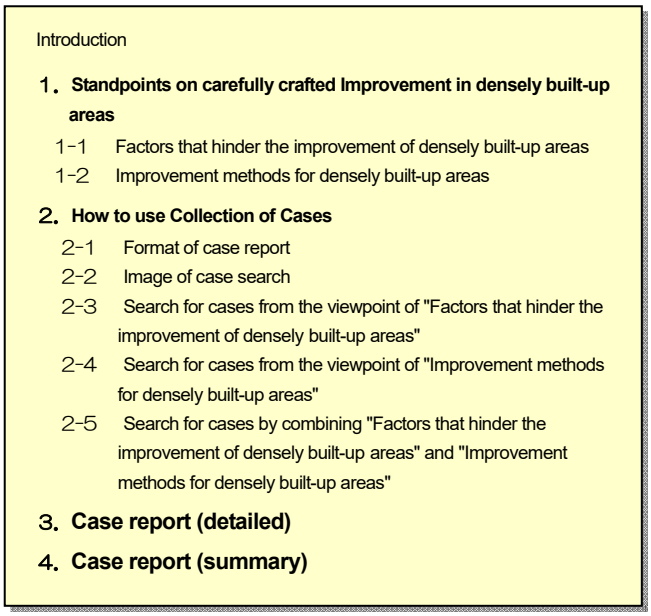

Figure 2: Structure of the Collection of Cases

areas.

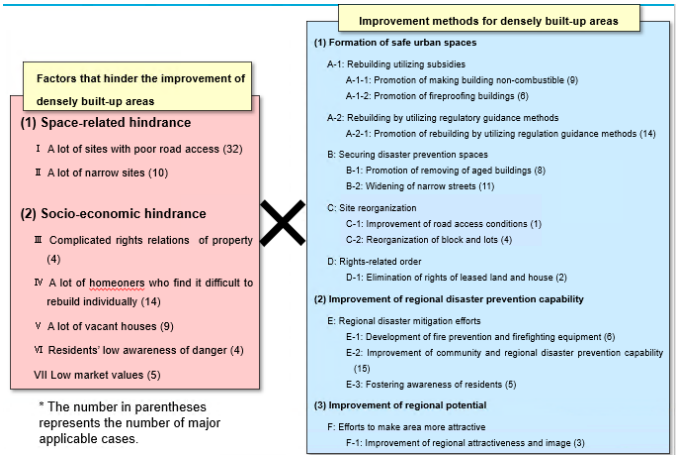

Figure 3: "Hindrance to the improvement of densely built-up areas" and "Improvement methods for densely built-up

Figure 4: Image of case report (detailed)

Figure 5: Image of case report (summary)

The Collection of Cases also includes many examples of efforts in the Kinki region (18 cases), where the improvement of dangerous densely built-up areas is a little behind the Tokyo metropolitan area, because further promotion of development is required. It also provides examples of related intangible measures in light of the fact that the basic plans for housing for people (National plan) include the policy to strengthen intangible measures that contribute to the improvement of regional disaster prevention capability.

4. Conclusion

The Collection of Cases is currently available for free in a PDF format from the website of NILIM, and we invite readers to download it.[1)] We hope that the Collection of Cases will serve as a reference for local governments, private companies including urban development consultants, NPOs, resident organizations, and others working to improve densely built-up areas.

☞ For more information:

1) Technical Note of NILIM No. 1167: Collection of Cases on Carefully Crafted Improvement in Densely Built-up Areas
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1167.htm

2) Press Release of NILIM: Toward the Elimination of Dangerous Densely Built-Up Areas! - Publishing the Summary of 55 Cases of Development in Japan with a Focus on "Anko" Parts.
http://www.nilim.go.jp/lab/bcg/kisya/journal/kisya20210826_1.pdf

Technical Development for Seismic Reinforcement of Deteriorating Residential Retaining Walls

(Research period: FY2020–FY2023)

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(Keywords) residential retaining walls, deterioration, antiseismic reinforcement

1. Introduction

With the progress of urbanization in Japan, residential land has been created with the construction of residential retaining walls in hilly areas. However, many cases of damage to residential retaining walls that have deteriorated due to earthquakes have arisen in recent years, and furthering seismic measures is now a major challenge. We began research into improving the earthquake resistance of deteriorating residential retaining walls in 2020 and briefly describe the current state of technical development.

2. State of technical development

(1) Measuring the strength of earthquake-damaged retaining walls

We tested the compression strength of concrete cores collected from retaining walls affected by the 2016 Kumamoto Earthquake. Cores were collected from retaining wall sections where we could confirm damage and from retaining walls that appeared sound.

(2) Centrifugal load testing of masonry retaining wall models

We conducted centrifugal load tests using retaining wall models to examine reinforcement methods for retaining walls. In the tests, we used models of masonry retaining walls and tested them with and without reinforcement (reinforcement by inserting reinforcing rods, by covering the wall surface with nets, and by adhering spaces in the masonry of the reinforcing walls with adhesive).

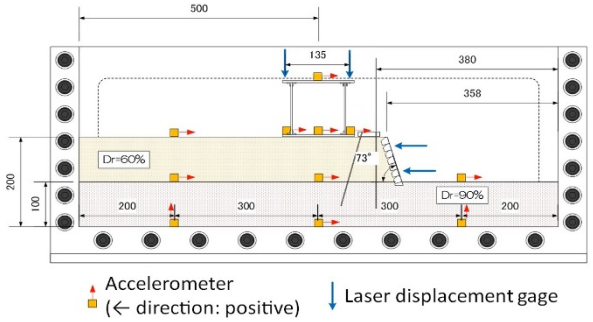

Fig. 1. Schematic diagram of centrifugal load tests (with reinforcement by inserting reinforcing rods)

The test results confirmed the collapse modes of residential retaining walls including buildings with the input of earthquakes of gradually increasing amplitude and the effects of reinforcing them.

(3) Analysis of the relationship between earthquake damage to residential retaining walls and buildings

The damage patterns in residential retaining walls and their effects on buildings in Sendai City damaged by the 2011 off the Pacific coast of Tōhoku Earthquake were examined based on the type of retaining wall, the distance between the wall and the building, the estimated seismic intensity, the microtopographic classification, and the inclination angle.

(4) Examination of estimated strength of residential retaining walls

Based on cases of residential retaining walls damaged in the 2016 Kumamoto Earthquake, we estimatied, considering the safety factor, the bending strength of the retaining wall by assuming earth pressure and the wall inertial force as external forces and the wall weight and bending strength as resistance.

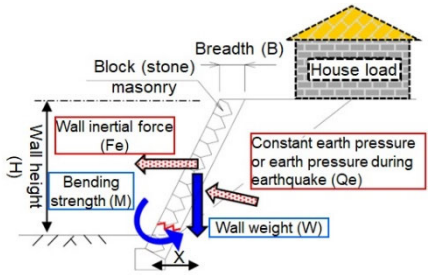

Fig. 2. Concept diagram of estimation of residential retaining wall strength

3. Conclusion

These examinations are currently being analyzed and considered in detail, and we intend to examine design examples for seismic reinforcement of deteriorating residential retaining walls in future based on the results obtained.

☞See here for detailed information

1) Outline of "Research and development for regeneration and resilience of cities by the rationalization of structural regulation related to buildings and ground"
http://www.nilim.go.jp/lab/hcg/kisojiban_hp/kisojiban.htm

Tsunami Damage Rate of Breakwaters

(Research period: FY2021)

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Head Kazuhiko Honda Research Engineer Fumiya Doukai

(*Keywords*) *tsunami fragility curve, the 2011 Tohoku Earthquake and Tsunami, port facility, damage*

1. Introduction

The 2011 Great East Japan Earthquake and Tsunami had a devastating effect on the population of the region and destroyed and swept away buildings, structures, and property. The tsunami caused severe damage to port facilities such as breakwaters, coastal dikes, warehouses, and cargo handling equipment, and it seriously disrupted port operations.

With the cooperation of port management bodies and the Ports and Harbours Bureau of MLIT (Japan's Ministry of Land, Infrastructure, Transport and Tourism), we have gathered data on the tsunami damage to each port facility. In this paper, we will use the results of this collected data on tsunami damage to report not only statistics on damages caused by the tsunami but also the tsunami fragility curve of the front-line breakwaters.

Fig. 1. Map of eastern Japan

2. Damage to Ports

Fig. 1 is a map showing eastern Japan and the major ports from Aomori Prefecture to Ibaraki Prefecture. Fig. 2 shows the estimated reconstruction costs of damaged public facilities in these major ports. The total cost is approximately 300 million yen. Very large tsunamis struck the bay-mouth breakwaters and front-line breakwaters in the ports of Hachinohe, Kamaishi, Ofunato, and Soma, causing extensive damage to these breakwaters. Hence, the cost of repairing damaged protective facilities for those ports is much higher.

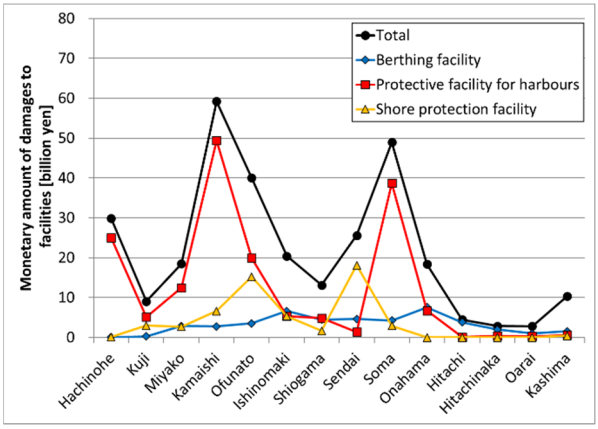

Fig. 2.1. Monetary amount of damages to facilities

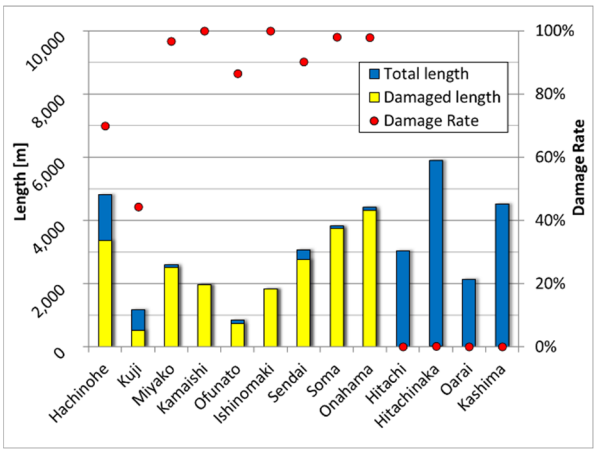

Fig. 3. Damage to front-line breakwaters

3. Damage to Breakwaters

Fig. 3 shows the damage rate of front-line breakwaters in these major ports. It was calculated as the length of the damaged portion of the breakwaters divided by the total length.

Fig. 4 shows the damage rate of the front-line breakwaters in Fig. 3 according to η_{max} (the maximum tsunami height in front of the breakwater) in each port. The value of η_{max} is the maximum value of the tsunami height along the front-line breakwaters in each port.

In this case, the strength against the tsunami force of the front-line breakwaters is not considered. That is why the three ports with almost the same tsunami height have different values for the damage rate. Therefore, in order to estimate the formula for the fragility, we should consider the design strength of the front-line breakwaters.

The main cause of damage to front-line breakwaters in Ishinomaki Port and Onahama Port was ground motion. In other ports, however, the main cause of such damage was the tsunami. Even in Ishinomaki Port and Onahama Port, where the tsunami height was not as large, the damage rate of the front-line breakwater is higher.

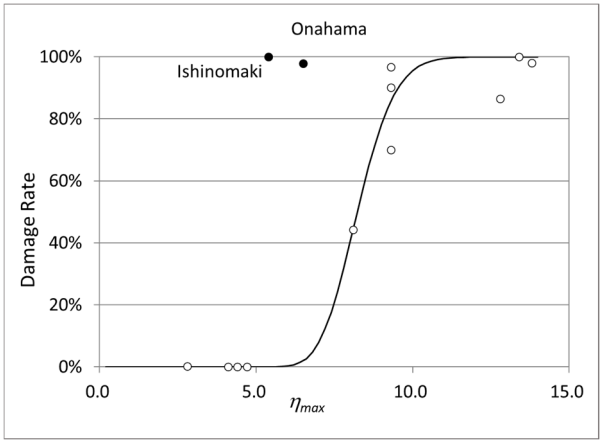

Fig. 4. Tsunami fragility curve (η_{max})

The design significant wave height represents stability against external forces, and can be an indicator of the strength against tsunami force. Fig. 5 shows the damage rate of the front-line breakwaters in Fig. 3 according to the parameter η_{max} divided by $H_{1/3}$ (the design significant wave height of the breakwater) in each port. Each part of a breakwater has a different design significant wave height, so the value of $H_{1/3}$ is the maximum value of the design significant wave height of the front-line breakwaters in each port.

The front-line breakwaters in Ofunato Port were designed against the force due to the design tsunami, because the force due to the design significant wave height is less than that of the design tsunami.

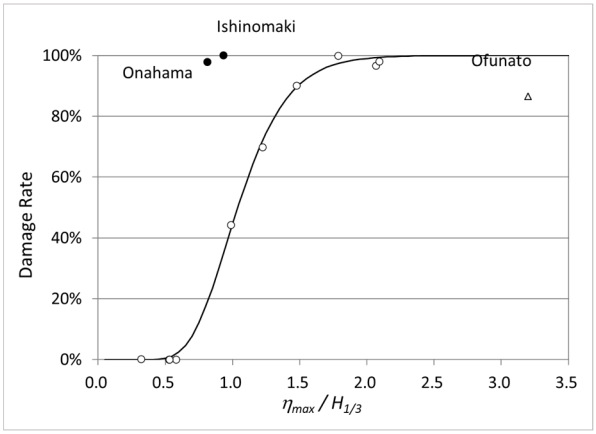

Fig. 5. Tsunami fragility curve ($\eta_{max} / H_{1/3}$)

4. Discussion

The tsunami fragility curve can generally be used to estimate the damage rate of facilities. Based on the results of this paper, it is possible to evaluate the damage rate of the target facility due to the possible tsunami generated by a Nankai Trough Earthquake. In this paper, we also proposed the tsunami fragility curve of warehouses in ports.

It should be noted that this tsunami fragility curve is not for each individual part of the front-line breakwater but for estimating the damage rate that is calculated as the length of the damaged breakwaters divided by the total breakwater length, and that the damage included not only severe damage but also comparatively slight damage.

☞Reference:

1) Technical Note of NILIM, No. 1173

https://www.ysk.nilim.go.jp/kenkyuseika/kenkyusyosiryou.html

Overseas Information Monitoring on Water Technological Policies Considering Climate Change.

(Study period: FY2015-)

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Climate Change Adaptation Research Group

Key words; water disaster, water resources management, climate change adaptation measures, overseas information, policy monitoring

1. Introduction

It is important to grasp the trends of technological policies in other countries, to confirm the advanced level of Japan's current technological policies, and to use the knowledge of other countries to promote domestic policies as needed. This paper introduces the initiative of the "Overseas Information Monitoring on Water Technology Policies in Light of Climate Change," which has been continuously conducted as one of the foundations for the smooth promotion of cross-disciplinary research activities in the Climate Change Adaptation Research Group (the "Research Group"; Head: Director-General of the NILIM).

2. Overseas information monitoring

The Research Group has been grasping technological policy trends related to climate change adaptation in 13 countries through case studies of climate change adaptation measures for water disasters and water resource management in the United States, the United Kingdom, and the Netherlands, as well as by obtaining technical standards and guidelines from other countries and visiting these countries to interview engineers and other experts directly.[1)] Considering the information thus accumulated and the efficiency of the survey, the initiative introduced in this paper serves to collect and summarize information on advanced climate change adaptation measures from websites of mainly overseas public organizations and post it on the Research Group's website as the latest overseas information, based on "fixed-point observation, " by regularly checking the official websites of selected priority organizations by country for information collection and tracking information updates as shown in Table.

Over the seven years from FY 2015, when this initiative was launched, to FY 2021, a total of 23 information aggregations were conducted and a total of 138 articles were published [2)].

Table: Number of articles published and target organizations for priority information collection by country

Country	Target organization for priority information collection	Number of articles
USA	Federal Emergency Management Agency, Army Corps of Engineers, National Oceanic and Atmospheric Administration, Geological Survey, etc.	64
U.K.	Department for Environment, Food and Rural Affairs, Environment Agency	42
Netherlands	Delta Commission, Royal Water Authority, etc.	11

*Number of articles is up to March 2021.

* In addition to the three countries listed above, the EU and other international organizations, foreign media, etc. were added to the survey in 2015 (10 articles), as well as France (8 articles) and Germany (3 articles) in 2019.

The number of articles by country shows the active movement in this field in the U.S. and the U.K., while the advanced technological policy trends in the Netherlands, which is systematically promoting flood control measures considering the progress in climate change prediction, are also interesting and suggestive references for Japan.

3. Future development

It is important to continue to collect, organize, and analyze the latest information on climate change adaptation measures in other countries, since the status of surveys, studies, and policy examination and implementation are changing constantly. We intend to continue the initiatives described in this paper, and promote effective and efficient technological policy monitoring combined with field surveys as necessary.

☞See the following for details.

1) Technical Note of NILIM No.749 pp. II-163-210
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0749.htm
2) Website of the Climate Change Adaptation Research Group, Overseas Case Studies
http://www.nilim.go.jp/lab/kikou-site/20info.html#T02

Demonstration Study of B-DASH Projects on ICT/AI-based Technologies for Sewage Treatment Plant Operation and Management

(Research period: FY2021-)
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Keywords: ICT, AI, efficiency enhancement of sewage treatment plant operation and management, infiltrated water during rainy weather, wide-area development

1. Introduction

In light of the financial difficulties and decrease in the number of technical personnel in municipalities engaged in sewerage projects, improving the efficiency of operation and management through the wide-area expansion of facilities and appropriately passing down the skills of skilled personnel have become urgent issues. As a method to solve these issues, use of operation management technologies based on ICT and AI is expected. On the other hand, relevant new technologies are being developed but many sewerage service providers are cautious about introducing them due to their limited track record. For this reason, the MLIT launched the "Breakthrough by Dynamic Approach in Sewage High Technology (B-DASH Project)" in FY2011. The Water Quality Control Department of the NILIM has been serving as an executing agency of this empirical project.
The purpose of this project is to demonstrate excellent and innovative technologies, formulate guidelines for introducing them, and disseminate them in order to realize cost reduction in sewerage service, efficient operation management, etc. In this paper, we report on three technologies for which we began a full-scale demonstration project in FY2021.

2. Outline of demonstrated technologies

The following provides an outline of each technology.

(1) Wide-area management system for sewerage facilities using ICT

This technology aims to realize a wide-area management system that efficiently performs remote monitoring and control for multiple and different treatment plants and pump stations by manufacturers of control equipment from a base facility. Specifically, the project will demonstrate the reliability and stability of communications and the effect of reducing construction and maintenance costs at six facilities in Kurashiki City by conducting remote monitoring and control, using a (i) common protocol method, (ii) remote desktop method, and a method that combines (i) and (ii), and defines common communication specifications for connecting systems of differing manufacture (**Fig. 1**).

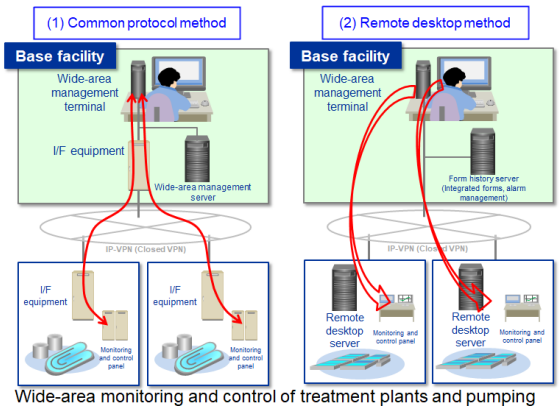

Fig. 1. Outline of the technology (Wide-area management)

(2) Advanced support technology for sewage treatment plant operation using AI

This technology aims to optimize and improve the efficiency of operation management by transferring the know-how of skilled engineers. Specifically, we demonstrate the stabilization of treated water quality and effect of reducing maintenance costs through operational support at the Seibu Water Reclamation Center in Hiroshima City and the Takase Sewage Treatment Plant in Funabashi City (**Fig. 2**), based on operation data on inflow water quality, treatment volume, etc. at the sewage treatment plants, using the following four functions:

(1) Image processing AI: Detects abnormalities from images such as the surface of water in settlement tanks;
(2) Water quality prediction AI: Predicts treated water quality for current and estimated operation volumes;
(3) Response decision AI: Visualizes the relationship between causes and responses, and presents measures to be taken, and;

(4) Operation AI: Derives optimum operation volume.

(3) AI-based support technology for water infiltration countermeasures for separate sewer systems in rainy weather

This technology aims to achieve optimal operation of separate sewer systems based on the increased volume of treated water at treatment plants due to infiltrated water in rainy weather. Specifically, at the Kinuura West Sewage Treatment Center in Aichi Prefecture, technology that supports the operation of pumps and other equipment during rainy weather will be demonstrated in terms of its effect on reducing operational burden, ensuring discharge water quality, and reducing overflow risk, by utilizing AI to learn inflow water volume, operational know-how of skilled engineers, etc. (**Fig. 3**).

3. Utilization of results and future development

In the future, we will compile research results as guidelines for each technology, based on the results of the demonstration studies and taking into account the opinions of experts and local governments. The standard structure of the guidelines is as follows.

Table: Structure of 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 of considering introduction, examples for consideration of introduction effect
Chapter 4. Planning and Design	Introduction planning, design
Chapter 5. Management	Inspection items, frequency, etc.
Data Part	Demonstration results, case studies, etc.

In addition, the NILIM is striving to disseminate and develop innovative technologies by holding guideline explanatory meetings, etc. As of May 2021, 52 technologies have been adopted for full-scale demonstration projects, 35 guidelines have been published, and 140 B-DASH technologies have been introduced for 13 technologies. For further dissemination and development, we are also working with the Sewerage and Waste Water Management Department of the MLIT to "establish energy performance indicators based on B-DASH technology and use the indicators as a grant requirement," "improve guidelines through follow-up of independent research after demonstration studies," and "create cost calculation tools". We will continue to work on the demonstration of new technologies as well as to promote their dissemination and development.

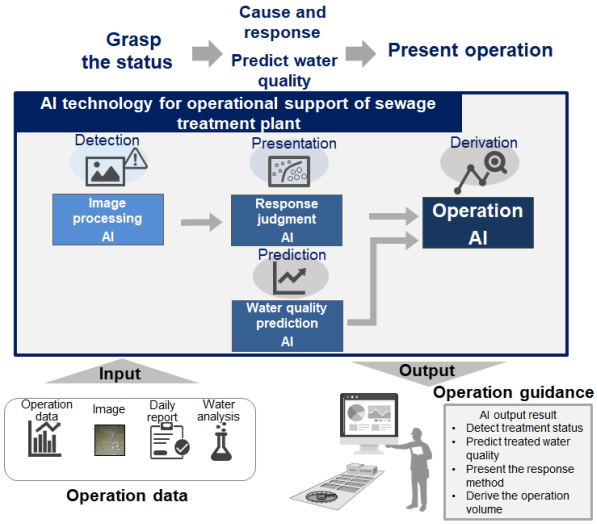

Fig. 2: Overview of the technology (AI-based operation support)

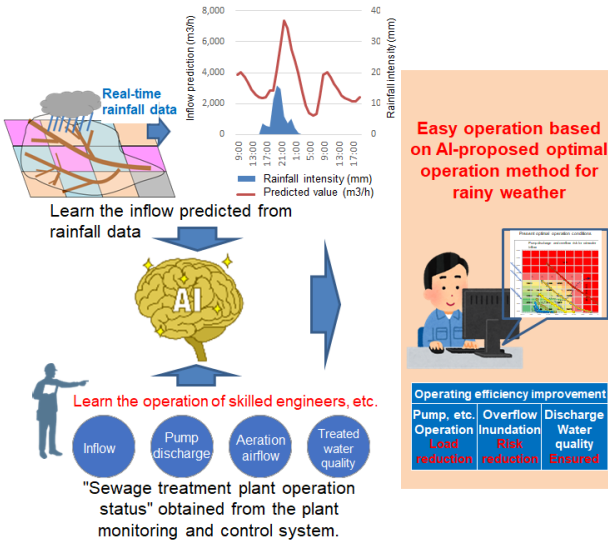

Fig. 3: Overview of the technology (Support for countermeasures during rainy weather)

☞See the following for details.

[Reference] Various guidelines are posted.

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

[Reference] B-DASH technology application chart, etc. are posted.

