Towards a Future-Oriented NILIM

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1. Introduction

NILIM's guidelines for research were defined in 2017. NILIM's stated mission is "As the only national research organization in the social infrastructure/housing field, our goal is to use technology as the driving force to create an attractive country and society that are safer, more secure, and more vigorous, both now and in the future." In addition, our basic stance is shown as being to:

○ participate in policy development of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) as a technical specialist taking into account the administrative perspective among other aspects;

○ return advanced, comprehensive technical capabilities cultivated by research activities to practical work fields; and

○ connect to the creation of new policy by insight into the future image of national land/society and promotion of technology development.

Public works-related facilities are extremely large in scale and are often exposed to harsh outdoor environments, and they are expected to be used over a long period with as little maintenance as possible. They are also characterized by the difficulty in obtaining accurate information about the environment surrounding them and the state of the interior of the structures themselves. Amid these circumstances, NILIM has accumulated specialized and technical knowledge in the fields of housing and social infrastructure from its research activities to date and its experience based on actual case examples on the ground, among other sources. We have made every effort to resolve the issues brought to us from work sites and other places by making use of this knowledge. Moreover, I feel that one of NILIM's greatest strengths is having a comprehensive scope that enables specialists from a wide range of fields to propose solutions in response to the various issues in each region.

2. Towards future research

What should NILIM do to continue fulfilling the mission set out in the basic guidelines?

1) Efforts for new technology and findings

The first is coordination with new technology and findings. In addition to the technical knowledge in the fields of housing and social infrastructure that each research department has accumulated, it is also possible to greatly evolve this technical knowledge by working on new technology and findings. An example is ETC 2.0. By using this with ICT technology to obtain volumes of automobile probe data (travel history and behavior history data) and analyze

it, we are now able to analyze individual congestion and traffic accident locations at the micro level. A number of research projects using this probe data are currently in progress. However, the ETC 2.0 service only began about ten years ago. The development stage preceding that took many years. For NILIM, it is very important that we are currently working on new technology and findings and searching for ways to improve each of the fields.

It hardly needs to be mentioned, but ICT technology has been progressing and spreading at a dizzying pace. The cameras and sensors installed in satellites, airplanes, and drones make it possible to collect information efficiently and with a level of detail that could not be obtained previously. In addition, there are also ICT technologies involved in AI analysis, growth in the amount of data that can be shared, and the spread of VR and other interface technologies, to name but a few. Collaborating with companies and universities that are active in these areas will enable much of the research we have been conducting to evolve in leaps and bounds. What is important here is to understand the strengths of new ICT technologies, while having a concrete, detailed understanding of where they can be applied in the existing fields of housing and social infrastructure and what required capabilities are demanded of the ICT technologies when doing so. I believe this is essential in the digital transformation of the housing and social infrastructure field.

Besides ICT technologies, it is also possible to coordinate with new materials, biotechnology, and the like. As a body that conducts comprehensive research in the housing and social infrastructure fields, NILIM expects that research will be produced to increase their abilities and potential.

2) Handling challenges

The second is conducting research leading to the resolution of current and future challenges. For example, (1) global warming and carbon neutrality, (2) deterioration of structures, (3) national resilience, and (4) increasing productivity across the entire construction industry are some of the major challenges that MLIT as a whole will have to work on over the long term. I would like each research department to set more specific research topics and targets and continue working on them.

In relation to (1), materials from the 32nd meeting of the Technology Subcommittee of the Council for Infrastructure claim that two-thirds of the CO_2 emitted in Japan relates to the housing and social infrastructure field.
I believe that there are still topics remaining that we can investigate to reduce CO_2 emissions in this field.

Recently, as energy supply and demand are under pressure due to Russia's invasion of Ukraine and other factors, efforts towards carbon neutrality and the like may have slowed down somewhat. However, given that global warming itself is still fundamentally unresolved, measures to counteract it will still be examined long into the future.

The Task Force on Climate-Related Financial Disclosures (TCFD) has recommended that companies and others disclose indicators, targets, and other information on risks related to climate change. Not having this will make it more difficult to procure funding internationally. Given such trends, the number of examples of companies conducting leading-

edge technical development relating to carbon neutrality is increasing. Whether we can coordinate with the movements of these private companies to expand our research leading to policies promoting carbon neutrality, from raw material procurement to maintenance, in such fields as housing and social infrastructure will be a challenge. It is a serious challenge, but I suggest it is also a venue where we can demonstrate NILIM's comprehensive and specialized abilities.

I have used global warming and carbon neutrality as examples, but there are also mountains of other challenges. I hope to remain sensitive and find challenges to think of research topics.

3. Conclusion

What I have written above is entirely obvious, but I have noted it to show an attitude requiring research that is not merely an extension (to a small degree) of past research.

We must set our sights high, take a wide view encompassing movements on work sites and in universities and companies, and turn our antennas towards challenges and examples of efforts, new technologies, and findings in other fields as well. Producing results often takes time, but I hope to continue NILIM's strenuous efforts.

☞See here for detailed information

1) NILIM website: NILIM's guidelines for research
http://www.nilim.go.jp/lab/bcg/busyoukai/kenkyuhoushin/00index.htm

2) Ministry of the Economy, Trade and Industry website: Basic Guidelines toward Achieving GX: Roadmap Looking Over the Next Ten Years
https://www.meti.go.jp/press/2022/02/20230210002/20230210002_1.pdf

3) MLIT website: Materials from the 32nd meeting of the Technology Subcommittee of the Council for Infrastructure, handout 3, p. 44
https://www.mlit.go.jp/policy/shingikai/content/001587784.pdf

Enhancing River Management Facility Maintenance and Management Efficiency through New Technologies including AI

River Department

In recent years, river management facilities owned by national and local governments have been aging. Malfunctions in these facilities could lead to severe consequences in the event of a disaster. Additionally, there has been a significant decrease in the number of inspection technicians. To tackle these urgent challenges, we are conducting research to develop streamlined inspection and evaluation methods for river management facilities, aiming to achieve labor savings.

Social background and challenges

- Because of a declining population, there is a shortage of skilled workers, and the transfer of expertise from experienced technicians has become a pressing issue.
- Meanwhile, advancements in digital technology have simplified the acquisition of image data and three-dimensional point cloud data. Additionally, data analysis through artificial intelligence (AI) and other methods has become more accessible.
- Thus, to ensure the sustainable maintenance and management of river management facilities, we explore ways to incorporate these new technologies in inspecting river levees.

Details of Research

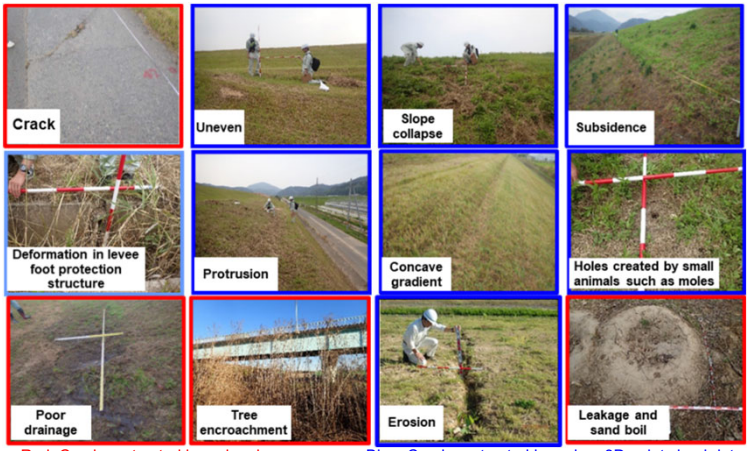
Development of technology for automatic deformation extraction, covering 12 inspection items for river levees (earthen levees)

We developed an AI-based technology capable of automatically detecting 12 types of deformations in levees as specified in the *Guidelines for Assessing Inspection Results of River Management Facilities, Including Levees**.

Based on specific characteristics of deformations that occur in earthen levees, we aimed to automatically identify 8 types of deformations, utilizing 3D point cloud data, and 4 types of deformations through image analysis.

* April 2019, River Environment Division, Water and Disaster Management Bureau, Ministry of Land, Infrastructure and Transport

Traditional approaches to extracting deformations from 3D point cloud data involve time-consuming processes such as converting the data into images and data thinning. Moreover, direct use of 3D point cloud data was not possible, leading to decreased data accuracy. This time, we have developed a technology that directly extracts deformations from 3D point cloud data using AI. This represents the first case of such technology in Japan's river management sector, allowing us to overcome the challenges discussed above.

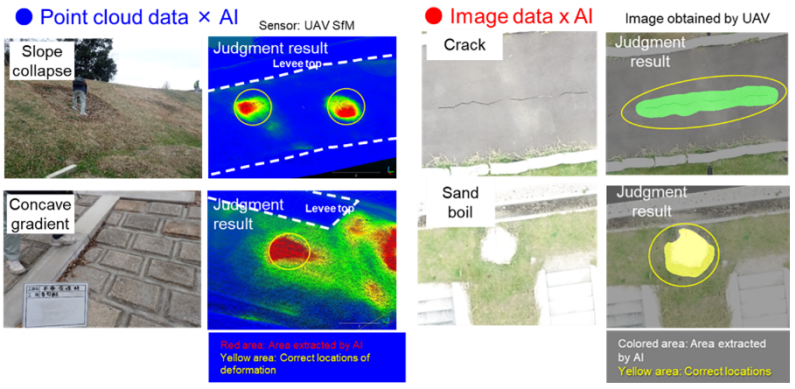


Levee deformations subject to automatic deformation extraction

On-site demonstration of automatic deformation extraction technology

During the weeding work, we captured images of deformations and simultaneously obtained 3D point cloud data using a UAV-based aerial photogrammetry survey. Subsequently, we discovered that our AI-based automatic deformation extraction method could efficiently identify all deformations. This method will enhance the efficiency of identifying deformations in levee inspections, a process that has traditionally been time-consuming and labor-intensive.

In the future, we plan to collect a large volume of deformation measurement data from real levees. This data will enhance the accuracy of automatic deformation extraction, enabling us to further our study for practical application in actual levee management.



Example of field demonstration of automatic deformation extraction

Contribute to the sustainable development and management of the infrastructure, even in the face of a declining population

☞Relevant articles
- Initiative to increase the efficiency of levee inspections utilizing new technologies, including AI (p. 48)

Probability Estimation of Radar Analytical Rainfall Products based on L-Moments method in the field of Sediment Disaster Area

Sabo Department

The Sabo Department is conducting research aimed at identifying statistical trends in rainfall indicators, which serve as fundamental data for the provision of sediment disaster warning information. Our study's objective is to disseminate highly reliable warnings for sediment disasters, particularly when there is an imminent risk of rainfall-induced sediment disasters.

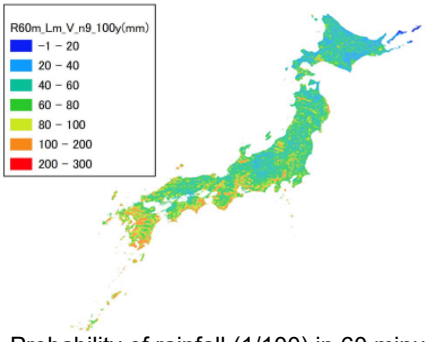
Social background and challenges

The sediment disaster warning information system is in operation to determine the risk level of sediment disasters based on rainfall indicators. Its objective is to alert individuals to the imminent threat of rainfall-induced sediment disasters and encourage timely evacuation. The analytical rainfall data employed in the sediment disaster warning information has the advantage of comprehensive national coverage. However, it suffers the drawback that the sample size is limited because the calculation method is improved drastically every ten years, making the data unsuitable for statistical processing. This has raised concerns about the reliability of the sediment disaster warning information system, given its reliance on analytical rainfall data for decision-making.

Detail of Research

Calculation of probable rainfall using the L-moments method

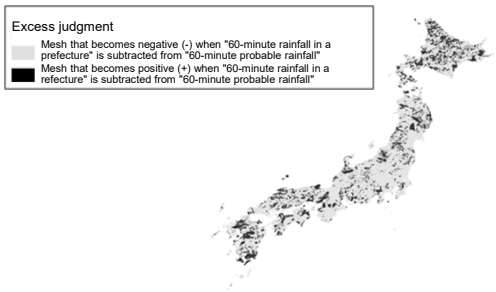
In a frequency analysis aimed at establishing the probability of rainfall for a recurrence interval, such as once in 100 years (1/100) or once in 50 years, an appropriate probability distribution type is chosen based on the accumulation of observational data spanning several decades. In recent years, the quality of analytical rainfall data used in sediment disaster warning information has been consistent since 2006 when the mesh size was standardized to 1 km, the update interval was set to 30 minutes, and data have been accumulated accordingly. Therefore, we employed a statistical method, specifically the L-moments method, to assess reliable rainfall probability and probability distribution models for the analytical rainfall data. This method is capable of mitigating the impacts of data variability and bias.



Probability of rainfall (1/100) in 60 minutes obtained using L-moments method

Can probable rainfall be applied to design rainfall?

Design rainfall intensity is employed in the planning and design of erosion control facilities, aiming to mitigate the risk of sediment disasters. The existing design rainfall intensity fails to account for shifts in rainfall patterns, such as the rise in short-duration intense rainfall, attributable to recent climate change. Hence, achieving more efficient and effective planning and design of erosion control facilities is possible by incorporating reliable rainfall probability. Currently, there is still some variation in the reliability of estimating rainfall probability using this method. However, as more analytical rainfall data accumulate and a certain level of reliability is assured in the future, it will become possible to verify the target maintenance level of erosion control facilities in specific regions using analytical rainfall-based probability values.



Mesh whose probable rainfall obtained by the L-moments method exceeds the design rainfall intensity (1/100, 60-minute rainfall)

Use of reliable rainfall indicators enhances the effectiveness of both structural and non-structural measures in controlling sediment disasters.

☞Relevant articles

- NILIM Reference No. 1222: Probability Estimation of Radar Analytical Rainfall Products based on L-Moments method in the field of Sediment Disaster Area

Support from Road Side Aimed at Realizing and Expanding Automated Driving

Road Traffic Department

Automated driving is expected to bring safer and smoother road traffic and contribute to the advanced use of road networks through the reduction of traffic accidents, traffic jams, and environmental impacts. We are proceeding with the research to contribute to supporting automated driving through the information provision from the road side with the aim of realizing and expanding automated driving.

Social background and issues

- The government goal has been set as "level 4* automated driving on expressways for private owned vehicle" by 2025.
  *: Completely automated driving under specific conditions (no driver takeover)
- The development of autonomous vehicle control technology, which is operated to accelerate, decelerate, keep a lane, etc., based on information detected by on-board sensor is progressing. On the other hand, the information detection by on-board sensor has some limits, and as a result, there are various situations in which the automated driving cannot be continued.
- Joint research and development with automobile and electronic equipment manufacturers etc. have been conducted to support automated driving from the road side.

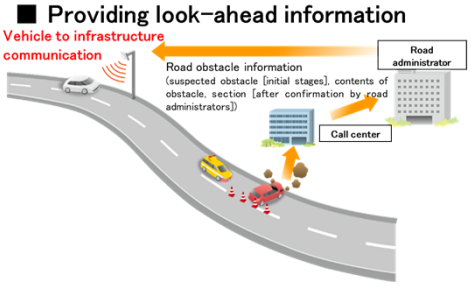
Research content

Research and development on automated driving support through cooperative ITS

Cooperative ITS aims to enable road administrators and automobile manufacturers to share information with each other by mutual communication to realize better road traffic.

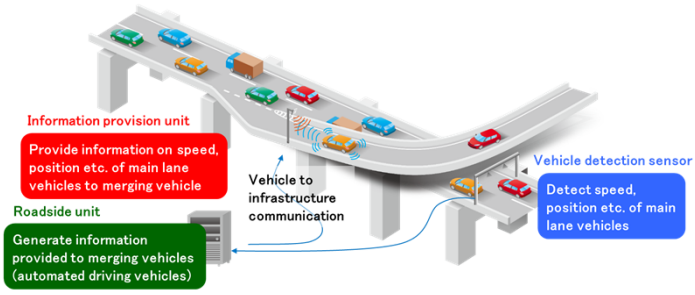
The content of information provided from the road side is considered and the effect of information provision is verified to realize smooth automated driving through cooperative ITS in situations where the automated driving cannot be continued with the information by the vehicle alone.

■ **Providing look-ahead information**



Grasp and provide the information on lane regulations, obstacles, etc. and support early lane changes, etc.

■ **Providing merging support information**

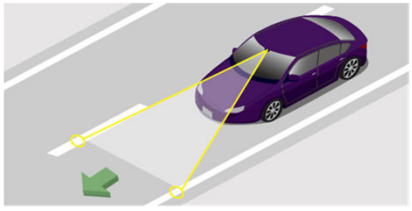


Provide the position, speed, etc. of main lane vehicles to merging vehicles and support merging into main lane safely and smoothly

Research and development on support for localizing vehicle

Automated driving vehicles identify their own position in the cross-road direction through on-board sensors, and travel in the center of the lane safely and smoothly.

To support continuing automated driving from the road side, the draft of requirements for lane markings are made and the field operational test are conducted to understand the faint level of lane marking where lane keeping assist can operate.



Support from road side for controlling automated driving vehicles appropriately
Realizing safer and smoother road traffic through automating mobility services/logistics services and labor-saving of them

☞See here for related articles
・Initiatives Aimed at Realizing Automated Driving on Expressways (p. 76)

Rapid Technical Support for Disasters and Faults

Road Structures Department

In the event of road structure loss of function due to disasters and faults, we rapidly dispatch employees and provide technical support for emergency measures and recovery efforts. Here we present examples of employee dispatch to torrential rain damage in FY2022 and examples of major responses to road structure damage due to the earthquake off the coast of Fukushima in March 2022, as examples of major responses.

Social background and issues

- In addition to earthquakes, damage has been frequently occurring due to torrential rain, and steadily inspecting aging road structures, implementing necessary measures, and taking other steps to ensure the health of the road network is a key issue.
- Due to the importance of securing the functions of the road network, rapid response reflecting the latest knowledge is essential when providing technical advice on a range of issues from the design of road structures to the management stage and providing technical support for damage and faults.
- Sharing technical information and knowledge rapidly is becoming more and more important in reducing faults and improving disaster responses throughout Japan.

Response state

State of responses in FY2022

In FY2022 again, disasters that severed the road network, such as bridge and road collapses, occurred in relation to earthquakes and heavy rain as shown by the examples in the table to the right, and we have cooperated with the Public Works Research Institute, Road Maintenance Centers in Regional Development Bureaus, and others on request to provide technical information and dispatch employees for technical support for emergency responses immediately after disasters occur, surveys to investigate the cause of damage, and evaluations for recovery, among others.

Many examples of disasters in recent years are due to the damaged structures being based on old standards or technologies or include deterioration or damage accompanying old age, and we provide technical advice that reflects technical standards and deterioration countermeasures from the national government.

Examples of major responses to requests for employee dispatch

Case example	Main disaster and dispatch locations	Main damage	Requesting party
Earthquake off Fukushima coast (March)	Kakuda, Miyagi (Edano Bridge); Fukushima (Date Bridge)	Damage to bridge shoes and substructures	Kakuda, Miyagi; Fukushima
Bridge, etc. damage due to heavy rain (July)	Maruyama Bridge, Kubokawara Route (municipal road) Maeda Bridge, Maebayashi Route (municipal road) (Ōsaki, Miyazaki)	Bridge collapse due to pier collapse Washout of approach section at back of abutments	Tohoku Regional Development Bureau
Bridge, etc. damage due to heavy rain (August)	Road collapse and washout, National Highway 121 (Yonezawa, Yamagata)	Collapse of a natural slope directly under a retaining wall	Yamagata Prefecture
Damage due to Typhoon No. 14 (September)	Road collapse, National Highway 327 (Morotsuka, Higashi-usuki, Miyazaki)	Road collapse	Miyazaki Prefecture
	Kuma Ōhashi, National Highway 262 (Nishiki, Kuma, Kumamoto)	Sinking of substructure in river	Kumamoto Prefecture

Example of response to road structure damage due to the earthquake off the coast of Fukushima in March 2022

● Edano Bridge, Kakuda Municipal Road (Kakuda, Miyagi)

After an earthquake, we dispatched employees on request from Kakuda City. Concrete in three reinforced concrete bridge piers had peeled and cracked horizontally, and the side blocks had broken or deformed in eight locations on the shoes, and we provided technical support in relation to assessments of structural safety, and investigations and examination of recovery methods aimed at prompt opening to traffic.

With our technical support, stopgap measures necessary for traffic were implemented and the route was reopened to traffic on June 30. Traffic restriction criteria until recovery was completed were formulated and a system to respond to aftershocks was developed.

On-site investigation of Edano Bridge

● Date Bridge, National Highway 399 (Date, Fukushima)

After an earthquake, we dispatched employees on request from Fukushima Prefecture. The expansion device was broken and the shoes and substructure were damaged, and we provided technical support in relation to detailed surveys and recovery guidelines. We are providing ongoing technical support in relation to superstructure deformation that was discovered in the detailed surveys.

With our technical support, recovery guidelines were announced in August, including replacement of the superstructure and reinforcement of the substructure. Ensured passage of traffic with a temporary bridge as the recovery works will take considerable time.

On-site investigation of Date Bridge and meeting with managers

Minimizing social effects from disasters and faults through rapid and appropriate technical support

☞See here for related articles
・ Analysis of the Impact on Traffic Functions of Scouring of Road Earthwork Structures and Slope Collapses, Etc. Due to Torrential Rain (p. 59)
・ Research to Gain Understanding of the Sense of Scale of Structure Damage Directly after Earthquakes (p. 61)

For Proactively Preventing Housing Abandonment

Housing Department

As the number of vacant houses increases, it is important not to increase the number of "dilapidated" vacant houses.
Therefore, we are conducting research to quantitatively show that there are cases in which it is more "beneficial" to "properly manage" vacant houses than to "not manage" them, and to promote proactive preventive measures.

Social background and challenges

- The number of vacant houses is increasing under the declining population, and there is a concern about the increase of "dilapidated vacant houses."
- Manpower is insufficient for "after-the-fact" response after becoming dilapidated.
  It is necessary to strengthen measures to prevent housing abandonment.
- There are 2 problems to be solved for promoting preventive measures. One is for owners, to present specific management actions to appropriately management. The other is for municipalities, to present quantitative demonstration of the expected effects of promoting preventive measures by municipalities.

Research contents

Consideration of minimum-required management levels for Preventing Housing Abandonment.

We organized the contents of management to maintain generally problem-free conditions by surveying and analyzing the contents of vacant houses by owners (management actions, frequency, cost, etc.) and the physical condition of vacant houses (situation of dilapidation, years since construction, surrounding environment, etc.).

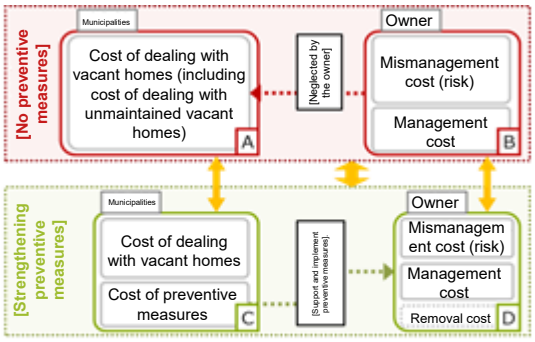
It is expected to be used as a reference for specific management by owners when trying to preventing housing abandonment.

Image of minimum-required management level

Development of a quantitative method to estimate the effects of measures for preventing housing abandonment.

For municipalities and owners of vacant houses, we developed a tool to quantitatively evaluate the effects of preventive measures.

This tool is intended to enable municipalities to consider specific measures for more efficient implementation of vacant house countermeasures, and owners to consider specific management details for appropriate management and utilization of their housing stock.
Case studies using the tool showed followings:
For municipalities, it is more advantageous to implement preventive measures. For owners, it is better to appropriately manage or remove vacant houses depending on its use plan.



Comparative image of costs, etc. according to whether or not there are preventive measures

By promoting the proper management, utilization, and removal of vacant houses, promote the prevention of mismanagement of vacant houses and contribute to a more comfortable living environment.

☞ See the following for related articles.
- Research on the quantification of the cost of management and countermeasures for vacant houses and effects (p. 109)

Development of technology to improve the mobility environment in suburban residential areas using "new mobility"

Urban Planning Department

We are conducting research on the restructuring and improvement of suburban areas based on suburban residential areas.
We aim to develop technologies for the revitalization of suburban residential areas through research on the complexification of facilities for convenient living and the introduction of sustainable transportation service that utilizes new mobility.

Social background and challenges

- Suburban residential areas that were planned and developed after the high-growth period are becoming old towns over time, and their residents have increasingly difficulty in moving around independently due to aging, etc.
- For sustainable urban development, it is essential to revitalize suburban residential areas as regional base and to restructure suburban areas and improve their nature as regional base.
- The issue is to improve and secure transportation services, which is one of the keys for solutions in revitalization of suburban residential areas.

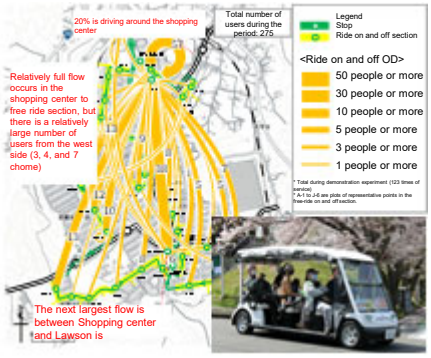
Research contents

Implementation of social experiments using Green Slow Mobility

In cooperation with local NPOs and local residents, we conducted a multi-year social experiment in three suburban residential areas near the Tokyo metropolitan area, and implemented interviews with local governments and transportation operators, as well as questionnaire surveys to local residents and users.
Based on these, we are working to analyze and accumulate knowledge for social implementation.

<Perspectives to be clarified for the realization of sustainable transportation service>
○ Service level ○ Effect of introduction ○ Operation method ○ Safety standard

[What is Green Slow Mobility?]
- A generic term for small mobility services including vehicles that utilize electrically powered vehicles capable of traveling on public roads at the speed of less than 20 kilometers per hour.
- Commonly called "Grislo," it has five characteristics: "electric," "small," "lightweight," "low speed," and "safe."

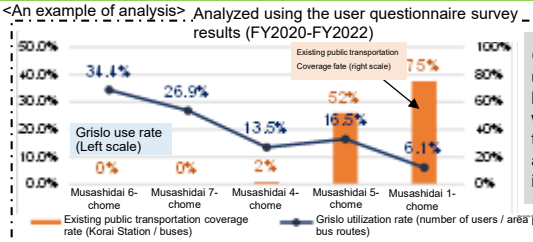


Social experiment (Koma-Musashidai, Hidaka City, Saitama Pref.)

Analysis for social implementation of Green Slow mobility

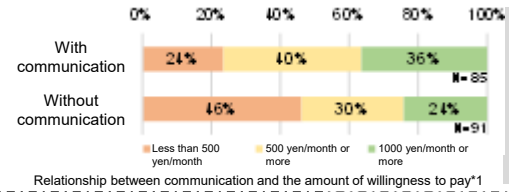
- We identified new ways to introduce mobility according to regional characteristics by advancing analysis from various perspectives, such as the relationship between user attributes and user satisfaction, using ride on and off data (number of users, OD, etc.), data from drive recorders and sensors, and results of questionnaires, etc.
- We obtained know-how for social implementation, including points of attention in discussing with related organizations, how to build consensus, and the process up to introduction.
- The results of the research will be compiled into a guide, guidelines, etc., and will be fed back to public organizations nationwide as information for social implementation.

<An example of analysis> Analyzed using the user questionnaire survey results (FY2020-FY2022)



Relationship between the rates of existing public transportation coverage and Green Slow utilization

○ The rate of Grislo use tends to be higher in areas where existing public transportation, such as buses, is inconvenient.



Relationship between communication and the amount of willingness to pay*1

○ Users who experience communication in the vehicle tend to have a higher willingness to pay the fare.

*1 In the case of future social implementation

By maintaining and revitalizing suburban residential areas through improved mobility, ensure sustainable regional bases and contribute to the formation of an intensive urban structure.

☞ See the following for related articles.
- Development of a method for grasping and estimating traffic flow using big data on urban traffic, etc. (p. 113)
- Research on urban functions and public spaces based on new lifestyles (p. 115)

Research Policy and Management at the NILIM

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

(Keywords) The NILIM research policy, management policy, the Ministry of Land, Infrastructure and Transport Basic Plan on Technology

<Research policy of the entire NILIM and management policies of individual departments>

The NILIM has a document titled Research Policy.[1] This policy comprises five key components: the mission, basic stance, activities forming the basis, research attitude, and the development of a supportive research environment. The entire document is available on the NILIM website for reference. Some excerpts are shown in the right column. The NILIM Research Policy, established in 2017, remains in effect and is not updated annually. Certainly, it is not applicable universally, but the research policy will be continually verified over time as circumstances evolve (though this may sound a bit of an exaggeration). This Research Policy serves as the foundation, streamlining essential perspectives common to various activities we engage in at the NILIM. It can guide our activities like a compass. The words and phrases in the Policy might be challenging for individual staff members to grasp. However, because of its significance, the Policy is consistently emphasized at the NILIM. For instance, we spend sufficient time to explain its concepts during briefings for newly hired and transferred staff members.

Every aspect outlined in the Research Policy holds significance. However, as an organization engaged in diverse research activities, we consider *research and development that support the planning, drafting, and spreading policy for land, infrastructure, transport, and tourism* to be the most crucial concept of all. This Research Policy does not provide specific guidelines for individual research projects, topics, or themes. The NILIM operates diverse research departments, each focusing on various fields. The Management Policy is updated yearly, outlining specific research themes that align with developments in individual fields. During the internal review meeting known as the Research Plan Review Meeting, the entire NILIM team collaborates to discuss and finalize the Management Policy. This policy outlines the mission of research departments, trends and future prospects related to specific fields in land and society, and implementation policies for emphasized research and activities. You can find these documents on the NILIM website. They are located on the Research Policy page[1] as well as on the main page of each research department.[2] Please take a moment to review them.

NILIM research policy[1)] (excerpt)

<Mission>
Being the only national research institute focusing on housing and social infrastructure, the NILIM strives to utilize technology as a driving force to create a safe, secure, dynamic, and appealing land and society both now and in the future.
<Basic stance>
○ Participate in the policy development of the Ministry of Land, Infrastructure, Transport and Tourism as a technical specialist taking into account the administrative perspective among other aspects.
○ Apply the advanced and comprehensive technical capabilities cultivated through research activities to the actual field of work.
○ Connect to the creation of a new policy using insight into the future image of national land/society and through the promotion of technology development.
<Activities Forming the Basis>
○ Research and development that support the planning, drafting, and spreading policy for land, infrastructure, transport, and tourism.
○ Support advanced technology to respond to natural disasters and accidents and sophisticate responding technologies.
○ Support the improvement of on-site technical capacity at Regional Development Bureaus and other facilities.
○ Gather, analyze, and manage data to develop the technical foundation for formulating policies and the utilization of the information for society.
<Attitude toward Research>
○ Understand the real needs of the government and the field and clarify the essential technical issues.
○ Formulate a research plan that includes hypotheses and verification methods to overcome challenges and a path to social application.
○ Review plans flexibly with an eye to the overall development of the research based on the facts obtained.
○ Systematically compile findings and evolve them into results that can be utilized in the field.
○ Establish a strategic path for the appropriate and smooth social application of research outcomes.
○ Follow up on the results of social applications, identify technical issues, and reflect them in the future research.
<Development of a Supportive Research Environment>
○ Develop management system to support high-quality research
○ Train human resources who have technological background and the ability to observe policy development from the perspectives of both researchers and administrator/on-site workers.
○ Own and reinforce the function of experimental facilities to support the research and development in the field of housing and social capital.