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

Testing the Stability of Estimated Results According to Different Numbers of Inputted Cross-section Locations in the OD Traffic Volume Inverse Estimation Method

(Research period: FY2015–)

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(Keywords) OD traffic volume inverse estimation method, ETC 2.0 probe information, number of inputted cross-section locations

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) gathers information about OD traffic volumes through the national Road Traffic Census (the Census), which is a sample survey conducted approximately every five years. For this reason, NILIM is developing an OD traffic volume inverse estimation method that estimates the OD traffic volume inversely from the cross-sectional traffic volume for roads, which can be measured easily, with the objective of finding out the probable OD traffic volume for an arbitrary day. This is expected to enable appropriate traffic management that allows for fluctuations in traffic demand according to the season or day of the week. However, previous studies have assumed that all observed cross-sectional traffic volumes from the Census are available. By contrast, to gain information on the OD traffic volume for an arbitrary day, we must confirm whether the OD traffic volume inverse estimation method can estimate the OD traffic volume accurately, even if fewer observation locations for cross-sectional traffic volume can be applied to the method, based on the fact that the observation locations for cross-sectional traffic volume would be limited to locations where traffic counters and the like are installed. This study examined several cases where the number of observed cross-sectional traffic volume locations applied in the OD traffic volume inverse estimation method was reduced, with the results discussed below.

2. Outline of the OD traffic volume inverse estimation method

The model equation for the daily OD traffic volume inverse estimation method is shown in equation (1). The model minimizes the residual sum of squares of the cross-sectional traffic volume and the residual sum of squares of the originating traffic volume and estimates the originating traffic volume in each zone as an unknown variable. The weighting is the inverse of the variance of each, based on error theory. The second weighting is the inverse of the variance assuming a normal distribution, in view of the fact that the survey accuracy of the originating traffic volume in the Census OD survey is supposed to "have a relative error for the originating traffic volume within a relative error rate of 20% at 95% confidence."

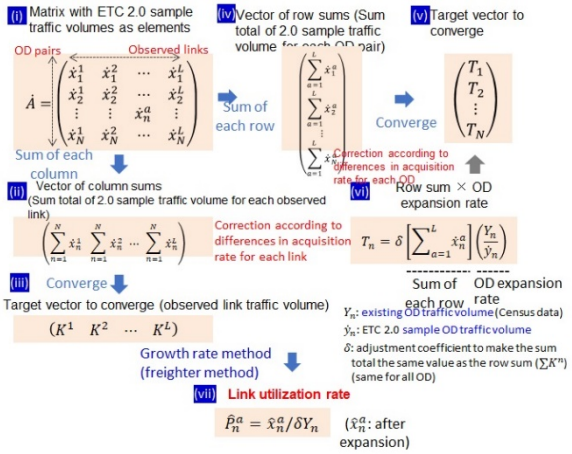
$$\frac{1}{(0.1/1.96)^2\sum_a (v_a^*)^2}\sum_a\sum_i\sum_j\left(\hat{O}_i m_{ij} P_{a,ij} - v_a^*\right)^2 + \frac{1}{(0.2/1.96)^2\sum_i (O_i^*)^2}\sum_i\left(\hat{O}_i - \hat{O}o_i^*\right)^2 \rightarrow Min \quad (1)$$

$$s.t. \quad (1/1.2)O_i^* \le \hat{O}_i \le (1/0.8)O_i^*$$

$P_{a,ij}$: utilization rate of link a for OD traffic volume ij
m_{ij}: destination selectivity between ij
v_a^*: observed cross-sectional traffic volume on link a
$\hat{O}_i$: originating traffic volume (unknown variable)
$\hat{O}$: total originating traffic volume ($\hat{O} = \sum_i \hat{O}_i$)
o_i^*: originating traffic volume proportion from existing data ($= O_i^*/O^*$)
O_i^*: originating traffic volume in existing data
O^*: total originating traffic volume in existing data

This study applies ETC 2.0 probe information to the link utilization rate and employs a method of correcting the link utilization rate with the growth rate method, according to differences in acquisition rate for each OD and link, consisting of the following two steps:

・ Step 1: Correct the ETC 2.0 probe information according to differences in acquisition rate for each OD and link (fig. 1)



・ Step 2: Process to make the sum of the route selectivity rates (the values obtained by dividing the traffic volume in each OD route by the OD traffic volume) 1.0

Fig. 1. Link utilization rate correction method

3. Testing the estimated results according to different numbers of inputted cross-section locations

(1) Test method

The input data for the daily OD traffic volume inverse estimation model is shown (table 1). In a constant observation system, the number of points available for obtaining observed cross-sectional traffic volume is limited to points where traffic counters and the like are installed, and it would therefore be fewer than the number of observation points in the 2015 Census in ordinary roads. Considering this, we set up several cases with different numbers of input points. The link utilization rate is computed by applying the correction method for the link utilization rate described above for case 0 (the basic case), in which all available locations are inputted.

Table 1. Input data

Target area	Originating traffic volume	Destination selection Probability	Link utilization rate	Observed cross-section traffic volume
Kinki region (896 zones)	Computed from OD traffic volumes in 2015 Census	Computed from OD traffic volumes in 2015 Census	Corrected link utilization rate computed from ETC 2.0 route information with the growth rate method	Applied OD traffic volume results in 2015 Census

(2) Test results

(i) Estimated results

The estimated results for cases 0 to 3 over the entire Kinki region are shown in table 2. Cases 1 and 2 remove inputted observation locations at random, while case 3 assumes the use of all constant observation locations that are currently available.

The %RMS of the estimated originating traffic volume in cases 1 and 2 was no more than 3.8% compared to case 0. On the other hand, in case 3, it was 6.4%, representing a slight increase on cases 0 to 2. The %RMS of the cross-sectional traffic flow shows a similar tendency, and although it is slightly larger in case 3 than in cases 0 to 2, the %RMS value was not greatly different and there was not a large difference in the estimate accuracy.

Table 2. Estimated results

Case	Inputted cross-section locations for observed traffic volume	Originating traffic volume		Cross-section traffic volume (Expressway + ordinary)	
		Traffic volume (100,000 vehicles)	%RMS (Compared to case 0)	Traffic volume (100,000 vehicles)	%RMS
Value from Census		147		490	
Case 0 Basic case	Total: 2,264 Ordinary: 1,770 Expressway: 494	145		482	18.1%
Case 1 Ordinary 40% down	Total: 1,556 Ordinary: 1,062 Expressway: 494	144	3.1%	478	18.3%
Case 2 Ordinary 60% down	Total: 1,202 Ordinary: 708 Expressway: 494	143	3.8%	476	18.3%
Case 3 Expressway + ordinary (constant observation)	Total: 510 Ordinary: 32 Expressway: 478	141	6.4%	469	18.9%

(ii) Fluctuation trends in originating traffic volumes

Fluctuation trends in the estimated originating traffic volumes in each zone in case 3 are shown in comparison with case 0, focusing on the areas in the Kinki region (fig. 2). Areas where the originating traffic volume is estimated to be lower were confirmed around suburban zones. The cause is thought to be insufficient correction of the input values for the link utilization rate. For the ETC 2.0 probe information that was applied for the link utilization rate, we collected data using route information collection devices installed on expressways and directly managed national roads. One factor appears to be that, because the network of expressways and directly managed national roads is sparse in these areas, the ETC 2.0 probe information subject to correction is insufficient and the link utilization rate has not been properly corrected.

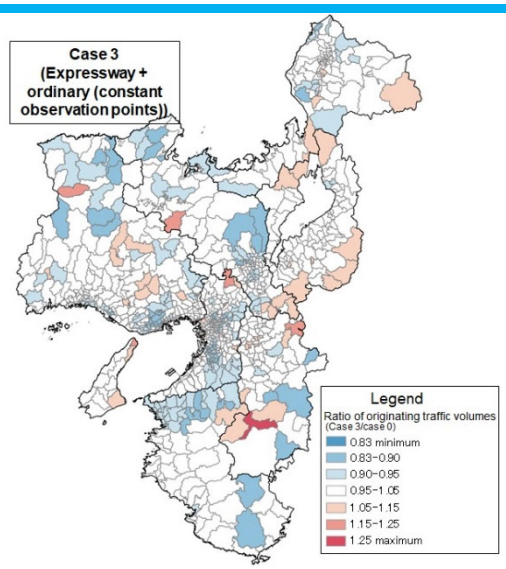


Fig. 2. Comparison of estimated originating traffic volumes between cases 0 and 3

4. Conclusion

This study set up several cases with different numbers of input points and tested the stability of the OD traffic volume inverse estimation results. The estimation accuracy of case 3, which assumed the currently realizable constant observation system, was not found to show large differences compared to the other cases over the entire Kinki region. On the other hand, if we focus on individual areas, some areas have low accuracy and it appears necessary to improve the correction method for the link utilization rate. In addition, some improvements to estimation accuracy can be expected from increased numbers of constant observation locations for traffic volumes in ordinary roads through CCTV camera (AI analysis), where efforts are currently underway.

☞See here for detailed information

1) 64th Proceedings of Infrastructure Planning (Sep. 2021)
Testing the Stability of Estimated Results According to Different Numbers of Observation Points in the OD Traffic Volume Inverse Estimation Method

Intentions of local governments and companies for transitioning to smart cities and related challenges

(Research period: FY 2020–2022)

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(Keywords) Smart city, local government, company

1. Introduction

In order to assist local governments in examining the resolution of major urban problems (transition to smart cities) utilizing new technologies such as the IoT, NILIM has been engaged in research and development on the systematic arrangement of new technologies that can resolve urban problems and the method of evaluating plans related to the resolution of major urban problems through the use of new technologies.

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

2. Summary of the questionnaire survey

The questionnaire survey was conducted with 61 local governments and 146 companies that applied in response to a call for proposals on needs and seeds for the realization of smart cities (hereinafter referred to as the "Needs and Seeds Survey") conducted by the Ministry of Land, Infrastructure, Transport and Tourism in FY 2018. The breakdown of the 61 local governments is: 5 prefectures; 34 government ordinance-designated cities, special wards, core cities, and special cities; and 22 other cities. (The questionnaire survey was conducted from December 2020 to January 2021 with a response rate of 96.7% from local governments and 62.7% from companies.) The local governments were asked to choose from a list of urban problems they hope to solve by introducing new technologies, and they were also asked to answer with regard to new technologies they hope to introduce to solve each urban problem. On the other hand, companies were asked to choose from a list of new technologies that they possess, and they were also asked to answer with regard to urban problems that they hope to solve using new technologies. The list of urban problems and new technologies was developed after NILIM subdivided the items based on the major classifications (12) of the Needs and Seeds Survey. In addition, the questionnaire asked about introduction status and challenges in introducing new technologies. Figure 1 shows the breakdown of the contact departments of local governments that responded to the questionnaire, and Figure 2 shows the breakdown of industries of the companies.

3. Summary of the results of the questionnaire survey

(1) Differences in trends between local governments and companies in choosing a combination of urban problems and new technologies

The results obtained by classifying responses according to the major classifications are shown in Table 1 to indicate the difference between the combinations of urban problems and new

technologies chosen by local governments and the combinations chosen by companies. Among urban problems, many of the local governments and companies chose combinations including the items "(a) Transportation and mobility," "(c) Disaster prevention," "(d) Infrastructure maintenance and management," and "(k) Compact city development." On the other hand, many local governments chose "(e) Tourism" and "(f) Health and medical care," but a small number of companies chose them. Among new technologies to solve urban problems, many respondents chose "(1) Communication network and sensing technologies" and "(6) Applied technologies using (1) to (5)."

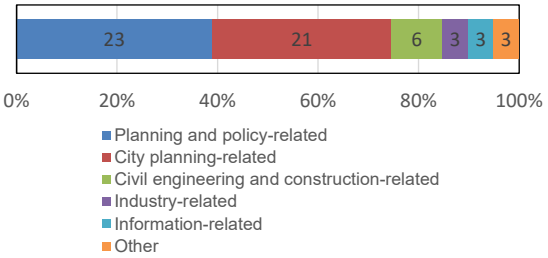


Figure 1: Breakdown of contact departments of local governments

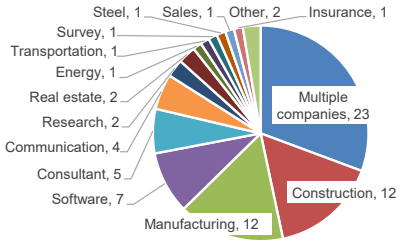
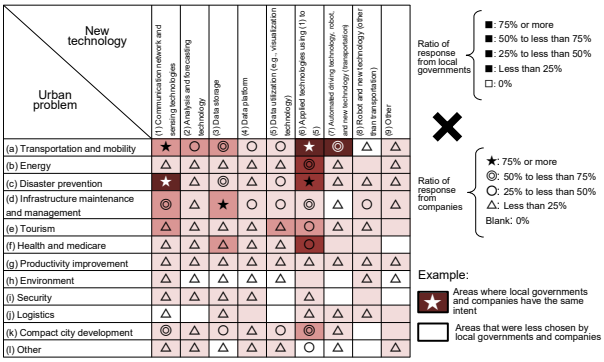


Figure 2: Breakdown of industries of responding companies

Table 1: Correspondence of responses between local governments and companies



(2) Challenges in introducing new technologies that local governments and companies recognize and their differences

Table 2 and Table 3 respectively show the results of summarizing challenges in introducing new technologies recognized by local governments and companies. First, for the introduction status of "Under consideration for introduction," the rate of "Unknown" is higher for new technologies that local governments hope to introduce. For the introduction status of "Under consideration for introduction," many companies also chose "Addressing urban problems" as a challenge, indicating that both have difficulty ensuring a correspondence between urban problems and new technologies. Next, an overall comparison of challenges in introducing new technologies between local governments and companies shows that many of them chose cost-related challenges in all new technologies. As the challenges of "(7) Automated driving technology, robots, and new technology (transportation)" and "(8) Robots and new technology (other than transportation)," both many local governments and companies chose "Current laws and regulations" in addition to cost-related items, which seems to be an obstacle in implementing them in society. For "(7) Automated driving technology, robots, and new

technology (transportation)," many local governments chose "Social acceptability," and it is expected that the understanding and experience of citizens with regard to using automated driving technology will mature.

4. Major issues for local governments in implementing smart cities initiatives

The results of this questionnaire showed facts including the following. Firstly, the correspondence of urban problems of local governments with new technologies of companies is making progress, such as in "Transportation and mobility," and so on; on the other hand, there are fields in which new applicable technologies are not sufficient, such as "Health and medical care," and in which urban problems that can be introduced are not recognized, such as "Analysis and forecasting technology," which reveals that information sharing on the correspondence of urban problems with new technologies is necessary. Secondly, the biggest challenge for the introduction of any new technology is the cost (introduction cost, operation cost, monetizing structure), and it is necessary to develop an evaluation method for quantitative forecasting and evaluation in the planning phase and during progress regarding the probability of solving urban problems with reasonable cost-effectiveness.

Table 2: Challenges for the introduction of new technologies (local governments)

Challenges in introducing new technologies \ Desirable new technology to introduce to solve urban problems		(1) Communication network and sensing technologies	(2) Analytics and forecasting technology	(3) Data storage	(4) Data platform	(5) Data utilization (e.g., visualization technology)	(6) Applied technologies using (1) to (5)	(7) Automated driving technology, robot, and new technology	(8) Robot and new technology (other than transportation)	(9) Other	Unknown
Number of responses for new technologies	Introduced (159)	34	9	9	14	16	46	20	4	7	0
	To be introduced (146)	20	18	20	9	13	42	9	6	3	6
	Under consideration for introduction (755)	112	54	74	30	31	212	100	20	10	112
Breakdown of challenges in introducing new technology[1]											
Introduction cost	Introduced	3%	0%	0%	0%	19%	2%	5%	25%	0%	
	Under consideration for introduction	18%	12%	20%	22%	26%	26%	30%	23%	15%	33%
Operation cost	Introduced	15%	22%	11%	7%	19%	20%	75%	25%	0%	0%
	Under consideration for introduction	19%	17%	19%	28%	32%	27%	22%	16%	54%	2%
Consensus building	Introduced	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Under consideration for introduction	3%	3%	1%	9%	3%	5%	2%	3%	8%	2%
Social acceptability	Introduced	0%	0%	0%	0%	6%	9%	0%	0%	14%	0%
	Under consideration for introduction	5%	2%	12%	6%	0%	4%	12%	6%	0%	3%
Current laws and regulations	Introduced	0%	0%	0%	0%	0%	2%	5%	25%	0%	0%
	Under consideration for introduction	1%	2%	1%	3%	3%	2%	12%	19%	0%	0%
Installation place	Introduced	9%	0%	0%	0%	6%	7%	5%	0%	0%	0%
	Under consideration for introduction	5%	5%	1%	0%	0%	2%	2%	0%	0%	0%
Shortage of human resources	Introduced	0%	11%	22%	7%	0%	0%	0%	0%	0%	0%
	Under consideration for introduction	3%	7%	5%	0%	0%	3%	1%	3%	0%	3%
Concerns over Accuracy [2]	Introduced	0%	11%	22%	0%	0%	0%	0%	0%	0%	0%
	Under consideration for introduction	10%	15%	9%	0%	12%	3%	4%	3%	0%	0%
Lack of index to measure effects [2]	Introduced	6%	22%	0%	0%	6%	7%	0%	0%	0%	0%
	Under consideration for introduction	3%	3%	2%	0%	3%	1%	4%	10%	8%	3%
Ground for selecting products [2]	Introduced	0%	0%	0%	0%	0%	0%	0%	0%	14%	0%
	Under consideration for introduction	0%	5%	1%	3%	0%	5%	3%	3%	0%	0%
Other	Introduced	12%	11%	0%	0%	19%	15%	0%	0%	43%	0%
	Under consideration for introduction	8%	10%	20%	13%	6%	17%	4%	3%	15%	18%
Blank	Introduced	56%	22%	44%	86%	25%	39%	10%	25%	29%	0%
	Under consideration for introduction	24%	19%	9%	16%	15%	7%	4%	10%	0%	38%

1) Percentage divided by the total number of respondents for each new technology
2) Questionnaires to local governments only

Table 3: Challenges for the introduction of new technologies(companies)

Challenges in introducing new technologies \ New technologies in possession		(1) Communication network and sensing technologies	(2) Analytics and forecasting technology	(3) Data storage	(4) Data platform	(5) Data utilization (e.g., visualization technology)	(6) Applied technologies using (1) to (5)	(7) Automated driving technology, robot, and new technology	(8) Robot and new technology (other than transportation)	(9) Other	Unknown
Number of responses for new technologies	Introduced (372)	88	27	61	36	38	89	15	14	4	
	To be introduced (118)	26	12	15	12	9	32	5	4	3	
	Under consideration for introduction (321)	63	13	62	18	19	97	41	8	0	
Breakdown of challenges in introducing new technology[1]											
Introduction cost	Introduced	19%	26%	18%	25%	21%	24%	27%	7%	25%	
	Under consideration for introduction	4%	0%	6%	0%	0%	4%	11%	13%	0%	
Operation cost	Introduced	28%	30%	25%	25%	26%	28%	0%	0%	25%	
	Under consideration for introduction	5%	7%	22%	6%	5%	5%	16%	25%	0%	
Consensus building	Introduced	2%	4%	2%	3%	5%	4%	0%	7%	0%	
	Under consideration for introduction	5%	0%	0%	0%	0%	2%	5%	0%	0%	
Social acceptability	Introduced	3%	0%	3%	0%	3%	3%	7%	0%	0%	
	Under consideration for introduction	1%	0%	3%	0%	0%	2%	5%	0%	0%	
Current laws and regulations	Introduced	1%	4%	0%	3%	0%	2%	0%	29%	0%	
	Under consideration for introduction	4%	0%	0%	0%	0%	5%	15%	13%	0%	
Installation place	Introduced	7%	4%	2%	0%	3%	3%	0%	0%	0%	
	Under consideration for introduction	4%	0%	0%	0%	0%	1%	0%	0%	0%	
Shortage of human resources	Introduced	2%	0%	2%	5%	5%	1%	0%	0%	0%	
	Under consideration for introduction	0%	0%	1%	11%	0%	0%	0%	13%	0%	
Addressing to urban problems [2]	Introduced	1%	0%	2%	3%	5%	3%	7%	7%	0%	
	Under consideration for introduction	10%	29%	6%	6%	10%	10%	0%	0%	0%	
Advantages over other companies [2]	Introduced	3%	0%	7%	0%	8%	7%	13%	7%	0%	
	Under consideration for introduction	0%	7%	3%	0%	0%	4%	2%	0%	0%	
Earning structure [2]	Introduced	12%	30%	21%	23%	21%	19%	27%	14%	0%	
	Under consideration for introduction	10%	29%	25%	22%	29%	35%	18%	0%	0%	
Other	Introduced	5%	0%	8%	3%	0%	4%	7%	21%	50%	
	Under consideration for introduction	18%	14%	10%	28%	10%	12%	9%	0%	0%	
Blank	Introduced	21%	4%	11%	13%	3%	4%	13%	7%	0%	
	Under consideration for introduction	38%	14%	22%	28%	48%	21%	18%	38%	0%	

1) Percentage divided by the total number of respondents for each new technology
2) Questionnaires to companies only

5. Conclusion

Currently, we are working on developing technical data by incorporating prior examples of ensuring the correspondence between urban problems and new technologies as well as information on their evaluation indicators, with reference to efforts in model projects by the central government.

☞ For more information:

Survey on Demands for New Technologies towards Smart Cities to Solve Urban Problems - Questionnaire Survey for Local Authorities Having Use Cases and Demands and Companies Holding Smart City Technologies - https://www.jstage.jst.go.jp/article/journalcpij/56/3/56_1413/_pdf/-char/ja

Study on the introduction of remote container cargo handling system to improve working environments

(Research period: FY 2019 - FY 2022)

Port and Harbor Department, Port Planning Division

Senior researcher Takashi Ueda

Head (PhD (Engineering)) Motohisa Abe

(Keywords) Container terminal, Remote-controlled RTG, improvement of working environment, cargo handling

1. Introduction

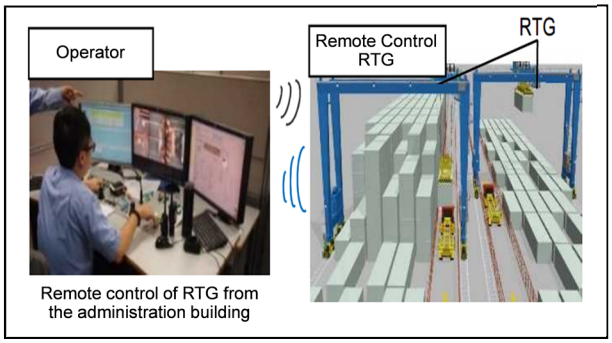
In recent years, there has been concern about the future shortage of port workers due to the decline in the labor force and an aging society. This is due to the severe working conditions (crane work, etc., in the field or in high places) at container terminals.

In order to improve the working environment and maintain and improve the functions of container terminals, the Ministry of Land, Infrastructure, Transport and Tourism is supporting the development of remote-controlled RTGs and facilities necessary for their introduction. This division is studying trends on the remote control of RTGs and the benefits they provide following introduction.

2. Significance and expected benefits of introducing remote control RTGs

RTG is an abbreviation for "Rubber Tired Gantry Crane" and refers to cranes used for the loading and unloading of containers onto trailers in the container storage area. RTG travels on a paved road surface with rubber tires and an open span that enables them to straddle piles of containers. At present, it is common for an operator to sit in the driver's seat at the top of the crane and operate the crane while facing downward, which tends to cause fatigue. Using a remote control RTG system, remote control can be performed from a container terminal management building, and by assisting some of the crane operations, a single operator can operate multiple cranes at the same time. The indoor operation room also provides a more comfortable and safer work environment for the operator.

Photo: Cargo handling using remote control RTGs



3. Verification of method of introduction and benefits of a remote cargo handling system

There are several considerations when introducing a remote control RTG system. While RTGs will be remotely operated, the trucks used to take the containers will still be driven by humans, therefore it is important to implement the necessary safety measures when delivering the containers. In addition, due to remote operation, visibility during cargo handling is reduced, and the cargo handling time per container may be slightly longer. As a result, it may be necessary to revise some of the operation methods and layout of the terminal.

This division is collecting and analyzing examples of remote RTG systems and studying methods to verify the benefits of remote control RTGs by numerical simulation.

4. Future outlook

While some ports are already introducing remote controlled RTGs, the aim of this study is to help improve working environments and resolve the labor shortage problem by conducting fact-finding analysis so that other ports can smoothly introduce RTGs as needed.

Analysis of offshore waiting of container ships causing a supply chain crisis

(Study period: FY2019-2021)

AKAKURA Yasuhiro, Head of Port Systems Division (PhD (Engineering))

Key Words: container ship, delay, terminal congestion, AIS

1. Global Supply Chain Crisis

The supply chain crisis has become a crucial issue all over the world, causing shortages of imported goods and delays in the delivery of Christmas gifts. It has also had an impact on civil life in Japan, with increases in the price of consumer goods due to the surge in transport costs, and limitations on sales of products such as french fries. Numerous container ships have been waiting weeks for berthing offshore of major ports in North America, China, and Europe.

In this study, the author (1) identified and analyzed congested ports causing long delays and (2) developed a method for grasping the situation of ships waiting offshore and analyzing the relationship between offshore waiting and terminal operation.

2. Occurring Delays at Congested Ports

The author grasped and analyzed the delays of all east-west container services that connect to Japan that were operated by three major alliances between April and December 2018 using data from the AIS (Automatic Identification System, which automatically transmits the name, dimension, location, speed, and other information of the ship on which it is installed) to compare the actual arrival dates and times against the schedule. **Fig. 1** indicates the share of the occurred delay, namely the increment of delays at a port, by area and by route. It was discovered that, in all routes, approximately 80% of delays occurred at ports in Europe, China, and North America. There was also a significant difference among the average delays of terminals at these congested ports.

One of the major factors of this congestion is the concentration of container services calling on highly efficient ports and terminals. Since the mid-1990s, shipping companies have continued to make ships larger to reduce unit costs, which has led to corporate M&As and reorganizations of alliances as larger ships need larger volumes of cargo at a time. As a result, container services have integrated and now concentrate to call at specific ports and terminals.

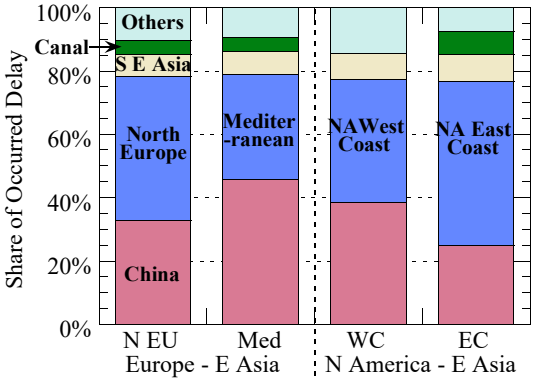


Fig. 1 Occurred Delay at Ports by Routes

3. Grasping and Analyzing of Offshore Waiting

Container ships are forced to wait offshore when there is no space for berthing at their destination terminal. The author developed a method for identifying offshore waiting ships by utilizing AIS data at congested terminals. **Fig. 2** shows a concept image of this method, setting the areas for judging of port entry and berthing, and identifying ships waiting offshore based on the times from port entry were longer than the threshold. This threshold is the maximum time needed for normal navigation and it is set by utilizing the anchoring signal and navigation speed of each ship.

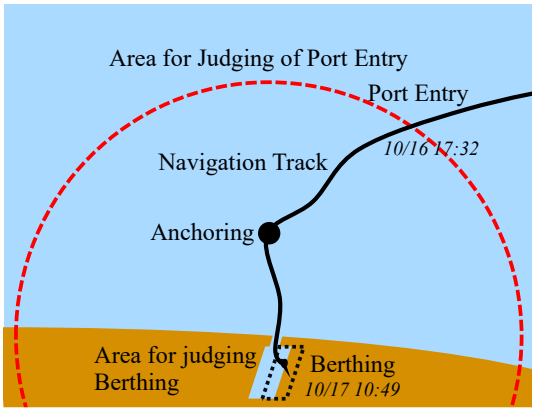


Fig.2 Concept Image for Identifying Waiting Ships

The estimation of offshore waiting covered major terminals in ports in Los Angeles/Long Beach (U.S.), Rotterdam (Netherlands), and Shanghai and Ningbo (China) in October 2019, and terminals in ports in Tokyo, Yokohama, Osaka, and Kobe (Japan) in October 2019 and January 2021. The author calculated the offshore waiting time-volume for each terminal, indicating how many containers wait and for how long, by assuming a 60% slot utilization rate.

Since it is assumed that the waiting time-volume is linked to terminal congestion, the relationship between the berth occupancy ratio, the share of occupied space and time by berthing ships against the total time and length, and the waiting time-volume per berth length was calculated as shown in **Fig. 3**. Increases in the berth occupancy ratio led to considerable rises in the waiting time-volume if the ratio exceeded about 30%. It was also found that the terminals with many ships berthed for short berthing times tended to cause a larger offshore waiting time-volume than those with few ships berthed for long berthing times. At Japanese ports located between the U.S. and the Netherlands, small ships made up a large proportion of waiting ships at that time.

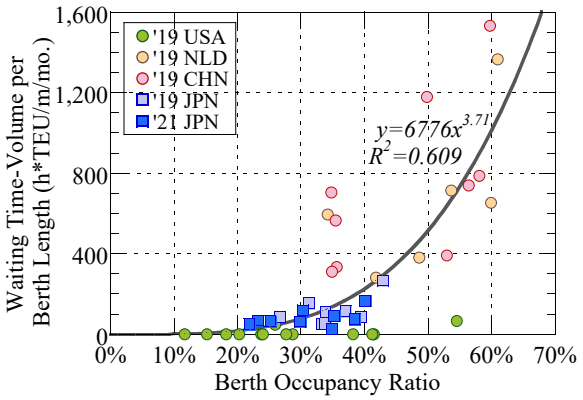


Fig.3 Berth Occupancy Ratio vs. Waiting Time-Volume

4. Surge of Waiting Ships in the Pandemic

The number of waiting ships has skyrocketed since winter 2020, especially at ports in North America, China, and Europe due to impacts from the COVID-19 pandemic such as surges in demand for stay-at-home consumption, capacity constraints at terminals, and shortages of drivers, port workers, containers, warehouses, and so on. For example, on November 19, 2021, there were 71 container ships waiting offshore of the Los Angeles/Long Beach port, and the longest wait time was 55 days. **Fig. 4** indicates changes in the volume of import laden containers and the average offshore waiting days at the Los Angeles port. The container volume increase after summer 2020 led to a surge in waiting days in winter 2020, and there was another such surge in summer 2021. It was presumed that terminals restricted the berthing of ships due to capacity constraints on the land side.

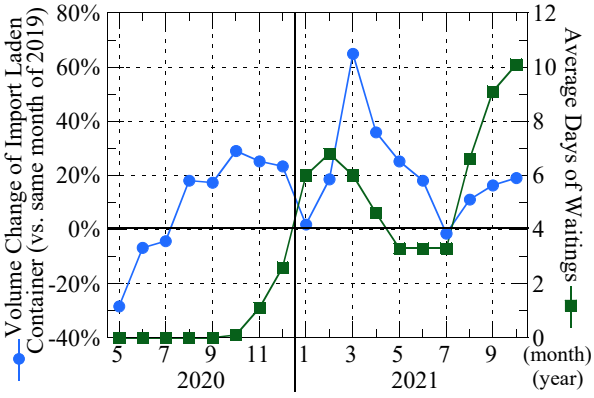


Fig.4 Container Volume and Waiting Days (LA port)

5. Research in Progress

The author is working to develop a system that calculates the offshore waiting time-volume in real time. It has been confirmed that the system can automatically calculate the waiting time-volume and the berth occupancy ratio of terminals at Yokohama Port using real-time AIS data up through the day before. The author is also estimating the CO_2 emissions of ships waiting offshore, as many container ships emit greenhouse gases during long periods of offshore waiting, and the Japanese government is aiming to achieve a carbon-neutral society by 2050 and decarbonization of international shipping is being discussed at IMO. These research results will be published in future papers.

☞Reference

1) Technical Note of NILIM, No.1097 (In Japanese) http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1097.htm
2) Journal of JSCE D3, Vol.76, No.1, 33-42 (In Japanese)
3) Journal of JSCE B3, Vol.77, No.2, I_157-I_162 (In Japanese)
4) IAME 2021 Conference
5) Journal of Coastal Zone Studies, Vol.34, No.3, 19-28 (In Japanese) https://www.ysk.nilim.go.jp/kakubu/kouwan/system/system2.html

Initiatives to introduce ICT and BIM/CIM at ports

(Research period: From 2016)

Port Construction Systems and Management Division | Head (PhD (Engineering)) Daisuke Tatsumi | Senior researcher Kenji Sakata

Senior researcher (PhD (Engineering)) Masashi Ogawa | Technical official Kouki Osada | Guest research engineer Kazuhiro Kojima

(Keywords) Productivity improvement, ICT construction, BIM/CIM

1. Introduction

ICT dredging work was started in FY 2017 in the port sector to improve productivity. Since then, various guidelines have been prepared and revised, and situations where ICT is now used is increasing. Since the introduction of BIM/CIM into design work in FY 2018, related guidelines have been established, and the implementation of BIM/CIM into construction is progressing.

2. Examining ways to improve the productivity of ICT construction

Divers use underwater staff to measure the formation of foundation work (rubble leveling), and it is expected that the efficiency and safety of work can be improved through the utilization of ICT. During this fiscal year, field tests were carried out on three types of performance measurement methods, namely multi-beam echo sounding, underwater sonar, and construction history data of rubble leveling machines, to verify measurement accuracy and to examine performance control standards.

In addition, it is difficult to completely remove the noise contained in the measurement data automatically from multi-beam echo sounding equipment utilized in ICT dredging work, etc., making this process both time and labor consuming. For this reason, we have developed a program to efficiently reduce the noise from multi-beam survey data using AI technology, and have applied this to measure data acquired at dredging sites to study methods to create training data used by AI and to verify accuracy (Fig. -1).

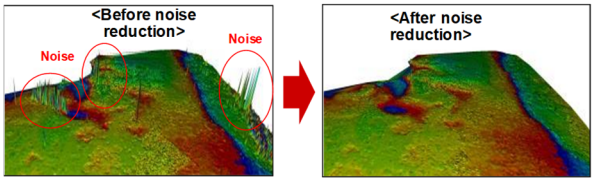


Figure -1 AI noise reduction program for multi-beam echo sounding data

3. Study on utilization of BIM/CIM at ports

In order to promote the utilization of BIM/CIM, 21 cases in which BIM/CIM were used for construction work in the port sector between FY 2018 and FY 2019 were extracted and in November 2021, we prepared and published[1] "BIM/CIM Case Studies ver.1 Ports and Harbors". In this case study, the main uses of BIM/CIM are classified into 4 types: coordinating information among related parties, calculation of quantity, construction cost, and construction periods, effective verification, and effective utilization during the construction stage. Examples are summarized for each use (Fig. -2). In addition, in order to reduce the time and labor required to create a three-dimensional model, generic objects are being examined.

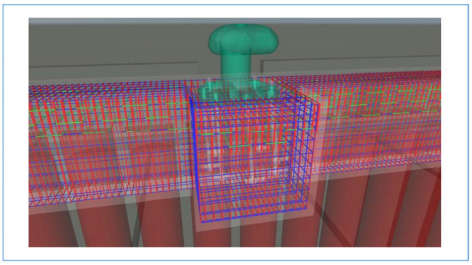


Figure -2 BIM/CIM Case Studies ver.1 Ports and Harbors (quality improvement by checking the interference of reinforcing bars)

4. Conclusion

In order to further improve the productivity at ports and harbors in the future, we will continue to consider the use of ICT construction and BIM/CIM.

See below for more detailed information.

1) BIM/CIM Case Studies ver.1 Ports and Harbors
https://www.mlit.go.jp/kowan/content/001442768.pdf

Analysis of Domestic Airfares after the Start of LCC Service in Japan

(Research period: from FY 2019)

Airport Department, Airport Planning Division

Head Yuka Kuroda Senior researcher Takashi Kamakura Research Engineer Tatsuya Morii

(Keywords) Domestic airfare, Real airfare, Low Cost Carrier, Aviation demand forecasting

1. Purpose and background of the study

Air traffic demand forecasting is an important source of basic data for the formulation of aviation policy. As airfares are one factor that affect air traffic demand, it is necessary for forecasting methods (forecast models) to reflect actual airfares (real airfares), in other words, not only standard fares, but also discount fares for each route. Airlines have set their own airfares since the liberalization in 1990, and airfares systems have become more complicated since the entry of Low Cost Carriers (LCCs) in 2012. In this study, in order to better understand real airfares for each route reflected in the forecast model, the most recent airfares have been analyzed.

2. Changes in domestic air fares after the entry of LCCs

Real airfares for each route were estimated based on the type of tickets obtained from “Dynamicsurvey for domestic air passengers” (Figure -1). Estimated real airfares in 2015, after the entry of LCCs in Japan, tended to be lower on many routes than in 2010, before LCCs entered service. In particular, there was a tendency for airfares to decline significantly on routes where LCCs competed with FSCs (conventional airlines).

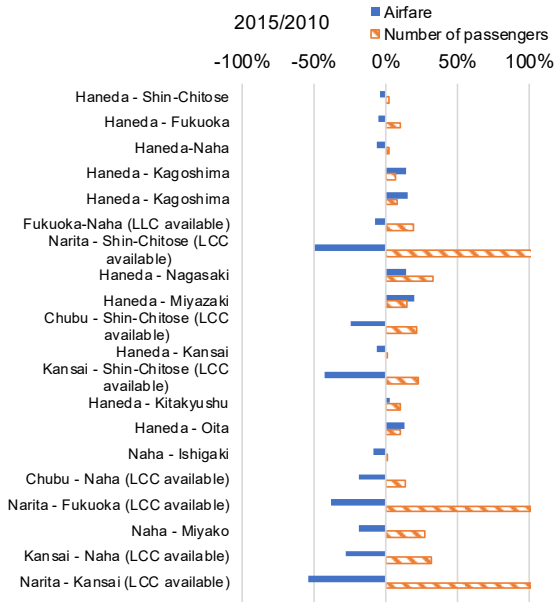


Figure -1: Change in estimated real airfares and number of passengers for each route

3. Fluctuation in airfares depending on the season and date of purchase

Comparing seasonal fluctuations for the cheapest airfares for each route, there was a tendency for large fluctuations, such as increases in airfares during the Obon festival, particularly for FSC routes (Fig. -2).

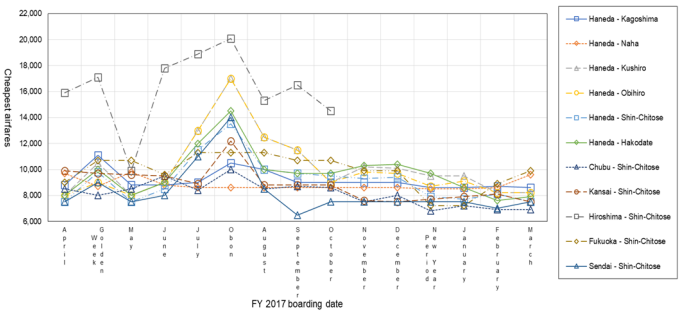


Figure -2 Seasonal fluctuation in FSC Airfares (cheapest airfares) (FY 2017)

Source) Compiled from the Civil Aviation Bureau's "Disclosure of Information on Air Transport Services"

Regarding dynamic pricing, in which airfares for the same month change depending on the date of purchase, we were able to gather some statistics from the Civil Aviation Bureau.

4. Future developments

Based on this study, we will further examine methods of setting scenarios for domestic airfares by each route in the aviation demand forecasting model. This is expected to lead to the development of a reliable air traffic forecasting method that appropriately reflects aviation service standards.

See below for more detailed information.

1) Technical Note of NILIM No. 1165
http://www.ysk.nilim.go.jp/kenkyuseika/kenkyusyosiryou.html

Development of guidelines for creating 3D model deliverables for detailed design

(Research period: FY 2017–)

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MIYAMOTO Ryosuke, Guest Research Engineer
NISHIMURA Toru, Head, Information Platform Division, Research Center for Infrastructure Management

(Keywords) Detailed design, 3D model, BIM/CIM

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has been examining the utilization of BIM/CIM (Building/Construction Information Modeling/Management) in processes such as surveys, investigation, and design in order to solve problems and improve the efficiency of the entire construction production and management system. In addition, MLIT has been promoting a BIM/CIM utilization project to create models necessary for later processes. The goal is to apply BIM/CIM to, in principle, all design and construction projects except for small-scale projects in FY2023, so it is necessary to develop various related conditions such as standards to achieve the goal.

In order to efficiently utilize BIM/CIM in the construction phase, it is necessary to use a BIM/CIM 3D model as a contract document. Therefore, with a focus on detailed design and contract documents, trials were performed to use a 3D model as a contract document by itself. As a result, also considering the status of implementation overseas, "Guidelines for Preparation of 3D Model Deliverables (Draft)" (March 2021) were formulated, in which 2D drawings are used as contract documents and 3D models are developed as models that satisfy the requirements for contract documents. The guidelines have been revised annually to increase the types of work, etc. This paper summarizes the background history that led to the development of the draft guidelines and their details.

2. Trial of using a 3D model as a contract document

Since 2D drawings are conventionally used as contract documents, the conventional method generates inefficient work such as creating both 2D drawings and 3D models and checking their consistency with 2D drawings in order to utilize 3D models. However, using a 3D model as a contract document eliminates this problem and improves work efficiency. In addition, using a 3D model as a contract document will lead to the employment of quality/work progress control and supervision/inspection methods based on new measurement technologies, such as work progress control using a laser scanner. On the other hand, the trials revealed that using a 3D model by abolishing a 2D drawing as a contract document has many problems such as a large amount of work and inadequate support by software.

3. Survey of contract methods overseas

Based on this issue, a survey was performed on overseas contract methods for construction projects using BIM and 3D models.

When the UK introduced BIM, the delivery of both BIM models and 2D drawings was required. The current contract stipulation states that if there is any inconsistency between the two, the 2D drawings shall prevail. However, it requires that 2D drawings be cut from the BIM model, eliminating the inconsistency.

In Germany, for the time being, contractors are required to deliver, along with 3D BIM models, 2D design drawings based on the conventional design document guidelines. When both 2D drawings and 3D models are lent at the start of a project, the contractor is required to check for any inconsistencies between the lent 2D drawings and 3D models and to point out any inconsistencies to the client.

4. Guidelines for creating 3D model deliverables (draft)

Referring to overseas contracts where BIM is utilized, draft guidelines for creating 3D model deliverables for detailed design work were created so that 3D models can be utilized as equivalents of contract documents, assuming that 2D drawings are used as contract documents.

The purpose of the draft guidelines is to show the methods and requirements for the creation of 3D model deliverables for detailed design work in order to improve design quality and to utilize 3D model deliverables, as equivalents of contract documents, in later phases of work.

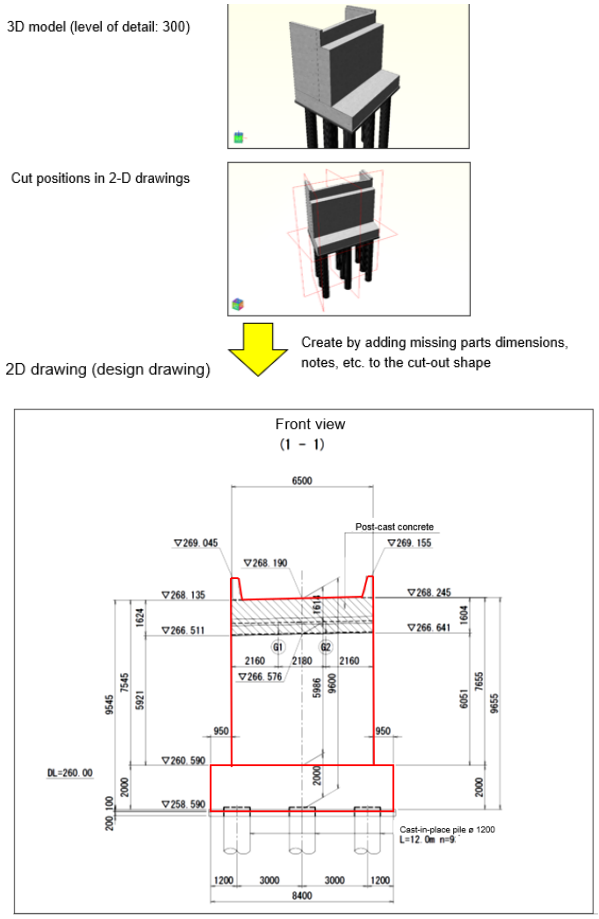

Figure 1: Development of a contract document (2D drawing)

The basic flow of detailed design work remains the same even when BIM/CIM is utilized. However, work that was previously performed using 2D drawings (design verification, meetings, stakeholder consultations, etc.) will be replaced by work utilizing 3D models.

The basic idea is to create a 2D drawing as the final product by adding dimensional lines and notes to 2D shape data developed by cutting or projection from a 3D model instead of creating a 3D model after creating a 2D drawing as in the past (Figure 1). However, the 3D model shall not include dimensions or notes, and the level of detail shall be about 300 to accurately represent the main structure, which is mainly used for contract documents. This does not apply to the level of detail of 3D models

that are created in stages during the course of work.

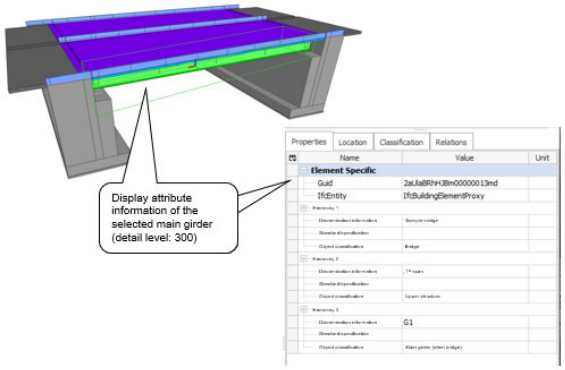

Figure 2: Example of assigning object classification and attribute information in detailed bridge design

It was decided to assign a minimum number of attributes to 3D models, and the hierarchy of attribute information to be assigned was defined at four levels for each object (Figure 2). Attribute information for Hierarchy 4 (members) is defined as arbitrary because there is a lot of information to be assigned and the requirements vary depending on the target member.

The draft guidelines not only define the requirements for 3D model deliverables but also present the basic method of creating a 3D model from the beginning of the design process, followed by discussions among related parties, design confirmation by clients, and design verification, leading to the creation of final 3D model deliverables.

In addition to using 3D models to create 2D drawings, the guidelines employ a policy to actively utilize 3D models during the course of work as well. For example, the quality of design results including 3D models can be assured by using 3D models to check the design results of detailed design work in stages. Furthermore, by using 3D models for design verification and stakeholder discussions, which were conventionally conducted using 2D drawings, it is possible to reduce the number of 2D drawings to be created during the course of work.

5. Summary

In using 3D models as contract documents, system-related and technical issues were clarified, and standards and procedures were developed in stages. It is expected that the draft guidelines will be utilized in public construction practice so that BIM/CIM will be applied, in principle, to construction work.

☞ For more information:

1) Guidelines for Preparation of 3D Model Deliverables (Draft)
https://www.mlit.go.jp/tec/content/001395713.pdf

Aiming to Build a Resource Recycling System that Links Sewage Treatment and Waste Treatment

(Research period: FY2021 to FY2023)

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Wastewater and Sludge Management Division, Water Quality Control Department

Keywords: global warming, effective use of local biomass, effective use of existing stock, wide-area expansion, linkage

1. Introduction

Sewage sludge generated in the sewage treatment process has high potential as fuel and fertilizer, and the sewage department is promoting the utilization of sludge. Meanwhile, in order to achieve a more sustainable resource-recycling society, it is necessary to promote further energy saving, energy creation, recovery of phosphorus and other materials, throughout the region. Accordingly, it is necessary to link sewage treatment and waste treatment and build a new resource recycling system that efficiently recovers energy and materials throughout the region and also reduces the amount of final disposal by accepting garbage, etc. incinerated at waste treatment facilities in the sewage system.

To achieve this, it is essential to conduct a technical study on the effect of accepting garbage, etc. in the sewerage system on sewerage facilities, and establish an evaluation method for the economic efficiency of the resource recycling system and environmental efficiency such as greenhouse gas reduction effects, etc. Hence, this research aims to establish and evaluation method and promote the construction of a sustainable resource recycling system.

This paper reports, based on the results of the survey on the actual status in advanced cases using questionnaires, etc., reports the results of organizing the important factors in realizing linkage and the impact on sewerage facilities, etc., as well as the patterns of linkage between sewage treatment and waste treatment typified based on the results of the actual status survey.

2. Outline of survey and organization methods, etc.

This year's research typified patterns of linkage between sewage treatment and waste treatment based on information extracted from the results of literature and questionnaire surveys focused on cities that are making advanced initiatives for linkage of sewage treatment and waste treatment. Specific research and organization methods are as follows.

(1) Literature survey and questionnaire survey

In order to grasp the actual status of resource recycling systems in advanced cities, focusing on facility and regional characteristics, we conducted a literature survey and a questionnaire survey of 12 treatment plants and organized survey results, regarding mainly "site conditions of sewage treatment plants," "maintenance and management issues at sewage treatment plants," "garbage sorting methods," "effective use of resources," and "trigger and background of linkage," etc.

(2) Organize patterns of linkage between sewage treatment and waste treatment

Based on the results of the survey conducted in (1), patterns of linkage were typified and organized.

3. Survey results and review, and classification of linkage patterns

(1) Literature survey and questionnaire survey results

As a result of the survey, it was found that the site conditions require a large area in the sewage treatment plant, since a facility to accept garbage is essential for the linkage.

As for maintenance issues, there was no particular technical impact of the filtrate generated in the digestion process after the acceptance of garbage on water treatment, and no countermeasures were required. However, it is inferred that the impact of an increase in the amount of garbage accepted should be kept in mind.

On the other hand, many respondents indicated that residents must sort garbage regardless of the availability of sorting machines, which suggests the importance of educating residents about garbage sorting.

As for the effective use of resources, digestion gas power generation was conducted at eight treatment plants (**Fig. 1**).