When formulating research management policies based on social trends and future prospects, it is crucial to understand not only the plans and policies of the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT)—such as the Priority Plan for Social Infrastructure Development, the DX Action Plan in the Infrastructure Field, and the MLIT Green Challenge—but also national plans and policies associated with MLIT administration as a whole, such as the Basic Plan for National Land Resilience. Furthermore, it is essential to consider information gathered from activities within Japanese and international academic societies, as well as policies from countries outside Japan. We believe that examining information from various perspectives will not only facilitate research that supports current MLIT policies but also drive technological advancements, leading to policy planning and formulation in the future.

<Ministry of Land, Infrastructure, Transport and Tourism's Basic Plan on Technology and the activities of the NILIM>

As mentioned earlier, one of the plans formulated by MLIT is the MLIT Basic Plan[3] on Technology, currently in its fifth period spanning from FY 2022 to 2026, hereafter referred to as "the Basic Plan on Technology." This plan might be less familiar to the general public in comparison to better-known plans like the Priority Plan for Social Infrastructure Development. However, it specifically targets research institutions like the NILIM that are engaged in technological development. The Basic Plan on Technology outlines the fundamental direction of technology policies. It is based on the national government's Basic Plan on Science, Technology, and Innovation, as well as the Priority Plan for Social Infrastructure Development and the Basic Plan on Traffic Policy, which collectively cover land and transportation administration. This document defines crucial initiatives for promoting research and development in technology (*), the efficient utilization of technology, and the training of individuals who support technology policies (the framework for promoting technology policies). Even though the plan spans five years, it also envisions a society to be achieved from a long-term standpoint (20 to 30 years into the future) as a prerequisite for formulation of the plan.

* The plan focuses on six key areas for technological research and development:

1. Creating societies where disaster preparedness and mitigation are prioritized
2. Ensuring sustainable infrastructure maintenance
3. Building sustainable and livable local communities
4. Developing infrastructure to support a healthy economic cycle
5. Promoting digital transformation (DX)
6. Enhancing the quality of life through decarbonization and versatile use of infrastructure and space

The NILIM has consistently been responsible for conducting research and development in collaboration with different divisions of the MLIT in support of their policies. Moreover, the NILIM will not only assess and reaffirm the ongoing research but also play a pivotal role as the "foundation" in organizing and evaluating research directions and activities, both in the medium and long term, including the future.

The Framework for Promoting Technology Policy outlines strategies for infrastructure development, international engagement, and human resource development to foster sustainable economic growth. It highlights key priorities, such as *open innovation, interdisciplinary approaches, industry-academia-government collaboration*, and the *promotion of open data*. Additionally, the Framework emphasizes the crucial role of research institute facilities and equipment, indicating the need for effective and systematic repairs, maintenance, updates, and enhancement to ensure that they fulfill their vital functions and roles effectively. The Research Policy (full text)[1] outlines the involvement in these aspects, and the NILIM is actively working on these areas too. The NILIM is collaborating with external organizations using diverse mechanisms[4] to drive technological development. For details on the outcomes of joint research and other activities from the last fiscal year, please refer to the article titled “Technical Collaboration”[5] in this report. Concerning facilities and equipment, we are not just

maintaining them; we are also enhancing and remodeling them to align with future research directions.[6] As discussed thus far, the Basic Plan on Technology serves as a crucial foundation as the cornerstone for validating the NILIM's overall research policy.

We have discussed the Basic Plan on Technology in this document. We remain dedicated to advancing *research and development that support the planning, drafting, and spreading policy for land, infrastructure, transport, and tourism*. To achieve this, we continuously monitor plans and policies of the MLIT and national policies, ensuring our research and management policies align with these trends. Our research activities are then implemented accordingly.

The 2022 NILIM lecture, titled "Responding to Climate Change - The NILIM's Approach to the MLIT Green Challenge," provided an overview of ongoing research in this field and outlined future directions. Lecture materials and videos can be accessed on the lecture webpage[7] and the NILIM YouTube channel.[8]

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1) NILIM Research Policy
http://www.nilim.go.jp/lab/bcg/busyoukai/kenkyuhoushin/00index.htm

2) The webpage of the River Department on the NILIM website, for example
http://www.nilim.go.jp/japanese/organization/river/jriver.htm

3) The Fifth MLIT Basic Plan on Technology
https://www.mlit.go.jp/report/press/kanbo08_hh_000891.html

4) Twenty-Year History of the NILIM, Promotion of Research in Collaboration with External Organizations (pp. 264-265)
http://www.nilim.go.jp/lab/bbg/20nenshi/index_20years.htm

5) Technical Cooperation pp.140-141 of this document

6) The NILIM Pamphlet 2022, Renewed Experimental Facility (p. 9)
http://www.nilim.go.jp/lab/bcg/siryou/k2022j.pdf

7) FY 2022 NILIM Lecture
http://www.nilim.go.jp/lab/bbg/kouenkai/kouenkai2022/koen2022.html

8) NILIM YouTube channel
https://www.youtube.com/@user-oq5ud7re1l

Study of Sewerage Systems for Climate Change Adaptation

SANNOMIYA Takeshi, Director , Water Quality Control Department

Keywords: Design rainfall, manhole cover safety measures, emergency recovery from disaster

1. Introduction

Climate change has resulted in a growing trend of more severe and frequent water-related disasters. The Working Group II report in the IPCC's Sixth Assessment warns that anthropogenic climate change is linked to a rise in both the frequency and intensity of extreme weather events. These events lead to extensive negative impacts, causing damage to both nature and humanity beyond what natural climate change would entail. In 2021, legislation (2021 Law No. 31) was passed to partially amend the Act on Countermeasures against Flood Damage of Specified Rivers Running Across Cities. The law, hereinafter referred to as "the Watershed Flood Preparedness Law," aims to enhance flood preparedness within watersheds by fostering collaboration among stakeholders to counteract the heightened risk of floods due to increased rainfall.

The Water Quality Control Department is conducting investigations and research of sewage systems designed to protect cities from flooding in response to recent legislative developments. This paper presents some of these investigations and research findings.

2. Study and research of flood control measures within urban areas.

2.1 Providing support for the development of mid- to long-term stormwater plans.

In the Watershed Flood Preparedness Law, the sewage work plan included a new section specifying the rainfall threshold, which serves as an indicator to initiate flood damage prevention activities. This threshold is hereinafter referred to as "design rainfall." The Comprehensive Stormwater Management Plan[1] outlines fundamental aspects of stormwater management, such as areas where flood control through sewage systems is necessary, targeted preparation standards, and a gradual facility construction policy. This plan also defines the design rainfall. To ensure consistency between the Comprehensive Stormwater Management Plan and the operation plan under Article 4 of the Sewerage Act (1958, Law number 79), we decided to incorporate the design rainfall into the operation plan (Figure 1).

The design rainfall, established to address climate change, was initially determined by multiplying the current design rainfall with region-specific rainfall change multipliers.[2] However, it is necessary to review the adequacy of the current design rainfall to avoid it being excessive or insufficient. To comprehensively understand the process of creating design rainfall in local governments, we investigated how they develop the design rainfall intensity formula and the rainfall data used in its creation. Most local governments followed the Sewage Facility Planning and Design Guideline, 2019 Edition, when creating the design rainfall intensity formula. However, a few of them used rainfall data from recent years to set the design rainfall. These data might have already been influenced by climate change. To calculate design rainfall, it is necessary to utilize rainfall data from a period that can be deemed regular.[1] Therefore, we intend to confirm that the rainfall data used are from a regular timeframe. Additionally, we plan to reevaluate the approach to designing sewage facilities to adapt to climate change.

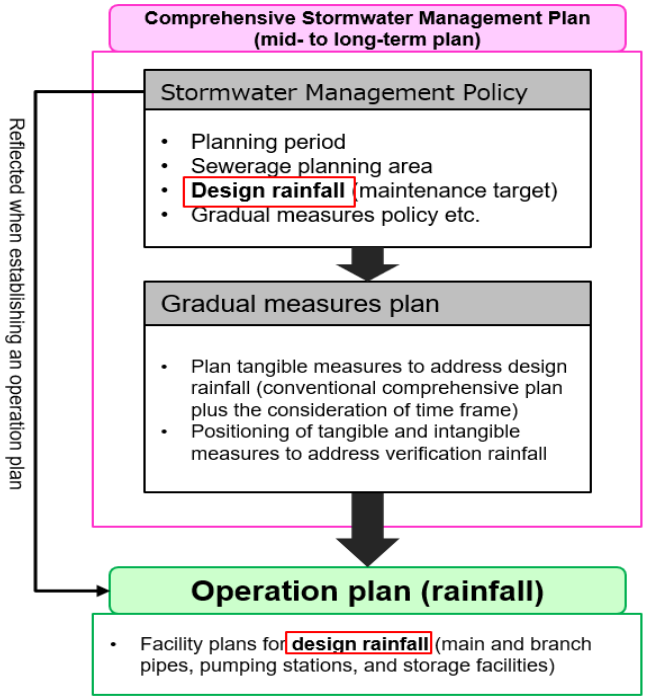

Figure 1. Relationship between the Comprehensive Stormwater Management Plan and the operation plan[1]

2.2 Study of safety measures for sewage pipeline manhole covers

Sewage pipe manhole covers frequently lift or break during heavy rainfall. These incidents pose risks to public health and road traffic safety. Even when a large amount of stormwater flows into sewage facilities, they must remain undamaged, and their functionality must be ensured. Hence, we examined how local governments are dealing with situations where sewage pipes were damaged during heavy rainfall. Our study also involved reviewing the existing literature, considering the aspects of structural mechanics, and conducting analyses using a runoff analysis model.

Through our investigation and study, we discovered that in areas with heavy traffic from large vehicles, manhole covers are prone to being pushed down too much into the receiving frame. To mitigate this, it is advisable to use next-generation pressure relief covers designed for easy internal pressure release or to employ lattice-type covers in these areas. Moreover, such factors as the spacing between manholes, the size of air holes on the covers, pipe diameter, and the amount of air sealed inside the pipes significantly impact the level of risk. Additionally, we developed a simplified risk level judgment chart (example) that quantifies the risk level of each manhole based on the estimated internal pressure in pipes in the event of manhole damage. Furthermore, we created a safety priority site matrix and a draft of the manhole cover safety examination flow.

The current draft of the sewage manhole safety guideline[3] does not fully account for the complexity of hydraulic phenomena during heavy rainfall or the quantitative risks arising from variations in local situations. We thus encourage local governments to use our investigation and research[4] as a reference for implementing prioritized safety measures and effectively preventing manhole damage.

3. Exploring emergency restoration methods for sewage treatment plants

We drafted the Approach to Sewage Discharge and Treatment During Disasters,[5] drawing from lessons learned from the Great East Japan Earthquake. In this draft, we outlined the process of selecting temporary treatment methods, defining target water quality, and specifying the timeline for achieving these targets during the emergency restoration stage after sewage treatment plants are damaged by earthquakes or tsunamis, causing a loss of functionality.

Typhoon Hagibis, which struck the eastern part of Japan in 2019, resulted in river flooding and inundation of sewage treatment plants at 17 locations. These treatment plants lost their functionality and were unable to process sewage. During the rainfall disaster, there was minimal damage to sewage pipelines and other civil structures. As a result, sewage continued to flow into the treatment plants from undamaged areas. Additionally, floodwater entered sewage treatment plants through sewage pipes. These characteristics differed from the damage typically faced

during earthquakes or tsunamis. Therefore, in collaboration with the Public Works Research Institute (PWRI), we proposed effective emergency restoration measures for sewage treatment plants damaged by flooding. We recommended methods to identify the factors hindering disinfection, implemented as an emergency measure, and suggested a method to monitor the generation of disinfection by-products, as well as efficient sewage treatment and disinfection methods along with emergency measures for early restoration. These emergency response strategies were developed through on-site inspections and testing at the Disaster Risk Management Experimental Facility located in the Ibaraki Prefecture Kasumigaura Sewage Treatment Center (Figure 2). We would like to reflect the findings in the draft Disaster Concept.

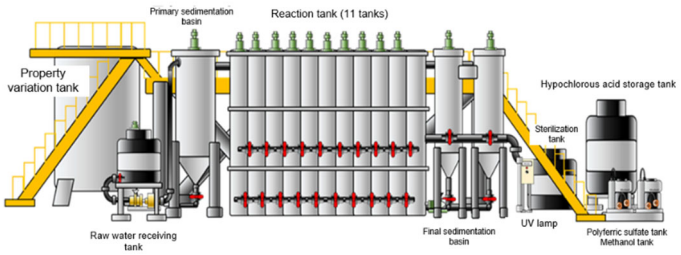

Figure 2. Disaster Risk Management Experimental Facility

(Normal water inflow: 24 m^3/day, Maximum water inflow: 48 m^3/day)

4. Conclusion (future activities etc.)

To ensure effective watershed flood control, it is crucial to develop infrastructure through initiatives like the Five-Year Plan to Accelerate Measures for National Resilience. Additionally, conducting an investigation and research to implement intangible measures effectively is also essential. The Water Quality Control Department has been working on predicting flooding using simulations and researching ICT/AI-based solutions as part of the Breakthrough by Dynamic Approach in Sewage High Technology Project Initiative.[6] We are committed to continuing our efforts in discovering effective ways to utilize new technologies. We will also proceed with our research in utilizing existing sewerage systems and evaluating the effectiveness of green infrastructures, such as stormwater infiltration facilities.

Local governments serve as sewage administrators, and their city size, financial resources, and technical capabilities can vary. Taking these factors into account and adopting a wide-area and comprehensive perspective as a nation, we aim to continue our research to support the planning, drafting, and implementation of sewage technical policies, contributing to the construction of a safe and resilient nation.

☞For more information:

1) Sewerage and Wastewater Management Department, Water and Disaster Management Bureau, Ministry of Land, Infrastructure and Transport: Comprehensive Stormwater Management Plan Establishment Guideline (draft). November 2021
2) Study Group on Urban Flooding Countermeasures in Light of Climate Change: Recommendation on the Promotion of Urban Flooding Preparedness with Sewerage Systems in Light of Climate Change. June 2020 (partially revised in April 2021)
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6) Breakthrough by Dynamic Approach in Sewage High Technology Project: http://www.nilim.go.jp/lab/ebg/b-dash.html

Started Development of Watershed Flood Control Digital Test Bed

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Keywords: Watershed flood control, digital test bed, public-private partnership

1. Introduction

To address the increasing frequency and severity of water-related disasters caused by climate change, many different stakeholders are collaborating to achieve watershed flood control and minimize these disasters across an entire basin. In implementing watershed flood control and fostering consensus among various stakeholders in a large region, it is crucial to have a clear visualization of flood control effects. Additionally, a robust system capable of promptly verifying and implementing the latest disaster control technologies from private businesses, universities, and research institutions is essential. To achieve this goal, the River Department of the NILIM has started the development of a watershed flood control digital test bed. This platform serves as a demonstration and testing platform, simulating a river basin in a virtual space. Its purpose is to expedite the implementation of watershed flood control measures.[1] We are planning to start its operation in FY 2025. Figure 1 illustrates a conceptual diagram of the digital testbed.

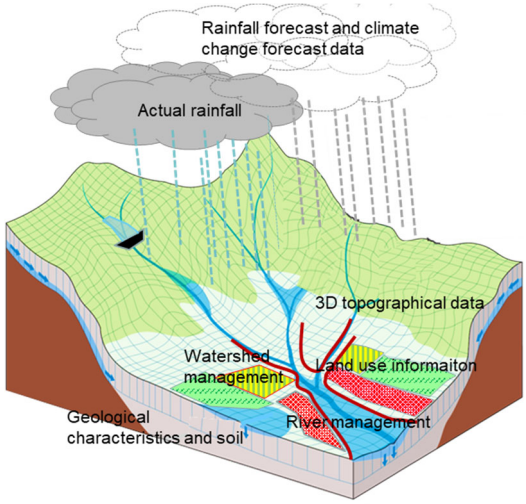

Figure 1. Conceptual diagram of the watershed flood control digital test bed

2. Purpose of developing the watershed flood control test bed

Watershed flood control necessitates several measures, such as utilizing reservoirs in catchment areas, creating rainwater storage and infiltration facilities, strengthening evacuation systems in flood-prone areas, and minimizing economic damage. Thus, it is crucial for stakeholders to establish consensus and develop a robust disaster preparedness structure.

Promoting watershed flood control in a large area like a first-class water system managed by the national government involves a wide range of many stakeholders. However, not all stakeholders have expertise in flood control due to their diverse and numerous backgrounds. To advance watershed flood control initiatives, it is crucial to clearly visualize water-related disaster risks and the benefits of flood control measures in an easily understandable way.

To ensure timely evacuation from flood damage, it is effective to establish a disaster preparedness system as early as possible, utilizing forecast information efficiently. To guarantee effective evacuation, the NILIM is currently developing forecasting technology to visualize flood risks.[2] However, the technology still requires further refinement and sophistication.

Hence, our focus in developing this digital test bed is on creating technology that visualizes the benefits of watershed flood control and the next-generation flood forecasting methods.

3. Utilization as a foundation for promoting public-private partnerships

In Japan’s technological development efforts,

technologies developed within Japanese institutions and existing seeds, including both technological advancements and data, have been combined. Additionally, in certain cases, collaborations with external R&D schemes, facilitated through programs, such as the Cross-ministerial Strategic Innovation Promotion Program (SIP) and the Public/Private R&D Investment Strategic Expansion Program (PRISM), have been utilized to introduce external technologies.

At the stage when the watershed flood control digital test bed becomes operational, it will be accessible to private businesses, universities, and research institutes. The first goal is to collaborate in developing technologies that enable the visualization of the benefits of watershed flood control measures.

Using this test bed, we will compile a dataset containing openly available topographical and meteorological information specific to individual watersheds. This dataset will be used to present watershed flood control measures and their effects in a clear and easy-to-understand manner. In the future, we anticipate that private businesses, universities, and research institutes will utilize this dataset to develop technologies through demonstration experiments in virtual spaces. These technologies will then be compared and assessed for their practicality and usefulness to achieve their implementation in society (see Figure 2).

We aim to expedite the implementation of technologies in society by combining and utilizing government-owned technologies with the diverse technological expertise of private businesses, universities, and research institutes.

4. Development and operation of watershed flood control digital test bed

Figure 3 illustrates the three-stage structure of the watershed flood control system's development and operation, encompassing *basic data, analysis*, and *utilization*. It also introduces the concept of areas where these stages operate in collaboration, as well as competitive areas.

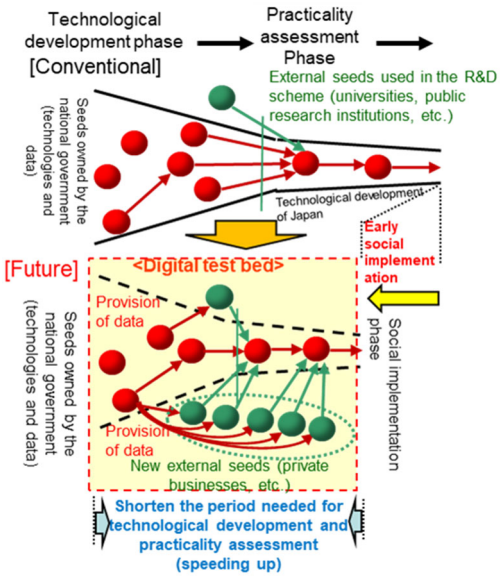

Figure 2. Accelerating technological development through public-private partnerships

In the initial stage, known as *basic data*, coordination is key. This phase primarily involves external data, such as three-dimensional topographical and geographic data, as well as rainfall data. The objective here is to create a watershed dataset for each first-class river system by coordinating and processing data from different open data sources. The national organization NILIM will play a central role in the system's development. The NILIM will conduct studies involving various entities and technologies to achieve *analysis* and facilitate *utilization*, including the visualization of risks and benefits.

In the second stage, *analysis*, private businesses, universities, and research institutes utilize their respective technologies, relying on the *basic data*. They collaborate or compete to develop hydraulic analysis and other technologies in this phase. When developing technology, it is crucial to consider the characteristics of each entity and the shared rights among them, particularly in competitive areas. Concerning public-private partnerships, we will carefully consider the approach needed to ensure that the technology becomes beneficial for social implementation.

In the third stage, *utilization*, we expect that the technology developed in the *analysis* stage will be employed for visualizing risks and the effects of countermeasures in the collaborative and competitive areas. The system is expected to be utilized by various entities, such as local governments responsible for disaster preparedness and community development, land and facility managers in the business sector, and companies aiming to develop business continuity plans or disclose climate change risks.

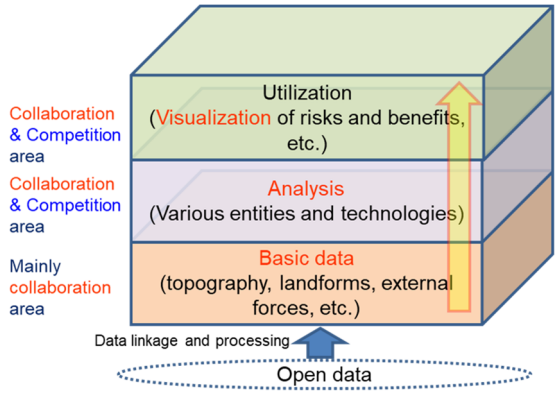

Figure 3. Development and operation of watershed flood control digital test bed

5. Conclusion

The advancement of digital technology will significantly expand the available information. Furthermore, technological advancements, including wide-area and high-frequency monitoring through satellites and artificial intelligence (AI), are progressing rapidly. We strive to fully incorporate these technologies to enhance watershed flood control efforts.

☞For more information:

1) Website of Water Cycle Division, NILIM

"Online Seminar on Watershed Flood Control Digital Test Bed Co-Creation"

http://www.nilim.go.jp/lab/feg/index.htm

2) FY 2022 NILIM Lecture Material: Visualizing Flood Risks to Adapt to Climate Change

http://www.nilim.go.jp/lab/bbg/kouenkai/kouenkai2022/kooen2022/pdf/siryou/2.pdf

"Efforts to Communicate"
- Toward Mutual Understanding between Residents and Administration -

TOMITA Yoko (Ph.D. in Agriculture), Director of the Sabo Department

(Keywords) The South Hyogo Prefecture Earthquake, town planning based on disaster preparedness, landslide disaster warning zone, information sharing and mutual understanding

1. Introduction

The South Hyogo Prefecture Earthquake on January 17, 1995, with a maximum intensity of 7 on the Japanese scale, led to the first comprehensive public disclosure of landslide hazard areas (a general term for areas susceptible to mudslides, landslides, and steep slope failures) in Japan. Landslide hazard areas had been identified across Japan by then. However, many of these areas had not been disclosed publicly because of concerns about their potential impact on the local reputation and property values.

The South Hyogo Prefecture Earthquake also marked the initiation of measures to prevent landslides in urban areas.

2. Landslide preparedness and community development through consensus of all stakeholders

2-1 Publication of landslide hazard map

The South Hyogo Prefecture Earthquake triggered multiple collapses on mountainsides in the Rokko Mountains. Helicopter surveys conducted immediately after the disaster, along with on-site inspections on the mountainsides by officials from construction bureaus and municipalities across Japan who arrived to provide support, confirmed over 700 collapsed areas. The Rokko Erosion Control Construction Office, part of the Kinki Regional Construction Bureau, began removing stones from existing erosion control weirs, installing steel frame weirs that could be quickly constructed, and implementing direct measures for collapsed slopes to prepare for the flood season. They also lowered the evacuation warning standard rainfall, taking into account ground loosening caused by the earthquake, in consultation with Hyogo Prefecture.

Given these conditions, the local governments at the foot of the mountain, having experienced multiple landslides due to rainfall in the past, opted to prioritize residents' safety by mapping and publicizing areas prone to landslides. First, they published a map in a local newspaper, indicating the mountainside collapse location identified by the Rokko Erosion Control Construction Office right after the earthquake. The map, though rough, displayed the locations of collapses in relation to the urban area, major roads, railroads, and rivers. By June, they distributed a more detailed map that included landslide hazard areas in addition to the specific collapse site.

2-2 Toward a comprehensive landslide preparedness[1]

Meanwhile, Hyogo Prefecture and local governments at the foot of the mountain recognized the necessity to develop erosion preparedness measures for their area's restoration. They decided to integrate traditional preventive methods, such as installing individual erosion control facilities, with city development efforts to be better prepared for future disasters. As part of earthquake reconstruction efforts, Hyogo Prefecture and Kobe City introduced Disaster Preparedness and Green Conservation of Mt. Rokko. Within this plan, Kobe City incorporated the concept of the *mountain-base greenbelt axis*, a strategy for disaster-prepared town planning at the foot of the mountain, into its reconstruction plan.[2] The mountain-base greenbelt axis serves as a buffer zone during disasters, preventing mountain collapses from reaching urban zones, and restricts unregulated urban development during normal times.[3] To support this project, the Ministry of Construction and the Rokko Erosion Control Office collaborated with local governments and experts. Together, they identified designated erosion control zones, high-risk slope failure areas, landslide prevention zones, and conservation forests within watersheds and slopes at the mountain's base. These interconnected high-risk erosion areas were designated as *mountain-base urban*

greenbelts,[4] encompassing areas linked with special green conservation zones under the Urban Greening Act. This initiative was positioned as their erosion project, termed the Mountain-base Urban Greenbelt Initiative and Project. Additionally, Hyogo Prefecture and Kobe City implemented specific actions to ensure the permanent preservation of green areas at the foot of the mountain. These steps included the initial urban planning decision in 1998 to classify slopes facing urban areas[4] as erosion control facilities (under the City Planning Act) and as special green conservation areas (under the Urban Greening Act) within the Mountain-base Urban Greenbelt.[4] As a result, certain urban areas have been designated to limit future development. This has allowed landslide preparedness measures to be incorporated into urban development plans.

This occurred because the local residents and the government shared a mutual understanding of the landslide risks in the disaster preparedness measures for the towns at the base of Mt. Rokko. As a result, they had a common foundation on which to build landslide preparedness measures and promote green urban development after the earthquake.

2-3 Efforts by the government and the private sector built on mutual understanding[1]

In multiple meetings, the public and private sectors discussed and mutually agreed upon the functions of the Mountain-base Urban Greenbelt. These functions include preventing sediment disasters, preserving and nurturing pleasant urban environment, scenic beauty, ecosystem, and biodiversity, curbing urban sprawl, and offering healthy recreational spaces. This has led to government-led disaster preparedness initiatives and the following efforts within the community. Residents are cleaning up local green spaces to sustain a safe and attractive living environment. The Board of Education has developed textbooks[5] on disaster preparedness and environmental education for schools. Additionally, private companies are engaging in green conservation initiatives, using government policies as part of their corporate social responsibility (CSR) efforts. However, these were routine activities that each of them had been carrying out daily. Administrative support, which involved offering forests as activity fields and providing tools and equipment for sharing maintenance policies,[6-9] was put in place. This support ensured the continuous implementation of these activities.

3. Landslide preparedness measures and urban development based on information sharing as a prerequisite

In July 1999, multiple landslides struck a vast region, spanning Hiroshima and Kure cities. This event led to the enactment of the Act on Sediment Disaster Countermeasures for Sediment Disaster Prone Areas in April 2001. This law focuses on the intangible aspects of disaster preparedness. According to this law, in the case of a collapse, mudslide, or landslide on a steel slope, prefectural governors are mandated to designate areas where residents' lives and health are at risk as the landslide warning zone (commonly known as the yellow zone). If building damage is imminent and residents' lives and health are significantly endangered, governors must designate the area as a landslide special warning zone (known as the red zone). This empowers governors to establish a warning and evacuation system. The previous landslide hazard areas referred to places near streams and slopes susceptible to landslides, but lacked legal definition. In contrast, the new law mandates the identification of areas prone to damage with legal backing. These zones are established using a method[10] developed by analyzing landslide data collected nationwide by the Sabo Department of the NILIM and a sediment management group at the Public Works Research Institute (PWRI).

Prefectural governors are not obligated by law to seek residents' consent when designating an area. However, officials from prefectural and municipal authorities diligently explained the details to residents, ensuring they fully understood before obtaining their consent. The advantage of zoning is that it ensures that residents in the relevant areas receive evacuation orders during heavy rainfall events. However, this benefit is only effective if residents within the area understand the zone designation. In fact, a study on evacuation rates during heavy rainfall found that areas designated as landslide disaster warning zones had higher evacuation rates compared to non-designated areas.[11] This no doubt highlights the significant contribution of thorough explanations to residents (through information sharing and mutual understanding) about zone designation.

We aim to consistently offer technical information useful for government officials. By taking this approach, residents will have even greater trust in the safety information disseminated by the government.

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Towards Realizing Safer, Smoother, More Comfortable Road Use

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

1. Introduction

Japan's roads have contributed greatly to enriching and improving the 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, and we must realize safer, smoother, and more comfortable road use. 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 a suggestion by the Roads Subcommittee of the Council for Infrastructure[1)] and a proposal by the Basic Policy Group of the same subcommittee.[2)] Conversely, as we work towards realizing road policy, we cannot omit the perspectives of coordination and cooperation with reforms of public services through the thorough use of data and digital technologies and movements towards a green society, including initiatives aimed at strategies to ameliorate climate change, which the government and the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) are moving forward.

This paper takes into consideration the above perspectives as it briefly describes representative initiatives in the Road Traffic Department, based on their relationship with road policy directions.

2. Road policy directions and Road Traffic Department initiatives

The (main) relationships between road policy directions concerning the road traffic field and research conducted by the Road Traffic Department are summarized in the table.

Table. (Main) relationships between road policy directions concerning the road traffic field and research conducted by the Road Traffic Department

Road policy directions concerning the road traffic field	Research conducted by the Road Traffic Department
(1) Strengthening growth potential through productivity improvements	
a. Ensuring smooth mobility In addition to improving the road network, etc., realizing stable, maximized use of the road network. Working towards achieving road traffic management that makes full use of ICT (Big Data, AI, etc.), acquires information about road traffic conditions, and introduces improvement measures to enable smart use of roads.	·Examining and developing methods for acquiring information about road traffic conditions in real time ·Examining and developing methods for predicting (near-future) road traffic conditions ·Examining various (data-based) performance monitoring methods and management strategies
b. Securing strategic flow of people and things Automating and reducing labor for movement of people and things through automated driving, and realizing safer, more efficient road services. Supporting 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.	·Developing automated driving technologies through road-vehicle linkages (examining specifications for information provision services for merge support, specific assistance information for self-positioning, etc.) ·Examining installation methods for automated driving assistance facilities, etc.
(2) Ensuring public safety and peace of mind	
a. Implementing comprehensive traffic safety measures Promotion of traffic safety measures in main roads, neighborhood roads, and roads used by school traffic to create road areas where everyone can travel in safety and comfort. Using traffic accident data and Big Data to extract locations with a risk of accidents and to draft and implement appropriate measures.	·Establishing methods for using Big Data with the aim of expanding traffic safety measures ·Establishing methods for traffic safety measures (including promoting the popularization of speed bumps and other automobile speed limiting facilities, roundabouts, etc.) ·Establishing environments for safe, comfortable bicycle use
(3) Building communities by contributing to improved vitality and quality of life	
a. Maximizing use of road spaces according to need Reconstructing road spaces across the road network to rehabilitate existing roads as human-centered road spaces. In roads in town centers, rolling out “curbside management” to allow road spaces to be used in various forms, depending on the day of the week and time.	·Organizing knowledge about reconstruction of existing road spaces, etc. ·Examining methods for forming vibrant road spaces

In addition to the research shown in the table, the Road Traffic Department is also moving forward with examinations based on the road policy directions regarding means of lowering costs and increasing speed in works to remove utility poles and methods of monitoring routes traveled by special vehicles, among other areas. In addition, we are considering essential reviews of technical standards for road geometric structure and traffic safety facilities, methods of conducting road projects, establishing technologies concerning standards, etc. for data collection, accumulation, and usage methods, and new administrative needs including digital transformation (DX), with a view towards the ongoing rollout of road policy.