As for other triggers and backgrounds of linkage, it was found that they are based on social demands for the formation of a recycling-oriented society, such as "effective use of resources" at six treatment plants (**Fig. 2**). It should be noted that about half of the respondents indicated that the timing of the renewal of facilities was a support for the realization of linkage in the process of consideration.

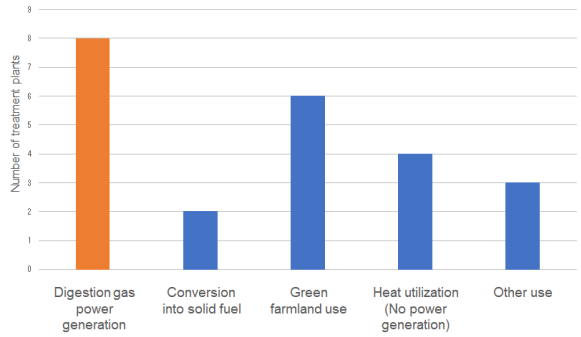

Fig. 1: Effective use of resources (with multiple responses)

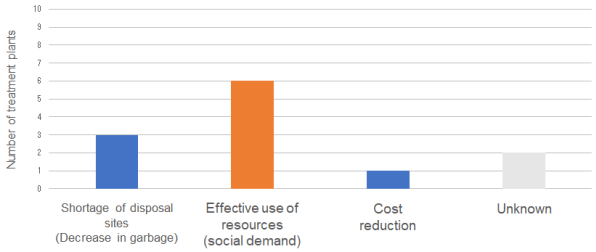

Fig. 2: Triggers and background of linkage

(2) Results of organizing patterns of linkage between sewage treatment and waste treatment

In typifying linkage patterns, we focused on the effective use of resources because the trigger for linkage is often a social demand for effective use of resources, and the facilities required differ depending on the method of effective use.

The resulting typified linkage patterns are shown below. Since digestion gas power generation is used in many of the linked treatment plants, the following categorization is made so that other resource uses can be additionally considered, while digestion gas power generation is the axis.

(1) Implement "Only digestion gas power generation," (2) "(1) + conversion of sludge into solid fuel," (3) "(1) + conversion of sludge into fertilizer," (4) "(1) + conversion of phosphorus into resources," and (5) "(1) + heat utilization (mainly waste heat utilization)."

As representative examples, the characteristics of the two patterns (1) and (3) are presented here (Fig. 3, Fig. 4).

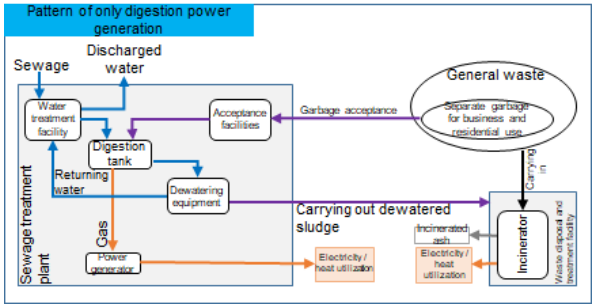

Fig. 3: (1) "Linkage pattern to implement digestion gas power generation"

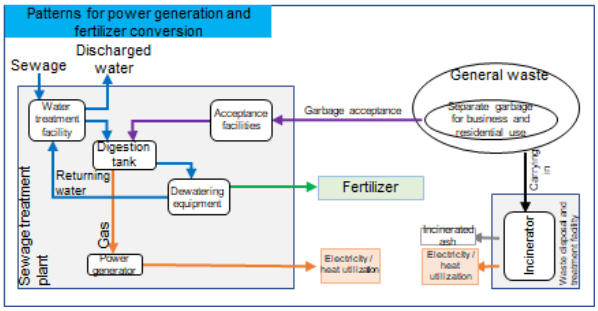

Fig. 4: (3) "(1) + Linkage pattern to convert sludge into fertilizer"

Pattern (1) is the simplest pattern, which only generates electricity from digestion gas. Therefore, unlike other patterns, it is easy to introduce. There are also advantages such as a case where even if the need for fertilizers and solid fuels decreases due to external factors in the region, it will not affect the continuation of the business.

Pattern (3) is a pattern in which, in addition to digestion gas generation, the remaining solid is converted to fertilizer. The main prerequisite for conversion to fertilizer is that there must be local need and drying facilities for fertilizer conversion are required. If these issues can be cleared, fertilizer can be used more effectively as a resource, and the burden of incineration and landfill could be reduced.

4. Future development

We plan to continue to verify each of the patterns typified this time in order to improve their accuracy, and study specific evaluation methods. The survey results also suggested that allowance in the site of sewage treatment plant, separation of garbage by residents, timing of facility renewal, etc. are important aspects in realizing the linkage. These findings will be used as points to keep in mind in addition to evaluation methods, as we formulate a study procedure for local governments in the future.

Technical Development to Popularize Physical Devices Contributing to the Formation of Safe and Secure Residential Streets

(Research period: FY2019–)

Road Safety Division, Road Traffic Department

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(Keywords) Residential streets, traffic safety measures, physical devices

1. Introduction

Traffic safety measures in residential streets basically consist of appropriately combining traffic regulations, such as speed restrictions, and physical device installations with the aim of suppressing vehicle speeds and through traffic (fig. 1).

Physical devices include road humps, where the road surface is raised, narrowing, where the section vehicles pass through is made narrower, and doglegs and chicanes, which cause vehicles to follow lines that zig-zag or deflect horizontally. While these have the effect of encouraging drivers to slow down, road administrators may hesitate to install them because of concerns about reaching agreement on them or their construction and maintenance. Therefore, NILIM has conducted technical development to resolve these concerns and ensure their popularization.

This paper reports on construction methods for asphalt-paved road humps and examples of managing physical devices in winter in snowy areas, which road administrators in particular often inquire about.

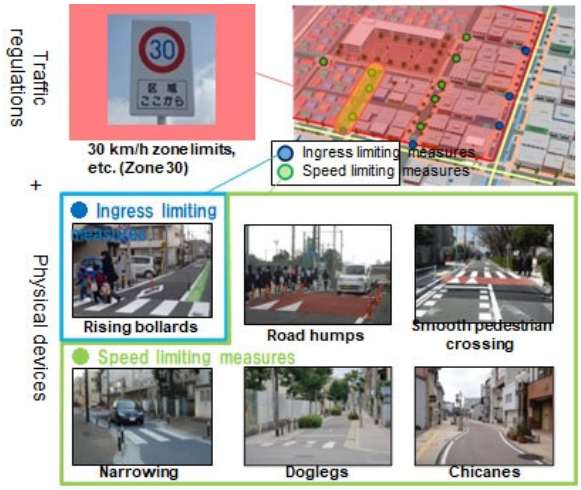

Fig. 1. Images of safety measures for traffic in residential streets

2. Construction method for asphalt-paved road humps

For the sloped portion of road humps, a sine wave shape is supposed to be preferable to limit noise and vibration. This shape is not formed by merely smoothing off both edges of the slopes, but rather as a continuously changing curved surface (fig. 2), but the formation method has not been shown and we receive many inquiries from road administrators. In addition, upon investigating the height of the road centerline in existing road humps using the Mobile Mapping System (MMS), we confirmed that differences from the sine wave shape arise in some cases (fig. 3).

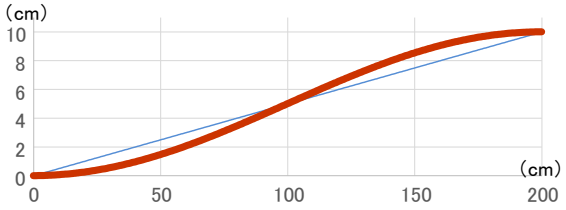

Fig. 2. Shape of the sloped portions of a road hump (sine wave shape)

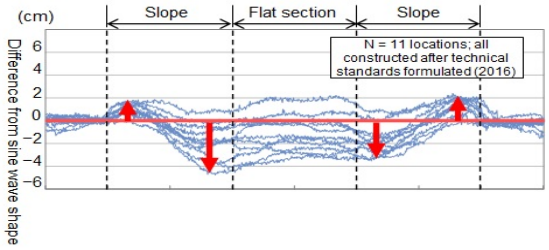

Fig. 3. Differences between existing road humps and the sine wave shape

Given this, we looked at ways to construct road humps through test construction on NILIM's test track. As a result, we were able to verify that a shape close to a sine wave can be made by constructing the sloped portions using sine wave-shaped forms (photo) and then adding innovations for the smoothed portion of the existing road surface, such as cutting part of the existing road surface to secure the pavement thickness. (The construction procedure for the sloped portion is shown in fig. 4.) The *Reference Materials on Construction of Road Humps (draft)*, which summarize these outcomes, have been published on the NILIM website, together with data on sine wave shapes (CAD, PDF).

Photo. Forms for sine wave shapes

(Can be manufactured at woodworking shops using CAD/PDF data)

Fig. 4. Construction procedure for sloped portions of road humps

3. Examples of managing physical devices in snowy areas

Many express hesitancy about installing physical devices due to concerns about winter management, but there are numerous examples of installation in snowy areas as well. We have investigated examples of managing locations like these during winter through on-site investigations and interviews with road administrators and snow removers (table).

Among the surveyed locations, Hokkaido used mechanical snow removal (snow removal by snow grader and snow transportation and clearing by rotary plow and dump truck). We found that snow could be cleared smoothly by raising the blade (fig. 5) where the road humps are installed and that poles or the like would preferably be installed at the positions of the road humps as a marker for this operation.

On the other hand, in surveyed locations in Hokuriku, snow was melted by installing snow-melting pipes and spreading water. In examples of road humps here, innovations were introduced by installing water nozzles running across the road on the flat sections of the road humps, where they would normally be installed along the length of the road (fig. 6).

We are still investigating traffic (speed reduction) conditions in winter, the conduct of mechanical snow removal, and thoughts about snow-melting pipe designs, among other topics, and we intend to create technical notes summarizing these outcomes in the future.

Table. Outline of investigation results

	Area	Physical device	Install date	Arrangement, etc.	Characteristics of winter management
Left in place during winter	Hokkaido	Road humps	1987	Several road humps on same route	Mechanical snow removal
		Road humps	c. 1999	Several road humps on same route	Mechanical snow removal
		Road humps	c. 2003–09	Several road humps in the area	Mechanical snow removal
	Hokuriku	Road humps	1987	Several road humps on same route	Snow-melting pipes (newly installed)
		Narrowing	2017	Several narrowings on same route	Snow-melting pipes (existing)
Removed during winter	Hokkaido	Narrowing	c. 2013	Several narrowings on same route	Narrowings (rubber poles) removed (mechanical snow removal)
	Hokuriku	Road humps	2017	One road hump location at village entrance	road humps (movable) removed (mechanical snow removal)

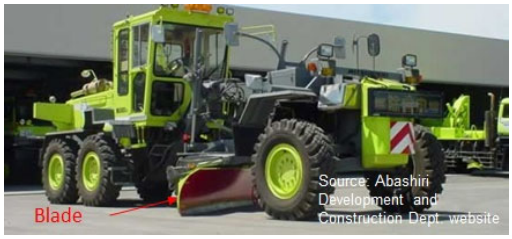

Fig. 5. Example of blade of snow grader

Fig. 6. Example of snow-melting pipe installation

4. Conclusion

This paper presented some of NILIM's efforts in technical development, etc. that support safety measures for traffic in residential streets.

We hope to work aggressively on technical support for local government, which is responsible for evaluating and implementing control measures in line with future policy enactment, and to continue working on the technical development necessary for that, incorporating comments from the field.

☞See here for detailed information

1) (NILIM) *Introduction of safety measures for residential streets*
http://www.nilim.go.jp/lab/geg/seikatsu.htm

Towards Further Cost Reductions and Acceleration in Utility Pole Removal

(Research period: FY2019–FY2021)

Road Environment Division, Road Traffic Department

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(Keywords) utility pole removal, cost reduction, project acceleration

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is promoting the removal of utility poles from the perspectives of improving disaster prevention, ensuring safety and comfort, and forming appealing landscapes. In May 2021, it decided on a new Plan to Promote Utility Pole Removal, pursuant to Article 7 of the Act on the Promotion of Utility Pole Removal.

This paper briefly describes research and study being conducted by NILIM with a view to thorough cost reductions and further acceleration of projects, among the initiative guidelines listed in the new Plan to Promote Utility Pole Removal.

2. Research and study aimed at cost reductions

The new Plan to Promote Utility Pole Removal provides that MLIT will work to reduce costs by about 20% on average by FY2025 and requires efforts to further reduce costs in addition to the adoption of low-cost methods that have been used to date.

Given this, NILIM has conducted a fact-finding survey of duct structures that have conventionally been widely used and smaller box (fig. 1), which are one low-cost method among common utility duct for power lines, with the objective of understanding the cost structure of common utility duct works with a view towards further cost reductions.

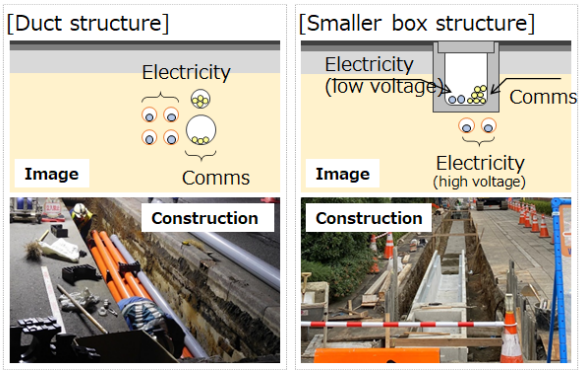

Fig. 1. Duct and smaller box common utility duct

The fact-finding survey analyzed the cost structure by capturing the construction conditions with video cameras, classifying and organizing the work time by workers, etc. for each job type, the operation time for each piece of construction machinery, and so on according to the fine distinctions in level 4 of the Works and Work Type Systematic Tree in the MLIT New Civil Engineering Works Quantity Surveying Outline, and then calculating the direct works costs using the unit prices in the quantity surveying materials for the same works (labor costs, machinery costs, materials costs, etc.).

This survey confirmed, albeit by comparisons of individual cases, that materials costs account for about the same proportion of works costs for the smaller box and for the conventional duct structure, and that this proportion is large (fig. 2). Based on the fact that economies of scale created by mass production, etc. have had little effect and materials costs remain high due to the small number of cases adopting the smaller box so far, and the fact that materials costs account for a large proportion of the works costs for the smaller box, further cost reductions may be achieved by lowering the costs of materials through

standardization and mass production.

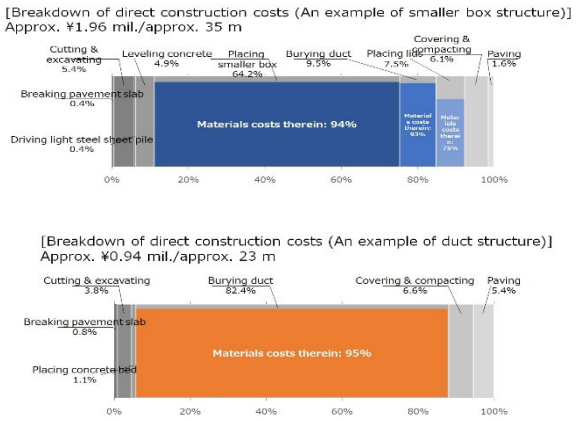

Fig. 2. Example of cost structure survey results

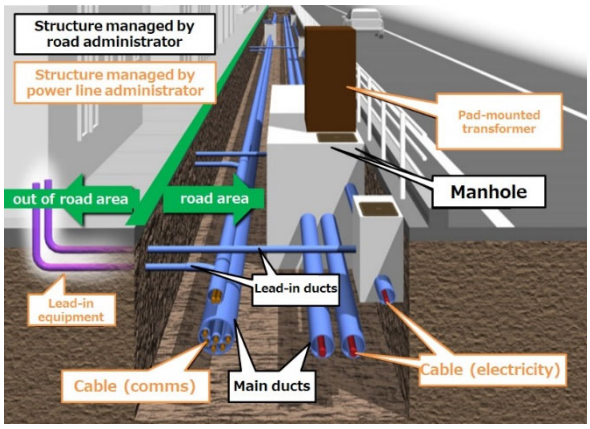

Fig. 3. Division of management in common utility duct (example of duct structure)

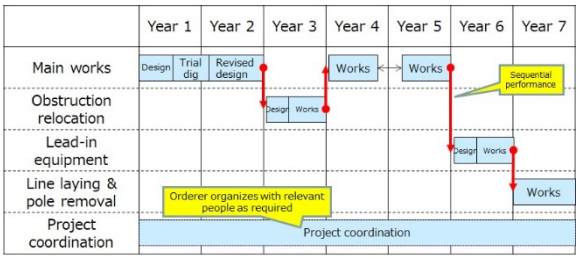

Fig. 4. Project period for common utility duct project

3. Research and study aimed at acceleration

The project period for common utility duct projects is supposed to average seven years at present, and the new Plan to Promote Utility Pole Removal is working to halve this period (to an average of four years).

As one approach aimed at reducing project periods, NILIM focused on the fact that construction in common utility duct (fig. 3) is performed separately by each administrator, which means that each administrator performs its construction in series (fig. 4), and we considered the possibility of increasing the speed of the project overall if parallel construction were made possible by changing the division of these construction works.

To examine this, we firstly sent questionnaires of road administrators, power line administrators, and construction companies involved with common utility duct. The questionnaires investigate the benefits and challenges when building by "simultaneous construction," where the same operator constructs the multiple structures currently constructed by the separate administrators, and by "continuous construction," where different operators construct them continuously. As a result, while many answers indicated that coordinating schedules and arranging the division of responsibility in continuous construction were challenging, we received responses saying that the respondents can expect shorter construction periods and smoother works as benefits of continuous construction, and the project period may be reduced by changing the division of construction.

Furthermore, the construction fact-finding survey described in section 2 also investigated the breakdown of work time for each fine distinction to get an idea of the scope for reducing construction times, and the results confirmed the reality that cutting, excavating, covering, and compaction work took about half of the time (fig. 5). This led to the finding that permanent work zones (work zones continually established over a longer period than usual that are retained day and night) to reduce the number of times that cutting, excavating, covering, and compaction work is required may be effective in reducing the project period.

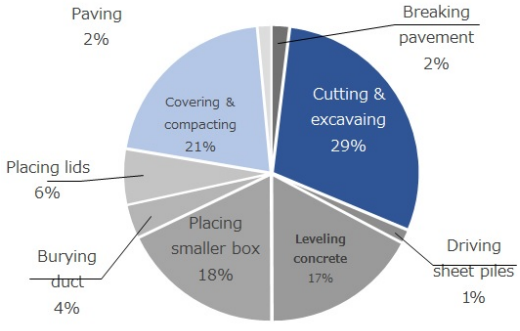

Fig. 5. Example of work time survey results

4. Towards further cost reductions and acceleration

The results of examinations to date have shown that increasing the projects that employ low-cost methods and moving forward with standardization of the products and materials that they use are effective in further reducing the costs of utility pole removal, and that changing the division of construction and promoting the use of permanent work zones are effective in further increasing speed.

Besides further consideration to reflect these initiatives in actual work sites, we intend to continue research and study aimed at additional cost reductions and acceleration from varied points of view, including consideration aimed at smoothing the formation of agreement.

☞See here for detailed information

1) MLIT: Plan to Promote Utility Pole Removal
https://www.mlit.go.jp/road/road/traffic/chicyuka/pdf/21-05.pdf

2) Road Environment Division website
http://www.nilim.go.jp/lab/dcg/kadai.html

Initiatives Aimed at Realizing Automated Driving on Expressways

(Research period: FY2019–FY2023)

Intelligent Transport Systems Division, Road Traffic Department

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(Keywords) automated driving, road-vehicle cooperation

1. Introduction

The automated driving is generally expected to be safer and smoother than the manual driving, and it is thought that it will contribute to the advanced use of the road networks (reducing the traffic accidents, the congestion, the environmental impact, etc.). The Public–Private ITS Initiative/Roadmap[1)] clarifies the goals for realizing the automated driving and specifies the achievement of the automated driving (Level 4) on expressways with a target of 2025 as a goal for private vehicles in particular.

The National Institute for Land and Infrastructure Management (NILIM) has conducted the research on cooperative ITS (the systems in which the road infrastructure and the vehicles share the information by mutual communication to realize the better road transportation), covering the settings where the vehicles cannot continue the automated driving on their own.

This paper describes the outlines of this research as a NILIM initiative aimed at realizing the automated driving on expressways.

2. Initiatives aimed at realizing automated driving on expressways

NILIM has conducted the joint public-private research with the automobile manufacturers, the road administrators, the communication device manufacturers, and others on the information provision services to enable roads to support the automated driving on expressways. The outlines of the information provision services we have considered so far are explained below with images of the systems.

(1) Merging support information provision service

The merging support information provision service gathers the information about the traffic conditions on the main lane via the vehicle detection sensors and provides it to the merging vehicles to support the smooth merging (Fig. 1).

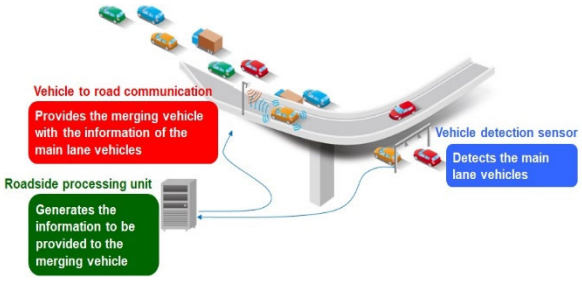

Fig. 1. Merging support information provision service (image)

Urban expressways in Japan have the locations where the acceleration lane is short and the main road is not readily visible from the connecting road. Therefore, by providing the information such as the speed of vehicles traveling on the main lane and the calculated arrival time at the merging section, it is expected that the merging vehicles will be able to adjust the speed and the timing of merging in advance. NILIM considered the contents of the provided information and the information provision formats etc.

(2) Look-ahead information provision service

The look-ahead information provision service provides the information on the items ahead that the on-board sensors cannot detect.

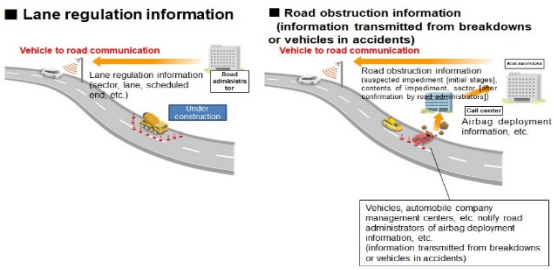

Fig. 2. Road obstruction information provision service

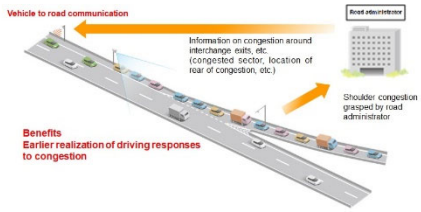

Fig. 3. Service providing information on congestion around interchange exits, etc.

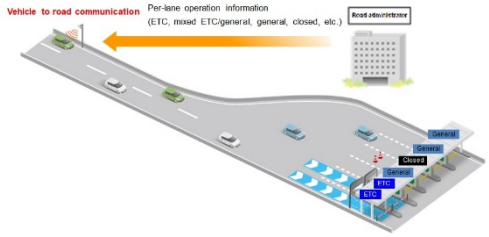

Fig. 4. Tollgate information provision service

The automated driving vehicles detect the surrounding conditions with on board sensors, but their scope of detection is limited. Providing the information in advance on items ahead is therefore expected to enable the automated driving vehicles to change the lanes or take other action for smoother automated driving. NILIM considered the details including the contents of the provided information and the information provision formats for providing it for the road obstruction information provision service, the service providing the information on congestion around interchange exits, etc., and a tollgate information provision service (Fig. 2–4).

(3) Information to assist localization

The lane-keeping assist systems (LKAS) in the automated driving vehicle read the lane markings with on-board sensors and automatically operate the steering wheel to travel in the center of the lane. However, on-board sensors may not be able to detect faint lane markings and the LKAS may not work. For this reason, we have conducted the research aimed at understanding the condition of lane markings recognition, which forms the base of the conditions for LKAS operation. We are currently investigating the faint level of lane markings (the proportion of the faint area in the area of the lane markings) using the image data, etc. acquired from on-board cameras and are actually driving vehicles with LKAS to understand the state of LKAS operation and analyze the relationship between the faint level of lane markings and the LKAS operation rate (Fig. 5).