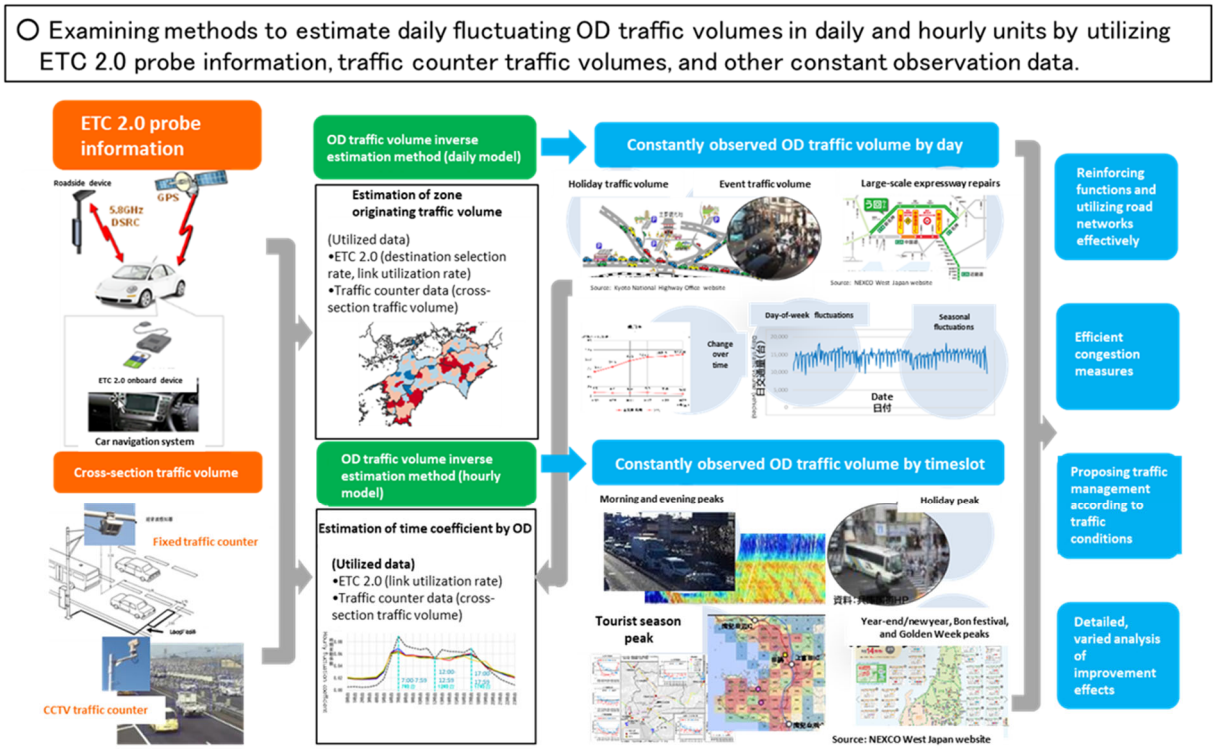

Fig. Estimating constantly observed OD traffic volume using ETC 2.0 probe information, etc.[3)]

3. Initiatives for ensuring smooth mobility

We will outline the Road Traffic Department's initiatives concerning "ensuring smooth mobility" (table, (1)a) among the directions for road policy.

The Road Traffic Department has conducted research aimed at constant observation of road traffic conditions by acquiring travel speed, traffic origins and destinations, and the routes used from ETC 2.0 probe information, in addition to cross-section traffic volumes from traffic counters and road management camera imagery. The figure shows a framework for the constant observation of originating and concentrating traffic volumes (OD traffic volumes) using the observation results, separated by day and timeslot. If we can acquire constantly observed OD traffic volumes, we can use the results of the distribution of traffic volumes to propose function reinforcement strategies for the road network through road improvement and road traffic management strategies that maximize leverage of existing road functions to combat traffic conditions.

This initiative makes thorough use of data and digital technologies, and at the same time, the effects it brings about may reduce CO_2 emissions through traffic flow improvements and contribute to "realizing a green society."

4. Conclusion

This paper presented some of the Road Traffic Department's initiatives based on relationships with road policy directions. At the Road Traffic Department, we are keen to continue the necessary research, with an appropriate understanding of the roles that roads should play within road policy.

[References]

1) Suggestion of the Roads Subcommittee, Council for Infrastructure: *Road and Traffic Innovation: Toward the Realization of Richer Lifestyles through the Pursuit of Functional Improvement and*

Utilization of Roads, Aug. 2017
https://www.mlit.go.jp/common/001201778.pdf
2) Proposal of the Basic Policy Group, Roads Subcommittee, Council for Infrastructure: *2040 Vision for Roads in Japan: To Shape a Better Future for People*, Jun. 2020
https://www.mlit.go.jp/road/vision/pdf/01.pdf
3) National Institute for Land and Infrastructure Management, Ministry of Land, Infrastructure, Transport and Tourism, et al.: *Estimating Constantly Observed OD Traffic Volumes Using ETC 2.0 Probe Data, Etc.*, Sixth Study Meeting on New Road Traffic Investigation Regimes Using ICT (Document 4), Nov. 2022
http://www.mlit.go.jp/road/ir/ir-council/ict/pdf06/04.pdf

Towards More Efficient Infrastructure Management

FUKUDA Yukihiro, Head of Road Structures Department

(Keywords) Road structures, road disasters, maintenance and disaster reduction, technical support, scouring

1. Introduction

In recent years, disasters affecting bridges and earthwork structures due to torrential rain have increased in frequency and severity (fig. 1). The Road Structures Department collaborates with the Public Works Research Institute to dispatch experts to these disaster sites and provide technical support in site surveys, investigating causes, and stopgap recovery efforts, among other support. We have dispatched experts 56 times just since the current emperor assumed the throne in 2019; 70% of these dispatches related to disaster cases related to precipitation, and nearly 60% of those were primarily caused by scouring (fig. 2). How we should respond to increasingly severe torrential rain damage is a major challenge and a key research topic for road researchers. Our department makes agile use of the national resilience budget with regard to these challenges and feeds the outcomes of research and study back to sites as necessary. This paper presents some representative initiatives and discusses collaboration between infrastructure administrators.

2. Results of disaster survey on road earthwork structures adjacent to rivers

Road earthwork structures that are adjacent to rivers were the subject of detailed surveys of cases of scouring damage, which were adopted as disaster recovery projects caused by torrential rain, etc. on directly managed national roads (40 locations in total over 31 years from FY1990 to FY2020).

As the result of an analysis that gathered information on the curves and other linear conditions of the rivers, the damage conditions, and other matters and focused on traffic function, cases where the outer curve of a river channel was adjacent to a road were found in 12 locations, and traffic was completely interrupted for over one week in 70% of these, suggesting the trend that damage in sections adjacent to outer curves produces a strong risk of longer traffic interruptions.

To date, among road earthwork structures, cut slopes of 15 m or more and fill slopes of 10 m or more have been inspected approximately once every five years as specific road earthwork structures.

Fig. 1. Damage to National Highway 121 due to torrential rainfall in August 2022 (Yonezawa, Yamagata)

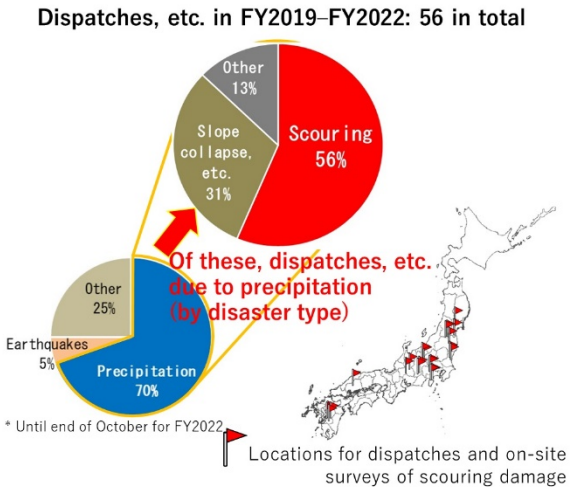

Fig. 2. Dispatching experts to a disaster site

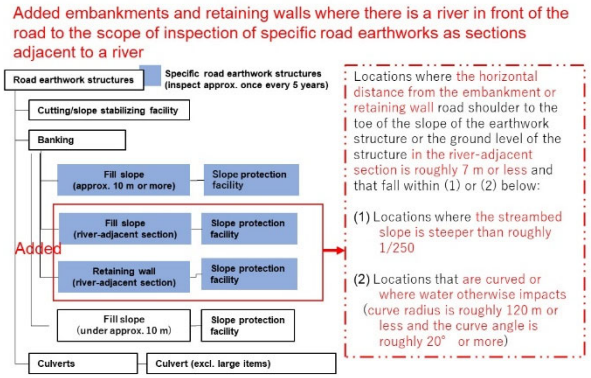

Fig. 3. Addition to the scope of inspections of road earthwork structures

Based on the results of this survey, we have added embankments and retaining walls in sections adjacent to rivers to the scope of inspections for specific road earthwork structures and have decided to place limits on the conditions when doing so, such as the horizontal distance from the road shoulder to the toe of the slope, the river slope, the curve radius, and the curve angle, and to concentrate on managing high-risk locations (fig. 3).

We have also focused on the manner of damage in streambed scouring and conducted on-site fieldwork in five damaged locations. In the on-site fieldwork, we surveyed the characteristics of the river channel in damaged locations (previously damaged locations) and undamaged locations and extracted differentiating conditions.

An analysis of changes to the river channel over time and the history of disaster in locations suffering damage in outer curve sections, with a focus on the streambed scouring mechanism found that a higher proportion of outer curve sections where sandbars have developed on the bank opposite the damaged location suffer damage, compared to locations where sandbars have not developed.

Figure 4 shows aerial photographs of National Highway 41 and the Hida River. Comparing the waterways 45 years ago and today reveals that the river channel has moved to the outer curve section with the development of sandbars, narrowing the river. Observing changes in sandbars over time appears to be an effective means of selecting locations at high risk of damage due to streambed scouring. This analysis is written in the Outline for Inspecting Road Earthwork Structures (Provisional Version) as a matter requiring attention and is to be notified on work sites.

3. Conclusion

The December 2022 meeting of the Technical Section of the Technical Subcommittee of the Council for Infrastructure and the Council for Transport Policy reviewed infrastructure maintenance initiatives over the previous ten years and created a summary as a new opinion on how maintenance should be conducted in future, Next-Generation Strategic Management to Revitalize Regional Infrastructure Groups to be Worked On at Full Strength: Towards Phase 2 of Infrastructure Maintenance. It proposes regarding multiple pieces of infrastructure in

several fields as regional infrastructure over a wide area, rather than locally, and managing them from a comprehensive, multifaceted perspective. For example, it proposes regarding several bridges managed by adjacent municipalities as a single group and generally entrusting them to the private sector.

Following this thinking even further, perhaps it would be possible to manage a river and the several bridges that cross it more effectively by regarding these as a single infrastructure group and ensuring coordination between river management and road management.

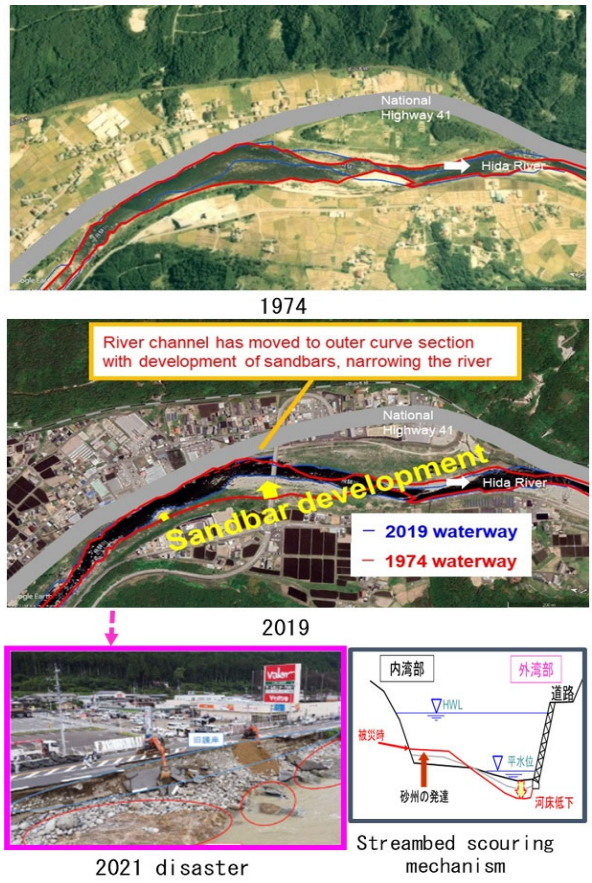

Fig. 4. Aerial photographs of National Highway 41 and the Hida River and conditions after disasters

Proceeding with the research described above may be one strategy for coordination between river management and road management.

As its name suggests, NILIM, which has researchers and experts in various fields, is a "place for researching policy based on technology relating to land comprehensively (in an interdisciplinary manner)," and we wish to make the most of our strengths to fulfill our role.

☞See here for detailed information

1) Outline for Inspecting Road Earthwork Structures (Provisional Version)
http://www.mlit.go.jp/road/sisaku/yobohozen/tenken/tenken-yoryo_202209.pdf

2) Analysis of the Impact of Scouring of Road Earthwork Structures and Slope Collapses, Etc. Due to Torrential Rain on Traffic Functions, p. 59 herein

3) Next-Generation Strategic Management to Revitalize Regional Infrastructure Groups to be Worked On at Full Strength,
https://www.mlit.go.jp/policy/shingikai/kanbo08_sg_000282.html

Building Department's Initiatives to Achieve Carbon Neutrality

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

Key words: climate change response, building, mid- and high-rise buildings, wood structure, new CO_2-saving concrete-based materials

1. Introduction

The Building Department is engaged in research to realize buildings that meet the diversification and advancement of societal needs by bringing together knowledge and other expertise in the specific fields of structure, fire protection, materials, equipment, etc. This paper introduces an overview and trends of the research being undertaken by the Building Department to achieve carbon neutrality.

2. Promotion and expansion of wood use in mid- and high-rise buildings

(1) Initiatives to date

As a measure to absorb CO_2 to achieve carbon neutrality, it is required to expand the use of wood in the building sector, which accounts for more than 40% of wood demand. The key to creating new demand for wood is to promote wood use in mid- to high-rise buildings of four or more stories, where wood structure has not been popular. However, because buildings of four or more stories need to be fire-resistant, fire-resistant covering is required when wood is used for the main structural parts, and wood cannot be utilized in a way that shows it as it is.

In light of these current issues, in order to promote wood use in mid- and high-rise buildings by adopting the "wood-mixed structure building" (Fig. 1), which combines CLT and other wooden structures with RC structure, steel structure, and other fire-resistant members, we have conducted a comprehensive project named "Development of Design / Construction Technologies for Mixed Construction Buildings Using New Wood Material" (FY2017 - FY2021).

In this comprehensive project, based on scientific findings from various experiments, analyses, etc., design methods, etc. were developed for wood-mixed structure buildings from the viewpoints of structure, fireproofing, durability, etc. For example, (i) with regard to structure, for each member of wooden, RC, etc. we made it possible to use the conventional general structural calculation methods (Horizontal load-carrying capacity calculation, Allowable limit stress, etc. calculation, Allowable limit stress calculation) in calculation and analysis. Further, based on the concept of preventing damage to the joints between structures of different types, we developed a method for applying general structural calculation methods to wood-mixed structures and specifications for joints between structures of different types. (ii) With regard to fireproofing, we, based on the concept of using wood within a certain area surrounded by a frame of noncombustible materials, we developed fire compartment, fire spread prevention design methods that respond to increase in combustible materials, as well as fireproof covering design methods for joints. The results of a series of researches were reflected in the revision of the Building Standards Act (in 2018 and 2022) and related notifications to promote the use of wood in mid- and high-rise buildings. Under the revised law, a combination of "noncombustible members" in the main structure and "wooden structure" that allows a certain level of fire damage is recognized as a "fire-resistant structure." Consequently, it has become possible for fire-resistant buildings to use wood for main structures in areas separated from other structures for fire protection and to adopt a design to show wood on the surface (Photo 1).

In parallel, we are implementing the "Technological Development for Dissemination of Large-Scale Buildings that Contribute to Increased Demand for Wood" (FY2020 - 2023), a public-private R&D investment expansion program.

Fig. 1: Example for the prototype of wood mixed structure:
Wooden walls and floors with RC frame on each floor (Left: Exterior, Right: Interior)

Photo 1: Design to show the timber as it is, which is the main structural member
(left: medium-rise large-scale building, right: high-rise building)

Photo 2: Example of "vertical wood-mixed structure": Mixed structure where the structure differs depending on floors. In this case, the first floor is RC and the second to fifth floors are wood (CLT).

This project will develop more rational, generalizable, and general-purpose design methods and examples of specifications, etc., by extending the research results of the comprehensive project in order to further promote the use of wood in large buildings, which will contribute to increasing the demand for wood. For example, we are working on (i) the development of rational structural design methods for "vertical wood-mixed structure" (Photo 2), which has great advantages in terms of structural strength and cost for wood mixed buildings, and (ii) the development, etc. of rational standard specifications for composite floors of CLT and RC structure, for which there is no general construction method and the cost can be higher if fire-resistant covering and sound insulation measures are provided.

(2) Policy for future initiatives

"Green Growth Strategy for Carbon Neutrality by 2050 (Dec. 25, 2020)" states that by 2030 "material standards for the use of wood in high-rise buildings, etc. will be studied" and by 2040 "technologies for the widespread use of high-rise wooden structures will be established."

Since the Building Department has so far researched mainly focused on buildings with four to six stories, it is necessary to further research to realize and promote the use of wood even for buildings with higher stories. For example, we consider that it necessary to study the following by 2030. (i) Structure: Grasp of the long-term performance of wooden buildings of approximately 10 stories, and study to develop recommended specifications, etc. for joints between members to respond to increased external forces due to higher-rise buildings. (ii) Fireproofing: Study to develop fireproof covering for long time (120, 150, 180 minutes, etc.) fireproof structure and notified specifications for long-tune fire prevention equipment to prevent the spread of fire to upper floors, etc.

3. Promotion of the use of CO_2 saving concrete as new material

As a CO_2 source measure, the challenge is to reduce CO_2 emissions in cement and concrete, which, along with wood, are the main materials in the building sector.

Accordingly, it is necessary to promote the use of new concrete-based materials that contribute to CO_2 reduction ("new CO_2-saving concrete-based materials" (Fig. 2)), which are being developed by the private sector, etc., for building foundation and major structural parts such as columns, beams, and walls.

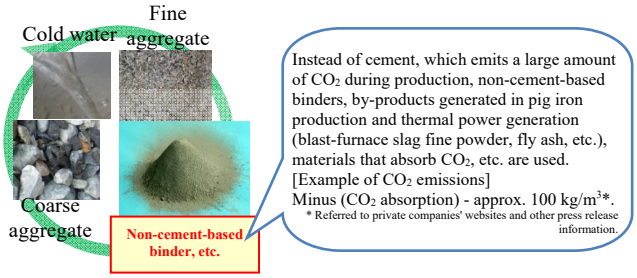

Fig. 2: Image of new CO_2-saving concrete-based materials

By the way, the Building Standards Act stipulates that materials that can be used for the main structural parts of buildings shall either conform to the Japanese Industrial Standards (JIS) or be certified by the Minister of Land, Infrastructure, Transport and Tourism. Various new CO_2-saving concrete-based materials currently being developed are not JIS-compliant materials and require individual ministerial certification. However, the notified standards for concrete used in the examination for ministerial certification do not, in the first place, expect materials that differ significantly from ordinary concrete in the constituent materials and their ratios, such as no use of cement.

Therefore, the Building Department has decided to implement a three-year plan, starting in FY2023 named "Research on evaluation indices for the application of new concrete-based materials to buildings that contribute to CO_2 saving." By clarifying the quality and performance of the new CO_2-saving concrete materials required to comply with the Building Standards Act, we aim for smooth and efficient ministerial certification and to expand their use in the main structural parts of buildings.

4. Conclusion

The Building Department intends to contribute to the realization of carbon neutrality by working on two major themes: further promotion of wood use in mid- and high-rise buildings and promotion of the use of new CO_2-saving concrete-based materials in buildings.

☞See the following for details.

1) Building Department's website
http://www.nilim.go.jp/japanese/organization/kenchiku/jkenchiku.htm

Acceleration of Energy-Saving Measures for Housing and Buildings

MAKATAYAMA Miho(Ph.D. in Engineering), Director, Housing Department

Key words: carbon neutral, Building Energy Conservation Act, energy-saving renovation, existing stock

1. Introduction

The goal of "achieving a carbon neutral, decarbonized society by 2050" was announced by then Prime Minister Suga in October 2020. Subsequently, in March 2021, as the basic measures of the “Basic Plan for Housing”, a guideline for housing policy, initiatives were announced, including expansion of ZEH stock, promotion of the evaluation and dissemination of LCCM housing, and establishment of an obligation to comply with housing energy-saving standards and its performance indication, etc.

In October 2021, the Global Warming Countermeasures Plan and the Basic Energy Plan were revised, requiring new housing and buildings to have the energy-saving performance at the level of the ZEH/ZEB standard (Fig. 1), and existing houses and buildings to have the energy-saving performance at the stock average level of the ZEH/ZEB standard. To achieve these initiatives, in June 2022, the Act amending the "Act on the Improvement of Energy Consumption Performance of Buildings (Building Energy Conservation Act)" was established.

As an initiative aimed at decarbonization, the Housing Department is working on research to promote energy savings focused on divisions of the environment field, as well as research on renovation technologies, etc., for existing housing to reduce damage caused by flood, which is becoming more frequent due to global warming. This paper provides an overview of research currently undertaken to significantly bolster energy-saving measures for housing and buildings.

2. Research required to accelerate energy-saving measures

Table 1 shows the major revisions to the Building Energy Conservation Act and other laws concerning the acceleration of energy-saving measures. Reinforcement of energy-saving measures requires research to support (i) to (iii) of the same table. Regarding (i), since all buildings including new housing will be obligated to comply with the energy-saving standards; it will also require development of methods of evaluation and so on that can be used by designers. It will also require establishment and promotion of evaluation methods of energy-saving performance for high-performance houses that exceed ZEH standards. Regarding (ii), it will be necessary to streamline the evaluation method for phased increase in the level of requirement standards for non-residential structures and development of evaluation methods for various energy-saving technologies that have high energy-saving effects, but have not been properly evaluated in the past, in order to guide them to the ZEB level.

As for (iii), the research is necessary to improve the energy-saving performance of existing housing stock, which has been insufficient compared to new housing. In order to effectively renovate existing stock, it is necessary to properly grasp the energy consumption performance of facilities and equipment, insulation performance, etc., and then renovate housing based on the results of the existing condition diagnosis, which, has not yet been fully developed. Methods diagnosing existing conditions, as well as design and evaluation methods for energy-saving renovation based on diagnosis methods must also be developed.

Note that one of the renewable energy facilities described in (iv) is a technology using photovoltaic power generation and storage batteries. This technology is very effective not only as an energy-saving measure, but also to enable home evacuation after a disaster. The Housing Department also conducts research from this perspective. Please refer to the article in this report for details of the research[1].

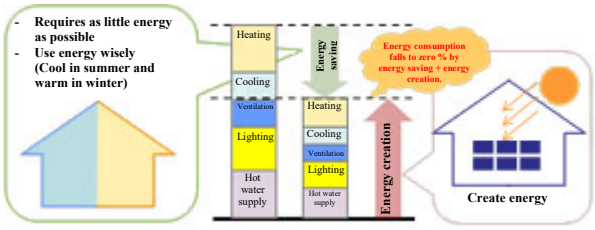

Fig. 1: Concept of ZEH/ZEB

Table 1: Major revisions to the Building Energy Conservation Act and other laws concerning the acceleration of energy-saving measures

(i)	**New housing and small non-housing**
	⇒ Bottom-up energy-saving performance
(ii)	**Medium to large new buildings (non-residential)**
	⇒ Induce higher energy-saving performance
(iii)	**Existing housing and buildings**
	⇒ Improve the energy-saving performance of existing stock
(iv)	**Promotion of the introduction of renewable energy facilities**

3. Energy-saving renovation technologies for existing stock

Regarding the research subjects for strengthening energy-saving measures mentioned in 2 above, for new housing and non-housing, an evaluation program

for energy-saving performance is already in operation for building permit examination, and technical standards, etc. are being developed.
On the other hand, initiatives for existing stock have been slow. A study on detached houses was started more than a decade ago; research has been conducted on the evaluation of energy-saving performance for outer shell and facilities/equipment as well as renovation technologies. However, with regard to the existing condition research required for setting energy-saving renovation targets, a unified existing condition research method was not presented. At present, the Building Standards Development and Promotion Project (by the MLIT) is in the process of studying practical energy-saving performance diagnosis and evaluation methods.
The same goes for non-housing buildings such as office buildings, with regard to existing condition research methods. It would not be accurate to say that appropriate research of existing conditions is being conducted prior to energy-saving renovation. At present, the same or equivalent facilities and equipment are simply replaced without evaluating the actual operation of facilities. In addition, in order to implement energy-saving renovation in the large-scale repair of condominiums, it is necessary to properly position it in the large-scale repair plan. However, the effect of energy-saving renovation is not always quantifiable, and it is difficult to build consensus among condominium residents.
Based on these circumstances, we are conducting the following studies:

(1) Renovation design method based on the existing condition diagnosis for energy saving in existing office buildings, etc. (FY2022-2024).

The study includes: (i) development of an existing condition diagnosis method, (ii) a method to design renovation based on the diagnosis results (**Fig. 2**), and (iii) development of a method to predict the cost-effectiveness of renovation.
Output of this study is expected as follows (i) Technical guidelines for designers that summarize diagnostic and design methods, as energy-saving renovation methods, (ii) tools for building owners and designers to calculate the cost-effectiveness of energy-saving renovation, and (iii) a collection of specific examples of energy-saving renovation for local governments and building owners.

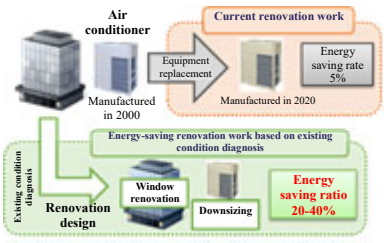

Fig. 2: Current renovation work and retrofitting based on the existing condition diagnosis

(2) Quantification of the effect of renovation to improve energy-saving performance in existing condominiums (FY2023 - 2025)

At present, 60% of the condominium stock was constructed in or before 2000, and many of them have inferior thermal insulation performance, etc. It is therefore essential to promote the renovation of existing condominiums to enhance energy-saving performance, mainly through thermal insulation.
The objectives of this study are to (i) select a renovation menu based on condominium types (**Fig. 3**), (ii) develop a method for estimating the cost of energy-saving renovation and effects, and (iii) develop a method for quantifying cost-effectiveness.
Regarding the results of study, following are expected concerning a method for quantifying the effect of renovation to improve energy-saving performance in existing condominiums: (i) tools for estimating the cost-effectiveness of energy efficiency renovation and (ii) a guide for positioning energy-saving renovation in long-term repair plans, etc.

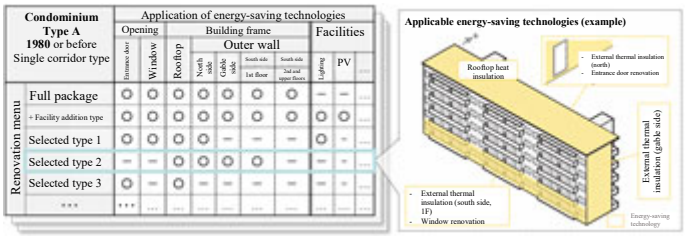

Fig. 3: Renovation menu according to the condominium types (image)

4. Conclusion

Realization of carbon neutrality would require significant enhancement of energy-saving measures for buildings. The Housing Department is working on evaluation standards, methods of diagnosis, renovation technologies, etc. While doing so, it is essential to consider not only the technical aspects of energy-saving performance, but also the realization of a comfortable indoor environment and the health of the people who live and work there. In addition, in order to smoothly implement energy-saving renovation of existing stock, it is equally important to build consensus among residents and users, and to enable them to become aware of energy saving, a quantitative method of presenting the benefits of energy-saving renovation is also needed.
We hope to continue our research so that we can provide not only the technical standards, etc., for engineers, but technical information required for people such as housing residents and building users.

☞See the following for related articles.

1) A study on design goals for self-sustaining energy systems for continued residence after a disaster (p66)

Compact, Human-centered Urban Development Using Smart Technologies

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Urban Planning Department

Key words: compact city, smart city, big data on traffic and human flow

1. Introduction

Among the recent Cabinet decisions related to urban policies, the "Basic Policy for Urban Revitalization (revised in part)" (Cabinet Decision in October 2022) states that, against the backdrop of a rapidly declining and aging population, proper town development requires: (i) creation of a safe, healthy and comfortable living environment for the elderly and the child-rearing generation, (ii) financially and economically sustainable city management, (iii) an urban structure contributing to decarbonization, and (iv) transformation to a compact urban structure to promote protection of human life from disasters, etc. In addition, the "Comprehensive Strategy for the Digital Rural City Initiative" (Cabinet Decision in December 2022) states that digital power will be utilized to deepen and accelerate initiatives to solve social issues and improve the attractiveness of rural areas.

In light of these recent national policies, the Urban Planning Department is working on compact city planning and smart urbanization for urban sustainability as a series of research themes. This paper provides an overview of the Urban Planning Department's research on this series of themes, divided into "compacting urban structures," "smart city," and "utilization of digital technology (traffic and human flow big data).

2. Compact urban structure

Due to population decrease, declining birthrate, and aging population, Japan is experiencing "urban sponging" in towns and cities, especially in local cities. In addition, the impact of COVID-19 infection has led to the development of remote work, changing the way Japanese people live and work. Accordingly, in downsizing the urban structure, it is considered important not only to revitalize the inner city, but also to aim for sustainable, human-centered, compact urban development where local life centers that support the daily lives of citizens are easily accessible.

As part of the comprehensive "Development of Strategic Stock Management Technologies for Regional Safe Residence Functions (FY2015-FY2017) project, for the purpose of supporting the location optimization planning system, the Urban Planning Department developed a future population structure projection[1)] based on subregional units so that appropriate placement of facility functions (medical facilities, welfare facilities, etc.) that support the security of local residence can be planned and evaluated, and developed technologies to predict and map the future requirements and excess/deficiency status of each function spatially and temporally.

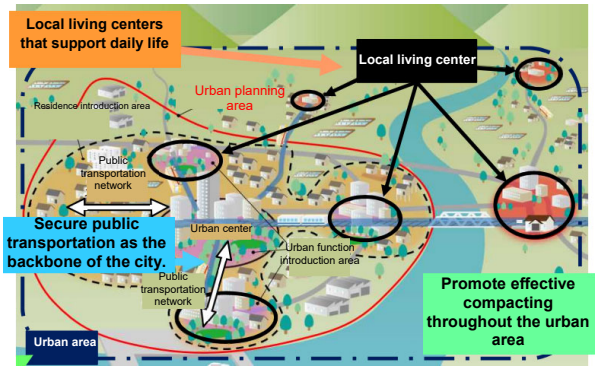


Fig. 1: Compact, human-centered urban development
(Prepared from data of the Subcommittee on Basic Urban Planning Issues in the Council for Social Infrastructure Development)

In the comprehensive "Development of Technologies Contributing to the Utilization of Existing Buildings through the Rationalization of Fire Prevention and Evacuation Regulations, etc." (FY2016 - FY2019) project, we developed a method of deregulation to encourage life support facilities to locate locally and published the results as Technical Note of NILIM [2)] for specific administrative agencies.

In the comprehensive project "Development of Technologies for the Revitalization of Suburban Residential Areas in Response to a Matured Society" (FY2018 - FY2022), we developed an introduction planning method for life support functions (living environment, mobility environment) to revitalize, as a hub, suburban housing complexes that are becoming old towns. For example, we showed that it is effective to integrate a convenience store and community facilities as support function for the living environment, and this was reflected in the "Guide for Revitalization of Housing Complexes" prepared by the Housing Bureau in March 2022. For the mobility environment, we showed through a demonstration experiment that the introduction of small mobility vehicles in areas where public transportation is not available can promote outings by local residents. The

results will be published as a Technical Note of NILIM.

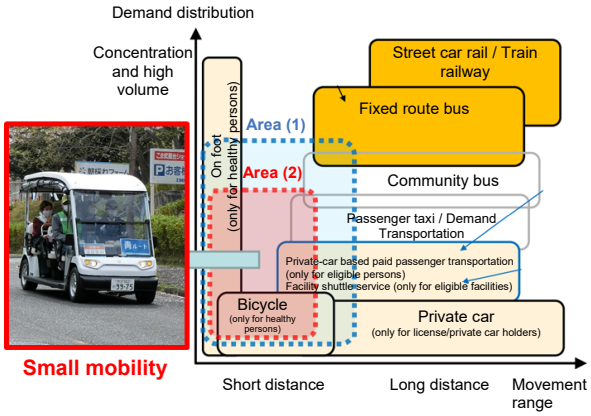


Fig. 2: Positioning of compact vehicles

3. Smart city

Recent technological innovations have led to the utilization of new technologies to solve urban problems, not only in energy conservation, but also in transportation, life support, disaster prevention, crime prevention, etc., and progressive local governments are conducting demonstration experiments for smart city development. In the itemized study titled "Development of Planning and Evaluation Technologies for Solving Major Urban Problems to Support Smart City Promotion" (FY2020 - FY2022), the Urban Planning Department systematically organized examples of smart city projects in which urban problems were solved with new technologies for local governments that intend to plan a smart city project. The results were published in October 2022 as "A Collection of Smart City Examples [Introduction]"[3]. We plan to continue to update this collection by adding new examples. We also plan to develop a method of evaluating the effectiveness of smart city introduction for local governments.

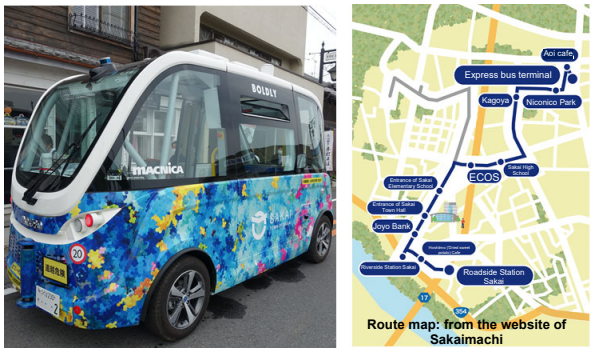


Fig. 3: Automated bus (Sakaimachi, Ibaraki Pref.)

4. Big data on traffic and human flow

Personal trip surveys of human mobility have been utilized in urban and transportation planning, but included issues such as low collection rate and high cost due to questionnaires and manual counting. To solve these issues, the Urban Planning Department developed a new technology for efficiently and accurately understanding human mobility utilizing big data such as GPS and cell phone base station data as a new technology that complements personal trip surveys as part of its "Development of a Method for Grasping Traffic Behavior Using Traffic-related Big Data" (FY2019 - FY2023). The results are intended to function as technical data for national urban transportation researches and as a tool to support urban planning by local governments.

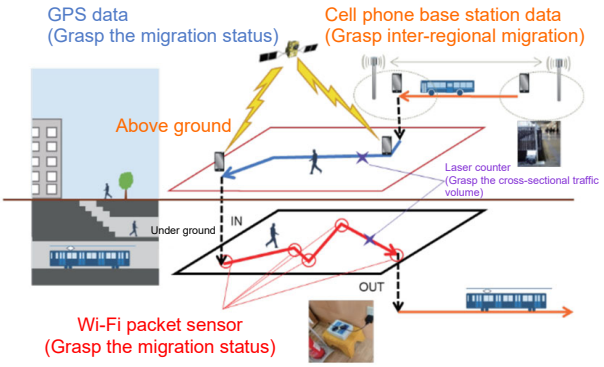


Fig. 4: Image of grasping the flow of people from wide area to narrow area

5. Future development

In order to pursue the long-term goal of compact cities and smart cities, the Urban Planning Department will promote research in cooperation with the MLIT (Urban Affairs Bureau, Housing Bureau, etc.), related organizations, and other research departments within the NILIM, and return the results to society.

☞See the following for details.

1) Future Population Household Projection Tool v2 2015 National Census version
https://www.geospatial.jp/ckan/dataset/cohort-v2
2) Actual Operation of Deregulation of Building Usage and its Explanation, Technical Note of NILIM No. 1123
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1123.htm
3) A Collection of Smart City Examples [Introduction]
http://www.nilim.go.jp/lab/jbg/smart/smart.html#smart

Toward the Creation of Sustainable, Safe and Secure Coastal Areas in the Future

ASAI Tadashi, Director of Coastal and Marine Disaster Prevention Department

(Keywords) Climate change, blue carbon ecosystems, disaster risk assessment, use of AI/UAV, increased efficiency in maintenance

1. Introduction

Being densely populated and industrialized, coastal areas are utilized in a diverse and high-density manner. These areas continue to play a diverse role as hubs that support regional vitality, serving as logistics and industrial bases, places of relaxation and excitement, and sites for exchange between visitors and local residents. To promote local revitalization in coastal areas, it is necessary to ensure coastal area safety and security as well as coastal area conservation and restoration.

As a recent move related to the above, the Port and Harbor Law was revised in 2022 to promote Carbon Neutral Port (CNP) initiatives, thereby contributing to the enhanced competitiveness of Japanese industries and ports and realization of a decarbonized society. One of these measures is to expand blue infrastructure to contribute to the realization of carbon neutrality through the expansion of CO_2 sinks utilizing blue carbon ecosystems and to realize a rich ocean through biodiversity.

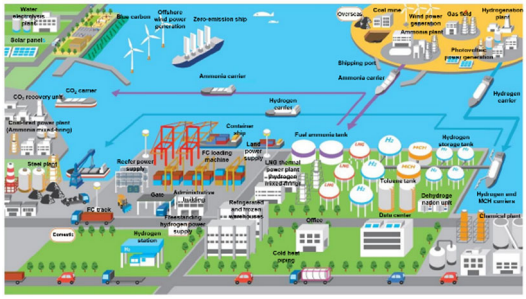


Figure: Conceptual image of Carbon Neutral Port (CNP) formation (Source: Ministry of Land, Infrastructure, Transport and Tourism)

In addition, the Disaster Prevention Committee of the Ports Subcommittee of the Council of Transportation Policy has been compiling a report on coastal area resilience in consideration of climate changes. This is in light of the clarification of the increased risk of meteorological disasters due to climate change, the imminent threat of large-scale earthquake and tsunami disasters, and changes in the environment surrounding ports including the formation of CNPs.

2. Development of Methods to Enhance Carbon Storage Effect in Coastal Environment Conservation Projects

In our efforts for promoting decarbonization, we are developing methods for creating tidal flats with a high carbon storage effect by utilizing dredged soil containing organic matter to promote blue carbon ecosystems as carbon sink measures utilizing coastal ecosystems.

Concretely, based on the calculation results of the carbon residual rate in the dredged soil utilized for the creation of tidal flats and seagrass meadows, we will arrange and organize the relationship between the carbon residual rate and various conditions, thereby promoting the development of methods for creating tidal flats and seagrass meadows considering the carbon storage effect[1].

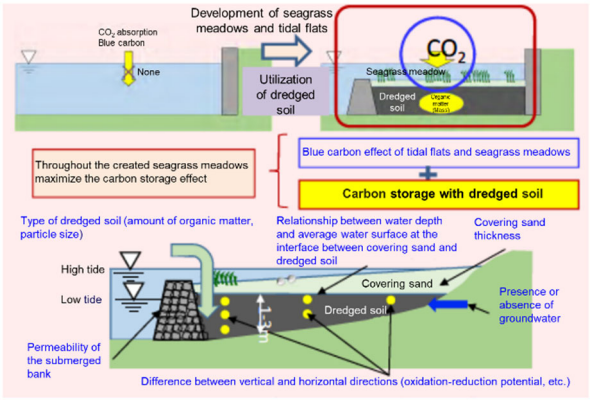


Figure: Development of methods for enhancing carbon storage effect in coastal environment conservation projects

3. Assessment of Disaster Risks due to Climate Change

To consider adaptation measures in response to the intensification of natural hazards induced by climate change, it is necessary to reflect not only mean sea-level rise but also the increases in extreme values of storm surges and high waves in the design. For this reason, research has been conducted on the impact on design external forces of port facilities and the impact on the inundation risk due to storm surges and high waves[2].

Using a large-scale ensemble climate prediction data set for forecasting and hindcasting of storm surges and waves, we are also conducting studies on how to evaluate the probability of storm surges and wave heights in the future climate.

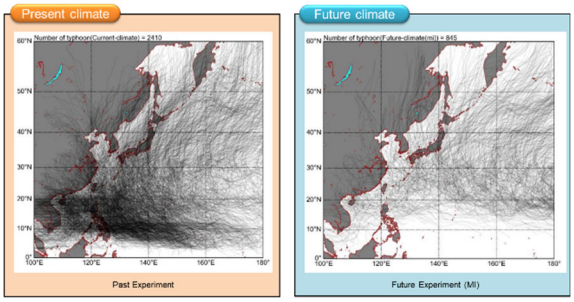


Figure: Example of changes in occurrence and tracks of typhoons in future climate

In 2018 and 2019, strong winds, storm surges and waves during typhoons caused containers to collapse or drift about. For this reason, we have been conducting quantitative evaluation of countermeasures against the collapse and drift of containers in strong winds, storm surges and waves. We conduct experiments using container models to consider how to design fences for preventing containers from drifting about and how to lash containers during strong winds such as typhoons[3].

4. Increasing Efficiency in Maintenance of Port Facilities Using AI and UAVs

With a limited workforce and budget, aging facilities have become an issue. For this reason, we are making focused and intensive efforts for ports and coasts to accelerate the measures against aging facilities in view of the conversion to preventative infrastructure maintenance and to promote digitalization for efficient advancement of measures for national resilience. Specifically, we are developing a system for improving the efficiency and sophistication of maintenance by utilizing AI and UAVs for inspection and diagnosis[4].

5. Active Publishing of Study Results

The above study results are presented at academic conferences, made known to employees of national/local governments and related industries through the National Institute for Land and Infrastructure Management (NILIM)'s website and training programs, and actively disseminated to the general public.

This year's Tokyo Bay Symposium was held face-to-face for the first time in three years after taking measures against the novel coronavirus. In this year, the 22nd session, which was entitled "Changes in the Environment of Tokyo Bay in Recent Years," was conducted in a workshop style. A number of people, including research institutions, NPOs, citizens, fishermen, and private companies, have provided information on the environment and living organisms in Tokyo Bay over the past 10 years, and the information was compiled, organized, and shared.

Photo: The 22nd Tokyo Bay Symposium
(held on October 13 at Osanbashi Yokohama Hall)

In addition to disseminating research information, we also identify issues related to spatial development trends in coastal areas and actively collect information by conducting current situation surveys in order to obtain suggestions for the future in light of recent social conditions such as economic security (resilient logistics, etc.), the return of manufacturing to Japan, and the establishment of a decarbonized society.

6. Conclusion

In accordance with the organizational revision in the next fiscal year, the Coastal and Marine Disaster Prevention Department will merge and reorganize with the Port Department, starting again as the Port, Coastal and Marine Department. This is expected to further strengthen cooperation among divisions in the department.

Urgent global issues include climate change, severe natural disasters, and pandemics, and prompt responses to these new risks are required. To promote and maintain the formation of sustainable, safe, and secure coastal areas in the future, we will continue as the new Department to vigorously promote initiatives in supporting the plan from the research aspect.

✓ Click here for more information.

1) Japanese Journal of JSCE B2, Vol. 78 No. 2, pp.I_913-I_918
https://www.jstage.jst.go.jp/article/kaigan/78/2/78_I_913/_article/-char/ja
2) Technical Note of NILIM, No. 1213, 13 p.
https://www.ysk.nilim.go.jp/kenkyuseika/pdf/ks1213.pdf
3) NILIM's YouTube Channel "Typhoon Experiment Wind Wave Channel," one of the largest experimental facilities in Japan to generate wind, flow and waves
https://www.youtube.com/watch?v=9iNZPw3VyXM
4) Journal of AI/Data Science, Vol. 3, J2, pp. 360-371
https://www.jstage.jst.go.jp/article/jsceiii/3/J2/3_360/_article/-char/ja

Research Trend in Carbon Neutrality and Climate Control

SAKAI Koji, Director of Port Department

(Keywords) *Carbon neutrality, supply chain, recycled materials, climate change*

1. Introduction

Addressing global warming is an urgent issue for the whole government, which has declared its intention to become "carbon neutral by 2050" and "aim to reduce greenhouse gas emissions by 46% by FY2030 in comparison with FY2013." Ports and harbors are key points in the international supply chain through which 99.6% of import and export cargo is transported. They are hubs of coastal industries where many power generation, steel, and other industries, which account for about 60% of greenhouse gas emissions, are located. They are also major energy consuming areas. Therefore, it is effective and efficient for realizing carbon neutrality to intensively take leading initiatives for decarbonization at ports and harbors. Accordingly, the Port and Harbor Law was revised in November 2022 to promote decarbonization initiatives on a continuous and systematic basis, including the creation of a "Port Decarbonization Promotion Plan" in collaboration with a wide range of stakeholders from public and private sectors related to ports and harbors. The Port Department is conducting studies necessary to promote port administration, and this article focuses on recent initiatives such as measures for carbon neutrality and climate change.

2. Streamlining Logistics throughout the Supply Chain

(1) Development of a terminal congestion index for improving the punctuality of container ships

A congestion index was developed to measure the margin of improvement in the utilization rate of terminals while ensuring the punctuality of container transport. In this study, we also estimated the CO_2 emissions due to offshore waiting by using the offshore waiting situation assessment tool. The results of this study are expected to improve the efficiency of logistics and reduce CO_2 emissions by using them for terminal operations such as Japanese ports and harbors and cargo owners' route selection.

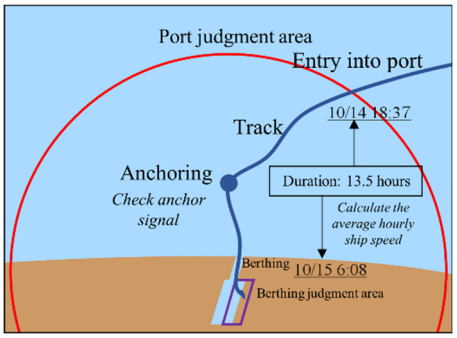


Figure: Example of the assessment of offshore waiting situation using AIS data

(2) Study on measures to improve the efficiency of international maritime container hinterland transport

Trucks are used for hinterland transport of international maritime containers by land, but the concern for the shortage of truck drivers is growing. Although container round use, which allows importing shippers to supply empty containers to exporting shippers, has been implemented, there is limited cooperation between individual companies, and it is necessary to encourage such cooperation throughout the society. Therefore, we are analyzing the efficiency and rationality of the current practices of hinterland transport for improvements. Our efforts will be contributing not only to mitigate the shortage of truck drivers, but also to reduce CO2 emissions significantly.

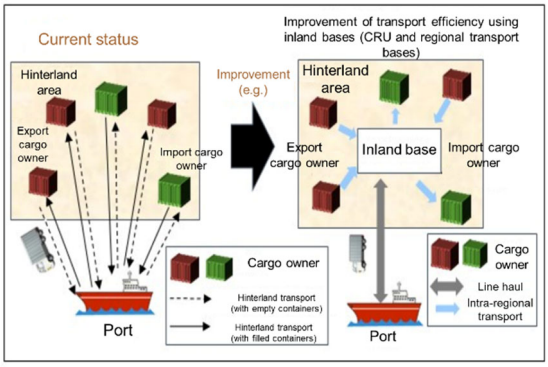


Figure: Conceptual image of improved efficiency of hinterland transport

(3) Analysis of decarbonization impact in port logistics forecasts

About 70% of Japanese trade value, or more than 99% of cargo by weight, is transported by sea. Cargo volume estimates are important basic information for the formulation and revision of port plans, which are the basis for port development at each port. Therefore, the Port Department conducts demand forecasting based on domestic and international data. Additionally, it has been very burdensome to forecast demand for cargo for port managers who formulate port plans. So far, we have provided support by publicizing training courses on basic port planning and a manual on cargo demand forecasting methods. In particular, as countermeasures against global warming, we studied and analyzed cargo trends related to decarbonization (including crude oil, thermal coal, wood pellets, etc.), confirming the medium- to long-term impact of decarbonization such as the shift to non-fossil energy and the impact on imports of crude oil and woody biomass.

3. Measures against Global Warming through Sophistication of Port and Harbor Construction Works

(1) Utilization of recycled materials in port construction works

As an initiative to reduce the environmental burden in port construction works, we are collecting and examining information on the utilization track records and quality performance of recycled materials. Based on study and analysis so far, the "Recycling Guidelines for Port and Airport Development" will be revised in FY2023.

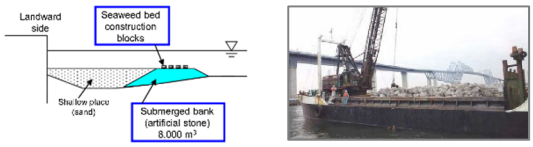


Figure: Example of shallow-place construction using iron and steel slag
Photo: Work vessel dumping artificial stone

(2) Study on visualization of CO_2 emissions in port construction works

To reduce CO_2 emissions from port construction works, we released the "Guidelines for Calculating Carbon Dioxide Emissions from Port Construction Works (Procurement Phase Edition)" in June 2022 after reviewing past knowledge such as the emission intensity, the concept of calculation, and prior examples of reduction. The guidelines (planning and design phase edition) (construction phase edition) will be examined and published in the future.

4. Study on Climate Change Adaptation Measures

(1) Study on application of stress test to container terminals

Future climate change is expected to cause more severe storm surges, waves, wind storms, etc. Therefore, using a container terminal (CT) as an example of a typical port facility, we conducted "stress tests" at model ports as a tool to grasp the risk of inundation in the CT during sea surface elevation due to storm surges, waves, etc., and to set countermeasure priorities for damage reduction, thereby proposing the application of the tool.

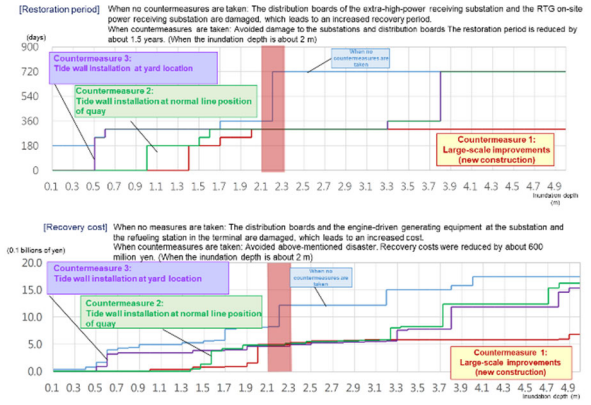


Figure: Comparison of recovery period and cost between different countermeasures

(2) Study on technology for implementation of climate change adaptation measures in ports and harbors

In August 2020, in the Council of Transportation Policy, a report on "Comprehensive Disaster Prevention and Mitigation Measures for Ports and Harbors in the Future with Hardware and Software Integrated" was submitted to call for responses to the intensified external forces induced by climate change. For this reason, we are working to revise specific standards so that we can design facilities based on future potential external forces (including tide level and waves) associated with climate change.

5. Conclusion

Ports and harbors are important infrastructures that support the Japanese economy and people's lives. We would like to promote study that provides technical support for port administration in response to various issues surrounding ports and harbors.

Circumstances Surrounding Airports and Recent Study Results

TANSEI Kiyoteru, Director of Airport Department

(Keywords) *Domestic airfares, LCC, market fares, urethane foam resin, Westergaard loading formula*

1. Introduction

Demand for domestic and international aviation is recovering, and further initiatives to strengthen airport functions and ensure safety are required. Initiatives to increase demand at airports and decarbonization in the aviation sector are being promoted. On the other hand, the shortage of people to bear responsibility is also becoming serious, so an urgent task is to respond to innovation in DX and aviation.

In light of these changes and trends in the social conditions, the Airport Department has published NILIM reports and technical notes as an important means of disseminating study results. The following are some of the NILIM technical notes published by the Airport Department in 2021 and 2022. (Note that "No." refers to the publication number of NILIM technical note.)

2. Analysis of Domestic Airfares after the Entry of LCCs(Low Cost Carriers) into Service (No. 1165)

Since domestic air fares were liberalized in 2000, a wide variety of ticket types other than standard fares have been sold by various airlines. In particular, LCCs, which entered domestic service in 2012, are considered to have an impact on the fare setting of airline companies. Accordingly, this technical note analyzes the trend in domestic airfares in the process of the entry and prevalence of LCCs in domestic airlines, and examines the market fare setting method applied to the air demand forecasting model.

As a result, the examination showed that LCC fares have remained consistently low relative to FSCs' (Full Service Carriers) fares on the same route since the new entrants (Fig. 1), and that the discount rate of the fares of LCCs with respect to those of FSCs, competitors on the same route, varied greatly from 20 to 60% depending on the route. Additionally, based on the results of this analysis in which the discount rate of LCCs to FSCs are different from one route to another, the report describes that it is necessary to consider setting fares based on the discount rate considering the route characteristics.

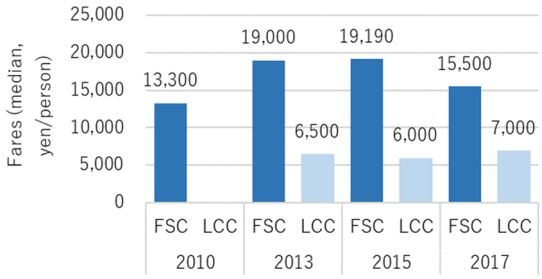


Figure 1: Changes in fare between Narita and Shinchitose (weekdays)

3. Consideration on Estimation of Market Fares for Domestic Airlines (No. 1227)

Based on the analysis results of recent trends in domestic air fares and the issues of the existing domestic market air fares estimation method (conventional method), this technical note has newly established a fare function that can estimate the market fares on a route-to-route basis by using multiple explanatory variables on route characteristics (such as the presence or absence of competitive routes and route distances).

The fare function enables us to reproduce the fares to some extent on competitive routes between FSCs and LCCs, which suggested that the market fares can be set with the route characteristics reflected. However, it has become clear that the correlation between the market fare reduction rate and the route characteristics has become weak, and that the impact of dynamic pricing is an issue to be addressed.

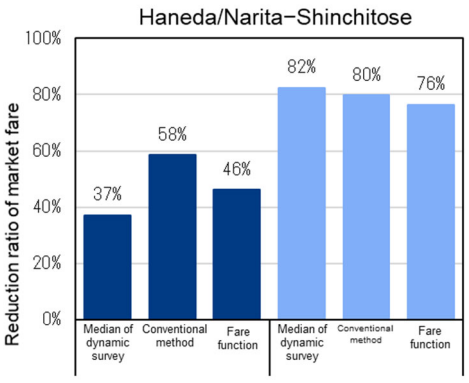


Figure 2: Reproducibility of fares on competitive LCC routes

4. A Study on Filling of Cavities of Undersurface of Airport Prestressed Concrete Slab with Urethane Foam Resin (No. 1177)

Cavities may be caused by the loss of grout filled in the lower surface of the prestressed concrete slab (PC slab) used in airport aprons and taxiways. Therefore, in this technical note, study of splinterless urethane foam resin was carried out.

As a result, it was found that the expansion of urethane foam resin continues for about 15 minutes after mixing, and stable properties can be obtained in about 60 minutes, and that there is a correlation between the density and compressive strength and elastic modulus of cured urethane foam resin, and it is possible to estimate the compressive strength and elastic modulus from the density. In addition, although the load stress generated in PC slabs by the aircraft load is larger than that in PC slabs filled with grout, it is also clarified that the load stress can be reduced compared with PC slabs with cavities unfilled. (Figure 3)

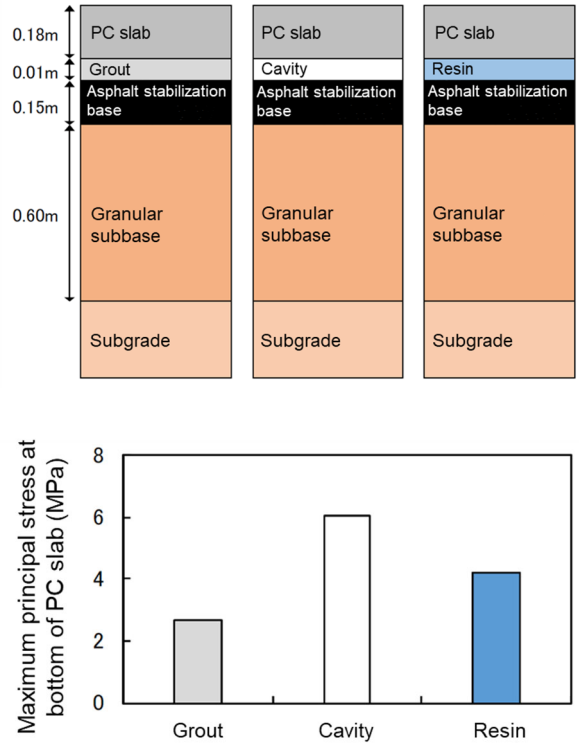


Figure 3: Maximum principal stress at bottom of PC slab

5. Consideration of Westergaard's Loading Formula and Radius of Relative Stiffness for Concrete Pavements (No. 1196)

One of the most famous study results on the calculation method of stress and deflection generated in concrete slabs is Westergaard's loading formula proposed by Harold Malcolm Westergaard after the 1920s. However, the study results and those of other researchers who have modified this loading formula are often very old and difficult to obtain.

Therefore, this technical note confirms the basis of the loading formula included in the Guidelines for Airport Civil Facility Design (Pavement Design Edition) in reference to Westergaard's original works and various pieces of literature. In addition, it was also confirmed that the radius of relative stiffness defined by Westergaard is the distance from the "loading center" to the "position of the inflection point of deflection" and the "position where the bending stress is reduced to zero" (Fig. 4), and that the distribution is the same regardless of the thickness of the concrete slab, the elastic modulus of the concrete, and the elastic modulus of the subgrade by using the radius of relative stiffness.

The deflection formula for center loading included in the Guidelines for Airport Civil Facility Design (Pavement Design Edition) has already been modified because it was confirmed that the deflection formula for center loading according to Westergaard was not a natural logarithm but a common logarithm.

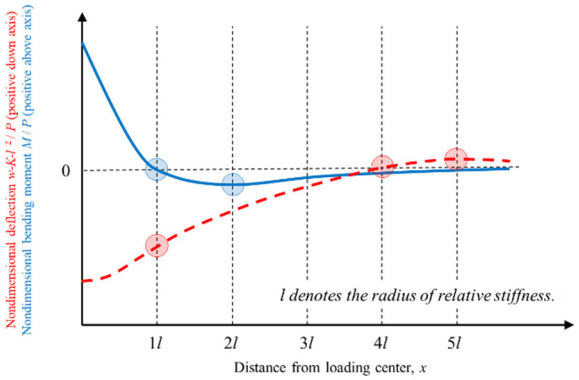


Figure 4: Distribution shown by Westergaard

6. Conclusion

Since the NILIM reports and technical notes serve as basic materials for policy-making and supporting materials for various standards, we will continue to work on studies on airports and publish the findings one by one.

✓ Click here for more information.

1) Website of the NILIM report and technical note
https://www.nilim.go.jp/english/documents/index.htm

Initiatives of the Research Center for Infrastructure Management Based on Changes in Natural and Social Conditions

SAITŌ Hiroyuki, Director, Research Center for Infrastructure Management

(Keywords) global warming, declining birthrate and aging population, productivity improvement, infrastructure DX

1. Introduction

With global warming and climate change (changes in natural conditions) and the increase in severity and frequency of flooding and sediment disasters said to accompany them, and with the aging and deterioration of infrastructure itself (changes in social conditions), the importance and necessity of infrastructure improvement, maintenance, and management may or may not increase in the future, but it is difficult to imagine it decreasing. Conversely, Japan's construction industry, which is involved in infrastructure improvement, maintenance, and management, is seeing more significant aging and decreases in the working population than in other industries (changes in social conditions), and it has been pointed out and feared in various sectors that the industry will shrink further. As shown in figure 1, the decrease in construction machinery operators has been particularly significant, and even looking at the number of people holding heavy vehicle licenses according to driving license statistics, further decreases are expected.

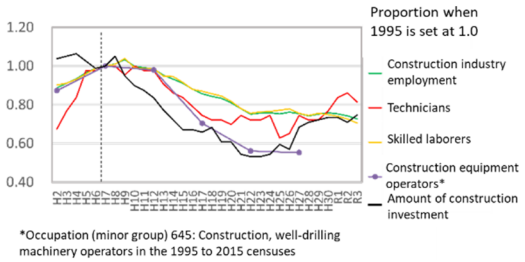


Fig. 1. Trends in worker numbers

In response to these changes in natural and social conditions, the Research Center for Infrastructure Management is working on research relating to improving productivity—especially labor productivity—in construction production systems from planning, investigation, and design, through construction, to maintenance and management, and function evaluations of parks, green spaces, and other so-called green infrastructure, which is supposed to be effective as a strategy for alleviating climate change.

One way to improve productivity in construction production systems is to maximize use of digital technologies. The National Institute for Land and Infrastructure Management (NILIM) is constructing the DX Data Center and the MLIT Data Platform, major parts of the efforts of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) in infrastructure DX. However, improving

productivity requires more than this—we also need analog methods to review and improve the regulations, standards, customs, and other rules that have been taken as given until now.

Here, we introduce the Research Center for Infrastructure Management's initiatives that leverage digital technologies and its examinations to improve concreters' productivity as one analog method.

2. Initiatives leveraging digital technologies

2.1 DX Data Center

NILIM is building the DX Data Center as a demonstrative research system to centrally store three-dimensional data, such as BIM/CIM 3D models and point group data, and smoothly share them between the orderer and the contractor in the processes of surveying, investigation, design, construction, management, and maintenance. Software that enables the 3D models for BIM/CIM, etc. to be displayed and edited has been installed by making use of schemes from joint research with software vendors and others, and as it is possible to browse 3D maps of rivers under administration, road MMS point group data, and other information besides 3D models for BIM/CIM, the center is expected to be an important tool for applying BIM/CIM principles. The center began operating in January 2023 and was made available to all contractors in directly administered projects from April 2023.

2.2 MLIT Data Platform

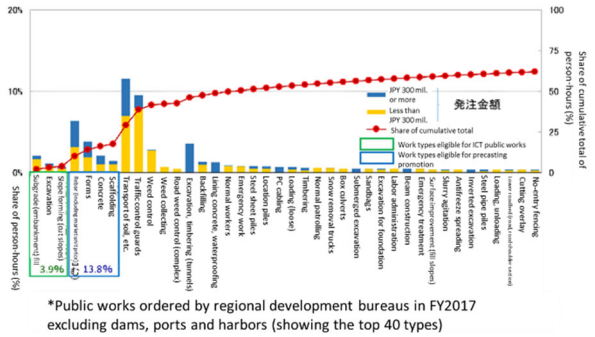
In addition to the various data held by MLIT, the MLIT Data Platform links technology and data held by other bodies, including the private sector, and makes it possible to display, search, and download them at once on a single platform. It was mostly completed and opened to the public in April 2020, and we are making ongoing improvements to create a system that is easier to use, such as continually expanding the linked data, upgrading the user interface, and strengthening search functions.

2.3 Standard development using experimental fields for construction DX

By making use of the earthworks field for developing and demonstrating unmanned construction and automated or autonomous construction and the construction DX experimental field with models for completed form measurement for demonstrative experiments on 3D measuring technologies for buildings, which NILIM and the Public Works Research Institute (PWRI) improved in a joint effort, we can test new technologies and create proposals for guidelines and standards concerning work progress management and testing, among other areas. These facilities are also lent to private companies, universities, and others, including startups, to support research and development.

3. Examinations to improve concreter's productivity

The amount of labor invested in concrete structures and related works in public works directly managed by the Japanese government accounts for 13.8% of the total (fig. 2), and improving labor productivity in this field is a matter of urgency. Progress is being made in maximizing the use of precast products, but it is also necessary to improve productivity for concrete poured on-site.