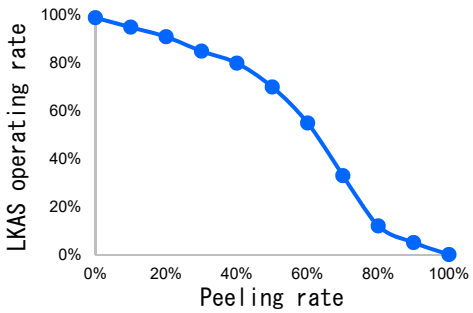

Fig. 5. Relationship between faint level of lane markings and LKAS operation rate (image)

3. Field operational test of the merging support information provision service

Regarding the merging support information provision service for which the NILIM created the technical specifications, the Cabinet Office Cross-ministerial Strategic Innovation Promotion Program (SIP) conducted the field operational test near Kuko-nishi onramp (upbound), Haneda Route 1, Metropolitan Expressway as the Field

Operational Test in the Tokyo Waterfront Area (photo). The FOT investigated the accuracy of the calculated arrival time from the merging support information provision system, the delay due to system processing, and the installation location of the roadside infrastructure and gained the information on challenges before practical application of the merging support information provision system and limitations on the application of the system.[2)]

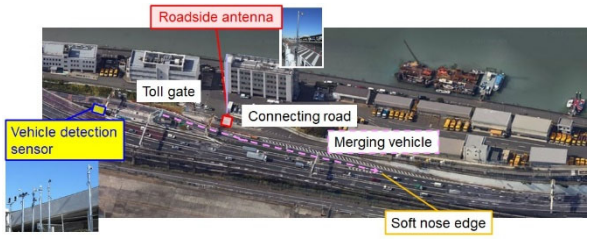

Photo. Field Operational Test in the Tokyo Waterfront Area (merging support)

4. Conclusion

For the early commercialization of the automated driving, it is important to develop the system that allows the road infrastructure and the vehicles to share the information through vehicle to road communication.

The merging support information provision service, look-ahead information provision service, and information to assist the localization are important services in expanding the automated driving. We hope to continue to contribute to the rapid practical implementation of the automated driving and the realization of the safe, secure, and smooth road traffic through joint public-private research.

☞See here for detailed information

1) Strategic Conference for the Advancement of Utilizing Public and Private Sector Data, Strategic Headquarters for the Promotion of an Advanced Information and Telecommunications Network Society. *Public–Private ITS Initiative/Roadmaps*, 2021.

2) Nakagawa Toshimasa, Sekiya Hirotaka, Nakata Ryō, Hanamori Teruaki, Fujimura Ryōta. "Verification of Merging Support Information Provision System (DAY1 System) through Field Operational Test in the Tokyo Waterfront Area." *Traffic Engineering*, vol. 8, issue 8/2022. pp.39–48. 2022.

Support to the Formulation of the Plans in Relation to the Housing Safety Net in Municipal Governments --Development and Publication of the "Program for Estimating the Number of Households That Require Consideration for Secured Housing" --

(Period of research: FY2020 - FY2021)

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(Keywords) Municipal governments, households that require consideration for secured housing, estimating program, public housing, unoccupied private houses

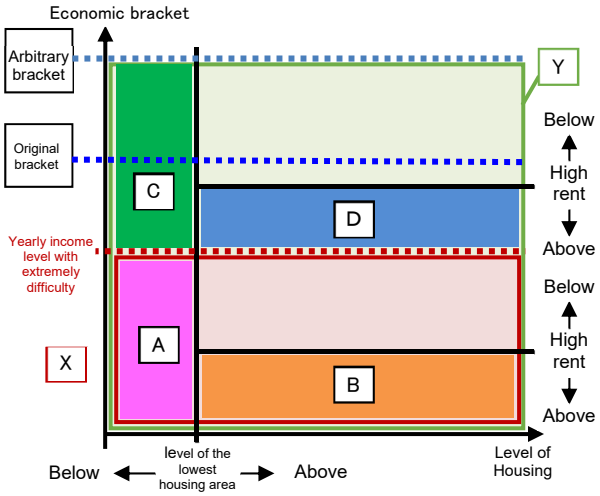
1. Introduction

The formulation of the following plans by municipal governments is desired in order to stably secure housing for those who require consideration, such as low-income earners, senior persons, and child-rearing households.

① "Plan to Elongate the Lifetimes of Public Houses etc." to systematically promote maintenance management and improvement of the public housing stock.

② "Plan to Promote Rental Housing Supply for Those Who Require Consideration for Secured Housing" to promote the registration and supply of rental houses that do not reject the residence of those who require consideration for secured housing by making use of unoccupied private houses etc. (hereafter referred to as "safety net houses: SN houses").

On the other hand, to set a target concerning the necessary amount of use of public and private unoccupied houses in the future in these plans (hereafter referred to as "the necessary number of public houses etc."), the appropriate method of estimating the number of the households of people who will require consideration for secured housing in the future has been a problem. This is why NILIM has developed and disclosed a program (October



Y: Households applicable to measures for public households (original bracket and arbitrary bracket *1)
X: Households belonging to "yearly income level with extreme difficulty" among households applicable to measures for public housing
A: Households below the level of the lowest housing area among the households below the yearly income level with extreme difficulty
B: Households at high rent paying level and above the level of the lowest housing area among households below the yearly income level with extreme difficulty *3
C: Households "below the level of the lowest housing area" that are the households with a yearly income level with extreme difficulty
D: Households at the high rent paying level that are above the level of the lowest housing area and that have a yearly income above the yearly income level with extreme difficulty

*1. The original bracket is for the households at or below the 25-percent income quotient. The arbitrary bracket is for the households that are defined in an ordinance as those that require consideration for secured housing with the upper limit being the 50-percent income quotient.
*2. Yearly income level with extreme difficulty: The households that do not reach the yearly income necessary for residence at a house in the area that satisfies the level of the lowest housing area (houses at the average rent per unit among private rental houses in each area) defined in the Housing Life Basic Plan (a nationwide plan) within the ratio of the maximum payment of appropriate house rent.
*3. Households paying high rent: Households paying for the rent above the average rent payment ratio among the households with a yearly income of less than two million yen that reside in a private rental house in each area.

Photo-1. Households within the scope of the estimate with the estimated PG along with their definitions.

8, 2021; January 14, 2022) that can estimate the number of people who require consideration for secured housing in the mid-to-long term, depending on the actual circumstances and needs of a local area (hereafter referred to as "estimated PG").

This essay introduces a method (idea) with which the necessary number of public houses etc. can be specified based on the results of estimation.

2. Overview of the Estimated PG

The estimation program uses statistical research, such as censuses (Statistics Bureau, Ministry of Internal Affairs and Communications) and Statistical Survey of Housing and Land (Statistics Bureau, Ministry of Internal Affairs and Communications) and is able to make a long-term estimation of the number of households with income lower than the yearly income level with extreme difficulty ("X" in Fig-1) and households with specific needs in terms of housing level and/or the rent load (from "A" to "D" in Fig-1) among the households for which measures for public housing are applicable ("Y" in Fig-1) in every five year period from 2020 to 2045.

3. Method of Specifying the Necessary Number of Public Houses etc.

For determining the target for the necessary number of public houses etc., the standard method is to set the target based on the total number of households after multiplication with the calculation ratio shown in Table-1, which is applied to the estimated number of households in each classification of A to D in Fig-1.

Table-1 Calculation ratio for target setting for the necessary amount of public houses

Classification	Priority	Calculation ratio
A	Low-income bracket and living in a small house with ratio lower than the level of the lowest housing area. The highest priority	Mandatory to calculate 100%
B	Residing in a house above the level of the lowest housing area, but included in the low-income bracket; therefore, the high rent paying ratio is exceeded and the priority is highest after A	Ideal to calculate 100%
C	Income bracket above the yearly income level with extreme difficulty; however, as they reside in a house below the level of the lowest housing area, the priority is as high as B	Ideal to calculate 100%
D	The high rent payment ratio is exceeded; however, this is the bracket of income exceeding the yearly income level with extreme difficulty and they reside in a house above the level of the lowest housing area, so the priority is the lowest.	Included in the calculation depending on the actual situation of the local area and/or the need for policy

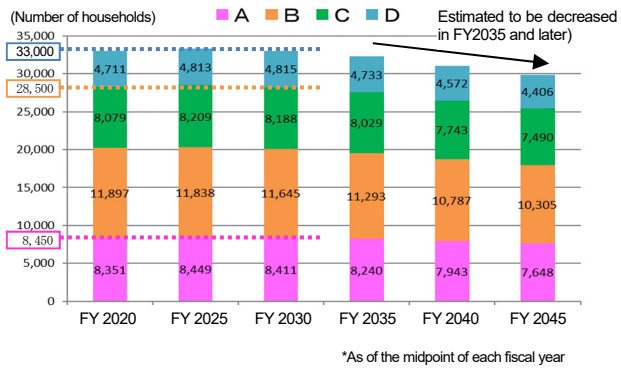


Fig-2. Results of the estimation of the number of households in each classification of A–D (example of City X)

We will show some specific examples. Fig-2 shows the results of the estimation of the number of the households in each of classification of A–D in a certain city (City X). It is estimated that the future trend in the numbers of each household should be generally the same up to FY2030 and should start decreasing thereafter. As for the number of

necessary public houses etc., approximately 8,450 houses should be necessary up to FY2030 for Classification A, which is necessary to calculate up to 100 percent. Furthermore, when we add Classifications B and C (up to 100 percent), approximately 28,500 houses should be needed up to FY2030. On the other hand, Classification D is judged to be included or not be included in public housing aid etc. on the basis of needs etc. in the policies of municipal governments (for instance, residence of younger generations, promotion of U, I, and/or J returns, support for child rearing, and so on; if this is also calculated, approximately 33 thousand public houses etc. should be needed up to FY2030.

Among the necessary amount shown above, as for the necessary amount of public houses, it is mandatory to secure a number of houses that is equivalent to the number of households in Classification A. In addition, it is preferable to secure a number of houses that is equivalent to the number of households in Classifications B and C. If the number of existing public houses is short, it is thought to be necessary for unoccupied private houses to be rented as private houses by governments and/or to supply SN houses etc.

Table-2. Estimated number of households in Classifications A–C according to the number of household members.
Results (example)

*Sixty years of age or seniors included in the estimation of one-person households.

	FY 2020	FY 2025	FY 2030	FY 2035	FY 2040	FY 2045
1*	5,718	6,043	6,240	6,301	6,230	6,132
2	10,118	10,207	10,142	9,921	9,551	9,188
3	6,628	6,630	6,519	6,303	5,991	5,690
4	3,972	3,801	3,606	3,386	3,153	2,969
5	1,516	1,456	1,393	1,325	1,243	1,174
6 or more	373	359	344	325	305	290
Total	28,327	28,496	28,244	27,562	26,473	25,443

From the viewpoint of public housing stock management, setting the target for the amount necessary for each public house size is also important. Fig-2 shows the results of the estimation of the number of households in each Classification of A–C in City X according to the number of members in each household. As of FY2020, two-person households accounted for the highest number of households, followed by three-person households. However, if viewed on a year-on-year basis, it is estimated that one-member households (60 years of age or older) should increase and that households with two or more members should decrease.

Therefore, it is suggested that it will be necessary to modify existing houses for large-scale households into share houses for single-member households and/or to increase the amount of small-sized houses making use of opportunities to reconstruct houses. However, if too many single-member households of seniors or the like are gathered at public apartment complexes, there will be problems in community functionality, self-governing functions, and so forth. It is important to specify some targets of the necessary amount in different house sizes while we link the use of public houses and unoccupied private houses (e.g., unoccupied private houses rented by governments) as public houses and/or using SN houses to cover part of the increase in single-member households etc.

4. Conclusion

We expect that the formulation of plans in relation to the housing safety net by municipal governments will advance with the use of the estimated PG. We will continue our follow-up in the future and will provide technical support to municipal governments in relation to setting targets for the necessary number of public houses etc.☞ Click here for more details

1) The following website discloses the estimated PG.
http://www.nilim.go.jp/lab/ibg/contents/SPG/stockProgram.html
2) The following links provide the user manual for the estimated PG and the technical description of the estimated PG.
NILIM material No.1168, NILIM material No.1183
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1168.htm
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1183.htm

How much do vacant houses cost? Estimating the cost of addressing vacant houses in municipalities

(Research period: FY 2020–2022)

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(Keywords) Vacant house, vacant house management, prevention of inadequate management, cost estimation

1. Introduction

In recent years, the number of vacant houses in Japan has been increasing, and with this increase, there is concern about the future increase in the number of inadequately managed vacant houses. In addition, an increase in the burden on municipalities and owners has been seen. It is necessary to strengthen measures to prevent inadequate management of vacant houses, including implementing appropriate management and providing information and advice on various sorts of assistance. To address this, NILIM conducted "Research on Quantifying the Effectiveness of Preventive Measures against the Inadequate Management of Vacant Houses," aiming to clarify the minimum management level required to prevent inadequate management and to develop a method of quantifying the effect of preventive measures against inadequate management. In other words, the goal is to plainly show how much loss may be incurred when a vacant house becomes dilapidated, and how much benefit can be achieved when it is properly managed.

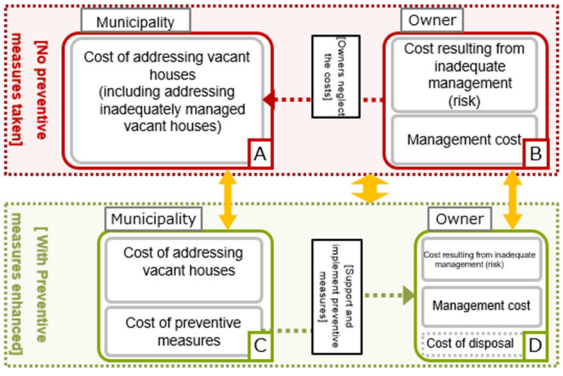

Figure 1: Conceptual image of cost estimation

The basic approach to quantifying the effect of the preventive measures is to compare the cost when a preventive measure is taken with the cost when no preventive measures are taken (Figure 1).

This fiscal year, we conducted a Web-based survey on vacant house management and the like for owners of vacant houses, and estimation of the costs and effects of preventive measures for inadequately managed vacant houses in municipalities.

2. Web-based questionnaire on the management of vacant houses, etc.

The management cost to owners and the risks (e.g., falling roof parts) that may result from inadequate management vary depending on how owners are actually managing houses and how they intend to manage them in the future. In addition, from the municipalities' point of view, the scale of subsidized projects for the utilization of vacant houses or for the disposal of vacant houses and their effects are expected to vary depending on, for example, the number of owners who desire to renovate or dispose of their vacant houses. Therefore, a Web-based questionnaire was conducted to identify the intentions of owners regarding future management and their intentions to

use subsidized projects related to vacant houses.

Based on the results of the questionnaire, owners were classified into the four types shown in the Table based on their management details, willingness to manage, etc. For example, the tendency to improve management by type of vacant house (Figure 2) shows a relatively high percentage of Type 3 respondents who answered that the owners would be motivated to improve management "When I found that the risk of collapse of this vacant house (e.g., accidents involving nearby residents) would be more significant than the cost of management and repairs."

Type 1	Vacant houses expected to be adequately managed	42%
Type 2	Vacant houses expected to be adequately managed for the time being	31%
Type 3	Vacant houses with relatively low willingness to manage by the owner	15%
Type 4	Vacant houses that are not being managed as the owner desires	12%

Table: Types of vacant houses

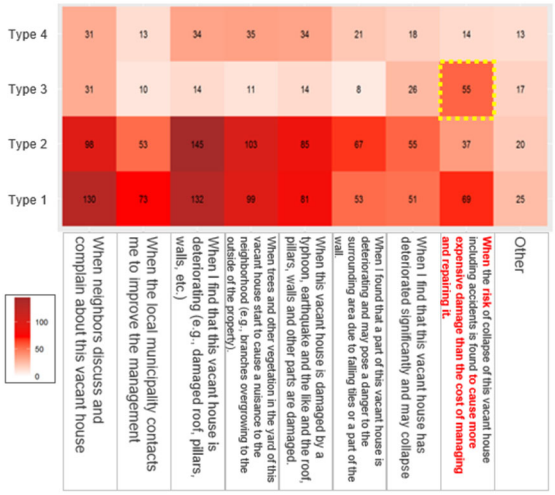

Figure 2: Intention to improve management by vacant house type

This may indicate that owners with relatively low willingness to manage do not necessarily understand the risks that may result from inadequate management, and that providing appropriate information may improve management and the like.

3. Costs and effects of measures for vacant houses by municipalities

The cost and effectiveness of measures for vacant houses in municipalities were estimated. The estimation was performed for a municipality model (75,000 households, 10,000 vacant houses, a vacancy rate of 13.5%), and the target period was five years. The two costs calculated were the cost of measures to prevent inadequate management of vacant houses and the cost of addressing vacant houses, etc.

Taking preventive measures as an example to obtain an image of the calculation, the cost of measures can be obtained based on the number of cases subject to measures (e.g., whether to target owners of vacant houses or to include owners of occupied houses as well), the unit cost, and the number of times the measures are implemented (Figure 3). In actual cost estimation in municipalities, in order to determine how to set the three aforementioned factors, it is necessary to take into account the policies of how to address vacant houses, population, household characteristics, and the like. This is regarded as a "scenario" in this research, and a "basic scenario" is tentatively set here.

To treat the effect of preventive measures, we set a percentage of vacant houses whose owners' management behavior has improved as a result of measures implemented by the municipality in a given fiscal year and reflected it in the cost calculation for the next fiscal year (Figure 3). Although the estimated values need to be further examined, the results of the estimation confirmed that preventive measures have a certain effect of reducing the cost of addressing vacant houses (Figure 4). Interviews were conducted with municipalities to discuss the

results, and specific opinions were obtained regarding the importance of securing a budget for human resources in preventive measures and a certain level of appropriateness with regard to costs for human resources necessary for the measures, which helped identify future improvements.

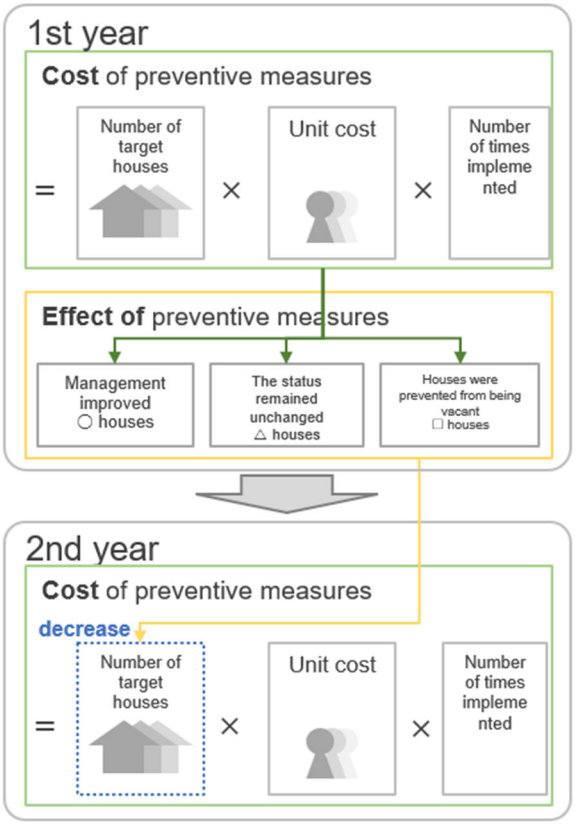

Figure 3: Conceptual image of calculating costs and effects of preventive measures

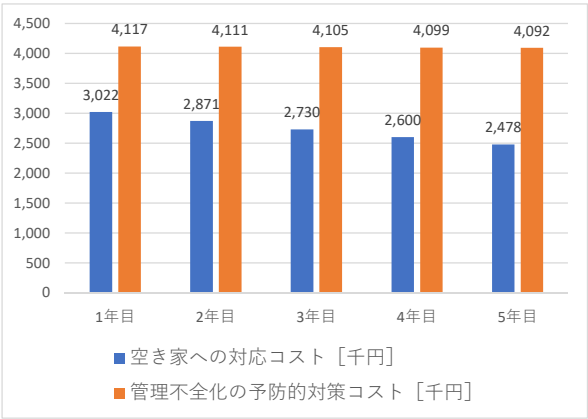

Figure 4: Results of cost estimation for preventive measures

4. Conclusion

The future plan is to conduct case studies and the like in multiple municipalities, including feedback on the results of interviews with municipalities and follow-up surveys of vacant house owners, in order to determine the minimum level of management required to prevent inadequate management, as well as to develop the method of quantifying the effect of preventive measures for inadequate management.

Note: Unit cost data and other data used for the estimation are based on the survey in FY 2020 and Web-based questionnaires.

Development of Technology to Improve the Mobility Environment in Suburban Residential Areas

(Research period: FY2018-)

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Keywords: urban sustainability, suburban residential area, quality of life, new mobility system

1. Background and purpose of research

In the suburban residential areas that were systematically supplied after the period of rapid economic growth, the number of residents with difficulties in independent travel is increasing due to the aging of the population, while the level of existing public transportation service is declining due to the sluggish demand and shortage of drivers. Under these circumstances, in order to improve the quality of life in suburban residential areas, which can be one of the hubs for the realization of sustainable cities, it is considered useful to improve the transportation environment by introducing a new mobility system (e.g., small electric cart with excellent environmental performance and mobility).

Therefore, in order to study how new mobility systems should be introduced, we conducted a demonstration experiment using small electric carts in several suburban residential areas (**Table 1**), where the population is aging and there are ups and downs that make walking difficult, and analyzed the effects, issues, etc. in introducing a mobility system.

Table 1: Target suburban residential areas (Outline)

	Name	Ryosei area	Kitanodai area	Komamusashidai area
	Location	Ayase-shi, Kanagawa	Hachioji-shi, Tokyo	Hidaka-shi, Saitama
	Distance from the center of Tokyo	About 40 km	About 40 km	About 50 km
Size	Population	About 3,500	About 6,800	About 4,700
Size	Area	About 44 ha	about 87 ha	about 93 ha
Size	Difference in elevation (slope)	About 30 m (about 4%)	About 40 m (about 4%)	About 70 m (about 5%)
Characteristics	Move-in period	From 1962	From 1976	From 1977
Characteristics	Population aging rate (2015 National Census)	42%	42%	45%

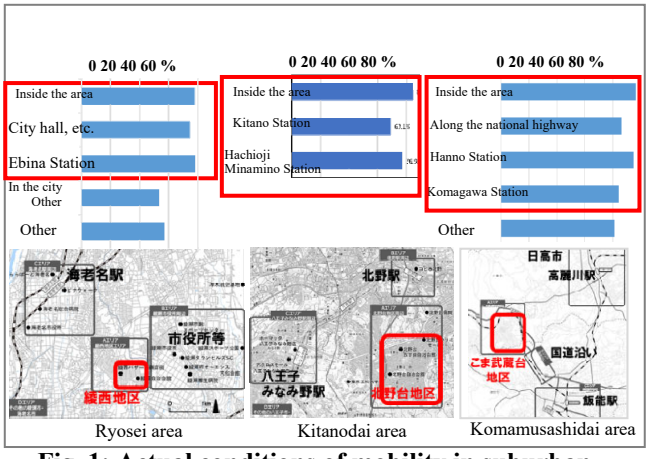


Fig. 1: Actual conditions of mobility in suburban residential areas

2. Actual conditions of mobility in suburban residential areas

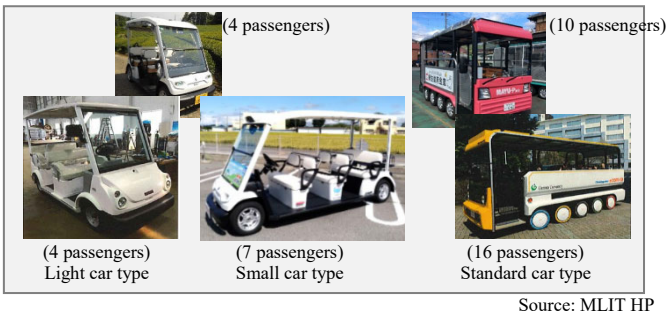
We conducted a questionnaire survey for the three areas in **Table 1** on the actual state of mobility in the suburban residential area, and found that the inside and outside of the area are almost comparable as the destination of daily activities (**Fig. 1**).

In the future, if the diversity and improved functionality of the suburban residential areas that serve as hubs increase their attractiveness, demand for travel within the area will grow, and their importance may increase further. Whether there is a demand for travel within the area and whether this demand is met can also be a barometer of whether the area is "independent and easy to live and work."

3. New mobility system "Green Slow Mobility"

In recent years, a variety of mobility tools such as walking aid tools, personal mobility, and micro-mobility have been popular and developed as a means to support intra-area travel and access to transportation outside the area. Among these, the use and combination of mobility tools such as "Green Slow Mobility" (abbreviated as "Grislo") (**Fig. 2**), which is allowed to be light-weight and open on public roads on the condition of low speed, depending on area characteristics and travel scenes including existing public transportation, are expected to contribute to a society where people can live on foot.

In this research we decided to use a seven-passenger vehicle that can make small turns on area roads and can be shared by multiple groups.



Source: MLIT HP

Fig. 2: "Grislo", one of the diverse mobility systems

4. Implementation and results of the demonstration experiment

Table 2 shows the results of the demonstration experiment conducted in FY2021. The number of users per day in each of three areas was 13 to 15, indicating a similar trend in demand for use.
In the questionnaire surveys conducted during and after the demonstration experiment, many users highly evaluated the communication function, etc. along with the improved mobility, saying "communication tool," "moving salon," "mobile community square," and "good opportunity for going out" (**Fig. 3**). This shows that a new mobility system has the potential to create diverse value.
In addition, respondents were also asked about the amount they would be willing to pay for the use of a new mobility system if it is fully introduced (**Fig. 4**).