*Public works ordered by regional development bureaus in FY2017 excluding dams, ports and harbors (showing the top 40 types)

Fig. 2. Amount of labor by work type (public works ordered by regional development bureaus in FY2017)

Because of this, the Research Center for Infrastructure Management is conducting research jointly with regional construction companies that are having difficulty securing labor on (1) improving productivity and the working environment by making use of materials and equipment like fixed horizontal jib cranes (fig. 3), which are used as standard in Western construction works, and system forms, and (2) improving productivity in technical work that has been finely divided into form work, rebar work, and concrete work by making use of multiskilled workers who can handle multiple work types. In particular, fixed horizontal jib cranes do not require the qualifications needed for mobile cranes and they allow workers to operate the cranes themselves to transport work that is mainly transported by hand, such as minor transportation of rebar and the like on site, thus leading to expectations of increased productivity and an improved working environment on site. To date, we have confirmed the cranes' utility through monitoring in nine test works.

Furthermore, with regard to using precast products as well, it is important from the perspective of securing labor to take into account the entire process including product standards, manufacturing, and transportation, as well as the work on site, when considering promoting its use.

Fig. 3. Fixed horizontal jib crane

4. Conclusion

As mentioned at the beginning, the negative impacts that changes to the natural and social conditions surrounding Japan exert on infrastructure improvement, maintenance, and management cannot wait any longer. Among these, the worker shortage, especially the decrease in skilled laborers and operators on-site, is considered likely to be the greatest problem in infrastructure improvement, maintenance, and management in a few years, and accelerating research and social implementation relating to increases in labor productivity in both digital and analog aspects, which the center is currently implementing. As they will also contribute to promoting strategies to ameliorate and adapt to global warming, we will also move forward with our initiatives on new issues, such as deepening our current research on function evaluations of green infrastructure and computing its greenhouse gas reduction effects.

Initiative to Increase the Efficiency of Levee Inspections Utilizing New Technologies, Including AI (Research period: FY 2019–)

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Keywords: River levee, inspection, AI, UAV, 3D point cloud data

1. Maintenance of river levees

River levees are extensive and large embankment structures. Ensuring proper maintenance and management is crucial because any partial loss of their functionality could result in significant damage during a flooding event. Furthermore, as the levee constitutes an embankment structure, it is susceptible to deformation over time due to variations in consolidation settlement. These variations are caused by the characteristics of the levee materials, properties of the foundation ground, or the historical context of the levee construction. Deformation can also result from other factors, including the impact of running water during floods, stormwater infiltration, river use, vehicle traffic, small animal burrows, tree roots, and other contributing elements. If left unchecked, these deformities could seriously affect the levee function and lead to disasters. Therefore, regular inspections are crucial. Furthermore, it is essential to perform comprehensive condition assessments following exposure to external forces, such as floods and earthquakes, while taking into account the design assumptions. Nevertheless, deformations on levees arise from diverse factors in various locations, and visual detection of deformations, such as widespread subsidence and slope bulging, can be difficult. Moreover, there is a significant shortage of inspection technicians, emphasizing the pressing need to transfer the expertise of experienced technicians. In such situations, it is crucial to recognize the importance of creating inspection and assessment methods for river levees that are both effective and less labor-intensive and actively strive to find solutions.

2. Enhancing management efficiency through new technologies

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is advocating digital transformation (DX) in the infrastructure domain. In the river sector, DX initiatives are underway across a series of operational processes, including surveys and planning, design, construction, and maintenance and management of river facilities, aiming to enhance operational efficiency. Specifically, in the maintenance and management phase, images and 3D point cloud data obtained through unmanned aerial vehicles (UAVs) and other devices are utilized to comprehend the deformation of river channels and levees. This aids in enhancing the efficiency of maintenance and management operations, including river patrols and inspections.

Consequently, we have been researching and developing artificial intelligence (AI) technology to effectively identify levee deformations, aiming to resolve the issues mentioned earlier. This research is being carried out through the commissioned research program as part of the public recruitment program for the river erosion technological development project. Our research aims to achieve the automatic detection of embankment deformations through AI using point cloud data and image data. In prior studies, AI has been employed to successfully identify 12 types of deformations in embankments as outlined in the Guidelines for Inspection and Assessment of River Management Facilities and River Channels, including Levees. For instance, when specifically targeting erosion on an actual levee, the program successfully identified the majority of

deformations observed during visual inspections **(Figure1).**

The AI program took approximately 10 minutes per kilometer (excluding measurement time) to identify deformations. This is shorter than the conventional visual inspection, which typically took around two hours, highlighting the potential for improved work efficiency with the AI program. Nevertheless, the AI-based deformity identification program exhibited instances of detecting deformations where none were present, known as "false positives." This suggests that further improvement is needed to enhance the accuracy of the program.

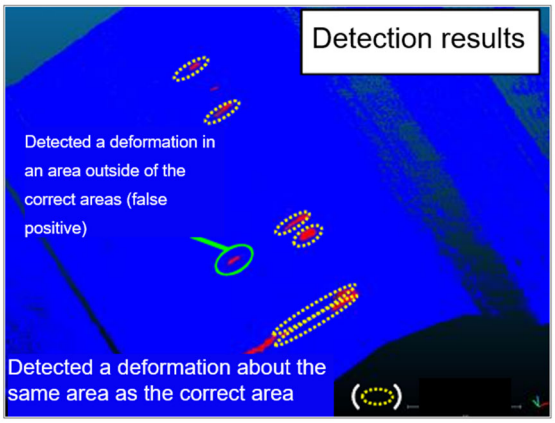

Figure 1. Example of identifying deformations with AI

3. Efforts to link the identified deformities with the effective execution of inspection tasks.

Technological development, as well as measurement accuracy, are expected to further improve in the use of AI for inspection and the use of image data and 3D point cloud data captured by UAVs for the identification of deformations. This is expected to lead to the easy identification of deformations, which have been difficult to capture. Conversely, these new technologies might identify numerous deformations that may not pose significant threats of disasters. Therefore, a new challenge arises in establishing evaluation criteria to determine whether detected conditions should be marked as deformations. In an attempt to address these challenges, we aim to enhance inspection efficiency by identifying deformations that could lead to disasters. To achieve this, we organized and examined actual damage to establish connections between various deformations observed at disaster sites, such as levee failure—potentially seriously jeopardizing the levee's function—and the causes of disasters.

In particular, the authors conducted on-site inspections for 32 cases of levee failures, including slope collapses, which occurred between 2009 and 2021. Our examination focused on determining if we could select deformations that could serve as early signals of an impending disaster.

For example, after examining cases where rainfall-induced erosion and infiltration were probable main causes of levee failure, we identified the following on-site conditions **(Figure 2).**

- The river level during the disaster was significantly below the planned high-water level, suggesting that the disaster was likely triggered by heavy rainfall over a short duration.
- The levee crown in the damaged area was the lowest compared to the upstream and downstream sections, creating a situation where rainwater drainage easily accumulated at the top of the levee in that specific section.
- We observed numerous longitudinal cracks in the slope at the top of the levee, along with erosion in the levee shoulder and the upper section of the levee slope. (a)
- A road was constructed on the crown of the levee, equipped with pedestrian/vehicle separation blocks. The top of the levee had a drainage structure designed to release water through a blocked drainage hole to the slope opposite the damaged side. Unfortunately, the drainage hole was obstructed, resulting in inefficient water discharge. (b, c)
- The repeated overlaying of the road on the levee crown has led to the slope taking on a concave shape, resembling the roof of a temple. (d)

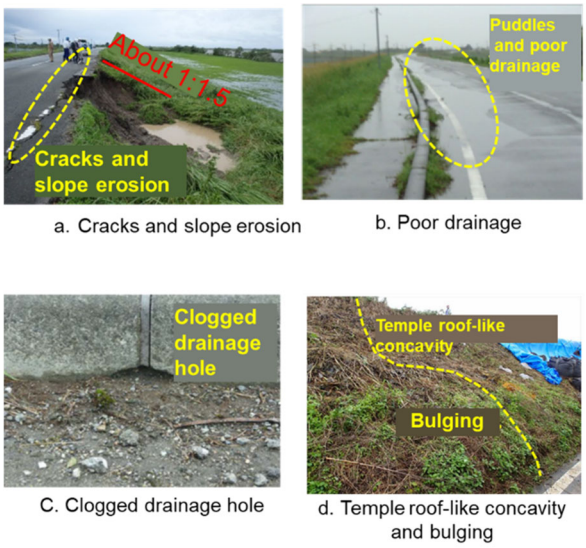

Figure 2. Deformation observed around the damaged area

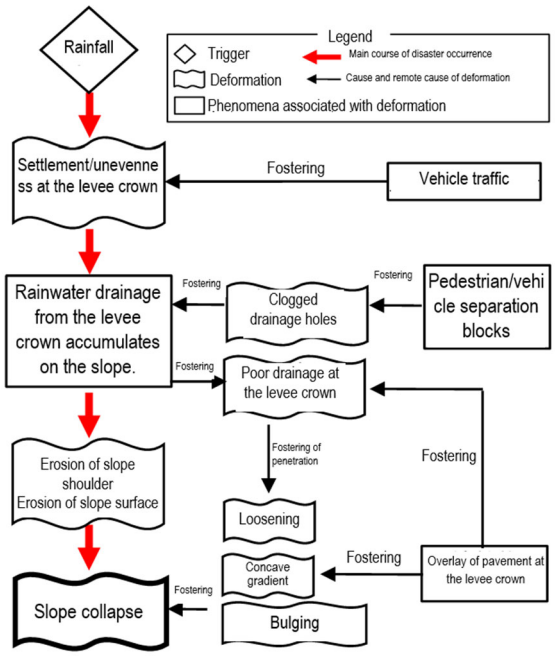

Figure 3. Chain of events leading to the slope collapse (estimated)

Based on the information above, the chain of events, from the formation of deformations found through the damage survey to the actual occurrence of damage, is organized as shown in Figure 3. We intend to employ the same process for other disaster cases and categorize them accordingly. The development of a successful AI model that prioritizes identifying deformations in areas with a higher likelihood of causing damage would enhance the efficiency of AI-based inspections.

☞For more information:

Tomura, Sasaoka. et al. Study on Efficient Deformation Identification of River Levees Using 3D Point Cloud Data and AI. Advances in River Engineering. Vol. 27. https://www.jstage.jst.go.jp/article/river/27/0/27_PS1-35/_pdf/-char/ja

Satellite Monitoring for Coastal Preservation: Mitigating Beach Erosion from Rising Sea Levels

(Research period: FY 2019–)

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Keywords: Coastal erosion, satellite images, deep learning, AI

1. Background and objective of study

Rising sea levels, one of the consequences of climate change, contribute to the erosion and depletion of sandy beaches. Frequent monitoring of sandy beaches is essential for identifying the future exacerbation of climate change effects and taking prompt action. The NILIM is developing a method to automatically extract shorelines from satellite images and track time series changes as a way to monitor beaches across Japan.

We have been working on extracting shorelines from synthetic-aperture radar (SAR) images, but the accuracy is notably lower on sandy beaches where the shoreline is made of sand. In this study, shifting our focus to optical images, we aimed to develop an image analysis method applicable to sandy beaches.

2. Approaches utilized for employing optical satellite images

We chose four representative beaches for our study: Shonan Beach (median grain size D_{50} = 0.3 - 1.8 mm) and Miyazaki Beach (D_{50} = 0.72 mm) to represent sandy beaches, and Shimoniikawa Beach (D_{50} = 5.7 - 13 mm) and Fuji Beach (D_{50} = 16 mm) to represent gravel beaches. For each of these beaches, we generated Normalized Difference Water Index (NDWI) images by storing the NDWI values, which were calculated from two reflection intensities in the green and near-infrared wavelengths observed by the optical satellite Sentinel-2 as grayscale values. The NDWI index uses the property that water tends to absorb near-infrared wavelengths, aiming to enhance the differentiation between water and land areas. Utilizing the obtained NDWI images, we experimented with two shoreline extraction methods: a conventional edge extraction technique and a method that uses deep learning **(Figure 1).**

In addition, in response to potential photography obstruction from cloud cover, we examined the relationship between the quantity of cloud metadata added

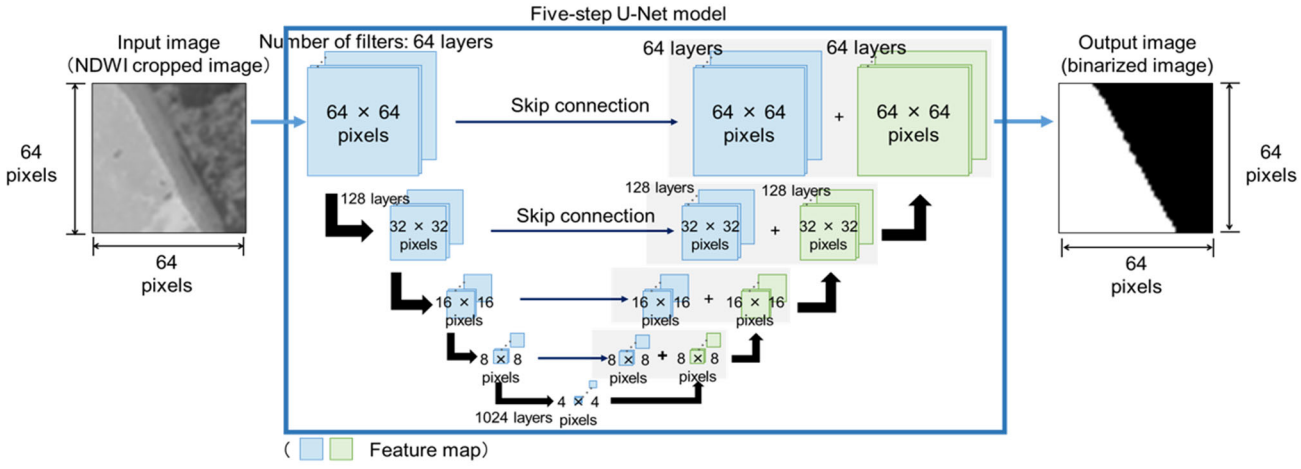

Figure 1. Simplified model of the network configuration (five-stage U-net) used for deep

to satellite images and the extraction results. Moreover, we experimented with techniques for cloud removal through image composition.

3. Enhancing extraction accuracy through the use of deep learning.

The edge extraction method frequently produced inaccuracies by wrongly extracting the offshore boundary of detached breakwaters and wave breaking zones, as well as the edge of the coastal forests. In contrast, the deep learning method demonstrated the ability to accurately extract the shoreline **(Figure 2).**

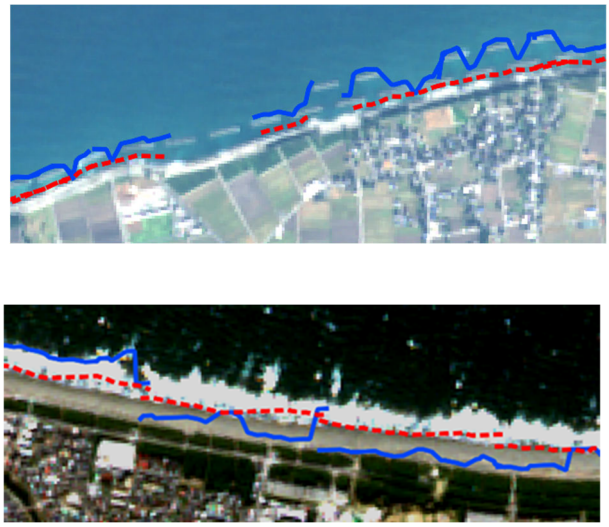

Figure 2. Difference of extraction results by shoreline extraction method
Top: Bottom: Example of wrongly extracted detached breakwaters, Bottom: Example of wrongly extracted wave breaking zone and coastal forest (blue solid line: edge extraction, red dashed line: deep learning)

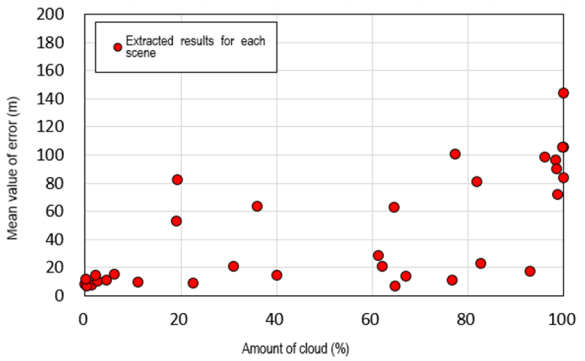

Figure 3: Relationship between errors in shorelines extracted using the deep learning method and the quantity of cloud cover (Shonan Beach)

The error, defined as the differencebetween surveyed results and the shoreline position along the evaluation line set at approximately 50-meter intervals in the coastal direction and averaged for each beach, tends to rise with the increasing amount of clouds in each scene **(Figure 3).**

Table 1. Error in scenes with the highest extraction accuracy (mean value ± standard deviation)

Beach name	Edge extraction (m)	Deep learning (m)
Shonan	21.3±30.7	6.5±6.1
Shimoniikawa	26.1±32.5	11.9±1.0
Fuji	22.8±20.3	9.4±5.5
Miyazaki	56.3±29.1	10.1±9.6

For each of the four beaches, the deep learning method consistently produced lower errors in scenes where beaches were most accurately extracted **(Table 1).**

In comparison to previous studies that extracted shorelines from satellite SAR images of the same beaches used in this study, the mean error value was smaller than that extracted from SAR images at three beaches, excluding Shimoniikawa Beach. Even for Shonan and Miyazaki Beaches—sandy beaches where shoreline extraction was challenging through SAR images—the accuracy of extraction was comparable to that in gravel beaches **(Figure 4).**

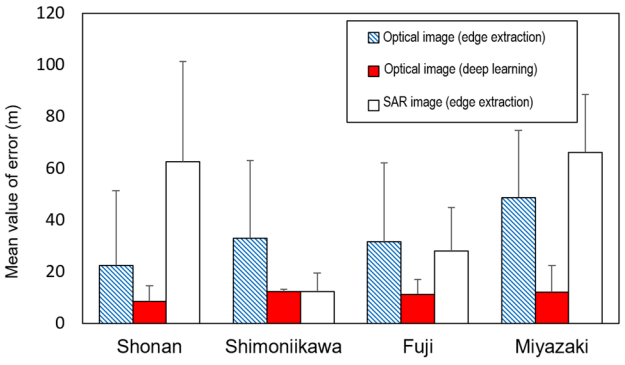

Figure 4. Difference in error based on satellite image types and extraction methods

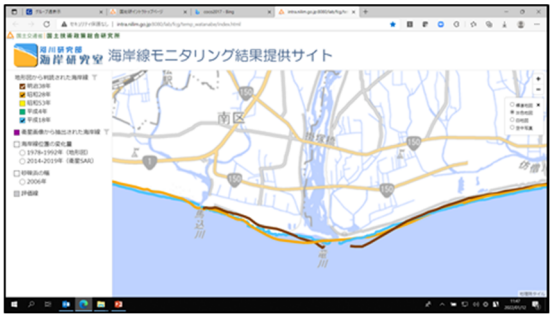

Figure 5. Prototype version of the monitoring results provision website

Given the 10-meter resolution of each Sentinel-2 sensor utilized in this study, the obtained extraction accuracy proves to be satisfactory, implying the effectiveness of shoreline extraction through deep learning.

4. Future prospects

Simultaneously with the development of the shoreline extraction method, we are in the process of establishing a website to compile and disseminate the shorelines extracted from optical satellite images and other relevant sources **(Figure 5).** Furthermore, we are in the process of creating a cloud application to enable coastal managers to access the automatic shoreline extraction method. Through these initiatives, our goal is to assist coastal managers in effectively monitoring shorelines, maintaining a high-frequency overview of beach conditions across Japan, and providing this information as open data.

☛For more information:

1) Watanabe et al. (2021) Evaluation of applicability of image processing methods for shoreline extraction from optical satellite images (in Japanese)
https://www.jstage.jst.go.jp/article/kaigan/77/2/77_I_1111/_article/-char/ja/

Developing 3D River Level Forecast Visualization with VR Technology

(Research period: FY 2020–2022)

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Keywords: River level forecast, virtual reality (VR), 3D images, flood control activities

1. Introduction

In recent years, flood disasters caused by torrential rains have occurred frequently throughout Japan. This has underscored the importance of providing timely flood forecast information, enabling the swift implementation of flood control measures and evacuations. In response to this situation, the NILIM developed a national flood forecasting model known as the Flood Risk Line. This model has been operational at the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) since 2019. Meanwhile, a study conducted by the Cabinet Office's "Review Meeting on Evacuation Behaviors After the Series of Torrential Rain Disasters Since July 2021" highlighted that inadequate communication about the urgency and realistic threat of an imminent disaster is impeding appropriate evacuation measures.

For this reason, NILIM has developed a three-dimensional (3D) display technology utilizing virtual reality (VR) technology, referred to as the *VR display*. This technology is integrated into the Flood Risk Line system as an additional function with the aim of conveying the urgency and realistic threat of disasters in a more easily understandable manner. The following section details the features of the VR display.

2. Development of VR display technology for river level forecast communication

(1) Validating the validity and feasibility of the VR display

During the technology development process, we conducted a survey of existing studies and case examples and found that utilizing VR technology to display river level forecast information could enhance evacuation behavior. Furthermore, regarding the 3D topographic data and background images crucial for the VR display, we confirmed that 3D topographical and urban models will be accessible through the 3D administrative maps, which are to be developed for all first-class water systems by the end of FY 2025, and the Project PLATEAU led by the MLIT.

(2) Development environment and selection of target rivers

When selecting the development environment for the VR display of river level forecasts, we emphasized the following three key factors and chose Unity, a gaming engine known for its easy 3D information processing and rich visual effects:

i) Operability: Prioritizing the speed of information display.

ii) Effects: Focusing on visual effects that effectively convey a sense of urgency and realistic threat.

iii) Accessibility: Ensuring compatibility with various devices and operating systems. We developed a system that enables users to access and interact with information through web browsers on both computers and smartphones. This was achieved by converting the Unity-developed environment into WebGL format.

We chose the Yamakuni River, a first-class water system, as our target river because we secured cooperation from the river administration office. During the system development for the Yamakuni River, there were no existing 3D administrative maps or urban models available. We thus captured photographic images using ground cameras and drones.

(3) Investigating methods to enhance operability

Improving operability posed a challenge because of the extensive 3D terrain data that needed to be processed. To address this, we created the 3D terrain mesh by reducing the number of polygons from around 10 million to approx. 30,000 per 30 km². This reduction was achieved through retopology (rearranging surfaces based on shape) as illustrated in Figure 1. Areas with complex shapes had increased polygon count, while areas with minimal shape changes had fewer polygons.

As a result, the data size (in bytes) was reduced to approximately 1/500 of the case where the 3D terrain mesh was directly generated from LP data. This reduction significantly enhanced both data transmission and display efficiency. Additionally, the time needed to draw each distance marker per screen was reduced from approximately 1 minute to around 0.1 seconds.

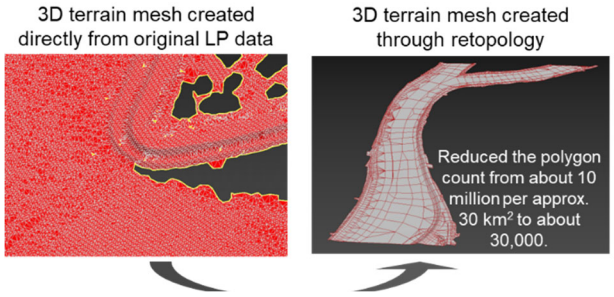

Figure 1. Retopology (reattaching a surface according to shape)

These enhancements have made it feasible to display river level forecast information in VR at a practical level.

(4) Creating 3D water surface model and adding effects

We added effects to enhance the realism of flooding threats, such as changes in water surface turbidity corresponding to water levels, the swaying of water caused by varying flow velocity and water spray, cloudy skies, and dynamic rainfall that changes based on measured and predicted rainfall data. Moreover, the water level at which evacuation decisions are made, as well as the flooding hazard level, are overlaid on the 3D model of the levee slope surface. This addition enhances the realism of the flooding threat.

(5) Creating VR operational screens

Figure 2 shows the operational screen displaying the VR images of river level forecasting information that we have created. This operational screen enables users to adjust and zoom their viewpoint. Users can also switch between current and projected times, distance markers, and the left and right banks. We are currently enhancing the display screen to support longer forecast times, extending up to 36 hours ahead for the flood risk line. Additionally, in collaboration with the Yamakuni River Office, we held discussions with disaster preparedness staff from local governments and river cooperative groups along the river. We received feedback, including the suggestion to include a sign indicating how much the water level can rise before reaching the flooding danger level, and incorporated these suggestions to enhance the display screen.

3. Observation on the VR display of river level forecasting information

(1) Benefits apart from communicating urgency and realism in disaster threats.

Figure 3 shows a comparison between an image taken from a CCTV camera at night (midnight, September 19, 2022) and a VR display at the same time when Typhoon Nanmadol (Typhoon #14) approached Kyushu near the 26.8 KP of the Yamakuni River in 2022. The VR display makes it visually easier to check the river level at night. Other advantages confirmed with the VR display include its ability to project forecasts up to six hours in advance, unlike CCTV cameras that can only show the current status. Additionally, the VR display can switch to showing areas where cameras have not been installed yet.

(2) Challenges in forecasting accuracy and communicating information during disasters

While we are working to enhance the accuracy of flood risk line forecasts by assimilating observed data, concerns persist regarding the potential impact on residents in the event of a significant disparity between forecasted information and actual conditions. This arises from the VR display of uncertain forecast information and the possibility of server downtime caused by access overload

during a disaster.

Figure 2. Operational screen for VR display we developed

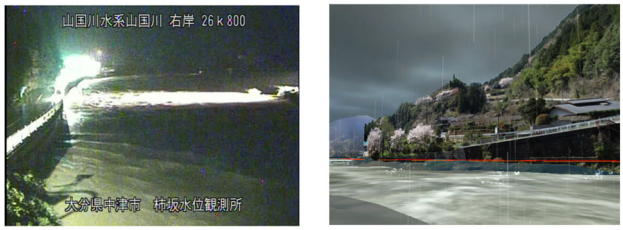

Figure 3. Comparison of CCTV and VR images at the same time at night (near the 26.8 KP of the Yamakuni River) (Left: CCTV camera image, Right: VR display image)

In addressing these challenges, we are improving the accuracy of flood risk line forecasts. At the same time, we are considering strategies, such as limiting VR displays to areas where a specific level of forecast accuracy is confirmed, such as near water level stations. Furthermore, we are contemplating the addition of a feature that allows the creation of trimmed videos with reduced data volume and limited duration.

4. Future outlook

The findings of this study will be published in 2023 as specifications for additional features of the flood risk line forecasting system. Furthermore, local governments along the Yamakuni River have requested the installation of VR displays at their Disaster Preparedness Offices. A trial operation is scheduled to start during the 2023 flooding season.

☞For more information:

1) Webpage of Water Cycle Division: Example of 3D Display of River Level Forecast using Virtual Reality (VR) Technology (under development)
https://www.nilim.go.jp/lab/feg/index.htm

Direction for Utilizing Flood Risk Maps to Enhance Watershed Flood Preparedness

(Research period: FY 2021–)

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YAMAMOTO Tetsuya, Researcher, Flood Disaster Prevention Division, River Department

Keywords: Watershed flood preparedness, disaster mitigation measures, flood risk map, consensus building

1. The starting point for watershed flood preparedness is to share a sense of crisis

In July 2020, the Social Infrastructure Development Council submitted a report regarding the transition to watershed flood preparedness. The report emphasizes that, beyond concrete actions by river administrators and evacuation plans by local governments, various stakeholders within a watershed should collectively participate in a range of measures implemented in catchment and flood-prone areas, hereafter referred to as "disaster mitigation measures," forming a multilayered collaborative approach.

Achieving collaboration in flood preparedness across a watershed begins with fostering a shared sense of crisis, realizing the need to take preventive actions and avert potential disasters. Achieving this necessitates the sharing of flood risks, specifying the locations and frequency of potential flood disasters linked to climate change. River administrators, who have diverse river-related information, are anticipated to provide flood disaster risk information, forming the essential basis for cultivating a shared awareness of the impending crisis.

In light of this awareness, the NILIM formulated guidelines[1] in January 2023 outlining the process of developing a flood risk map and concurrently conducted a study on their effective utilization.[2] This paper presents the results of these initiatives.

2. Flood risk map emphasizing the likelihood of flooding

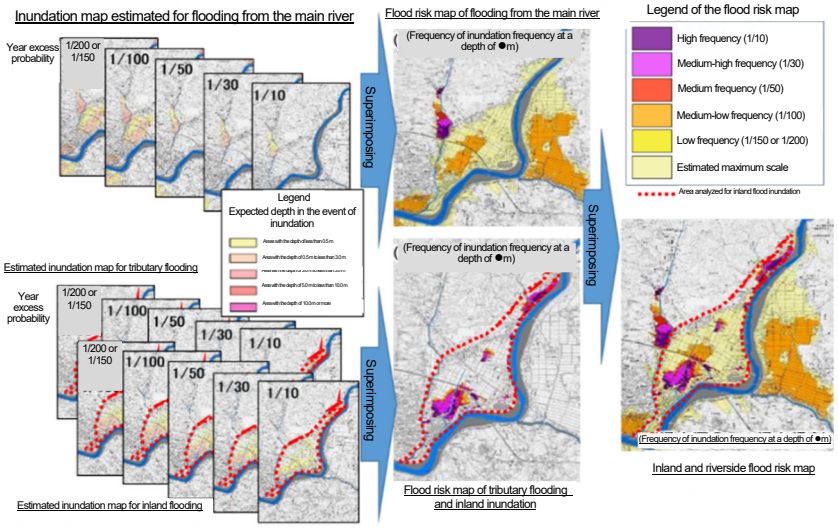

Figure 1. Illustration of creating a flood risk map

Figure 1 illustrates the steps involved in crafting a flood risk map. For more detailed steps, please refer to the reference.[2] The flood risk map displays the distribution of rainfall levels (annual exceedance probability) anticipated to result in inundation depths of 0.5 meters or more and 3.0 meters or more referred to as "inundation frequency." Traditional flood inundation area maps depict flood depths and other information during the peak anticipated rainfall, helping estimate potential damage to an area in the event of a major flood. These maps have been frequently utilized for implementing evacuation measures. In contrast, flood risk maps concentrate on the likelihood of flooding (frequency of occurrences). The flood risk map, covering both landside and riverside waters, enables users to identify the frequency of inundation by depths and occurrences caused by branch rivers and within levees.

With this map, local residents find it easier to comprehend the inundation conditions resulting from the different levels of rainfall they have experienced. This type of map, by depicting inundation in a manner closely aligned with the perception of local residents, is anticipated to serve a wide range of purposes.

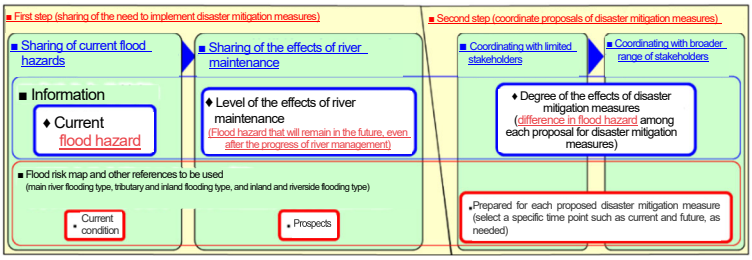

Figure 2. Disaster mitigation measures consensus building process and flood risk maps and other references utilized

3. The process of building consensus among diverse stakeholders within the watershed

Figure 2 illustrates two structures of the consensus-building process that led to the collaboration of all stakeholders in the watershed. The first step involves stakeholders sharing a collective awareness of the urgency to take action and reaching an agreement to implement disaster mitigation measures. In the second step, stakeholders specifically explore and coordinate the specific combination and approach of disaster mitigation measures to be implemented on-site by reaching an agreement.