Table 2: Results of the demonstration experiment (FY2021)

	Name	Ryosei area	Kitanodai area	Komamusashidai area
	Area	About 44 ha	about 87 ha	about 93 ha
	Difference in elevation (slope)	About 30 m (about 4%)	About 40 m (about 4%)	About 70 m (about 5%)
Experiment outline	Operation period	Oct. 17 - End of March	Nov. 11 - Dec. 1	Dec. 7 - Jan. 9
Experiment outline	Operation days	5 months (35 days *)	21 days	30 days
Experiment outline	Route (Number of services)	3 routes (12 services)	1 route (4 services)	Weekday: 1 route (5 services) Holiday: 2 routes (8 services)
Result	Number of users (persons)	537 (*up to Jan. 4)	274	381
Result	Number of users / day	15.3 / day	13.0 /day	12.7 / day
Result	Number of users / service	1.3 / service	3.3 / service	2.2 / service

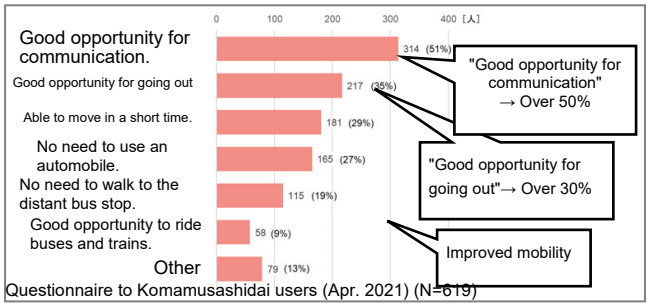


Fig. 3: User evaluation of ''Grislo''

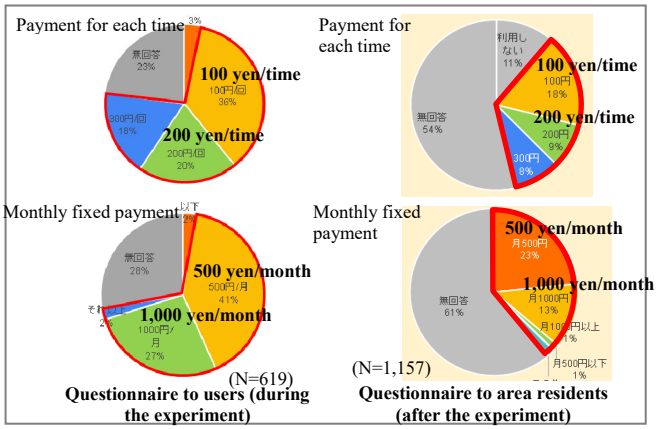


Fig. 4: Amount willing to pay for ''Grislo''

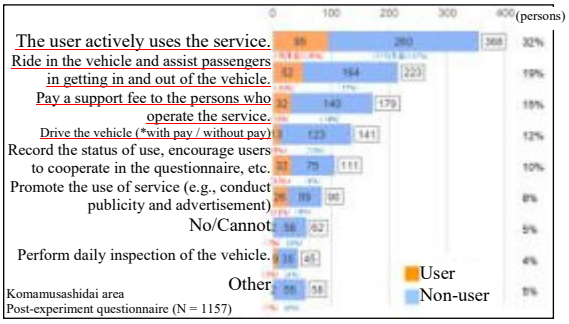


Fig. 5: Intention to contribute to the initiative

In the case of Komamusashidai (implemented in March and April 2021), respondents answered that they would pay 100 yen or 200 yen for each ride and pay 500 yen or 1,000 yen for a fixed monthly fee. It should be noted that in the post-experiment questionnaire survey to all residents, there was a certain percentage of people, including non-users, who were willing to pay for both the one-time payment and the fixed monthly payment.
Based on these results, we estimated the income and expenditures, although it is hypothetic. Income was expanded to the entire area based on the results of the post-experience questionnaire survey and multiplied by the amount of willingness to pay.
500 yen/month (estimated number of payers: approx. 1,000) 6.1 million yen/year
1,000 yen/month (same approx. 380 persons) 4.6 million yen/year
On the other hand, as for expenditures (costs), the total of rewards for drivers, vehicle procurement cost (depreciated over 3 years), and other overhead costs are 5 million yen/year (3.3 million yen/year after depreciation). The result was roughly balanced.
We can get a glimpse of the value assessment by the area's residents.
In addition, when we asked about their willingness to contribute to such an initiative, we confirmed their willingness to provide direct and indirect support and cooperation (**Fig. 5**). From the above, it can be assumed that a certain degree of local acceptance of a new mobility initiative will be formed, and above all, it can be imagined that such an initiative can help revitalize the community and various activities for self-reliance and self-help.

5. Future initiatives

We conducted a long-term demonstration experiment to collect and analyze information on changes in residents' behaviors, etc. In the future, we will compile information on introduction methods for a new mobility system and safety standards for each type of urban area to serve as a reference across the country.

☞See the following for details.

1) Journal of the City Planning Institute of Japan No.355, pp.62-65 (March 2022)

Research on urban area simulation using 3D city models

(Research period: FY 2021–2023)
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(Keywords) 3D city model, CityGML, simulation

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism has been promoting Project PLATEAU[1)] as a leading project for the development, utilization, and data disclosure of 3D urban models to promote the digital transformation of urban infrastructure and city planning. The 3D city models in Project PLATEAU, developed using international standard specifications (CityGML), are expected to create new innovations when used by governments, private businesses, and residents according to their purposes.

This paper describes the efforts to utilize 3D city model data for the simulation of wind environments and fire spread in urban areas.

2. Research overview

In order to promote the utilization of 3D city model data in PLATEAU, the Urban Planning Department has been conducting "Research on Promoting the Disclosure and Utilization of City-Related Data"[2)] and working on the following items (1) through (3).

(1) Study of specifications for extending 3D city models

Studying the specifications for extending 3D city models in order to develop detailed attribute data needed to examine various urban issues (environment, disaster prevention, etc.).

(2) Study on reducing the cost of creating and updating 3D city models

Studying methods to reduce the cost of creating and updating 3D city models by utilizing existing point cloud data acquired through aerial laser surveying, etc.

(3) Verification of specifications for extension, etc. through case studies

Studying individual environment and disaster prevention issues and verifying data consistency between the common specifications of 3D city models and the added extension specifications through case studies.

3. Study of extending specifications for 3D city models

The simulation of urban wind environments and fire spread requires attribute data such as the fire prevention capability of building windows and leaf density of exterior trees, in addition to geometric shape data obtained from 3D city models (Figure). This study extended the common specifications of PLATEAU, examined the specifications for storing these data, and also created sample data, clarifying issues in converting the data to data used for simulations.

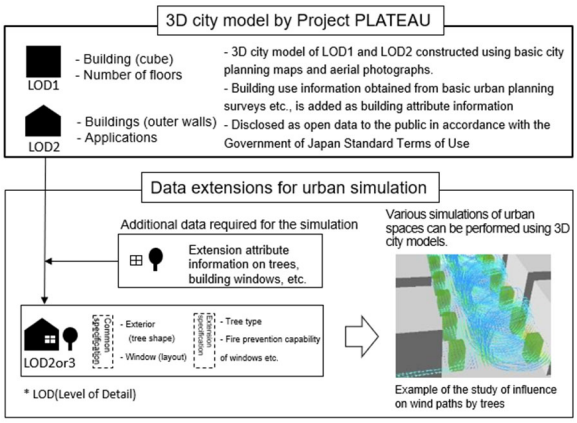

Figure: Flow of simulation with data extension

4. Conclusion

In this paper, a study was conducted to standardize the method of storing data for extending specifications. The future plan is to create data for a wider area based on the extended specifications, conduct urban area simulations to verify them, and publish them as examples of use cases.

☞ For more information:

1) Project PLATEAU: https://www.mlit.go.jp/plateau/
2) Press release: "National Institute for Research on Society's Future: Seven Research Projects to Protect, Improve, and Create Society: FY 2021 Budget Request," September 25, 2020, pp. 7 http://www.nilim.go.jp/lab/bcg/kisya/journal/kisya20200925.pdf#page=9

How Should Green Infrastructure with Diverse Functions Be Evaluated?

(Research period: FY2019–)

Landscape and Ecology Division, Research Center for Infrastructure Management

Research officer (DAg) KIM Bohyun Head OISHI Tomohiro

(Keywords) green infrastructure, parks, green spaces, community building, rainwater collection and infiltration, river basin flood control

1. Introduction

Green infrastructure (GI) is expected in the Fifth Priority Plan for Infrastructure Development to be used in "disaster prevention and mitigation leveraging rainwater collection and infiltration and ecosystems, conservation of the natural environment that considers ecosystem networks, healthy, relaxed community-building suited to new lifestyles, environmentally friendly regional development in line with the SDGs, conservation and sustainable use of biodiversity, [and] realization of regional development, etc. through tourism," and the plan is moving forward as a means capable of handling a variety of challenges.

GI planning requires quantitative evaluations that can show how well the GI functions as infrastructure, and NILIM is conducting research into these evaluation methods, based on investigations of systems in other countries that are introducing GI and case examples of functional evaluation.

Photo. Examples of green infrastructure (Machida, Tokyo)

2. The definition of GI

A commonly used definition of GI is shown in the 2015 National Spatial Strategy: "making use of the diverse functions of the natural environment in both tangible and intangible aspects, such as the development of social infrastructure and land usage, to build a country and regions that are sustainable and attractive."

GI as introduced in this initiative is diverse, consisting of parts and green spaces made up mainly of trees, grasses, and soil cover, as well as rain gardens (photo: top) and bioswales (photo: bottom), which add stones, gravel, crushed rock, and the like to planted areas, and rooftop gardens and wall greening installed on buildings.

3. GI evaluation methods in regional planning

As shown above, GI takes many forms, some of which exhibit functions and performance that differ depending on the type and are uncertain, so it is difficult to move forward with planning while quantitatively demonstrating the effects of GI introduction.

Liverpool and London in the UK, which this study investigated, have regional planning that evaluates how well the current GI is functioning across the region as a whole and introduces the necessary GI in areas where it is lacking. This appropriately resolves the issues facing each area in the region and has the targeted effects of adapting to climate change, health and welfare, and economic growth, among others.

This is one method of planning to evaluate and introduce GI, but the ideas of setting targets for functions and effects and evaluating the current situation is a valid method when effectively planning and distributing GI, including making use of existing GI and other infrastructure.

4. Example of a GI function evaluation method (rainwater collection and infiltration function)

GI, with its diverse functions, is often hoped to be effective in mitigating urban flooding in recent years, and there is demand for computations of the amount of rainwater collected and infiltrated to contribute to prevent it from flowing out. However, the quantity that green spaces made up of trees and other greenery can handle is difficult to compute because it is affected

the state of the soil and other conditions.

This study investigated examples from other countries of evaluations of green spaces as GI (table 1) and summarized their thinking about evaluation, computation methods, etc. One of these, GI-Val, is used by many countries and local governments, mainly around the UK, and it computes different rainwater outflow volumes according to land coverage and soil class in GI planning (table 2). In this way, it evaluates the reduction in rainwater entering the combined sewerage system and converts it into monetary value by estimating the energy-saving effects pertaining to sewerage treatment.

Table 1. Example of evaluation method (mitigating urban flooding)

Evaluation method		Evaluated function
I	GI-Val	Rainwater collection and infiltration function of green spaces (Reducing rainwater flowing into combined sewerage, lowering construction costs of conventional infrastructure)
	i-Tree Eco	Rainwater collection and infiltration function of green spaces (Reducing rainwater outflow)
II	LEED ND	Floodplain avoidance functions Rainwater management functions
	Eco Districts	Resilience (Proportion of land area of 100-year floodplain)
III	TESSA	Flooding control functions
	InVEST	Flood risk mitigation functions

* I: GI evaluation tool II: Accreditation system III: Ecosystem service evaluation tool

Table 2. Coefficients to evaluate the mitigation of rainwater outflow (GI-Val)

Land coverage class	Soil class			
	A	B	C	D
Buildings	98	98	98	98
Other impermeable land	98	98	98	98
Treed land	25	55	70	77
Shrubbed land	45	66	77	83
Land with mowed lawn or grass	39	61	74	80
Land with lawn or grass	30	58	71	78
Farmland	67	76	83	86
Water surface	0	0	0	0
Bare land or graveled land (pavement, etc.)	74	83	88	90

* Green infrastructure valuation toolkit calculator v. 1.6 (created for reference)

In reducing the rainwater outflow by introducing GI, there are many examples of quantitative evaluations using the area occupied by green spaces, but GI-Val is characterized by the way that the soil class condition greatly affecting the evaluation outcomes. Evaluations by soil class like this have been used in the UK, as well as several local government areas in the US, and classes A to D have been created to make determinations from existing soil data or on-site measurements, based on table 3.

Table 3. Examples of soil classes for evaluating rainwater infiltration capacity

Class	Saturation infiltration coefficient (The right side is the standard when the distance to the impermeable layer exceeds 100 cm)	
A	> 40.0 μm/s (> 144 mm/h)	> 10.0 μm/s (> 36 mm/h)
	Low possibility of rainwater outflow. Soil consists of 10% or less of clay and 90% or more of sand, gravel, sand and gravel, etc.	
B	≤ 40.0 to > 10.0 μm/s (≤ 144 to > 36 mm/h)	≤ 10.0 to > 4.0 μm/s (≤ 36 to > 14.4 mm/h)
	Moderately low possibility of outflow. Soil consists of 10% to 20% clay and 50% to 90% sand.	
C	≤ 10.0 to > 1.0 μm/s (≤ 36 to > 3.6 mm/h)	≤ 4.0 to > 0.4 μm/s (≤ 14.4 to > 1.44 mm/h)
	Moderately high possibility of outflow. Soil consists of 20% to 40% clay and under 50% sand.	
D	≤ 1.0 μm/s (≤ 3.6 mm/h)	≤ 0.4 μm/s (≤ 1.44 mm/h)
	High possibility of outflow. Soil consists of over 40% clay and under 50% sand.	

* Hydrology National Engineering Handbook, 2007, NRCS (created for reference)

Japan is also establishing rainwater infiltration facilities and the like after examining the geology, soil qualities, groundwater level, and other factors when planning the facilities, and the standards and ideas concerning soil classes and the computation methods that are used when doing so can also be used when introducing GI. GI evaluations using land coverage and soil class can make rainwater collection and infiltration function clearer and can be expected to promote plans for higher-functioning GI. In addition, in plans covering an entire region, such as river basin flood control, this method shows the potential for use in establishing appropriate locations and scales for GI, such as in coordination with other infrastructure and considering target sites suited to the introduction of rainwater collection and infiltration functions.

5. Future research

In future, we will research and study methods for computing rainwater collection and infiltration function and on-site measuring methods, as well as examining easy-to-use evaluation methods with a view towards social implementation in Japan and conducting research with a view towards creating technical materials capable of supporting GI planning and maintenance.

☞See here for detailed information

1) Tech. Note of NILIM, No. 1166, pp. 19–20
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1166pdf/ks1166_05.pdf

Development of a System to Forecast Inundation Damage from Storm Surge and High Waves in Advance --- Aiming to Provide Easy-to-Understand Information That Leads to Evacuation Action

(Research period: FY2020 to FY2021)

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Coast Division, River Department

Key words: storm surge, high wave, wave runup height, inundation risk

1. Introduction

In recent years, large storm surge and high waves have occurred and caused inundation damage in many areas. For example, Typhoon No. 21 in 2018 caused the tide level in Osaka Bay to exceed the previous highest level by about 40 cm. On the Saisho Coast, in 2017 and 2019, inundation damage caused by high waves resulting from typhoons occurred. The damage due to storm surge and high waves was serious, including the closure of roads for long hours. In order to protect the coastal hinterland from such damage and to mitigate human damage, it is necessary to forecast and disseminate the danger of inundation by storm surge and high waves at the appropriate timing, in addition to implementing structural measures such as building coastal dikes. Evacuation orders by municipalities are often issued in conjunction with storm surge warnings, but storm surge warnings alone cannot determine whether waves are overtopping coastal dikes. Therefore, it is necessary to disseminate easy-to-understand forecast information to those involved in flood prevention activities, including local governments and residents who will actually have to evacuate so that they can more concretely visualize the danger of inundation.

The Coast Division has been operating the "Wave Runup Height Forecast System," which forecasts the risk of inundation in real time, on a trial basis, since FY2007, with the aim of supporting flood prevention activities during storm surge and high waves. In this research, we extended the "Wave Runup Height Forecast System" to the "Storm Surge / High Waves Disaster Mitigation Support System" and verified the accuracy of the wave runup height forecast. This paper presents the outline of these activities.

2. Outline of the Storm Surge / High Waves Disaster Mitigation Support System

The "Storm Surge / High Waves Dissater Mitigation Support System" consists of the "Wave Runup Height Forecast Function" (**Fig. 1**) that forecasts wave runup height at 500 points nationwide based on the wave and tide level forecasts by the Japan Meteorological Agency, and the "Inundation Risk Forecast Function" that displays the risk of inundation along the coastline throughout Japan in different colors. This forecast can be viewed through a browser by the personnel in charge of coastal areas in the Regional Development Bureaus and prefectural offices.

The Wave Runup Height Forecast Function uses the runup calculation formula selected according to the seabed slope at the forecast point, and takes into account the topography and the shape of facilities, as well as the effect of wave-dissipating facilities in some points, to forecast the wave runup height every hour up to 39 hours in advance, and provides a visual indication of when and for how long overtopping waves will occur (**Fig. 2**). When a typhoon approaches, a total of five courses, which include the center of the typhoon forecast circle and four points around it, are forecast.

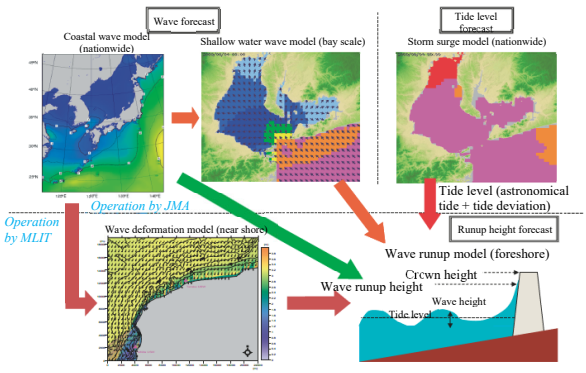

Fig. 1: Overall structure of the wave runup height forecast function

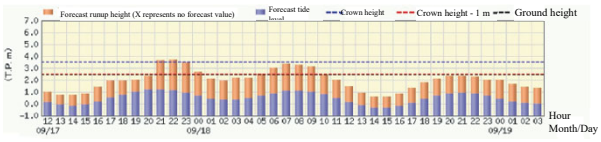

Fig. 2: Example of displaying wave runup height forecast

The newly added inundation risk forecast function targets points along coasts where the crown height is relatively low and evaluates the inundation risk of those coastal areas in three levels with a warning indicator corresponding to the wave runup height (in

principle, the sum of the forecasted tide level and the forecasted wave height x 1/2) and through a comparison of forecasted tide level with crown height, and displays the results in color on the coastal line on the map (**Fig. 3**). Compared to the wave runup height forecast function, the forecast accuracy is lower, but the nationwide situation can be easily grasped.

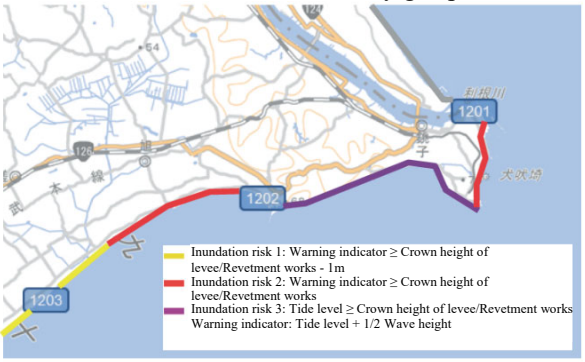

Fig. 3: Display image of inundation risk forecast

3. Verification of the accuracy of wave runup height forecast function

For the wave runup height forecast function, we conducted a quantitative verification for the typhoon No. 19 in 2019, and a qualitative verification for storm surge and high wave cases in the past five years.

In the verification of typhoon No. 19's approach, we compared the wave runup trace heights measured along the coast of Sagami Bay with the forecasted wave runup heights. As shown in **Fig. 4**, along the Odawara Coast of the Sagami Bay, the forecasted wave runup height (solid line) was higher around 18:00 on October 12, and its time maximum value was about 10 m above sea level, which was almost the same as the measured value (dashed line). Along the adjacent Ninomiya and Hiratsuka coasts, the time maximum values of the forecasted wave runup height were almost identical to the measured values.

In addition, for the storm surge and high wave cases from January 2016 to January 2021, we confirmed the number of cases where the forecast was correct, missed, or wrong by verifying whether the forecasted wave runup height exceeded the crown height when the wave overtopping occurred, and whether the wave overtopping occurred when the forecasted wave runup height exceeded the crown height. In 7 of the 28 cases where wave overtopping occurred, the forecast was correct. Missed forecasts were relatively common on the Kochi coast, where the wave forecasts of the coastal wave model were used to forecast the wave runup height. On the other hand, in the 157 cases where the forecast value exceeded the crown height, there were many cases of wrong forecast where no wave overtopping was assumed to have occurred (**Fig. 5**), which may be due to the fact that the overtopping was not fully grasped by the coastal managers. Even in the case of wrong forecast, the difference between the forecast value and the crown height was within 1 m in many cases, which indicates that the difference was relatively small, although the forecast tended to be somewhat excessive.

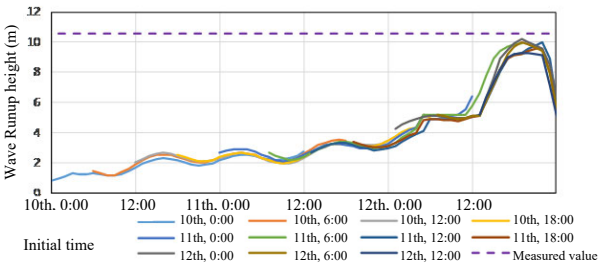

Fig. 4: Comparison of forecast and measured values (Odawara coast)

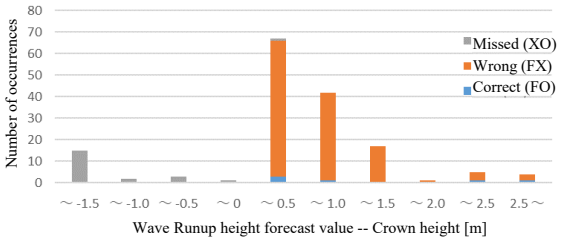

Fig. 5: Distribution of difference between crown height and forecasted wave runup height

4. Future development

In the future, we will continue accuracy verification and promote initiatives to establish an observation system for wave overtopping in order to further improve forecast accuracy. In addition, based on the opinions of the municipalities that have voluntarily started an initiative to view the forecast results on a trial basis, we would like to improve the forecast to make the forecast information intuitive and easy to understand, and provide information widely to the public to support municipalities that actually engage in flood prevention activities and encourage residents to evacuate.

☞See the following for details.

1) KATO Fuminori and FUKUHARA Naoki: Validation of Wave Runup Height Prediction During Typhoon Habibis, 2019, Based on Field Observation Data, Journal of JSCE, B2, No. 72, Vol. 2, pp. I_841-I_846, 2020
https://doi.org/10.2208/kaigan.76.2_I_841

Examination of lighting equipment plans for evacuation plans in a natural disaster

(Research period: FY 2020–2021)

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HIRAMITSU Atsuo (Ph.D. in Engineering), Head, Equipment Standards Division, Building Department

(Keywords) Evacuation, lighting equipment, safety and security, visibility evaluation, image photometry

1. Introduction

In the event of a natural disaster, lighting facilities are indispensable for evacuees to recognize the direction of evacuation and to confirm the safety of walking routes when they evacuate from danger zones to safe places. While the ease of evacuation depends on factors such as light intensity, the arrangement of equipment, and the illuminated target, the methods of planning lighting equipment that can be applied to plans for these factors have not been well developed.

NILIM has conducted research and development to address this issue since FY 2020. This paper provides an overview of the method of evaluating lighting environments for examining lighting facility plans and describes the future plan.

2. Overview of the method of evaluating lighting environments for evacuation routes

Conventionally, road surface illuminance, which indicates the degree of light falling on a road surface, is often used as one of the indicators for evaluating the visibility of walking space. Road surface illuminance is found to be useful as one of the effective indicators in terms of ease of calculating light intensity over the entire evacuation route and developing designs. However, to help evacuees recognize and determine the evacuation direction, it is necessary to take into account the relationship with luminance, which is information on the brightness that reaches pedestrians' eyes directly from buildings, stairs, trees, and light sources that are in their field of vision. In this study, information on luminance distribution by image photometry was obtained using a commercially available digital camera, and a subjective evaluation of the ease of identifying surrounding spaces and the visibility of road surfaces was conducted to examine their relationship.

As an actual example of a night outdoor lighting environment evaluation, Figure 1 shows the results of subjective evaluations of different lighting conditions (bright and dark) at two different points (Point A and Point B), and Figure 2 shows the luminance distribution obtained using image photometry. As Figure 1 shows, the subjective evaluation of the ease of identifying walking space and visibility of the road surface decreased under dark lighting conditions at both Points A and B. The luminance distribution in Figure 2 shows that the subjective evaluation tends to improve as the number of sites from 1 to 10 cd/m^2 increases, indicating the usefulness of lighting environment evaluation based on luminance distribution.