The first step requires identifying flood risks that persist both presently and in the future even as river improvement measures are underway. In the second step, it is necessary to identify the locations of existing flood risks and anticipate how they might change as a result of implementing disaster mitigation measures.

4. Challenges in using flood risk maps

To identify the flood risks required at each step of the consensus-building process outlined in section 3 above, the interpretation of flood risk maps and other references is needed. This process organizes information on inundation depths and inundation frequency categorized by different depths for the present, future, and before and after the implementation of disaster mitigation measures.

Conversely, the flood risk map illustrates an instance of numerical analysis results obtained by uniformly configuring such conditions as the spatiotemporal distribution of rainfall and initial water level. On the

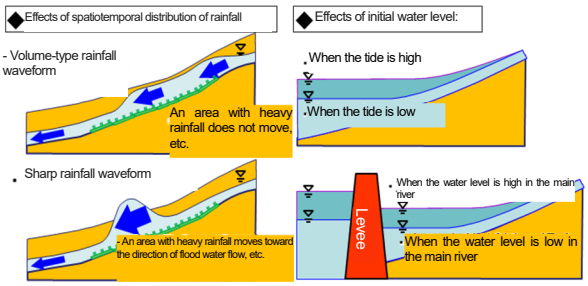

Figure 3. Example of a variety of natural phenomena which affect numerical analysis (illustration)

contrary, the flood risk generated based on actual flooding, a natural phenomenon, inherently carries uncertainty. This uncertainty arises because, even with the same level of rainfall, there can be variations in the spatiotemporal distribution of rainfall, as well as differences in river levels, flooding, and inundation conditions **(Figure 3).**

Moreover, a variety of disaster mitigation measures exist, including utilizing rice paddies and reservoirs, and installing rainwater storage facilities and double levees. The effectiveness of these measures varies based on their types, the volume and flow movement of inundation water, and the terrain. In certain instances, these specific measures prove effective in mitigating the damage caused by mid-to-small-scale inundations. In mid-to-small-scale flooding events, such factors as sewage pipes, microtopography, and channels influence the amount and direction of inundation flow. However, enhancing the sophistication of models for sewage pipes and other factors requires significant costs in terms of both finances and time.

Simply put, we must employ numerical analysis to

evaluate current and future flood risks as well as the effectiveness of disaster mitigation measures. However, there is often a large discrepancy between the actual inundation volume and flow direction during real disasters and the outcomes of numerical analysis. Hence, we must devise an evaluation method that takes into account both the impact of this disparity and the influence of numerical analysis on the assessment.

5. Future prospects - for the progress of watershed flood preparedness -

To encourage the progress and effectiveness of watershed flood preparedness, it is crucial to implement effective disaster mitigation measures. Achieving this requires consensus building among diverse stakeholders within the watershed. Moreover, as the Task Force on Climate-related Financial Disclosures (TCFD) issues recommendations[3] and environmental, social, and governance (ESG) investment gains popularity, there is a growing societal interest in flood risks.

This paper has introduced flood risk maps as a tool to illustrate flood risks in the context of advancing watershed flood preparedness.

We will continue to develop tools and conduct additional research to ensure the accuracy and fairness of flood risk information, including flood risk maps, in order to meet their intended purpose.

☛For more information:

1) Guidelines for Studying and Creating Multi-Level Inundation Estimation Maps and Flood Risk Maps http://www.mlit.go.jp/river/shishin_guideline/pdf/guideline_kouzuishinsui_2301.pdf
2) Inoue, et al. Utilization of Flood Risk Maps for the Advancement of Disaster Mitigation Measures in Watersheds (in Japanese). *Civil Engineering Journal*, Vol. 64, No. 12, 2022, pp. 28-31.
3) Task Force on Climate-related Financial Disclosures. Final Report: Recommendation by the Task Force on Climate-related Financial Disclosures. 2017.

Analyzing House Damage from Mudflow and Flood Inundation through Two-Dimensional Riverbed Change Calculations

(Research period: FY 2020–2022)

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Keywords: Mudflow and flood inundation, two-dimensional riverbed change calculation, house damage

1. Introduction

In recent years, the increased frequency of mudflow and flooding, attributed to climate change, has led to the release of muddy water containing a large amount of sediment from the river channel. This has resulted in damage to numerous houses and the loss of many lives. This study seeks a detailed understanding of the factors contributing to damage from mudflow and flood inundation. We first conduct calculations to reproduce mudflow and flood scenarios. Subsequently, we analyzed the correlation between these scenarios and the extent of damage sustained by houses.

2. Outline of investigation

We examined the watershed of the Gofukuya River, a tributary of the Uchi River in the Abukuma River system. This investigation focused on areas where mudflow and flood inundation took place as a result of the rainfall from Typhoon Hagibis in 2019. The analysis utilized the degree of house damage, as determined by the findings of Sakai et al.[1] The two-dimensional (2D) riverbed change calculation model, employed in the reproduction calculations, was developed based on Wada et al.[2]

3. Investigation findings

Figure 1 displays the final sedimentation depth obtained from the reproduction calculations and the actual riverbed changes recorded through aerial laser surveys conducted before and after the disaster. The sedimentation trends overall showed a close similarity with the reproduced calculations depositing within approximately 90% of the sediment compared to the actual sediment deposited as determined through differential analysis of the aerial laser survey. This implies that the reproduced calculations accurately replicate the actual conditions of sediment discharge and deposition.

Figure 2 illustrates the relationship between the hydrodynamic force and the degree of house damage as calculated through the reproduction calculations. As the hydrodynamic force increases, the extent of house damage also rises, indicating that the reproduction calculation can reasonably capture the occurrence of damage caused by mudflow and flood inundation.

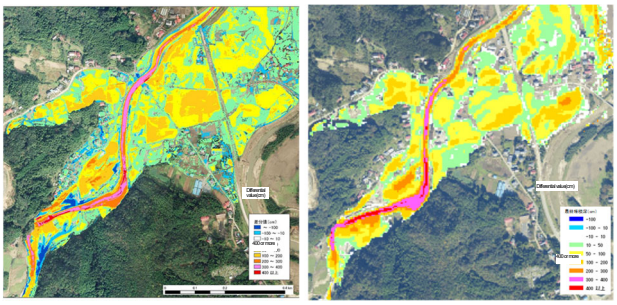

Figure 1. Actual riverbed change (left) and reproduced calculation results (right)

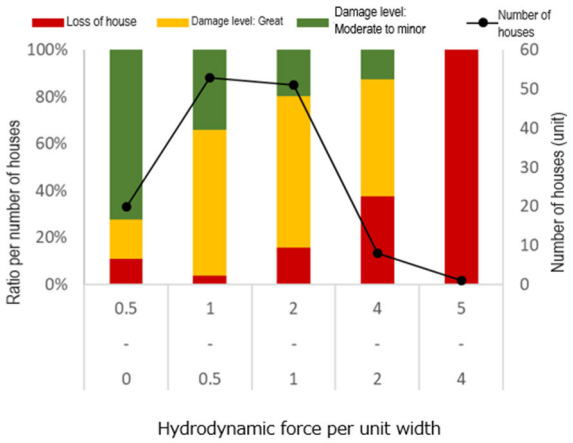

Figure 2. Hydrodynamic force and extent of house damage

4. Summary

In future studies, we plan to conduct more detailed investigations to understand the causes of house damage during mudflow and flood inundation events, the influence of sediment on this damage, and indicators for accurate estimation.

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Exploring a Simplified Approach for Assessing the Flow of Collapsed Sediments

(Research period: FY 2020–2022)

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Keywords: Sediment flow, AMI, soil testing

1. Introduction

Approximately 70% of Japan's terrain is mountainous, and the country experiences frequent slope failures due to earthquakes and heavy rainfall. Hence, multiple surveys and studies have been undertaken, resulting in the accumulation of diverse findings. The Act on Sediment Disaster Countermeasures for Sediment Disaster-Prone Areas incorporates these findings, exemplified by designations like the Landslide Special Warning Zone (red zone) and Landslide Warning Zone (yellow zone). These measures contribute to the safety of local residents as illustrated in Figure 1. Meanwhile, reports have highlighted the fluidization of sediment flowing from collapsed slopes, primarily occurring in regions with volcanic soil originating from volcanic ash and pyroclastic flows. When sediment undergoes fluidization, it can extend beyond the anticipated sediment reach as illustrated in Figure 1. This can lead to severe and extensive damage, particularly in areas where countermeasures and preparedness measures are inadequately implemented. Sediment fluidization is primarily facilitated by the weathering and alteration of volcanic soil as noted by Chigira et al. (2012). Consequently, the urgent tasks from the perspective of disaster preparedness and damage mitigation involve identifying slopes with these geological risks and implementing effective countermeasures. The Sabo Department has compiled survey results on landslides in Japan and explored the feasibility of assessing the Approximate Mobility Index (AMI) as an indicator of sediment mobility, which uses an evaluation method based on soil properties.

2. Methods and Samples

The Approximate Mobility Index (AMI), introduced in the United States, is calculated by dividing the soil's saturated water content ratio (%) by its liquid limit (%) (Ellen and Fleming, 1987). Developed through research focusing on diverse sediment mobility processes in slope failure, this index has seen limited application in Japan with only a few cases documented, such as in the work of Yamamoto et al. (1999). In Japan, there are indicators like

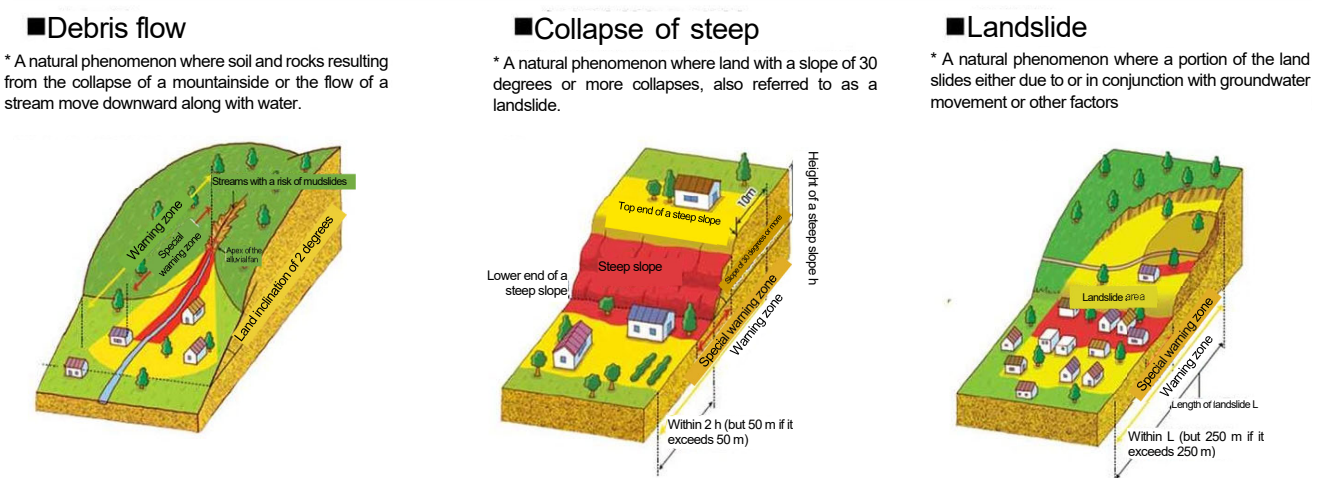

Figure 1. Range of Red Zone and Yellow Zone for mudslide, collapse of steep slopes, and landslides, based on the website of the Ministry of Land, Infrastructure, Transport and Tourism

the equivalent friction coefficient for assessing sediment mobility. However, these may not be suitable for evaluating potential geological risks because they necessitate an examination of such factors as slope height, sediment transport distance, and other factors. In contrast, the AMI is distinctive in that it does not signify the susceptibility of slope failure but rather the fluidity of the sediment when failure occurs. Furthermore, calculating the AMI does not necessitate any specialized machinery or processing; it can be derived from soil test values commonly conducted according to JIS standards. As mentioned earlier, the limited use of the AMI in Japan can be attributed to two primary reasons. First, in many slope disaster investigations, some soil tests are not conducted. Second, the geological complexity in Japan surpasses that of the United States, making interpretation challenging.

$$AMI = \frac{W_{sat}(Saturated\ water\ content)}{W_L(Liquid\ limit,\ \%)} \cdots Equation\ (1)$$

The formula for calculating the AMI is presented in Equation (1). However, as previously discussed, certain soil tests are omitted in the slope failure case studies we gathered. In these instances, the AMI was computed either by substituting the standard values provided by the Japanese Geotechnical Society or by estimating the substituted values through the conversion equations proposed by Matsuo et al. (1970) and Kek et al. (2021). This study involved computing the AMI for 173 samples from 21 cases of sediment disasters, accompanied by reported sediment flow incidents across Japan. These incidents include factors such as the cause of landslides (induced by earthquakes or rainfall) and geological characteristics (volcanic or non-volcanic etc.).

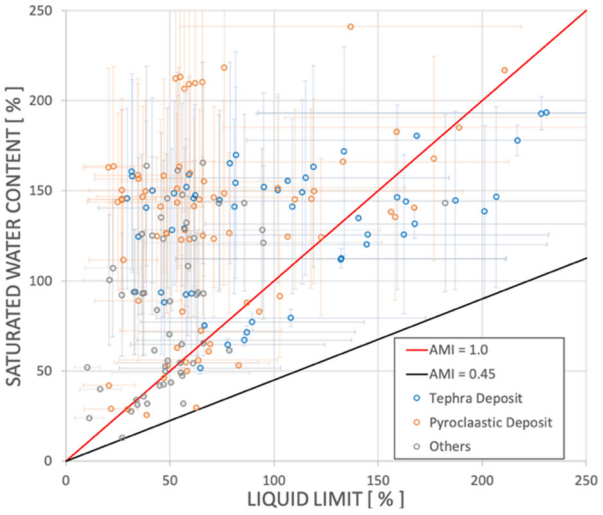

Figure 2. AMI distribution based on differences in geological differences

The red line indicates AMI = 1.0 and black line AMI = 0.45.

Table 1. Sediment flow characteristics based on AMI value range

AMI < 0.45	Sediment is not fluidized.
0.45 < AMI < 1.0	Sediment is not fluidized, but is fluidized by excessive moisture supply
1.0 < AMI	Sediment is fluidized.

3. Results

As illustrated in **Figure 2**, the AMI values are designed to exhibit varying flow characteristics in three regions defined by the red and black lines. The AMIs acting as boundary values are set at a black line = 0.45 and a red line = 1.0, with the flow characteristics of each region detailed in **Table 1**.

Overall, approximately 80% of the samples exhibited a value of 1.0 or higher, while the remaining fell within the range of 0.45 to 1.0. This suggests that the AMI closely aligns with the actual cases, showing minimal deviation. In addition, the estimated range depicted by the error bar in **Figure 2** does not go below 0.45. This suggests that even the estimates derived from converted values do not exert a substantial influence on the results. Moreover, the AMI values for samples from volcanic geology (represented by blue and orange circles) ranged from 0.9 to 3.0, indicating a trend towards higher flowability compared to non-volcanic geology.

Once more, considering the formula presented in Equation (1), the AMI reflects the water volume ratio with the numerator representing the maximum water retention

of a natural slope and the denominator indicating the minimum water retention necessary to sustain flowability after a collapse. In other words, a higher AMI value implies a longer duration for the disturbance and drainage of collapsed sediment as well as an extended distance of sediment movement. This is consistent with both the organized results and the actual sediment dynamics.

4. Summary

Despite its origin in the United States, the AMI, when interpreted in light of its physical properties, has demonstrated potential applicability in evaluating the flow of collapsed sediment in Japan as well. This is noteworthy given the complex distribution of geology and the humid climate zone in the region. However, caution is necessary in handling errors when utilizing estimated values. We plan to incorporate topographical conditions and other factors into our future studies.

Analysis of the Impact on Traffic Functions of Scouring of Road Earthwork Structures and Slope Collapses, Etc. Due to Torrential Rain

(Research period: FY2021–)

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(Keywords) road earthwork structures, scouring, torrential rain, slope collapse, road function

1. Introduction

Road earthwork structures have been damaged due to disasters such as scouring and slope collapses, which have been caused by increasingly severe torrential rain, and there have been many events where the traffic function of roads has been lost.

This study analyzed the extent of the effects on traffic function (the state of traffic restrictions), looking at the manner of damage due to scouring (40 locations in FY2015–FY2020) and road slope collapse, etc. (112 locations in FY2019–FY2020: collapses of fill and cut slopes, sediment inflow, slope collapses) that were applied for and adopted as disaster recovery projects due to torrential rain, etc. on directly managed national roads.

2. Scouring of road earthwork structures

When we focus on the disaster factors in scouring disasters on roads adjacent to rivers, disasters caused by streambed scouring and full closures due to erosion from the revetment crown often occur. In outer curve sections (roads located on the outer shore side with respect to the curve in the center of the stream in a curve section of river), where streambed scouring occurs particularly easily, the proportion roads that are not passable to normal vehicles within one week after the disaster is high at about 70%. Because of this, we selected five representative locations of the above manners of damage (Hokkaido, Gifu, Hiroshima, Oita, Kumamoto), checked existing materials and conducted on-site investigations, while making use of topographic maps created with aerial laser surveying for contiguous sections including the damaged location (approx. 3 km), and compared damaged and undamaged locations in the section to extract conditions at high risk of damage.

(1) Damage due to streambed scouring

When grasping the state of streambed scouring, directly confirming scouring locations is not easy if the water flow is great, so we focused on the development of sandbars, which is one cause of streambed sinking, and analyzed changes to sandbars over time through past aerial photographs as a comparative easy method. As a result, the proportion of locations that suffered damage was roughly tripled if the location had a sandbar develop on the bank opposite the damaged location, compared to locations without a sandbar (fig. 1). Because of this, observing changes in sandbars over time appears to be effective as one method of inspecting to ameliorate the risk of damage.

(2) Disaster due to erosion from revetment crown

As a result of an analysis focusing on the disaster water level in the event of torrential rain (DHWL) and the revetment structures, structures with tamping above the revetment crown were damaged more easily than structures without it (fig. 2), and damage occurred in all locations when the water level in flood exceeded the revetment crown. In future, it is necessary to consider countermeasures incorporating conditions with a high likelihood of disaster, as there are many similar locations.

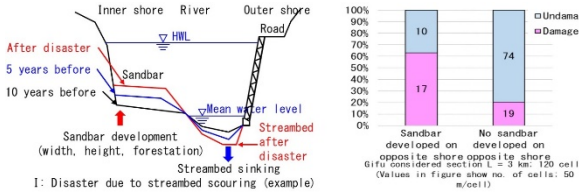


Fig. 1. Example of scouring damage due to sandbar development

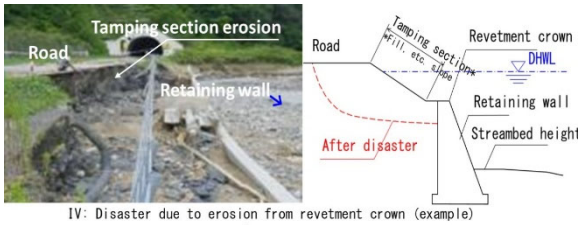


Fig. 2. Example of damage during water level rise due to torrential rain

3. Slope collapse, etc. on roads

The relationship between the manner of disaster and the level of its effect on traffic function shows that roads are likely to be entirely closed to traffic if sediment inflows from a stream, etc. or the slope collapses, and that most roads tend to be entirely closed to traffic when sediment inflow occurs in particular. Moreover, locations with catchment topography had a high proportion of full road closures for any manner of disaster. Because of this, we selected nine representative locations (sediment inflow: Iwate, Fukushima, Kanagawa, Kumamoto, Kagoshima; slope collapse: Kanagawa, Yamanashi, Oita, Kagoshima) for the above manners of disaster and took contiguous sections including the damaged location (approx. 1 km) as the sections for consideration. For these sections, we checked existing materials and conducted on-site investigations, while making use of topographic maps created with aerial laser surveying, and compared damaged and undamaged locations by making determinations based on whether sediment, etc. reached the road or not to extract conditions at high risk of damage.

(1) Disaster due to sediment inflow

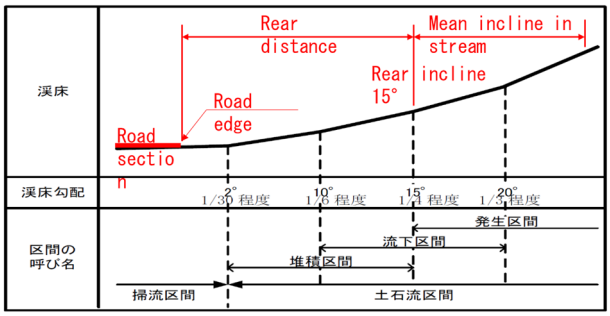
We analyzed disasters due to sediment inflow, organizing them by the catchment area of the stream, distance, etc. In relation to the stream incline, we used the streambed incline for the manner of sediment movement (fig. 3) as a guide, and focused on an incline of 15° for the accumulation section, at which sediment begins to accumulate, established a rear incline, incline distance, and mean incline in stream as shown in red in figure 3, and organized the section distances between them.

As a result, when focusing on the relationship between the rear distance and the rear incline, sediment tended not to reach the road if the rear distance was 100 m or more (fig. 4). Moreover, the relationship between the stream catchment area and the mean incline in stream showed a trend where the damaged and undamaged locations can be classified at the point where the mean incline in stream is approximately 25° (fig. 5).

(2) Disaster due to slope collapse

We analyzed disasters due to slope collapse, organizing them by slope area, incline, catchment topography, etc. As a result, generally if the mean incline of the slope is less than 25° and the catchment area of the slope is less than 15,000 m²,

sediment did not reach the road in all locations. Conversely, generally if the mean incline of the slope is 20° or more and the catchment area of the slope is 15,000 m² or more, sediment reached the road in a high proportion of the locations (fig. 6). It should be noted that the learnings obtained from this study in relation to sediment inflow and slope collapse refer to trends in the extracted representative areas, and further consideration concerning their applicable in varied conditions on the ground appears necessary.



Rear distance: Distance from road edge to streambed incline less than 15°
Rear incline: Streambed incline 15°
Mean incline in stream: Mean incline from streambed incline 15° or greater to upstream edge of ridge

Fig. 3. Settings for matters for organizing sediment

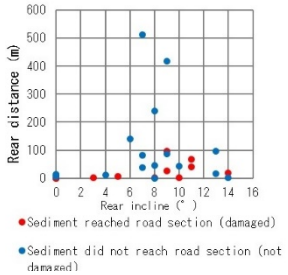


Fig. 4. Rear distance and rear incline

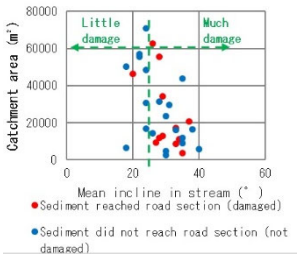


Fig. 5 Catchment area and mean incline in stream

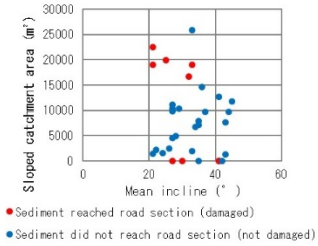


Fig. 6 Catchment area and mean incline in slope

4. Summary

As a result of an analysis of the effects on traffic function using the case of disasters on directly managed national roads due to recent torrential rain, etc., we obtained knowledge relating to conditions of high disaster risk, such as sections located on the outer curves of rivers and sections where the rear slope has an incline above a certain level and the catchment area is large. It should be noted that some of these analysis results are in the extracted representative sections, and we intend to continue collecting and analyzing disaster cases and reflecting the knowledge obtained in technical standards and other references.

☞See here for detailed information

"An Analysis of the Impact of Heavy Rain Damage to Road Earthwork Structures and Slopes on Road Traffic Functions", Civil Engineering Journal (2002), vol. 64, no. 8, pp. 30–33 [in Japanese]

Research to Gain Understanding of the Sense of Scale of Structure Damage Directly after Earthquakes

(Research period: FY2009-)

Earthquake Disaster Management Division, Road Structures Department

Researcher NAKAGAWA Takuma Head NAKAO Yoshihiro Senior researcher NAGAYA Kazuhiro

(Keywords) disaster response, gathering disaster information, acceleration response spectrum

1. Introduction

When a large-scale earthquake occurs, road administrators conduct patrols to gather information about the extent of the damage, but as it takes time to confirm the damage, a period without information arises.

As part of initiatives relating to gathering information about damage in the period without information, the National Institute for Land Infrastructure Management (NILIM) is trialling initiatives to automatically distribute information inferring the sense of scale of structure damage focusing on acceleration response spectra (below, "spectrum analysis information") to disaster response personnel and others approximately eight minutes after an earthquake occurs. This paper presents an outline of spectrum analysis information.

2. Background and outline of spectrum analysis information

Seismic intensity is one piece of information that is available directly after an earthquake occurs, but because the period of the seismic motion, which significantly affects the computation of the seismic intensity, differs from the natural period at which public works structures are affected by strong vibrations, it has been pointed out that the seismic intensity does not necessarily match with significant damage to public works structures.

Given this, the researchers in this study

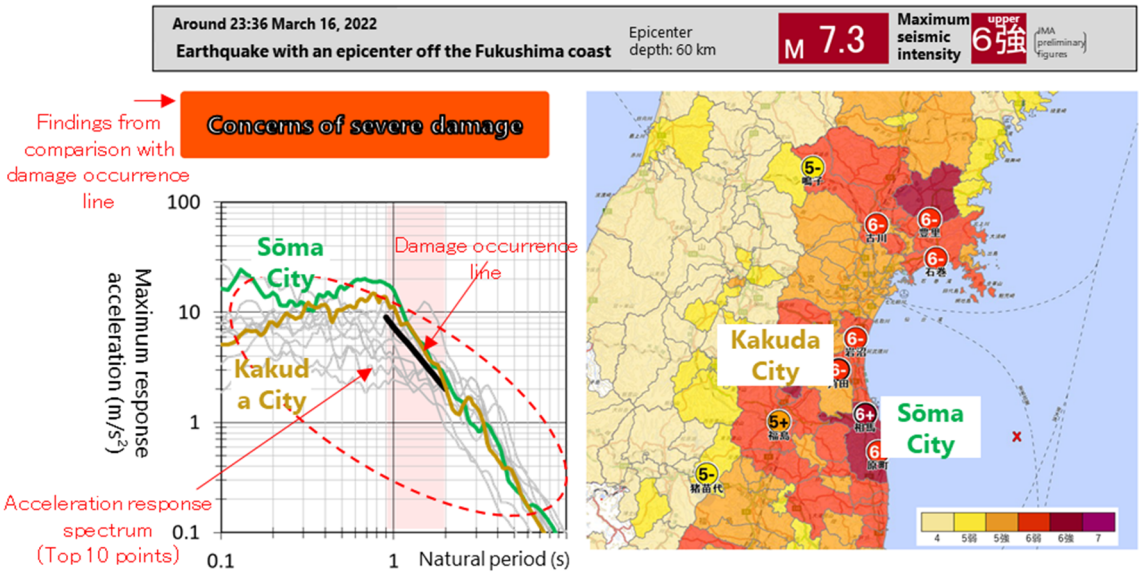


Fig. 1. Example of spectrum analysis

thought it may be possible to gain an understanding of the sense of scale of damage to structures by focusing on natural periods between 0.9 and 2 seconds, which highly correlate to structural damage, within the acceleration response spectrum, which shows the maximum response acceleration of the elastic response computed by having seismic motion operate on structures with various natural periods. Specifically, this method gains information about the sense of scale of structural damage due to an occurring earthquake by comparing the "damage occurrence line" that is defined based on the accelerated response spectra obtained in previous earthquakes when damage was limited with the acceleration response spectra of the seismic motion measured at seismographs throughout Japan when a new earthquake occurs (see fig. 1). We have built a system to create and distribute this spectrum analysis information automatically and have implemented automatic distribution.

3. Comparing spectrum analysis information and actual damage

The acceleration response spectrum shown in figure 1 is from an earthquake off the coast of Fukushima with a maximum seismic intensity of 6 upper that occurred late in the night of March 16, 2022. This earthquake surpassed the damage occurrence line at nine observation points. As vibration surpassing the damage occurrence line was observed throughout the entire region at a natural period of 0.9 to 2 seconds, which correlates strongly with structural damage, at the two observation points in the cities of Sōma and Kakuda in particular, we inferred "concerns of severe damage" from the spectrum analysis information.

As a result of patrols by the road administrator after the earthquake, road surfaces had developed differences in level on the E6 Jōban Expressway and National Highway 6 in Sōma. Furthermore, in Kakuda, the substructure of the Edano Bridge on a municipal road was damaged (photo 1) and the bridge was closed to traffic for approximately three months until stopgap recovery works were completed, which shows that the spectrum analysis information was able to accurately infer the sense of scale of the damage.

Photo 1. Edano Bridge in Kakuda City, which was damaged by an earthquake

4. Contributing to lessening burdens on the ground

Road patrols after earthquakes have been conducted as a trial initiative from FY2019, and spectrum analysis information has been given a new position within them.

Conventionally, directly managed national highway offices that measure an earthquake with a seismic intensity of 4 or higher are required to conduct road patrols for emergency inspection "immediately" after the earthquake occurs, but partly because of the construction of an environment where information on the sense of scale of structural damage is

distributed approximately eight minutes after an earthquake due to spectrum analysis information, the response when an earthquake with a seismic intensity of 4 occurs is being changed in a trial. Specifically, they are trialling operations where, if there are no concerns about damage occurring due to recent weather and other factors and the concerns about damage occurring are minor due to the result of the spectrum analysis information, inspections are conducted in "the road patrols in normal hours on the day of or the day following the occurrence of the earthquake." (Operations in the case of an earthquake with a seismic intensity of 5 lower or higher has not changed.)

In other words, the spectrum analysis information is being used, and it appears that it is leading to lesser burdens on the ground, including for road administrators and the affiliated companies that are contracted for maintenance and management operations, etc.

Over the 12 months of FY2021, 43 earthquakes with a maximum seismic intensity of 4 occurred throughout Japan. Of these, 11 occurred during working hours (8:30-17:15 on weekdays), while the other 32 occurred outside working hours on a weekday or at any time on a holiday. This is thought to have changed 32 initial responses on the ground just in this one year, and it could be considered to have contributed to DX in disaster response.

5. Conclusion

This paper presented the background to spectrum analysis information, which infers the sense of scale of structural damage focusing on acceleration response spectra, and a comparison with actual damage, as part of initiatives to fill in the period without information directly after an earthquake.

The automatic distribution of spectrum analysis information began in FY2017, but since then, we have made improvements to the system with the aim of increasing immediacy and stability of the distributions and enriching the content that is distributed. In FY2022, we moved the system server onto the cloud to enable stable distribution in the event of a large-scale earthquake and made general improvements to the system. We intend to continue the automatic distribution initiative while validating the accuracy of the inferences, among other work.

☞See here for detailed information

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http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1204.htm

2) Nakagawa Takuma, Nakao Yoshihiro, Nagaya Kazuhiro: Gaining Understanding of the Sense of Scale of Structure Damage in the Period Without Information Directly after Earthquakes, *FY2022 Proceedings of the Land Technology Research Society, MLIT*, p. 5, Nov. 2022

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Development of New Performance Indicators and Evaluation Programs to Contribute to the Advancement of Fireproof Performance of Non-residential Buildings

(Research period: FY2020 to FY2022)
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DEGUCHI Yoshikazu (Ph.D. in Engineering), Senior Researcher,
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Keywords: non-residential building, fireproof performance, performance indicator

1. Introduction

This research described herein concerns methods to rationalize fireproof performance indicators for non-residential buildings utilizing the comprehensive assessment of fire-related risks. This paper introduces the framework of the research.

2. Indexing using comprehensive risk assessment

Fireproof performance of buildings is primarily divided into multiple target performances such as evacuation safety, collapse prevention, and fire spread prevention. Risk assessment frameworks that have been introduced in the past often covered specific target performances. In other words, performance has been verified by confirming whether the safety of the building or occupants is ensured against the design fire source under assumed fire scenarios appropriate for the evaluation of each target performance. In contrast, this research comprehensively evaluates the damage patterns that can result from a single fire source, and then incorporates the results into the evaluation of the associated target performance. This allows for relative positioning between target performances.

Fig. 1 shows the event tree assumed in this research. In this Figure, the fire scenarios that could occur in one of the compartments of a building are classified into 22 patterns based on a combination of eight probabilistic events: (1) fire breakout, (2) smoke intrusion, (3) smoke control and evacuation failure, (4) fire intrusion, (5) fire growth, (6) compartment breakthrough, (7) collapse, and (8) fire spread to adjacent buildings. The damage caused by a compartment is assumed to be independent of other compartments. However, smoke and fire intrusion from the adjacent compartment is separately evaluated to take into account the spreading effect of fire.

3. Performance indicators

The target performances that constitute the fireproof performance of a building are broken down into seven items given in **Table 1**. By linking these performances to an appropriate damage indicator L (amount of damage or probability of damage occurrence), the results of risk assessment can be used to evaluate target performance. The damage indicator L is primarily a reverse indicator of target performance. Therefore, as shown below, the reverse of the amount of damage L normalized by the reverse of the amount of damage L_0 under the reference condition is defined as the performance indicator F.

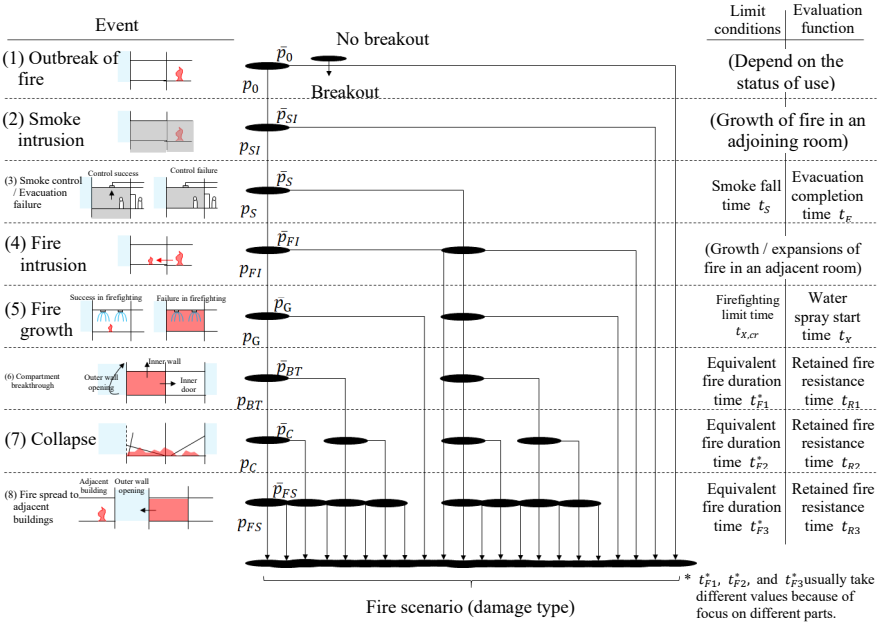

Fig. 1: Event tree focused on fire intrusion in each compartment

Table 1: Examples of target performance and damage indicators

Target performance	F value	Example of damage indicator L
Fire prevention performance	F_1	Probability of fire
Fire growth prevention performance	F_2	Fire growth probability
Collapse prevention performance	F_3	Collapse area, collapse probability
Fire spread prevention performance	F_4	Number of burned buildings, fire spread probability
Evacuation safety performance	F_5	Number of people who cannot evacuate, Probability of evacuation failure
Firefighting activity support performance	F_6	Probability of firefighting failure
Functional continuity performance	F_7	Renovation cost, Number of days for restoration

$$F_i = \frac{1/L_i}{1/L_{0,i}} \quad (i = 1, \cdots, 7)$$

Table 1 lists examples of damage indicators L suitable for evaluating each target performance. Although the properties of the seven target performances are different, they are associated with the common event tree to allow comparison among them.

4. Case study

To examine the characteristics of performance indicator F, we conducted a case study for an office building of S structure, three stories high and total floor area of 3,168 "m^2" as shown in **Fig. 2**. In this study, we focused on the three fireproof specifications shown in **Table 2** (fire resistance time t_R (RS) of the main structure parts, installation of sprinkler system (SP), and compartmentalization of room D (C)), and examined the relationship between the combination of these specifications and the performance indicator F. However, the evaluation targets are four target performances that can reflect the effect of fireproof specifications at present (i.e., collapse prevention performance F_3, fire spread prevention performance F_4, evacuation safety performance F_5, and functional continuity performance F_7).The damage indicator L, shown as a boxed line in **Table 1**, was used in the calculation of each performance indicator F.

The calculation results are shown in **Fig. 3**. While the installation of sprinkler systems (SP) and compartmentalization (C) improved all target performances, the strengthening of major structural parts (RS) showed no effect only in the evacuation safety performance F_5. This is a measure where strengthening of the main structural parts (RS) is effective after the fire has grown and reflects the different nature of the measures required to improve the F_5 value. Note that compartmentalization (C) is also generally regarded as a measure that is effective after the fire has grown, but the division of room D reduced the time to become aware of the fire and the time to walk, which led to reduction in the evacuation

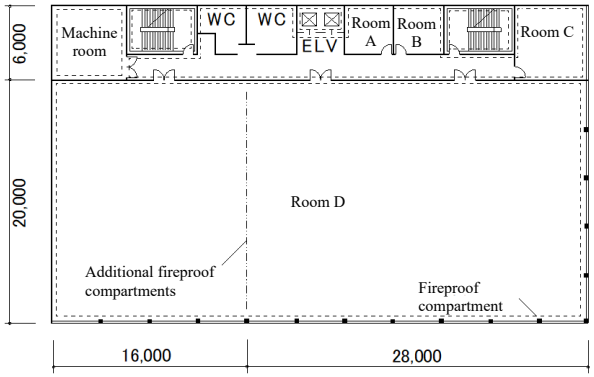

Fig. 2: Reference floor plan of target building (Unit: mm)

Table 2: Calculation conditions

Conditions	Item		Basic plan (O)	Improvement plan
RS	Fire resistance time t_R	Main structural part	60 min.	90 min.
		Outer window	20 min.	
SP	Sprinkler system		None	Available
C	Number of fire proof compartments in Room D		1	2

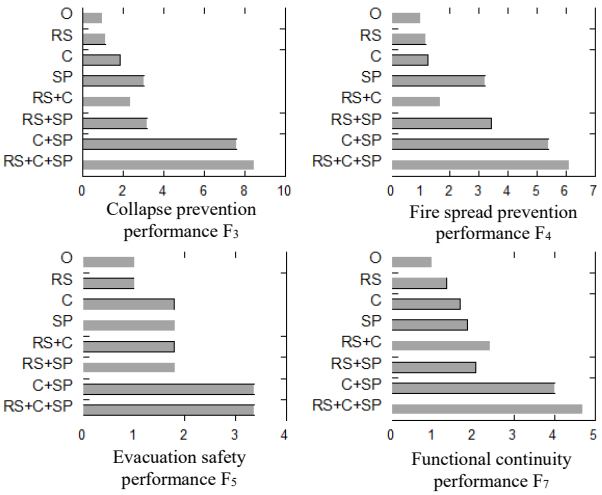

Fig 3: Calculation result of performance indicator *F*

completion time t_E. However, given that the ratio of transit time of an evacuation exit to t_E is often not small, it is generally expected that the effect of improvement in F_5 value by compartmentalization (C) will only be limited.

5. Conclusion

This research proposes a new performance indicator F considering the quantification of the evaluation axis and the ease of interpretation of evaluation results. In the future, we will continue to improve the performance indicator F by reviewing the calculation methods of event occurrence probability p and performance indicator F.

Design Targets for Independent Energy Systems for Continued Living after a Disaster (Research period: FY2020 - FY2022)

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Key words: photovoltaic power generation, storage battery, design target, house, power outage, continued living

1. Background and purpose

One measure to enable people to continue living in their houses under the conditions of continuous power outage after a disaster is to use a system that combines photovoltaic power generation and storage batteries ("independent energy system"). To ensure the effectiveness of an independent energy system, it is important that the building owner and designer can determine whether the system has adequate performance against disasters and changing conditions. However, as for continued living in a house after a disaster, since there are no design targets developed for independent energy systems in house design, there are no performance indicators that serve as a basis to determine whether the performance is suitable, and the development of such indicators is an urgent issue. Thus, we started "Research on Design Targets of Independent Energy Systems for Continued Living in a house after a Disaster" in 2020. This research provides insights into the electricity applications necessary to continue living in a house after a disaster, quantify the requirements for independent energy systems in house design, and organize these results into design targets for independent energy systems to continue living in a house after a disaster. In FY2022, we studied methods to calculate the amount of electricity needed to stay at home and the amount of electricity supplied by independent energy systems, assuming that residents would use their devices during a power outage. In this report, we present the outline of the calculation method and the results for a house that uses only photovoltaic power generation as an example of the application of the calculation method.

2. Outline of the calculation method and examples of application

To calculate the residential electricity demand (electricity consumption) and the amount of electricity generated by photovoltaic power generation, the calculation method based on the "Act on the Improvement of Energy Consumption Performance of Buildings", (enforced in April 2016; hereinafter referred to as the "2016 Energy Conservation Standards") was applied. **Table 1** shows the calculation conditions for the application examples listed below.

The use of devices during a power outage was set up as shown in **Table 2**, assuming that in addition to the case where the family spends time as usual, the use of various devices is restricted based on the assumption that the family gathers in certain rooms (in this case, living room, dining room, kitchen and the couple's bedroom). The devices to be used during power outage was prioritized based on the results of a questionnaire survey conducted in previous years regarding inconveniences in daily activities during power outage.

Table 1: Calculation conditions

Item			Setting
Region			A3 category in 6 areas of the 2016 Energy Conservation Standards (Warm with moderate annual insolation)
Setting of a house	House plan		A standard house that meets the 2016 Energy Conservation Standards
	Floor area		120 m^2 (equivalent to a 4-person household under the 2016 Energy Conservation Standards)
	Outer shell performance		2016 Energy Conservation Standards
	Device performance		Average performance at the time of calculation
	Heating / cooling system		Air conditioner
	Hot-water supply system		Electric heat pump
	Other		Equivalent to all electrification
Photovoltaic power generation	Panel	Number of faces	1 face
		Angle of direction	South
		Angle of inclination	30 degrees
	Power conditioning system	Rated load efficiency	92.7 %
	Array	Capacity	4.0 kW
		Installation method	Roof-mounted
Power outage situation	Date and time of occurrence		Midnight on the day when the annual maximum temperature is reached (July 23)
	Device use level	Lv.0	Use the devices as usual
		Lv.1	Limit the use to some extent
		Lv.2	Limit the use to maximum in order to ensure safety

Table 2: Device usage level settings during power outage (Change point from Lv.0 Change point from Lv.1)

Use	Set device usage levels in the event of power outage		
	Lv.0: As usual	Lv.1: Limited to some extent	Lv.2: Ensure safety and limit to the maximum
Heating	- Use in each room when occupied (except when sleeping).	- Limit the use to living room, dining room, kitchen and master bedroom. - When the average outside air temperature from 12:00 to 14:00 is 13°C or higher, stop the heating system during the same time zone.	- Limit the use to living room, dining room, kitchen and master bedroom. - Unconditionally stop the heating system from 12:00 to 14:00.
Cooling	- Use in each room when occupied.	- Limit the use to living room, dining room, kitchen and master bedroom. - When the average outside air temperature from 16:00 to 24:00 is 25°C or lower, stop the cooling system during the same time zone. - When the average outside air temperature from 23:00 to 8:00 in next morning is 25°C or lower, stop the cooling system during the same time zone.	- Limit the use to living room, dining room, kitchen and master bedroom. - Unconditionally stop the cooling system from 16:00 to 8:00 in next morning.
Ventilation	- 24-hour use.	- 24-hour use.	- 24-hour use.
Lighting	- Use in each room according to the life schedule.	- Limit the use space to the first floor. - Light reduction to 50%.	- Limit the use space to the first floor. - Light reduction to 10%.
Hot water supply	- Use according to the life schedule.	- Use according to the life schedule.	- Use according to the life schedule.
Other	- Use in each room according to the life schedule.	- Limit appliances to those used in living room, dining room, kitchen and master bedroom (refrigerator, electric rice cooker, TV, PC, etc.).	- Stop the use of any device.

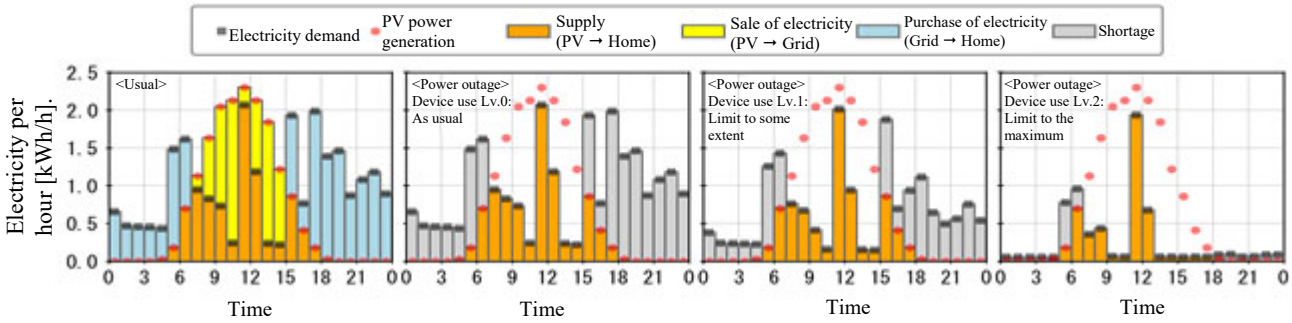

Figure: Example of application of the calculation method developed in this research (Assumption for the day of power outage: Time changes in residential electricity demand and supply from photovoltaic power generation, etc. for the 24 hours from the power outage)

As a result of the calculation, **Fig. 1** shows the time variation of electricity demand and supply from photovoltaic power generation, etc. for the 24 hours from the occurrence of the power outage (July 23, 0:00). As shown in the **Figure**, the calculation method developed in this research can reproduce the suppression of electricity consumption by residents who refrain from using devices during power outage and the supply situation from photovoltaic power generation.

4. Future development

We plan to compile technical data to study the design targets of independent energy systems for continued living after a disaster by organizing the results obtained from the questionnaire survey conducted in previous years on the inconveniences of daily activities during power outage and a parametric study to which the calculation method described in this report was applied.

For Improving Local Disaster Preparedness in Densely Buit-up Areas

(Research period: FY2021- FY2023)

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Key words: densely build-up area, local disaster preparedness, soft measures

1. Introduction

The Basic Plan for Housing for people (decided by the Cabinet on March 19, 2021) positioned the strengthening of soft measures that contribute to improving local disaster preparedness in densely built-up areas. On the other hand, since the current measures for dense urban areas and disaster prevention performance evaluation focus on hard measures such as road and park development and noncombustible rebuilding, it is difficult to activate incentives for local residents to engage in soft measures such as fire prevention and initial firefighting. Therefore, an accurate evaluation method is required for the effect of soft measures. This paper presents a perspective on research on quantitative evaluation methods for the effect of soft measures, which NILIM is working to develop.

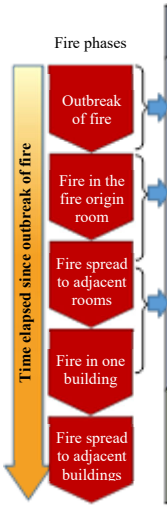
2. A perspective on quantitative evaluation of the effect of soft measures

We focused on the fact that implementation of soft measures improved the capacity of each of the following phases of regional firefighting and evacuation shown in the Table and as a result, particularly, the fire occurrence probability in each district that may lead to urban fires reduced (phases: (1) Fire outbreak prevention (do not allow fires to start indoors) => (2) Initial firefighting at the fire origin (if a fire starts indoors, put out the fire yourself) => (3) Local firefighting (recognize a fire at an early stage and cooperate with local residents to put out the fire) => (4) Evacuation (if local firefighting is not possible, evacuate outside the district as soon as possible). The success probability of fire outbreak prevention and initial firefighting of each measure can be obtained through firefighting related statistics and spatial analysis using GIS, and then multiplied by the implementation rate of each measure, which results in the fire occurrence probability for each district. Then, by improving the current method of calculating the evaluation indicators for fire spread risk and evacuation difficulty so that the fire occurrence probability of each district can be incorporated as a variable, it is possible to quantitatively evaluate the overall disaster prevention performance, reflecting the effects of both hard and soft measures.

3. Conclusion

In the future, we would like to verify the effect of measures in various densely built-up areas to demonstrate and implement the aforementioned evaluation method.

Table: Examples of soft measures by phase of local firefighting and evacuation



Phase of local firefighting / evacuation		Examples of areas of action and measures		
		Structure (people)	Equipment and materials (goods)	Information
Firefighting phase	❶ Fire Outbreak Prevention			
	Initiatives for measures to control fires during an earthquake, etc.	- Participation in seminars on fire prevention, including fire outbreak prevention measures - Breaker turn-off recognition rate during evacuation	- Installation of earthquake-sensitive circuit breakers - Installation of furniture fall prevention - Percentage of combustible material scattering prevention measures implemented	- Disseminate the danger of large fires. - Disseminate information on fire hazard areas (e.g., disaster prevention map)
	❷ Initial firefighting at the origin of fire			
	Initiatives for initial firefighting measures by individuals at the origin of fire	- Conduct initial firefighting training (how to use fire extinguishers, etc.) - Early notification training	- Install fire extinguishers for residential use - Install residential fire alarms	–
	❸ Local firefighting activities			
	Initiative for measures to prevent the spread of fire	- Establishment and activities of voluntary disaster prevention organizations - Flying spark alert activities - Conduct initial firefighting training (how to use standpipes, portable pumps, etc.) - Secure the number of firefighters.	- Installation of standpipes, portable pumps, etc. - Installation of street fire extinguishers - Secure and maintain fire prevention water tanks and fire hydrants - Seismic retrofitting of fire hydrants and water pipes - Interlocking fire alarm - High-place AI cameras, drones, etc.	- Dissemination and clarification of information on water use locations, etc. - Disseminate how to use fire prevention water tanks. - Provide information using ICT-based tools to support disaster prevention activities.
Evacuation phase	❹ Evacuation			
	Initiatives to implement evacuation in the event of a disaster	- Conduct fire drills (when and how to evacuate).	- Maintenance of obstacle removal equipment (crowbar, jack, etc.) - Maintenance of evacuation areas, etc. - Interlocking fire alarm - High-place AI cameras, drones, etc.	- Dissemination of evacuation routes and evacuation sites. - Developing an evacuation plan in the event of a disaster - Creation of a list of persons in need of assistance in the event of a disaster, etc. - Provide information using ICT-based tools to support disaster prevention activities.

Analysis of Damage Patterns of Old Residential Retaining Walls

(Research period: FY2020 to FY2023)

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Key words: residential retaining wall, aging, earthquake damage

1. Introduction

Plains in our country are limited, and as the population increases, housing sites requiring the construction of with retaining walls have been developed in hilly areas, etc. (see Photo). However, a large number of cases old residential retaining walls have been damaged by earthquakes, and it is therefore an important issue to promote inspections and earthquake resistant measures. In response, we have begun to develop technologies for earthquake resistance of old housing site retaining walls from 2020. This paper presents the results of damage analysis according to the separation distance between housing site retaining walls and buildings as part of the current status of technological development.

Photo: Example of a housing site with retaining wall construction

2. Damage analysis according to the separation distance between the retaining wall of housing site and the building

(1) Residential retaining walls subject to analysis

The soundness of residential retaining walls is influenced mainly by factors indicated by the blue boxes in Fig. 1. Residential retaining walls that have lost their soundness due to aging or other reasons may suffer earthquake damage, which may cause damage to building foundation, etc. Therefore, we focused on the separation distance between retaining walls and buildings, and decided to analyze the effect of damage to retaining walls on buildings, targeting the residential retaining walls in Sendai City that were damaged by the Great East Japan Earthquake.

(2) Analysis results

AS a result of summarizing the degree of building damage according to the results of hazard assessment on damaged housing sites, which is conducted to mitigate and prevent secondary disasters in housing sites, the percentage of buildings totally destroyed was slightly under 46% for those with a risk rating of "large" (384 samples) and about 17% for those with the same risk rating of "Medium" (1,593 samples). Next, we tabulated the percentage of building damage by separation distance between the residential retaining wall and the building for those housing sites with a risk rating of "large" or "medium" for which the separation distance from the building was known (1,500 samples), but could not obtain any clear trend. Therefore, the results were tabulated based on the cumulative number of building damages, and it was found that the composition ratio of total and major partial building damages together tended to be higher when the separation distance was 1.0 m or less (Fig. 2).

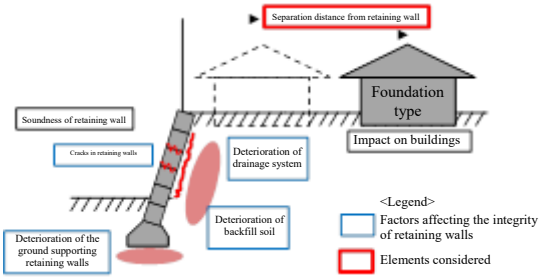

Fig. 1: Elements considered in this research

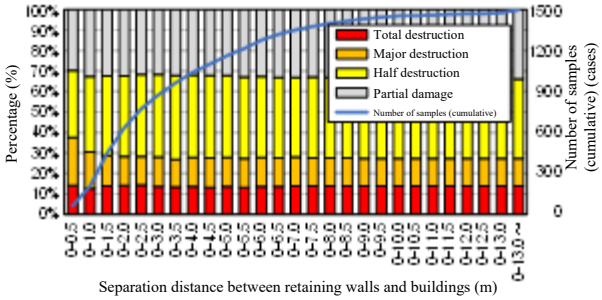

Fig. 2: Building damage by separation distance between retaining wall and building

3. Conclusion

We plan to continue to study the impact of damage to residential retaining walls on building damage so that results can be used as a criterion for identifying residential retaining walls that need to seismic retrofitting.

☞See the following for details.

1) Outline of "Technical Development Contributing to Urban Regeneration and Resilience through Rationalization of Structural Regulations for Buildings and Ground"
http://www.nilim.go.jp/lab/hcg/kisojiban_hp/kisojiban.htm

Improving Efficiency in Maintenance of Port Facilities Using AI

(Study period: FY2018–)

Coastal Disaster Prevention Division, Coastal and Marine Disaster Prevention Department

Senior Researcher SATOMURA Daiki

(Keywords) *AI, UAV (unmanned aerial vehicles, drones), maintenance*

1. Introduction

In ports and harbors, breakwaters, quays, and other facilities are built in both land and sea areas, and some facilities extend over several kilometers. Inspections for facility maintenance require significant labor. In addition, port facilities are mainly located in the marine environment and are therefore exposed to a more severe environment compared with other civil structures. With limited human and financial resources, port managers and private companies are required to perform maintenance and management of port facilities with more efficiency and accuracy.

2. UAV Inspection and Diagnosis System

The Coastal Disaster Prevention Division utilizes new technologies such as UAVs and AI to develop an "inspection and diagnosis system for port facilities using UAVs" (UAV inspection and diagnosis system) with the aim of improving the efficiency and sophistication of maintenance of port facilities, especially general regular inspection and diagnosis, thereby reducing the burden on port managers.

The UAV inspection and diagnosis system consists of a remote image transmission system and a deformation detection system (Figure). In the system, engineers determine the degree of deterioration and evaluate the degree of performance drop based on the result of deformation detected by AI, etc.

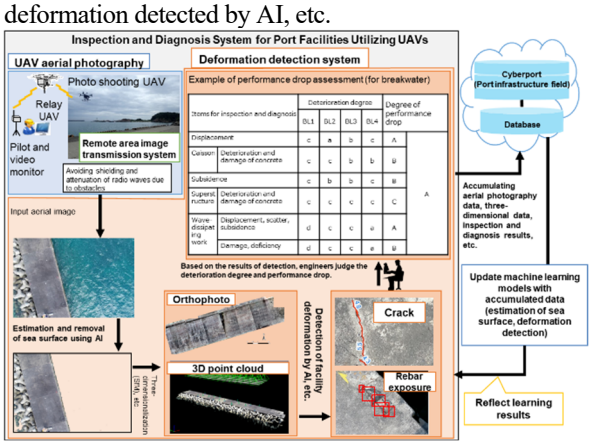

Figure: Conceptual diagram of UAV inspection and diagnosis system

3. Efficiency of Field Operations

In the demonstration experiment conducted in fiscal 2021, the field work time was reduced by about 30% (Table). Although there is some variation depending on the type and size of facilities, the experiment showed that the efficiency of field operations can be improved by using UAVs.

Table: Comparison of field operation hours

	Visual inspection (hours)	UAV photography, etc. (hours)	Time reduction percentage
Mooring facility 1	3.5	2.0	43%
Mooring facility 2	2.5	1.5	40%
Mooring facility 3	2.5	2.0	20%
Protective facility 1	3.0	1.5	50%
Protective facility 2	4.0	3.5	13%
Total	15.5	10.5	32%

Actual results in the FY2021 demonstration experiment. UAV photography includes ground mark installation and observation.

4. Future Development

Although the UAV inspection and diagnosis system is intended for use during normal times (general regular inspection and diagnosis), how the system can be utilized for inspection after a disaster will be examined in the future.

In the present UAV inspection and diagnosis system, deformation is detected by AI, etc. while the degree of deterioration and the degree of performance drop are determined and evaluated by engineers. In the future, we aim to automate the process of determining the degree of deterioration and evaluating the degree of performance drop.

✓ Click here for more information.

1) Technical report of NILIM No. 1135
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1135.htm

2) Daiki Satomura: AI-based detection of sea surface and sky and detection of rust and exposed rebar with aim of more efficient inspection and diagnosis of port and harbor facilities, *AI/Data Science*, vol. 3, No. J2, pp. 360-371, Japan society of civil engineers, 2022

3) Daiki Satomura: Using UAVs and AI to improve the efficiency of inspection and diagnosis of port facilities, *Ports and Harbors*, vol. 99, No. 8, Japan Port and Harbor Association, 2022.

Capturing the Behavior of Ships During a Tsunami

(Study period: FY2021 to FY2023)

Port Planning Division, Port Department

Head (Doctor of Engineering) ABE Motohisa Researcher SHINONAGA Tatsunori

(Keywords) *Tsunamis, ship, emergency evacuation*

1. Introduction

When the Great East Japan Earthquake occurred, tsunami caused ships to drift about, and this led to increased damage in ports. In order to reduce such damage, when a tsunami is expected, it is necessary to take measures such as emergency evacuation. In this study, we analyzed the behavior of ships at the time of tsunami using Automatic Identification System (AIS) data.

2. Analysis Overview

In many cases, AIS data were not captured due to the power outages after the Great East Japan Earthquake, but we conducted analysis using the data available, from Kashima Port, Tomakomai Port, and the Tokyo Bay area. The behavior of ships in each port at the time of the earthquake was tracked over time to grasp the situation of evacuation.

3. Situation at Each Port

Kashima Port, which is near to the epicenter, was hit by large tsunamis several times, and about half of the ships drifted. Only relatively small ships that could leave the pier within about an hour after the earthquake were able to evacuate outside the port. After the tsunami warning was issued in Tokyo Bay ports, ferries and medium-sized ships capable of leaving the pier by themselves first evacuated outside the ports. Since large vessels such as container ships usually leave the pier with tugboat support, the time that these vessels evacuated depended on the time when tugboats arrived. There were a number of vessels that chose to continue mooring, but these did not drift. In Tomakomai Port, first of all, ferries and RORO ships, which were capable of leaving the pier by themselves, evacuated, and then many cargo ships left the pier by themselves. At this time, it was confirmed that ships were evacuating at regular intervals in order, and there was no significant decrease in ship speed and collisions between ships were not observed.

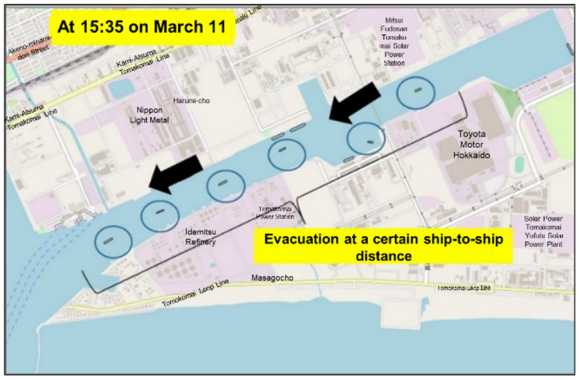

Figure: Emergency evacuation situation (Tomakomai Port)

4. Suggestions for Facilitation of Future Emergency Evacuation

First of all, whether or not a vessel of a certain size or larger can quickly obtain the support of a tugboat is a necessary factor for rapid evacuation. However, tugboats also need to avoid tsunami damage, so it is advisable for these vessels to leave the pier by themselves whenever possible. Therefore, it is also worth considering ways to secure a turning basin of sufficient size and shift to mooring head out (a mooring method in which turning is performed at the time of arrival at piers to eliminate the need for turning at the time of departure).

Second, not only emergency evacuation but also strengthening of mooring facilities to withstand tsunami can be considered as an option, so technical studies such as considering tsunami flow as external forces in design are necessary. Third, it is expected that emergency evacuation will take place when the water depth decreases due to backwash before a spilling wave arrives, and it is necessary to evaluate the water depth allowance of harbor facilities. From now on, at each port an assessment of tsunami risks after a large-scale earthquake will be conducted, and we will continue to conduct analysis to accumulate knowledge.

✓ Click here for more information.

1) NILIM material No. 1217
https://www.ysk.nilim.go.jp/kenkyuseika/pdf/ks1217.pdf

Initiatives for Realizing Automated Driving on Expressways

(Research period: FY2021-FY2023)

Intelligent Transport Systems Division, Road Traffic Department

Head (Ph. D. Eng) ITSUBO Shinji Senior researcher NAKAGAWA Toshimasa Researcher ISHIHARA Masaaki

Guest researcher YUASA Katsuhiko Guest researcher HANAMORI Teruaki

(Keywords) automated driving, vehicle-to-infrastructure (V2I), merging support information provision system, lane marking

1. Introduction

Automated driving is expected to be safer and smoother than manual driving, and it is anticipated that it will also contribute to alleviating traffic jams, reducing environmental impact etc., The Public-Private ITS Initiative/Roadmap[1] clarifies the governmental goals for realizing automated driving (level 4) on expressways with a target of 2025 for privately owned vehicles.

This paper describes the outlines of research on “merging support information provision system” and “self-positioning identifying information (lane marking)” as NILIM initiatives aimed for realizing automated driving on expressways.

2. Merging support information provision system

A merging support information provision system supports safe and smooth merging by providing an information about a speed, a location etc., of main lane vehicles upstream an expressway to automated driving vehicle (Fig. 1). The information provided by this system is used to adjust a speed of a merging vehicle in advance on the connecting road when merging safely and smoothly. DAY2 system detects a speed, a location etc. of main lane vehicles in a certain section and provides the information to the merging vehicles continuously.

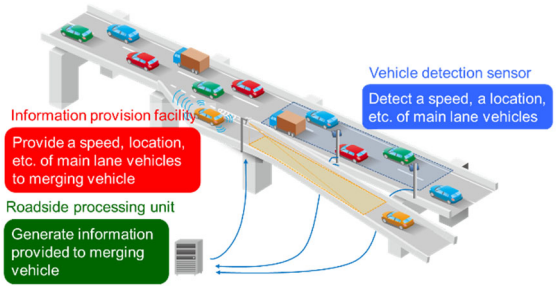

Fig. 1. Merging support information provision system

NILIM developed a section imitating a merging section on expressways on a test track, installed vehicle detection sensors on the main lane side and information provision facilities on the connecting road side, and verified the effects of merging support information (a speed, a location etc. of main lane vehicles) through DAY2 system (Fig. 2, Photo 1). As a result, all merging vehicles were able to merge “with merging support”, even though a length of acceleration lane was short (Fig. 3).