3. Future plan

Lighting planning that demonstrates resilience in the event of a disaster is drawing growing interest not only in Japan but also worldwide. The future plan is to develop a method for lighting equipment planning that utilizes the knowledge gained from this research.

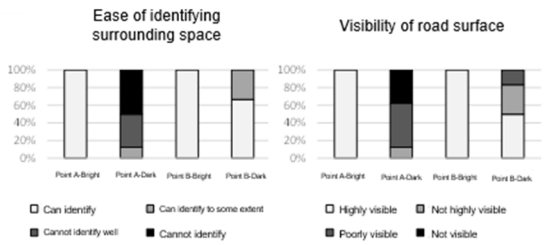

Figure 1: Results of subjective evaluation

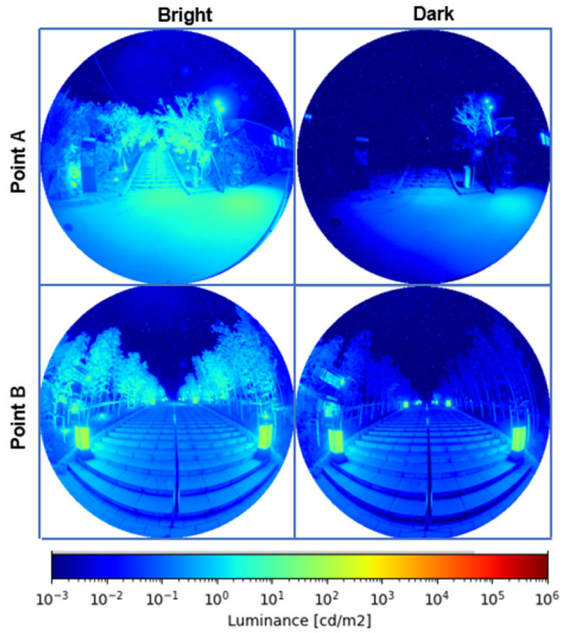

Figure 2: Results of luminance distribution measurement

Current State of and Challenges in Support Policies for Activities by Local Residents, Etc. to Remove Snow from Roads

(Research period: FY2019–FY2021)

Construction Economics Division, Research Center for Infrastructure Management

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(Keywords) road snow removal, resident participation, administration support

1. Introduction

While the way snow falls has changed in recent years, with extremely heavy snowfalls occurring with greater concentration and for longer, the environment surrounding snow removal work has become more difficult for local construction companies and others responsible for removing snow from roads, such as through the deterioration of snow removal machinery and the aging of highly skilled operators. The MLIT-established Committee on Considering Measures to Secure Winter Road Transportation[1)] offered an opinion on mechanisms allowing local communities and private-sector groups to actively participate in snow removal (May 2018). For this reason, NILIM is investigating methods to encourage resident participation in winter road measures with the aim of building mechanisms allowing local communities and private-sector groups to actively cooperate in snow removal from roads.

In this study, we surveyed support measures for road snow removal activities by residents, etc. in regions with heavy snowfall, with the objective of providing information to local governments, local residents, and others as fundamental materials for investigating and encouraging such policies.

2. Surveying support policies for activities by residents, etc. to remove snow from roads

We conducted a survey on the current state of activities by residents and others to remove snow from roads and support policies by administrations. First, we identified 161 municipalities and 231 projects where we could confirm from the website of the relevant local government, existing literature, and other sources that the local government is providing support for local residents, etc. to remove snow from roads, based on the survey results of the "Basic Survey of Heavy Snowfall Areas" (MLIT, conducted in 2020) covering local government areas designated as heavy snowfall areas or special heavy snowfall areas under the Act on Special Measures Concerning Countermeasures for Heavy Snowfall Areas (532 municipalities, as of April 1, 2021). We also investigated the weather conditions in the 161 municipalities from Japan Meteorological Agency observation data and the socioeconomic conditions, such as population, age structure, and financial situation, from materials from the Statistics Bureau in the Ministry of Internal Affairs and Communications and other sources, and summarized the relationships between the provision of support for resident snow removal activities and these weather and social data.

(1) Provision of support by municipalities

Municipalities providing support for road snow removal activities by residents and others account for 30% in heavy snowfall areas (161 of 532 municipalities), and within these, 25% in special heavy snowfall areas (50 of 201 municipalities) and 34% in municipalities designated as heavy snowfall areas but not as special heavy snowfall areas ("non-special heavy snowfall areas"; 111 of 331 municipalities) (fig. 1).

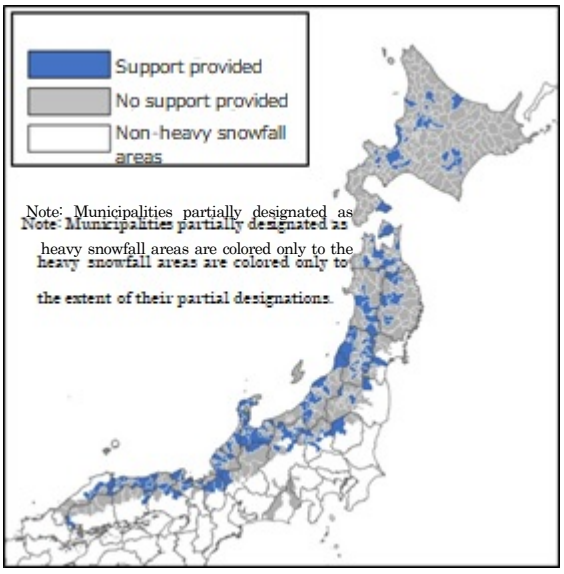

Fig. 1. Provision of support for road snow removal activities

Looking at the provision of support measures by prefecture, among the 14 prefectures that have at least 10 municipalities designated as heavy snowfall areas, Tottori (79%), Toyama (73%), Ishikawa (63%), Fukui (53%), and Yamagata (51%) have the greatest proportion of municipalities that provide support.

(2) Content of support measures

The content of support for road snow removal activities by residents and others in heavy snowfall areas is most commonly "lending snowplows" at 16%, followed by "assisting with activity costs" (14%) and "support for snowplow purchases" (10%). Conversely, looking only at special heavy snowfall areas, "assisting with activity costs" is most common at 17%, followed by "lending snowplows" (12%) and "support for snowplow purchases" (5%) (fig. 2). We observed many cases in regions where residents do not own snowplows where lending machinery made it possible for resident participation to supplement the labor, and many cases in regions where residents do own snowplows where support is provided through aid for actual costs or supplying fuel.

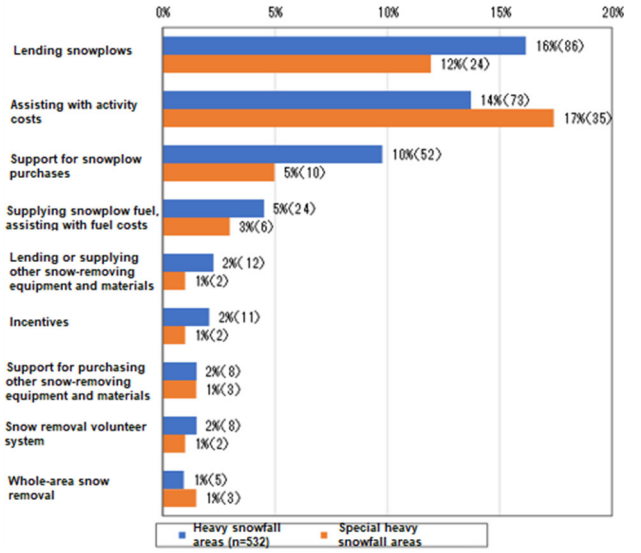

Fig. 2. Content of support for activities by residents to remove snow from roads

3. Relationship between support measures and social conditions

When we summarized the relationship with social conditions in the 532 municipalities in heavy snowfall areas and the 161 municipalities among them that provide support, we observed certain trends. Some of these are shown below.

(1) Population size in the local government area

Municipalities with larger populations have a higher proportion of support (fig. 3). As a factor, we observed cases where municipalities merged and the support system in a former municipality before the merger was inherited by the local government after the merger.

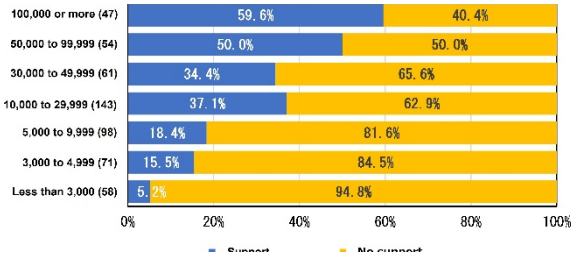

Fig. 3. Provision of support measures (by population)

(2) Population structure in the local government area

Municipalities with a large population of working age, i.e., between 15 and 65, have a higher proportion of support (fig. 4). This suggests that support is provided for road snow removal activities in municipalities with many residents in the working-age generations, as they can take charge of resident snow removal.

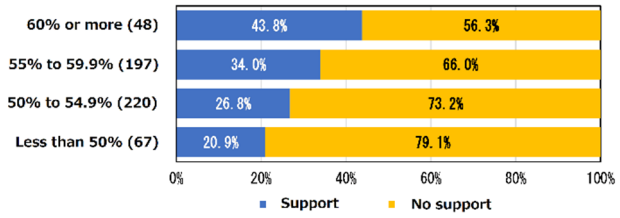

Fig. 4. Proportion of population of working age

(3) Length of managed roads

Municipalities with greater lengths of road under their management have a higher proportion of support (fig. 5). In this situation, snow removal by residents and others supplements the parts that road administrators are not capable of clearing, and the administration provides support for that.

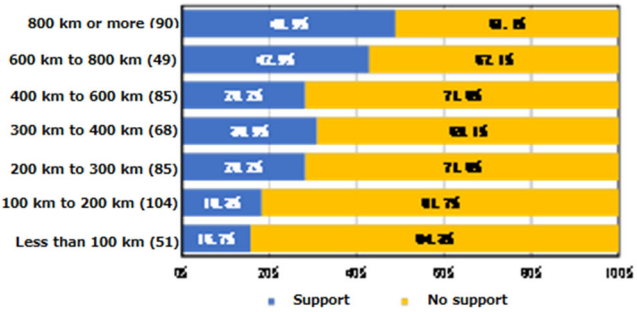

Fig. 5. Length of managed roads

4. Conclusion

As a result of mergers of many of the municipalities that were designated as heavy snowfall areas or special heavy snowfall areas in the Heavy Snowfall Areas Special Measures Act, a number of local government areas have mixtures of designated and nondesignated areas and of heavy snowfall areas and special heavy snowfall areas. This leads to difficulty in accurately gaining information in the Basic Survey of Heavy Snowfall Areas, which is conducted according to the current municipalities, but we believe we have grasped certain trends. The support systems in each local government area are based on regional characteristics and historical practice, and it is possible to see settings where the need for review has arisen due to changes in social circumstances. We intend to organize the results of this survey as a technical note in order to create materials to contribute to this examination.

☞See here for detailed information

1) MLIT: Committee on Considering Measures to Secure Winter Road Transportation
https://www.mlit.go.jp/road/ir/ir-council/toukidourokanri/index.html

The Five-year History of the Kumamoto Earthquake Recovery Division and its Aim to Recover from the 2016 Kumamoto Earthquake

(Research period: FY2017–FY2021)

Kumamoto Earthquake Recovery Division, Research Center for Infrastructure Management

Head NISHIDA Hideaki Research officer NISHIMURA Kaichi

(Keywords) Kumamoto Earthquake, cables, three-dimensional point group data

1. Introduction

The Kumamoto Earthquake Recovery Division (the Division), which was established in 2017, was permanently stationed at the recovery site and worked on resolving issues that require advanced expertise, in order to speed up recovery and restoration after the 2016 Kumamoto Earthquake. In addition, the Division also engaged in research to gather the technical findings gained through the recovery project and reflect them in technical standards, etc. Table 1 outlines the main research topics and outcomes from our work over the past five years. This report briefly describes research case examples concerning new issues that we found based on on-site investigations.

2. Main research outcomes

(1) Research on assessments of cable load-bearing capacity and durability

The Kuwazuru Ōhashi, a cable-stayed bridge, suffered damage to the cable coating materials due to cable twisting and contact with the lighting poles by the earthquake. This disaster led to awareness of the issue of how to gain information on and diagnose the load-bearing capacity and durability of cables..

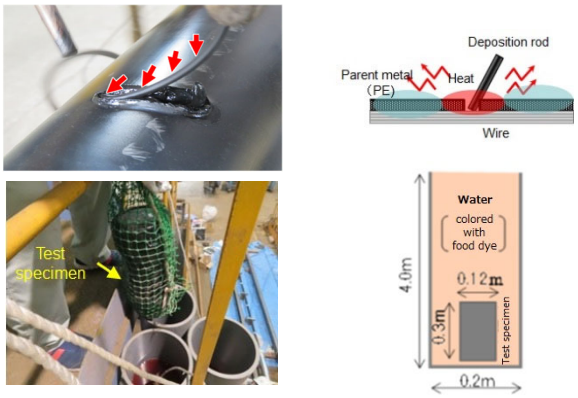

Fig. 1. Repair method (top) and waterproofing testing method (bottom)

Table 1. Main research topics and outcomes of the Kumamoto Earthquake Recovery Division

Research topic	Main outcomes
Minimizing effects of ground deformation on bridges	· Proposing damage control methods (failure modality and design methods) for fulcrum sections, contributing to reductions in bridge collapses and faster restoration of road functions · Proposing methods for rapidly gaining information on slope deformation along roads
Methods for checking repair effects on bridges restored after earthquakes	Proposing monitoring methods for checking the repair effects in earthquake recovery works, using ICT technology
Assessments of cable load-bearing capacity and durability	· Accumulating findings on cable load-bearing capacity · Proposing cable covering repair method and waterproofing testing method
Gathering state information on foundations, and the conditions for foundations less susceptible to damage	· Proposing methods for using high-frequency impact probing in foundation damage investigations · Accumulating findings on the impact of foundation structural forms and topographical conditions on foundation damage
Information that should be acquired in earthquake recovery works and is useful in maintenance, and its usage methods	Presenting methods of using information gained in earthquake recovery works in maintenance and recording and storage methods

Based on such a background, the research on assessing the load-bearing capacity and durability of cables coated with high-density polyethylene (PE) was conducted by using the cables removed from the bridge because of deformations observed in their external appearance.

In the investigation of the load-bearing capacity of the steel wires inside the cable, tension tests of the steel strands of the cable were conducted and it was found the trend between the state of rustproofing or external deformation and the tension strength. Furthermore, a method of checking for corrosion

within the cable coating by drilling minute holes in the PE coating was proposed. In proposing the location and diameter of the holes, we took into account the ease of the checking work and repair methods to fill the holes, among other factors. For the coating repair method, we made use of the removed cables and devised a waterproofing testing method where the repaired test specimen is placed in colored water at high pressure to check suitable quality, Furthermore, it was suggested how to give the heat when the coating was repaired by welding method (fig. 1). The outcomes of the above were reflected in checks of the condition of the steel wires inside the remaining cables and the repairs of the sections drilled to check them.

(2) Examination of method for gaining information on slope deformation along roads using 3D point group data

The Kumamoto Earthquake caused damage that impeded road functionality due to the effects of ground deformation; some of these roads ran along steep slopes and took a long time to restore. In order to determine whether roads in such conditions are passable after an earthquake and how to restore them temporarily as quickly as possible, gathering information on the condition of slopes quickly and broadly was recognized as an important point. The Division conducted research on a method to gain information on deformations using three-dimensional point group data acquired by UAV laser surveying, as a method to quickly and broadly gain information on the state of slopes that are difficult to approach.

Laser surveying measures in a way that fulfills the required point density for original point group data based on the Public Survey Manual. However, when seeking to evaluate deformations across an entire slope from differences between data from two different periods at a similar accuracy, it also seems necessary to have a small dispersion in point density due to the angle of the subject slope and the degree of unevenness of the surface and to have similar measurement accuracy between the two periods. Therefore, the matters that should be required in order to evaluate deformation from the differences were considered.

Here we show the examination results relating to the flying

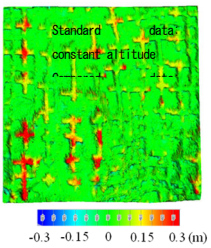

Fig. 3. Difference diagram

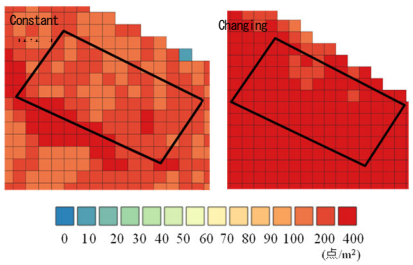

Fig. 4. Point density distribution diagram

altitude of the UAV as one such matter. For this examination, we acquired point group data at the same time under conditions with the UAV flying altitude kept constant and with it changing according to the slope (fig. 2).

To verify the accuracy, we created a three-dimensional model (TIN model) from three-dimensional point group data under constant flying altitude conditions and then evaluated the normal distance from the measured points acquired under changing altitude conditions to the surface formed by the TIN

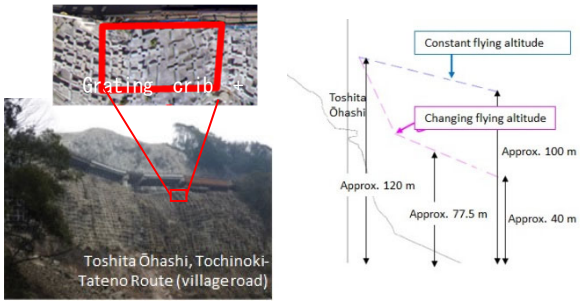

Fig. 2. Location for measurement

model as the difference.

Figures 3 and 4 show a difference diagram and a point density distribution diagram at the locations where work for the grating crib wall and its anchors was performed (fig. 2). As the data was acquired at the same time in the same location, there should be no difference in the first place, but figure 3 shows significant differences around the pressure plates towards the bottom of the slope in particular. The point density is somewhat lower with constant flying altitude than with changing flying altitude. Figures 3 and 4 suggest that measurement at constant flying altitude may not fully capture the slope shape around the pressure plates due to the effects they exert.

As shown above, we confirmed that in order to gain information on deformation with similar accuracy across an entire slope, it is necessary to acquire point group data by

shining lasers from various angles, such as by changing the flying altitude of the UAV, to enable data density to be secured near uneven sections on the slope in particular.

Based on this examination, we organized the main factors that influence the accuracy of information on deformation of the subject slope (table 2) and summarized the requirements regarding data acquisition, etc. in the case that three-dimensional point group data from UAV surveying is used to measure slope deformation.

3. Conclusion

In conducting the technical support and research relating to restoration, we received assistance in various forms from many people, including the MLIT Kyushu Regional Development Bureau, NILIM, the Public Works Research Institute, Kumamoto Prefecture and Minami-Aso Village, which were the road administrators, and various businesses involved with investigations, design, and construction. We express our gratitude to all of them.

Table 2. Main factors affecting the slope deformation evaluation accuracy when using point group data from UAV laser surveying

Item	Contents (main factors)
1. Method to acquire original point group data	○ Measurement method ○ Flying conditions (course (altitude, overlap), speed)
2. Method to process point group data	・ Number and location of control points ○ Filtering method to remove effects of trees, etc. ○ 3D model creation methods
3. Method to evaluate deformation	○ Method to evaluate differences

Utilization of AI in Safety Management of Dams --- Development of Dam Management Support Technology to Enhance the Quality of Maintenance

(Research period: FY2020 to FY2022)

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Keywords: dam, safety management, abnormality detection, AI, LSTM, Isolation Forest

1. Introduction

With such a large number of dams having been constructed during the high-growth period and now in service for a such a long period of time, there is concern about the shortage of skilled personnel with extensive experience in safety management who monitor the condition of dams through patrols and measurements to ensure that there are no abnormalities. It is typical of dams that safety management is based on various types of measurement data, yet some on-site workers have commented that it is difficult to clearly determine the presence or absence of abnormalities even by analyzing reliable data. Therefore, we examined an abnormality detection method using AI, which has been used in many fields in recent years, as a technology to assist dam managers in judging the presence or absence of abnormalities based on various measurement data acquired on site for safety management.

2. Anomaly detection method

Measurement data acquired for the purpose of dam safety management includes leakage volume, pumping pressure, deformation (displacement), and seismic motion (acceleration waveform) (**Fig. 1**).

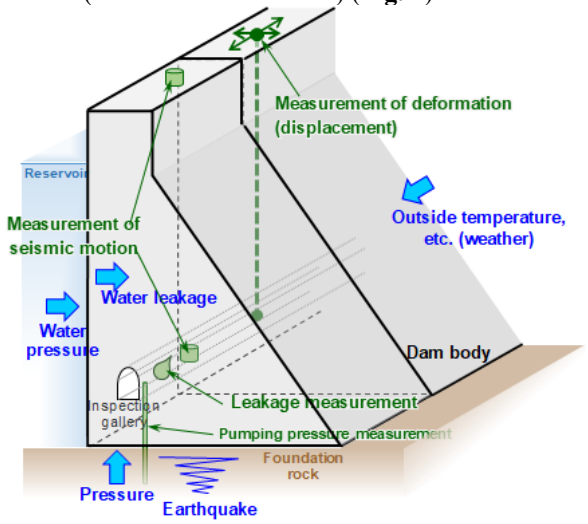


Fig. 1: Main measurements for dam safety management (Example of concrete gravity dam)

Of the foregoing, we examined the possibility of detecting abnormalities with AI technology using data on deformation of the dam body (relative displacement of the dam foundation and crest; hereinafter, the "amount of dam body deformation") and seismic motion (acceleration waveform observed at the crest of the dam). They are common in that they are obtained as time series data.

For concrete dams, it is known that the amount of dam body deformation is generally affected by the reservoir water level and temperature, and that cyclic changes are repeated. Therefore, to detect abnormalities based on the deviation between predicted and measured values taking into account the reservoir level and outside temperature, we tried to apply LSTM (Long Short Term Memory, **Fig. 2**), a neural network algorithm applicable to regression problems of time series data, which can make predictions by treating past data as long-term memory.

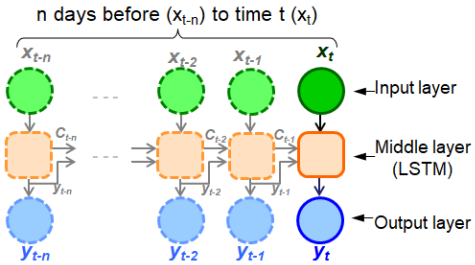
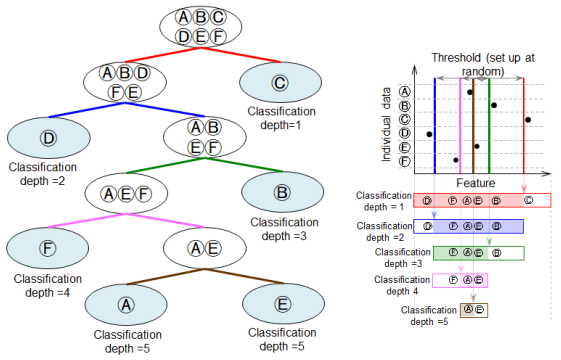


Fig. 2: Outline of LSTM model

On the other hand, the seismic motion data observed in the dam body will reflect the response of the dam. For this reason, we considered abnormality detection from changes in seismic response, which could be due to structural damage. However, actual damage cases are limited in dams. Therefore, as a machine learning algorithm that can detect abnormalities from normal data, we attempted to apply an Isolation Forest (IF, **Fig. 3**), which determines isolated data as abnormalities at an early stage by repeatedly dividing (classifying) the data using decision trees.



(a) Isolation tree (b) Division by features

Fig. 3 Outline of Isolation Forest

3. Attempt to detect abnormalities using measurement data at the dam

(1) Detection of abnormality in the amount of dam body displacement using LSTM

We used LSTM to make it learn historical measurement data on the amount of dam body deformation (upstream and downstream components) for a domestic concrete gravity dam (about 120 m in height). Time-series data on reservoir water level and temperature (outside temperature and dam body temperature) were input as data corresponding to explanatory variables in the input layer of the model shown in **Fig. 2**. A comparison of the predicted data obtained from the output layer and measured data on the amounts of dam body displacement is shown in **Fig. 4**. The figure also shows the results of multiple regression analysis, which is a conventional method, but since the LSTM prediction represents well the actual measured values, it is expected to be used for abnormality detection by setting an appropriate threshold for the deviation from the actual measured values.

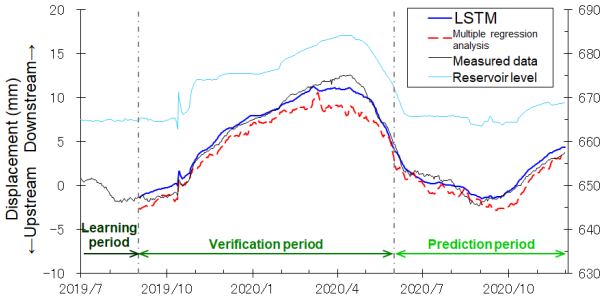
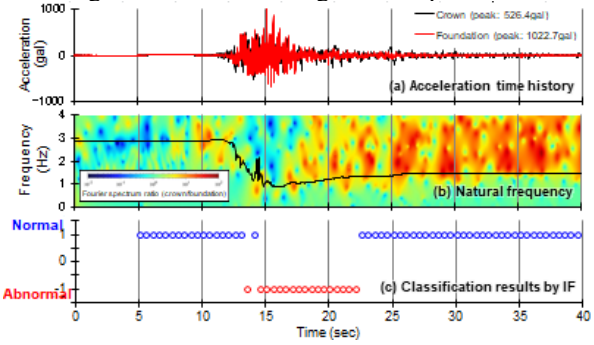


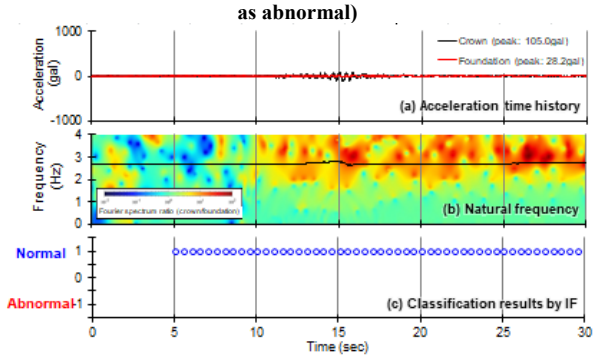
Fig. 4: Prediction of the amount of dam body deformation (LSTM)

(2) Detection of abnormalities in seismic response using an Isolation Forest

From the seismic motion data (acceleration waveform) and its frequency characteristics data during large and small earthquakes observed by seismometers installed at the crest of a rockfill dam (about 75 m high) in Japan, we identified various statistics, etc., as features, and implemented machine learning by IF (classification of normal and abnormal). As a result, of the data in which the acceleration level was large and a decrease in the dominant frequency, which is considered to correspond to the natural frequency of the dam, was found, the data during the time period in which the change occurred was determined to be abnormal (**Fig. 5**). Since a decrease in natural frequency has been observed in foreign dams where structural damage was reported at the time of an earthquake, this method is expected to be used for detecting abnormalities during an earthquakes.



(a) Data showing a decrease in the dominant frequency (judged as abnormal)



(b) Data showing no decrease in the dominant frequency (judged as normal)

Fig. 5: Example of abnormality detection in seismic motion data (IF)

4. Conclusion

The results showed significant potential for using AI-based methods in dam safety management to assist in determining the presence or absence of abnormalities based on measurement data. Although visual confirmation and other investigations and analyses are necessary to determine whether or not the dam actually has abnormalities, if this method can be used for screening large amounts of data and determining the need for further analysis, it is expected to help rationalize the safety management of dams. In the future, we would like to further expand the target data and create practical support tools that can be used in the field.

☞See the following for details.

KOBORI Toshihide, SATO Hiroyuki, NIKAIDO Ryohei, Bin Fu, and KONDO Masashi: An Attempt to Use AI for Abnormality Detection by Measurement Data for Dam Safety Management, Civil Engineering Journal, Vol. 64, No.1, pp. 38-41, 2022.

Development of BIM models assuming utilization in existing public rental housing

(Research period: FY 2019–)

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TAKAHASHI Satoru, Director
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(Keywords) BIM, public rental housing, maintenance, i-construction

1. Introduction

In Japan, as we enter an era of population decline, it is expected that the number of workers, who have supported economic growth so far, will decrease, and it is also necessary to aim for a "productivity revolution" that realizes economic growth by improving productivity in excess of the decrease at construction sites. For this reason, the Ministry of Land, Infrastructure, Transport and Tourism has been promoting "i-Construction" to improve the productivity of the entire construction production system by utilizing Information and Communication Technology (ICT). As part of this, the utilization of Building Information Modeling (BIM) has been promoted. In the field of construction, BIM is also expected to be used in maintenance management and real estate distribution.

The promotion of DX including the introduction of BIM is considered to be one means of promoting streamlining and efficiency improvement of operations throughout (and at each stage of) the life cycle of public rental housing businesses, improving the efficiency of maintenance and management, and so on. Therefore, the Housing Department has been conducting a BIM study survey on public rental housing with the cooperation of the Building Research Institute to study the development of BIM models for maintenance and management based on the actual conditions of maintenance, management, and operation of public rental housing.

2. Current status of maintenance of public rental housing and the needs for efficiency improvement using BIM

In the BIM study survey on public rental housing, the needs for efficiency improvement in public rental housing has been investigated by interviewing workers in the field and so on.

In the field of public rental housing, and particularly with regard to the maintenance and management of existing housing, it is necessary to appropriately maintain, manage, and operate a large number of public rental housing facilities in the face of financial constraints on local governments, etc., aging of technical staff, and reduction of human resources. It is also necessary to promote preventive management such as appropriate planning and repairs based on inspection results. On the other hand, in the practice of maintenance and management, periodic inspections mandated by law and daily inspections with higher frequency have been carried out, and it was identified that hard copies such as drawings are brought to the site in daily inspections, etc. Processing inspection records and reports takes time and effort because staff return to the office to record and type their data in a finalized format, causing a risk of mis-copying,

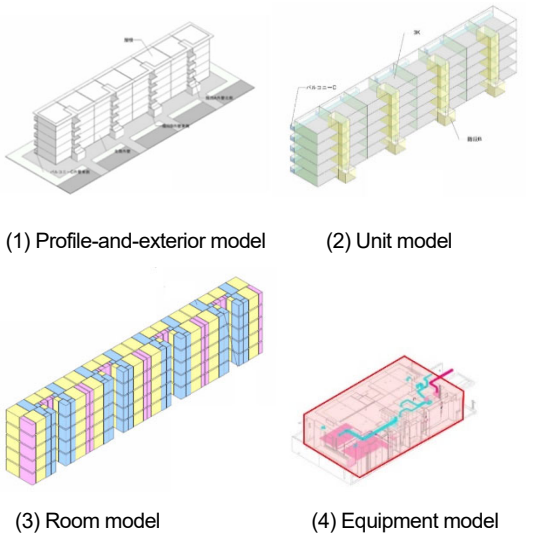
and there is a risk of mis-confirmation in checking past inspection results for ordering repair work.

A possible method to address this by improving the efficiency of recording inspection results and maintenance is to change the recording method by introducing tablets that can be carried at the site instead of records using hard copies, and the needs for utilizing the saved data for optimization of maintenance while utilizing BIM, etc., was confirmed.

3. Development of BIM models for maintenance and management of existing public rental housing

Many public rental housing facilities were constructed with a relatively simple design such as a standard design and do not have complex equipment. Therefore, the information handled in the maintenance and management of public rental housing does not need to include details of parts and materials that are used in the implementation design and construction site. A BIM model is considered to be necessarily and sufficiently detailed as long as the information enables the records and updates needed in maintenance and management phases. For this reason, as a BIM model for maintenance and management in public rental housing, a model composed of simple objects that handle space was created.

This BIM model for maintenance and management consists of the following: (1) a profile-and-exterior model, (2) a unit model, (3) a room model, and (4) an equipment model. (The image of each model is shown in Figure 1.) When created for the maintenance and management of public rental housing, the model shall be basically a BIM model based on (1) and (2); it is assumed that a model based on (3) and (4) will be created if a management party needs it.



(1) Profile-and-exterior model (2) Unit model

(3) Room model (4) Equipment model

Figure 1: BIM models of public rental housing

Figure 2 shows an image of linkage with inspection work, and Figure 3 is a conceptual configuration diagram of BIMs for maintenance and management. The system does not require the administrator to operate the BIM software. Instead of managing data with a BIM model, a BIM model is regarded as a system and visualization tool for allocating location information and IDs, and it is assumed it will be used as an index to extract information from a database.

Absolute coordinates (latitude and longitude information and height) are regarded as unique IDs (UIDs). This makes it possible to manage maintenance and management information using location information as a key (used for linking information as a unique ID), and linkage with GIS and the like will also become possible.

In addition to organizing the configuration of a BIM model for maintenance and management, demonstration experiments were performed on the utilization of tablets and the BIM model for maintenance and management in daily inspections, etc., and the possibility of streamlining operations (recording inspections and so on, improving the reliability of performance of work, sharing records and data, and so forth)

was examined.

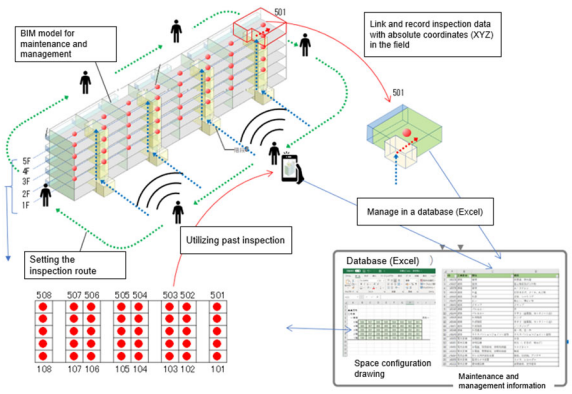


Figure 2: Image of linkage with inspection work

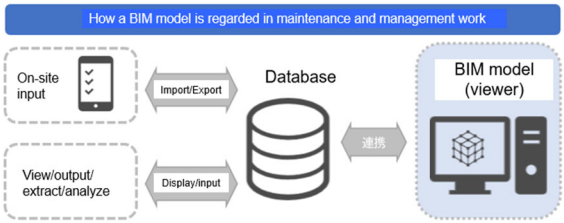


Figure 3: Conceptual configuration diagram of a BIM model for maintenance and management

In addition, using drawings and maintenance and management information on residential buildings of active public rental housing complexes in use that were provided by local governments, case studies of BIM models for maintenance and management were performed using specific information and opinions were exchanged on the usefulness of the BIM models.

4. Future direction

In the future, based on the results of the development of the BIM models, BIM models for the public rental housing business will be created and guidelines for their use will be formulated.

*The results of this paper are attributable to the implementation of the Public/Private R&D Investment Strategic Expansion Program (PRISM).

☞ For more information:

1) Website of the Housing Stock Management Division
http://www.nilim.go.jp/lab/ieg/index.htm

Clarification of actual building envelope and equipment design specifications using energy conservation standard application data

(Research period: FY 2020–2021)

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MIKI Yasuhiro (Ph.D. in Engineering), Research Coordinator for Housing Information System, Housing Department

(Keywords) Non-residential buildings, energy conservation, carbon-neutral, actual condition survey, building envelope design, equipment design

1. Introduction

To realize carbon neutrality by 2050, further energy conservation in homes and buildings is necessary, and to achieve this energy conservation, it is important to accurately identify the actual status of conservation and take more effective measures. However, for non-residential buildings in particular, there are few past surveys on the actual status of building envelope and equipment design specifications for each building use type and scale, making it difficult to study effective measures based on the characteristics of use type, etc.

To solve this problem, NILIM has been collecting input/output data of a program (Web program) for determining compliance with energy conservation standards with the permission of the program's users, in an attempt to clarify the actual status of design specifications for non-housing buildings.[1)] This report covers a summary of the results of an analysis conducted on newly constructed office buildings (1,731 in total) of application data of the FY 2018 energy conservation standard (14,802 in total).[2)]

2. Grouping using energy conservation standard evaluation indicators

Figure 1 shows the distribution of the results of primary energy consumption performance evaluation (BEIm) by the model building method (simplified evaluation route). BEIm is a value obtained by dividing the design primary energy consumption (energy consumption calculated based on design specifications) by the reference primary energy consumption, and if BEIm is less than 1, the building is in compliance with the standard. Figure 1 shows that there is a large change in the number of cases after BEIm = 0.55, 0.65, and 0.85. Therefore, based on BEIm, an analysis was performed by dividing the results into the five groups (Group I, II, III, IV, and V) shown in Figure 1. Since the trend for Group I varies greatly depending on the presence of photovoltaic power generation equipment, the properties in Group I without photovoltaic power generation equipment (35 in total) were extracted as Group I-npv and are shown separately from the

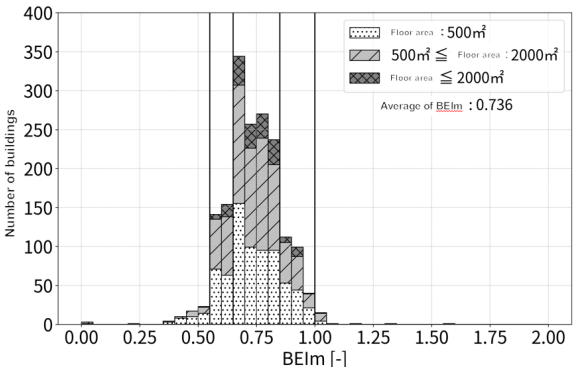

Figure 1: Distribution of BEIm (new office buildings)

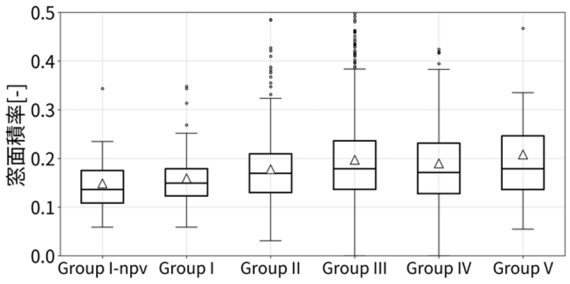

Figure 2: Window area ratio

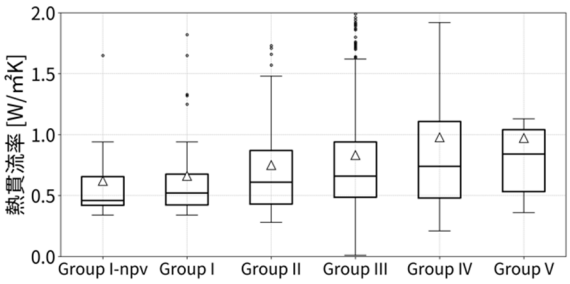

Figure 3: Thermal transmittance of exterior wall

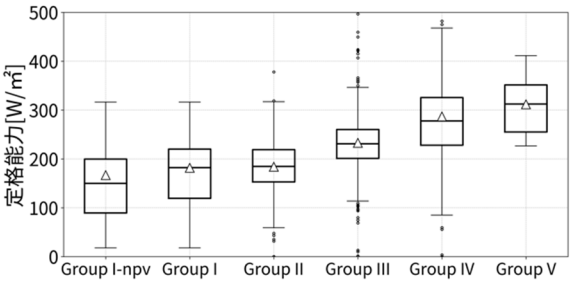

Figure 4: Rated capacities of air-conditioning (cooling/heating) equipment

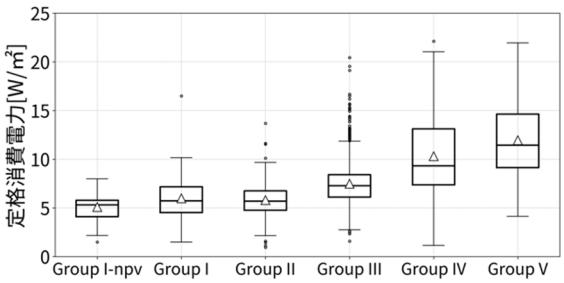

Figure 5: Rated power consumption of lighting fixtures

Group name	Envelope						Air-conditioning				Lighting	PV panel power generation capacity [W/m²]
	Exterior wall ratio [-]	Coef. of heat transmission of wall [W/m²K]	Coef. of heat transmission of roof [W/m²K]	Window area ratio [-]	Coef. of heat transmission of window [W/m²K]	Solar heat gain coef. of window [-]	Rated capacity of heat source [W/m²]		Rated efficient of heat source [-]		Power consumption [W/m²]	
							Cooling	Heating	Cooling	Heating		
Group I-npv	0.75	0.45	0.40	0.15	4.5	0.50	150	180	1.5	1.7	5	Not installed
Group I		0.50	0.40	0.16			180	210	1.4	1.6	6	12
Group II		0.60	0.45	0.17								2
Group III		0.65		0.20			230	260	1.3	1.4	8	Not installed
Group IV		0.75	0.50				290	320	1.2	1.3	11	Not installed
Group V		0.85					320	350	1.1	1.2	13	Not installed

Table 1: Standard building envelope and equipment facility design specifications (new office buildings)

overall results of Group I.

3. Analysis of building envelope design specifications

As an example of analysis of building envelope specifications by group, the window area ratio (window area divided by building envelope area) and thermal transmittance through exterior walls (unit: W/m²K; the smaller the value, the higher the insulation performance). Figure 2 and Figure 3 show the results (△ in the figures indicates the average). Regarding the window area ratios in Figure 2, while there is no large difference among the groups, groups with smaller BEIm tend to show slightly smaller window area ratios. The mean is 0.159 for Group I, 0.176 for Group II, and 0.191 for all groups. The thermal transmittance of exterior walls (Figure 3) varies among groups, with Group I having a median of 0.52 W/m²K, Group II 0.61 W/m²K, Group III 0.66 W/m²K, Group IV 0.74 W/m²K, and Group V 0.84 W/m²K.

4. Analysis of equipment design specifications

As examples of analysis of equipment specifications by group, Figure 4 and Figure 5 show the results of analysis of rated capacity per floor area of air-conditioning (cooling/heating) equipment and

power consumption per floor area of lighting fixtures. The average of the rated capacity of cooling/heating equipment (Figure 4) is almost the same in Group I and II, with a value of about 182 W/m^2, increasing to 232.6 W/m^2 for Group III, 286.8 W/m^2 for Group IV, and 311.6 W/m^2 for Group V, in this order. The average of rated power consumption of lighting fixtures (Figure 5) is about the same in Group I and II with a value of about 5.9 W/m^2, followed by 7.48 W/m^2 for Group III, 10.30 W/m^2 for Group IV, and 11.94 W/m^2 for Group V.

5. Standard design specifications by group

Based on the findings from the data analysis, Table 1 shows the results of identifying standard design specifications for each group. By utilizing the application data of energy conservation standards, the standard design specifications for Japan as a whole, which were previously unknown, were shown quantitatively.

6. Summary

Currently, there are discussions on strengthening energy conservation standards to realize a decarbonized society. Utilization of the results from this report will clarify what needs to be done, for example, to improve the thermal transmittance of exterior walls from 0.75 W/m^{2}K to 0.60 W/m^{2}K or reduce the power consumption of lighting from 11 W/m^2 to 6 W/m^2, to improve from the Group IV level to the Group II level. The results are expected to be useful for central and local governments in formulating subsidy programs, design guidelines, etc., and for architects and designers in setting design goals.

☞ For more information:

1) Technical Notes of NILIM No.1107 and No.1143
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1107.htm
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1143.htm
2) Masato Miyata, Susumu Hirakawa: Analysis on building envelope and building service equipment design specification using the input and output data from the calculation program to confirm compliance with building energy code (part 1): Identification of the design specification for newly built offices in Japan according to the evaluation result of the building energy code, Japan Architectural Review (Translated Paper), pp.1–12, 2022.4, https://doi.org/10.1002/2475-8876.12265

International Research Activities

1 International research activities at the NILIM

While considering the relevant policies of the MLIT, the NILIM is promoting exchanges mainly with overseas government agencies and governmental research institutions, as well as international research activities based on the following three perspectives.

(1) Technical contribution to domestic policies

The NILIM is utilizing bilateral, multilateral cooperation and other agreements concluded by it and the MLIT to build a network with overseas government agencies, etc., collect information on advanced cases, damage in disasters, etc., and to reflect what can be learned in domestic policy proposals, technical standards, etc.

(2) Technical cooperation for developing other countries

The NILIM is making use of the knowledge and lessons learned on the maintenance of public facilities and disaster response in Japan obtained from a standpoint similar to a public facility manager, as well as research results on the advancement of disaster prevention and mitigation measures that reflect such knowledge and lessons learned, to provide support to developing and other countries for measures that address advanced technical issues facing local governments, the formulation of technical standards, skill improvement of engineering officials in governments, etc.

(3) Development of infrastructure systems overseas

The NILIM is utilizing its knowledge on the formulation of technical standards to support policy development in Japan, to customize Japanese technical standards to the various conditions of the relevant country. Meanwhile, the NILIM also participates in committees for international standardization, plays a leading role in the internationalization of technical standards, and ensures consistency between domestic and international standards. Thus, the NILIM provides technical support for the development of infrastructure systems overseas.

2. Main international research activities in FY2021

In FY2021, due to the spread of COVID-19 variations such as the Delta and Omicron strains, many countries continued to restrict cross-border travel by immigration control, etc. Therefore, as in the last fiscal year, international conferences and meetings were cancelled or postponed and replaced with online meetings.

The following are representative international research activities we conducted in FY2021 during the COVID-19 pandemic.

2.1 Exchange of opinions with overseas organizations on road bridges

The Road Structures Department hosted the “U.S.-Japan Bridge Engineering Workshop” in an online format, based on the U.S.-Japan Memorandum of Understanding for Transportation Infrastructure Cooperation concluded between the U.S. Department of Transportation and the MLIT. In this year's Conference, we held discussions for three days on seismic design, repair and reinforcement cases, new construction methods and new materials, and shared new knowledge on new construction and maintenance of road structures that both countries have.

In addition, an online meeting was conducted based on the "Memorandum of Understanding on Agreement for Joint Research and Development on Road Bridges"[1)] between the Directorate for Roads of Viet Nam: (DRVN) of the Ministry of Transport and the NILIM. During the meeting, there was a lively exchange of opinions about bridge monitoring and cases of rehabilitation and reinforcement of concrete box girder bridges, which provided a meaningful opportunity to improve the technical level of both countries.

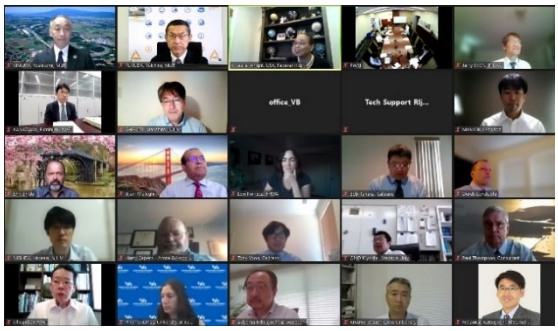

Photo 1: U.S.-Japan Bridge Engineering Workshop

2.2 Exchange of opinions with Germany on standards and measures for energy-saving in buildings

In FY2019, the NILIM signed a Memorandum of Understanding on research cooperation between NILIM, the Building Research Institute (BRI), and the German Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR)[2)]. Based on this MOU, in the online bilateral meeting of the current fiscal year, researchers mainly from BBSR (Germany), NILIM, and BRI introduced the initiatives of Japan and Germany regarding the trends in energy-saving standards and measures for buildings and exchanged opinions.

2.3 Cooperation in the formulation of national port standards in Vietnam

Based on the "Memorandum of Understanding for Cooperation in Developing National Technical Standards for Port Facilities" between the MLIT and the Ministry of Transport of Vietnam (signed in March 2014, renewed in July 2016 and renewed again in October 2020), the Port and Harbor Department has been conducting workshops to formulate national standards for ports in Vietnam in cooperation with the country's research institutes, etc. So far, seven parts of the Vietnamese National Port Standards (General Provisions, Loads and Actions, Material Conditions, Foundations, Ground Improvement, and Mooring Facilities in the Design Standards, Construction and Inspection Standards, and Maintenance Standards) have been officially issued by the Vietnamese Ministry of Science and Technology.

Photo 2: Japan-Vietnam Technical Workshop

In FY2021, based on the renewed MOU, the Port and Harbor Department held a total of four web workshops in Japan and Vietnam for two standards out of the design standards, i.e., Breakwaters, and Dredging and Reclamation (**Photo 2**), and both countries jointly edited the draft of the Vietnamese National Port Standards.

2.4 Activities concerning ISO

The Research Center for Infrastructure Management participated in meetings on information exchange at construction sites, and discussed and reported online on the establishment of a new standard, Part 4 (construction site topography) of the Standard for Information Exchange between Equipment at Construction Sites (ISO 15143) (TC127). In addition, the Building Department discussed international standards for fire resistance test methods for hydrocarbon fires at an online meeting (TC92). The Water Quality Control Department participated in the annual meeting on water, wastewater and rainwater management and in online meetings as a member of the WG on Climate Change (TC224/WG16).

2.5 Cooperation in JICA projects and training

The NILIM accepts trainees from overseas in response to JICA requests, and conducts lectures at its institutes and tours of its test facilities every year. The following training sessions were conducted in online formats this year as well.

- **(1)** Project management in social infrastructure development (Research Center for Infrastructure Management) [5 trainees]
- **(2)** Dam safety management (River Department) [9 trainees]
- **(3)** Port development and planning (for port engineers) (Administrative Coordination Department) [15 trainees].
- **(4)** Port maintenance planning (Administrative Coordination Department) [14 trainees]

☞See the following for details.

1) NILIM Website (regarding the Japan-Vietnam Agreement)
http://www.nilim.go.jp/lab/beg/foreign/kokusai/viet_nam.htm
2) NILIM Website (regarding the Japan-Germany Agreement)
http://www.nilim.go.jp/lab/beg/foreign/kokusai/germany.htm