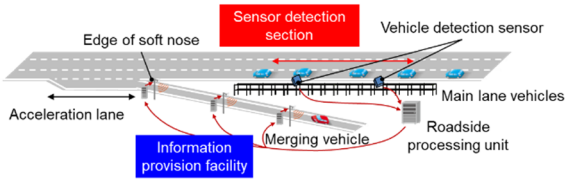

Fig. 2. Field operational test for verifying information provision by DAY2 system

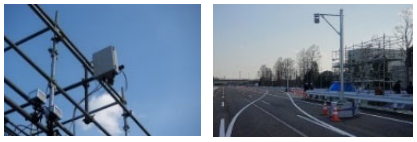

Photo 1. Devices used at FOT
(left: vehicle detection sensor; right: information provision facility)

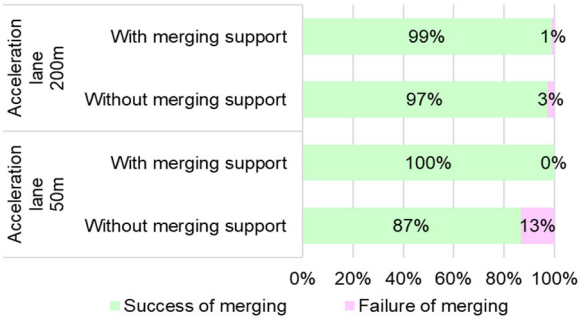

Fig. 3. Success rate of merging

Moreover, it was confirmed that the merging vehicles were not side by side with main lane vehicles "with merging support", when they reached to an end of soft nose and were able to merge into the main lane (Photo 2). Based on the findings acquired in the field operational test, NILIM has organized the technical specifications for the merging support information provision system.

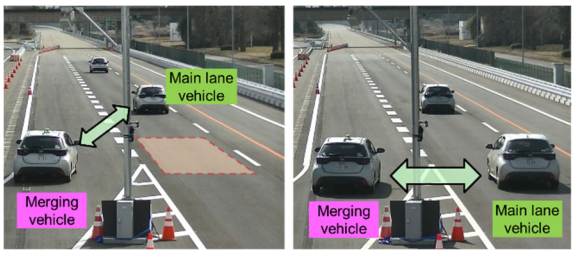

Photo 2. Relative position between merging vehicle and main lane vehicles
(left: with merging support; right: without merging support)

3. Self-positioning identifying information (lane marking)

Lane keeping assist system (LKAS) is a function that assists automated driving vehicle to travel near the center of the road, but it may not operate where a lane marking is faint.

NILIM conducted the field operational test to investigate LKAS operation from the perspective of a faint level of lane marking in order to acquire basic knowledge to organize ideas about maintaining lane markings. Specifically, we prepared lane markings at various faint levels on the test track (Photo 3, Photo 4), made vehicles with LKAS run under various conditions, and measured the state of operation of the LKAS.

Based on the results obtained in the field operational test, we have collated the relationships between the faint level of lane markings and the state of operation of LKAS (Fig. 4). We are also analyzing the maximum faint level (threshold value) that will still allow LKAS to operate and factors that affect LKAS operation and the extent of their impact. We intend to make use of the knowledge acquired in the field operational test to organize requirements for lane marking maintenance from the perspective of faint level to allow LKAS to operate and drivers etc,.

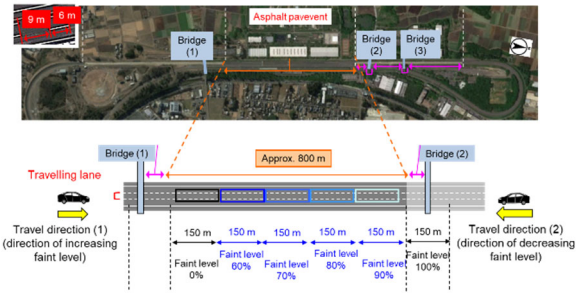

Photo 3. Layout for installing lane markings

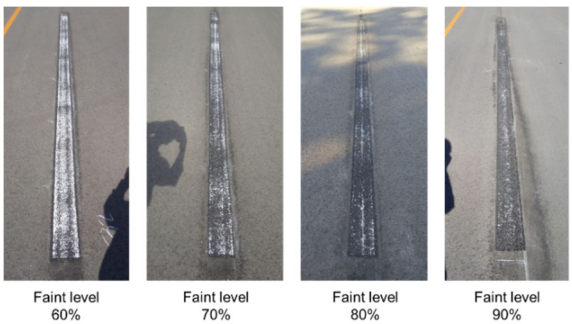

Photo 4. Faint lane markings

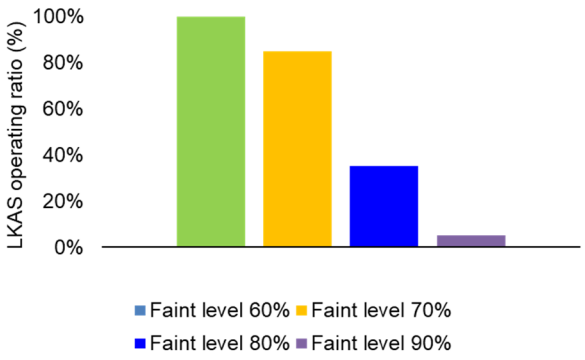

Fig. 4. Relationship between faint level of lane markings and LKAS operating ratio (image)

4. Conclusion

Developing system that allow road infrastructure and vehicles to share information each other through vehicle-to-infrastructure cooperation is important in early realization of automated driving on expressways. It is recognized that the merging support information provision system is an important one to support safe and smooth merging in merging sections, and that lane markings are recognized as important facilities to support a localization on the main lane. We hope to continue to contribute to early realization of automated driving and the safe, secure and smooth road traffic through public and private joint research and development etc..

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3) Hanamori Teruaki, Ishihara Masaaki, Nakagawa Toshimasa, Itsubo Shinji, Nakata Ryō, Fujimura Ryōta: Analysis Between The Corresponding Faint Level of Lane Markings and The Detection Status By On-Board Camera, *66th Proceedings of Infrastructure Planning (Fall Symposium)*, 2022.

Development of Maintenance BIM models for Utilization in Public Rental Housing Stock

(Research period: FY2018 - FY2022)

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Key words: BIM, public rental housing, maintenance

1. Introduction

Initiatives are now underway to introduce BIM and promote DX to improve productivity throughout the building lifecycle. On the other hand, due mainly to the financial constraints of local governments and the reduction in the number of engineering employees, proper maintenance of the large of public rental housing stock has become a challenge. Under such circumstances, we developed a BIM model (maintenance BIM model) for use in the maintenance of public rental housing stock, and created a draft of guide through the verification of application in the case study of actual public housing properties, etc. in order for local governments, etc., which are the management entities of public rental housing, to effectively introduce the maintenance BIM model.

2. Concept and structure of the maintenance BIM model

(i) Concept of the maintenance BIM model

Comprised of objects that are simple and can be easily created and adapted to the units used to handle maintenance information, the maintenance BIM model is designed for use with existing housing (stock). Spatial objects defined as maintenance BIM model are employed for intuitive and easy recognition of where and in what part of the building the inspection and repair points are located, and to create various maintenance information in units that can be spatially understood (**Fig. 1**).

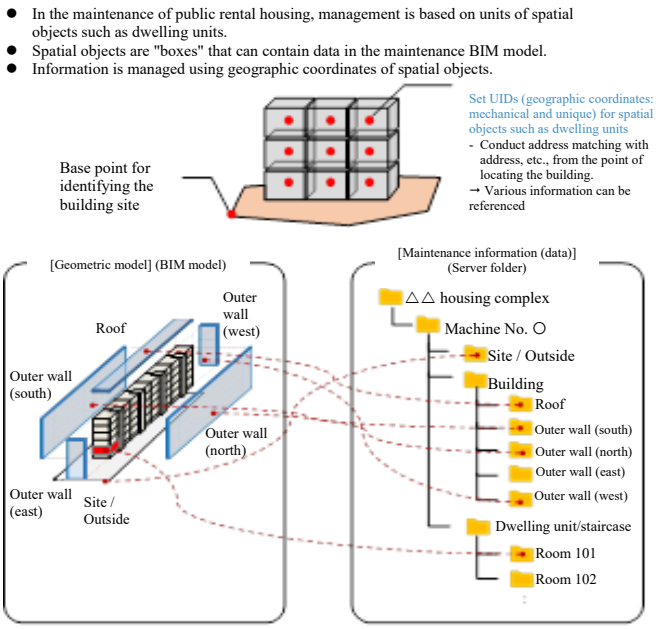

Fig. 1: Conceptual image of the maintenance BIM model

(ii) Structure of the maintenance BIM model

The maintenance BIM model for public rental housing is an integrated model that combines a "dwelling unit model" consisting of spatial objects such as dwelling units, common stairs, corridors, an "exterior model" that includes information on roofs and outer walls, etc., and an "outdoor facility model" that includes information on the site and outdoor ancillary facilities. A system that accumulates maintenance information is realized by linking these defined spatial objects with existing or new databases (including those using spreadsheet software such as Excel).

(iii) Data linkage using location information as a key

Spatial objects are assigned a unique identifier ("UID") based on location information (combination of latitude, longitude, and elevation of the geographic coordinates where the building site, etc., exists). A base point to determine location information is set to spatial objects. UID is stored as attribute information of the base point for each object. A database that can be linked to the maintenance BIM model is established for data linkage using location information as a key.

3. Case study to verify the application of the maintenance BIM model

With the cooperation of S and O Prefectures, we conducted a case study to verify the application of the maintenance BIM model in public housing complexes (actual properties).

(i) Validation of the structure of the maintenance BIM model and the way of information linkage.

Using the maintenance BIM models created for each subject complex and the Excel data (intermediate data table) created for BIM model linkage based on actual maintenance data, we confirmed the structure of the maintenance BIM models and how to organize maintenance information.

Regarding the utilization of maintenance BIM models, we also demonstrated the linkage between maintenance BIM models and maintenance data using a viewer and confirmed its usefulness in order to confirm the needs for the future development of viewers, etc., and the potential for their use in inspection and repair work (**Fig. 2**).

(ii) Confirmation of the method of inputting and storing inspection information with a portable terminal (tablet terminal) using the inspection application

We confirmed input items of inspection information and the methods of recording, storing, and viewing inspection information on actual properties, targeting daily inspections out of all the operations for maintenance.

We operated an inspection application installed on the tablet terminal (iPad) to perform a simulated inspection. Inspection routes and failure events were set up in advance, and the results were saved in the inspection application. Regarding recording of inspection results, we confirmed the operability, evaluation of functions, requests, etc., for each of the three recording methods (recording in checklist, recording in photographs taken on the site, and recording in drawing data) (**Fig. 3**).

The saved inspection result data (CSV) was transferred from the tablet terminal (iPad) to Excel data, which was assumed to be used as a database, and stored as historical information; viewer software (Navisworks Manage) was used to confirm that the newly accumulated data was linked to the maintenance BIM model.

4. Guide to Maintenance BIM Model Introduction (the Guide)

Regarding the method for local governments, etc., who are responsible for management of public rental housing, an initial draft of a guide based on the questionnaire survey of public rental housing operators and case studies, etc. in public housing complexes was created to facilitate effective introduction of maintenance BIM models.

This Guide consists of two parts. In Part I, the structure, procedures, etc. of BIM model are presented to enable local governments to smoothly introduce maintenance BIM models for maintenance of public rental housing. Next, in Part II, for new construction and renovation of public rental housing, points of attention are presented using, as a reference, the

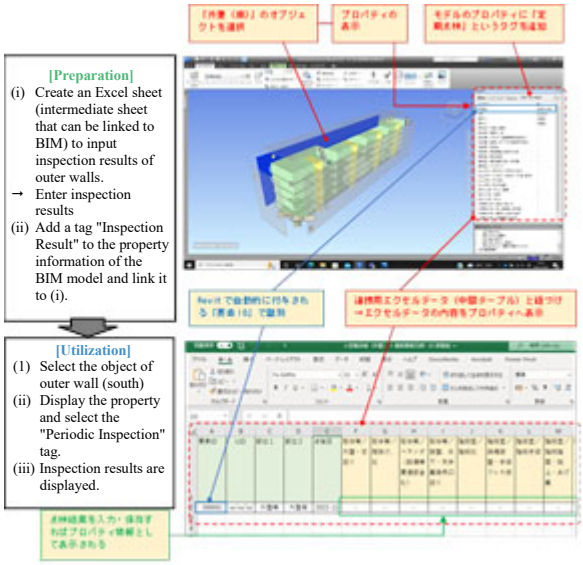

Fig. 2: Inspection results displayed in property information

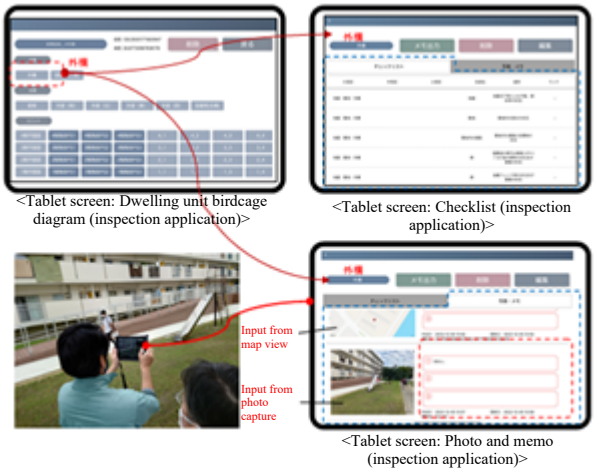

Fig. 3: Inspection of outdoor facilities (playground equipment)

"Guidelines for the Creation and Use of BIM Models in Government Repair Projects (revised in March 2022)" by the Government Buildings Department.

* The results of this paper are based on the implementation of the Public/Private R&D Investment Strategic Expansion PrograM (PRISM). This project is also being implemented based on an agreement between the Building Research Institute and the Urban Renaissance Agency.

* The inspection application used is a trial version being developed by the Building Research Institute.

Publication of "Smart City Case-Study Collection [Introduction]"

(Research period: FY2020 to FY2022)

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Key words: smart city, case-study collection, matching urban problems with new technologies

1. Introduction

In October 2022, the NILIM released "Smart City Case-Study Collection [Introduction]" ("Case-Study Collection"), which allows users to search for new technologies to solve urban problems regarding 76 smart city projects around Japan[1) 2) 3)]. The purpose of the Collection is to support the implementation in each district and promote nationwide horizontal development by presenting in an easy-to-understand manner issues and responses to the introduction of new technologies that address urban problems, methods for evaluating the effects of introduction, and examples of evaluation indicators. This paper describes the outline of the Case-Study Collection.

2. Background and purpose of the Case-Study Collection

For the development of smart cities aiming to solve urban problems through the use of new technologies such as IoT, the number of initiatives in each region is steadily increasing due to the promotion of national model projects and the sharing of know-how through the Smart City Public-Private Partnership Platform. However, there are still many local governments that have not yet implemented such initiatives, and the issue of nationwide horizontal expansion is still an issue.

According to the results of a questionnaire survey[4)] conducted by the NILIM to local governments and companies to grasp the issues in implementing smart city initiatives, many respondents answered that they were uncertain about what new technologies could be used to solve urban problems. Since the need for support through information sharing and systematic organization regarding the matching of urban problems and new technologies was recognized, the NILIM worked on the preparation of the Case-Study Collection.

3. Outline of the Case-Study Collection

(1) Characteristic

The Case-Study Collection is expected for use by local governments and companies that intend to work on smart cities in the future. Although there are many publicly available information and materials on smart city initiatives, most are presented on a project-by-project basis. The Case-Study Collection is characterized by introducing new technologies that could be introduced for major urban problems on a one-to-one correspondence basis and therefore allowing local governments and others to search for possible solutions to their urban problems using the new technologies as a dictionary (for this reason, the title is appended with "[Introduction]").

(2) Targeted "urban problems" and "new technologies"

Focusing on cases adopted by national model projects, out of the smart city initiatives around the country that have a track record of introduced new technologies at the implementation or demonstration experiment stage, we extracted 76 cases of combinations of urban problems and new technologies as shown in **Table**, taking into account the balance between the classification of urban problems and new technologies and the variation of combinations.

(3) Table of Contents

Three tables of contents are provided to facilitate search: "List of Urban Problems," "List of New Technologies," and "List of Local Governments," which are arranged in a different order of cases.

Table: Targeted "urban problems" and "new technologies"

Urban problems \ New technology		h Automobile	f Data utilization	c Analysis and / forecast	b Observation	a Communication	i Robot / drone	d Data base	e Big data	g Energy	Grand total
A	Transportation	13		3		2	1	1			20
C	Liveliness	2	4	4				2	1		13
D	Health / Medical	2	3	1	1	1		2	1		11
G	Disaster prevention		1		2	2		1	2		8
B	Industry	2	1				4				7
E	Infrastructure	1		1	2		1	1			6
H	Security				2	3					5
F	Environment				1		1			2	4
I	Common to all fields		2								2
Grand total		20	11	9	8	8	7	7	4	2	76

(4) Information contained

For each combination of urban problems and new technologies, information on the following items is presented in a common format of basically three pages. **Figure** below shows an image of the information provided in the case studies and how to see case studies (extracted from the Case-Study Collection).

1) Information on features and introduction of new technologies
- Outline of urban problems and new technologies
- The effects of solving urban problems expected from new technology introduction
- Conditions for application of new technologies, and challenges and responses in introducing new technologies

2) Data on Key Performance Indicators (KPI) to measure the effects of new technology introduction
- Example of evaluation viewpoints
- Examples of KPI setting and quantitative indicators

4. Conclusion

The NILIM is also developing methods for evaluating the effect of solving urban problems through the introduction of new technologies.

In the future, we intend to revise the Case-Study Collection from time to time, such as increase in the number of cases in the environment field of high social concern and update of the content to reflect increase in the number of cases of smart city initiatives and technological innovations.

☞See the following for details.

1) "Smart City Case-Study Collection [Introduction]" PDF file URL (Available in NILIM's Urban Planning Division website.)
http://www.nilim.go.jp/lab/jbg/smart/smart.html#smart

2) NILIM Press Release Material "The latest 76 smart city case studies in Japan -- Smart City Case-Study Collection [Introduction]"
http://www.nilim.go.jp/lab/bcg/kisya/journal/kisya20221021.pdf

3) Smart City Public-Private Partnership Platform: Report on the 2nd Online Seminar in FY2022
https://www.mlit.go.jp/scpf/archives/docs/event_seminar_221021_kokusouken.pdf

4) KATSUMATA Wataru, KUMAKURA, Eiko, and SHINGAI, Hiroyasu (2021), 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-, Journal of the City Planning Institute of Japan, Vol. 56-3, pp. 1413-. 1420
https://doi.org/10.11361/journalcpij.56.1413

Figure: Image of the information provided in the case studies and how to see case studies (extracted from the Case-Study Collection).

BIM/CIM Generating Method for Existing Port Facilities for Efficient Maintenance

(Study period: FY2022–)

Port Construction Systems and Management Division

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(Keywords) *Productivity improvement, BIM/CIM, maintenance*

1. Introduction

In order to improve productivity in the port sector, the introduction of Building/Construction Information Modeling, Management (BIM/CIM) is being promoted in port design and construction works. However, studies to date have mainly focused on new structures, and studies on BIM/CIM of existing port facilities have not yet been sufficiently conducted. This study is intended to develop a BIM/CIM generating method for existing port facilities with the goal of efficient maintenance.

2. Development of BIM/CIM Requirements for Existing Port Facilities

The effects of introducing BIM/CIM in maintenance include the visualization of inspection and diagnosis records, centralized management of maintenance-related data, and information platform functions linked to measurement equipment. On the other hand, it is very difficult in an existing port facility to create a BIM/CIM model with the same level of accuracy as that of a newly constructed structure.

In this fiscal year, we focused on the effects of introducing BIM/CIM in maintenance, and narrowed matters down to the minimum BIM/CIM requirements for existing port facilities to reduce the burden of creating BIM/CIM models. Then, according to the narrowed-down requirements, we created BIM/CIM models from two-dimensional drawings of the maintenance management plan, and provided the models with inspection and diagnosis records as attribute information (Fig. 1).

Currently, we use the created BIM/CIM models to hold interviews with facility managers and maintenance operators. In the future, we will review the BIM/CIM requirements for existing port facilities and develop an efficient generating method.

3. BIM/CIM Generic Object Example

One of the efficient BIM/CIM generating methods is to provide generic objects. A generic object is a three-dimensional part model constituting BIM/CIM, and is characterized by having a shape independent of a specific manufacturer.

Therefore, we extracted parts that are in high demand as constituent parts of BIM/CIM for port facilities and are expected to shorten the creation time of three-dimensional models, created generic objects, and began publishing and providing the objects on the website of the Ministry of Land, Infrastructure, Transport and Tourism in October 2022 (Fig. 2).

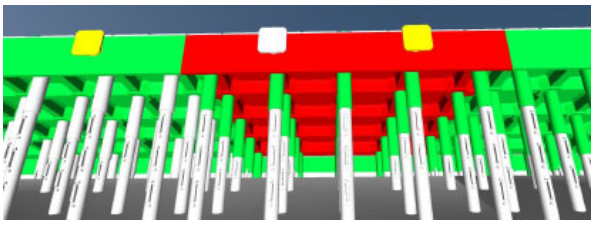

Figure 1: BIM/CIM of existing port facilities
(Example of a pier—the color represents the degree of degradation of each part)

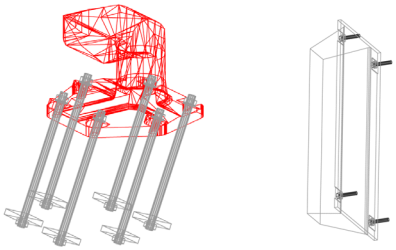

Figure 2: BIM/CIM generic objects
(Left: mooring post, right: fender beam)

✓ Click here for more information.

1) Examples of BIM/CIM generic objects in the port sector
https://www.mlit.go.jp/kowan/kowan_fr5_000084.html

Research for Automation and Labor-saving in Airport Snow Removal — Analysis of Work Patterns and Development of Evaluation Methods for the Effect of Labor-saving and Automation Technology Introduction —

(Study period: FY2020 to FY2022)

Airport Planning Division, Airport Department

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(Keywords) Airport snow removal, labor-saving, automation, evaluation of introduction effect

1. Purpose and Background of the Research

As we look to welcome 60 million international visitors to Japan in the years to come, we are making efforts to enhance airport functions to maintain an environment to receive airline passengers. On the other hand, as Japan's working-age population decreases, it is anticipated that it will become difficult to secure operators in the future due to a fall in the number of and the progressing aging of operators of snow removal vehicles. This poses a problem in maintaining the necessary framework for snow removal at our airports. In order to address this issue, the introduction of automation and labor-saving technologies for airport snow removal is under consideration as part of the "Aviation Innovation" utilizing advanced technologies and systems in the aviation field[1].

Photo 1: Example of airport snow removal vehicle (snowplow)

2. Analysis of Work Patterns and Examination of Feasibility of Automation and Labor-saving Technologies

In order to ensure stable operation of aircraft, airport snow removal demands high requirements in terms of snow removal accuracy (coefficient of sliding friction of road surface when snow removal is completed) and target working time. It is necessary to examine the applicability of automation and labor-saving technology to airport snow removal, because the operation requires know-how of skilled operators.

First, we collect data on the driving position, route, driving speed, and the operator's operation of each snow removal vehicle in the current snow removal work to identify routine works which are prospective subjects for introducing automation and labor-saving technology in airport snow removal[2]. For example, in the case of a snowplow, the longitudinal inter-vehicular distance is 50 to 300 m, the lateral distance 3.5 to 8.0 m, and the distance to the runway lights approximately 6 to 7 m. (Figure)

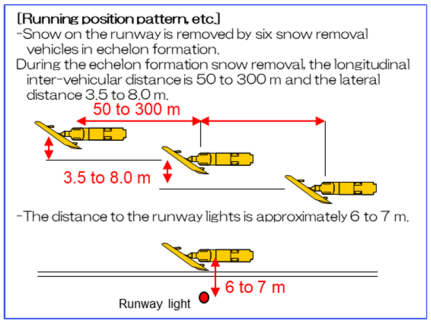

Figure: Travel pattern of snowplows

Based on the analysis of the above work pattern, we also organize the feasibility of automation and labor-saving technologies through a questionnaire given to airport snow removal operators. For example, regarding the feasibility of a driving support guidance system (a device for measuring the vehicle position with sensors or the like attached to the vehicle and displaying the positional relation with surrounding facilities and approach notification on an on-board monitor) (Photo 2) to snowplows, the highest percentage of respondents who indicate that guidance is necessary was for snow removal work when approaching lights such as runway lights and taxiway lights, and a certain number of respondents indicated that guidance is necessary in grasping the positional relationship with other vehicles. (Table 1)

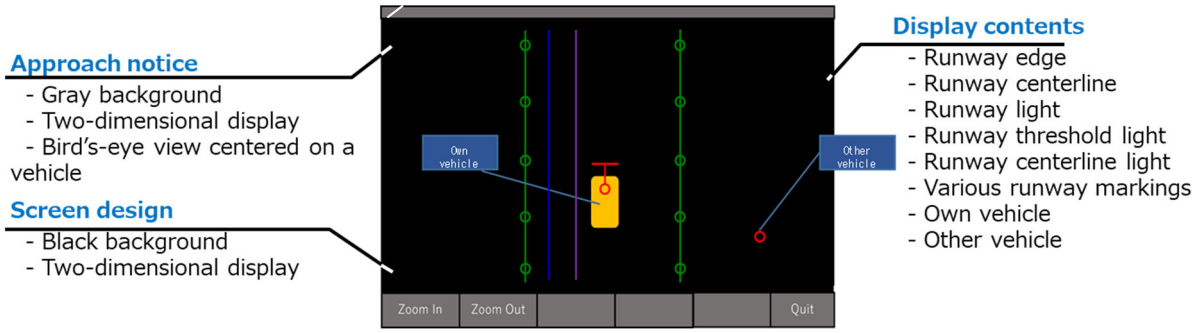

Photo 2: Driver assistance guidance system (on-vehicle monitor)

Table 1: Results of questionnaires to airport snow removal operators

When grasping the positional relationship with other vehicles during echelon formation snow removal (on runway)	When grasping the positional relationship with other vehicles other than during echelon formation snow removal (on apron or taxiway)	When operating the equipment when approaching the runway threshold light	When snow removal is carried out by approaching lights such as runway lights and taxiway lights	When moving the vehicle backward (backward operation)
41.7%	41.7%	54.5%	63.6%	58.3%

*The numbers in the table represent the percentage of respondents indicating that guidance is necessary.

3. Development of an Operational Method of Automated and Labor-saving Airport Snow Removal and a Method for Evaluating the Introduction Effectiveness

For the stable operation of aircraft, we are revising operational regulations (such as airport snow removal work plans) necessary for the introduction of automation and labor-saving technologies to airport snow removal, and developing methods to quantitatively and qualitatively evaluate the effect of introducing labor-saving and automation technologies.

On the assumption of the introduction of automation and labor-saving technologies, a revision of the operating regulations is to be carried out from the viewpoint of organizing the operating rules, reducing the number of assistants and others associated with the introduction of the technologies, and measures to ensure safety in spaces where both the technology-introduced and conventional vehicles are intermingled.

With regard to evaluating the effect of the introduction, we aim to develop quantitative and qualitative evaluation methods from the following perspectives: working hours and costs associated with snow removal work, total working hours, late-night and early-morning working hours, usability of automation and labor-saving technologies (visibility of screen display of driving support guidance system, etc., monitor update speed, accuracy of map display, accuracy of hazard notification), application conditions (adaptability to visibility conditions, climate (wind, temperature, etc.), quality and quantity of snow), improved safety in snow removal work, and ensuring the quality of snow removal. (Table 2)

Table 2: Evaluation index of introduction effect

Item	Perspective	Details	Evaluation index
Quantitative assessment	Manpower saving effect	Working hours and costs associated with snow removal work	- Reduction of workforce and working hours by saving labor - Reduction of the number of people waiting
	Improvement in working environment	Total working hours, late night and early morning working hours	- Reduction of long working hours, late-night and early-morning workers
Qualitative evaluation	Usability of introduced technology	Visibility of screen display	- Monitor size and brightness - Excess or lack of displayed information and ease of viewing
		Monitor update speed	- Monitor update speed - Presence or absence of display's delay
		Accuracy of map display	- Presence or absence of deviation between the display position and the actual position of road signs and aeronautical lights - Presence or absence of deviation between the indicated position and the actual position of other vehicles
		Accuracy of hazard notification	- Presence or absence of delay/omission of notification - Presence or absence of discomfort with the notification method
	Applicable conditions	Feasibility to visibility conditions, climate, quality and amount of snow	- Feasibility under low visibility, snowfall, and snow cover
	Contribution to work safety	Improved safety in snow removal work	- Near-misses, accidents, etc. that are suppressed or eliminated by the introduced technology
	Effect on snow removal quality	Assuring quality of snow removal	- Difference in snow removal work hours (difference in finish during continuous snowfall) - Difference in road surface finish

✓ Click here for more information.

1) Demonstration Experiment Review Committee for Labor-saving and Automation of Airport Snow Removal
https://www.mlit.go.jp/koku/koku_tk9_000038.html

2) Paper presented at the 23rd Airport Technical Meeting
https://www.mlit.go.jp/koku/content/001578595.pdf

Analysis of the Effects for Travel Speed on Arterial Roads by Unsignalized Intersections Access

(Research period: FY2020–FY2023)

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Guest Research engineer SHIGETA Kengo

(Keywords) road hierarchy, travel speed, delay

1. Introduction

In the road network in Japan, the travel speed on ordinary roads remains at a low level and there are few roads that ensure an intermediate speed based on the difference with the travel speed on expressways, and thus appropriate hierarchical road network has not been achieved. The travel speed on ordinary roads is obviously affected by medians, unsignalized intersections access, the spacing between signalized intersections, and other factors, and NILIM aims to present a guide for road structure requirements to achieve a target travel speed.

Our analysis focuses on unsignalized intersections access as an influence on travel speed on ordinary roads; we firstly gained an understanding of the actual effects that entering and exiting vehicles on an arterial road with two lanes on each side have on vehicles directly behind them, and then examined their influence on entire sections using traffic simulations based on these results (fig. 1).

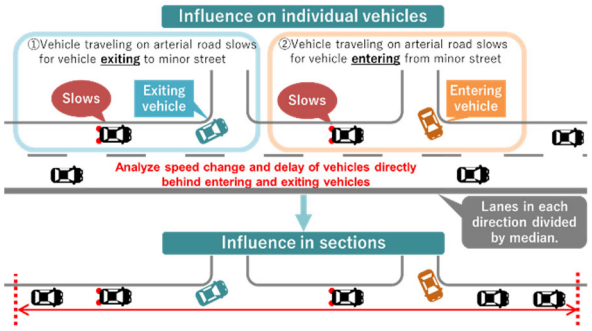

Fig. 1. Image of analysis target

2. Effect of entering and exiting vehicles on vehicles traveling on arterial roads

(1) Investigation outline

We installed video cameras so that they can shoot entry and exit sections and the areas upstream and downstream of them in four locations connected to National Highway 21 and two locations connected to National Highway 274 with unsignalized intersections. Each point had two lanes in each direction, divided by a median, and entry and exit behavior was limited to left-turn exits and entries.

(2) Analysis of speed changes of individual traveling vehicles

From the vehicles traveling on the arterial road, we extracted any vehicle where an entry or exit occurred within the section approximately 150 m ahead with that vehicle as the vehicle directly behind an entry or exit and acquired its speed immediately near the entry or exit, at three points

upstream, and at one point downstream. The distribution of the change in speeds for each vehicle directly behind an entry or exit is shown in figure 2, using one of the investigated unsignalized intersections as an example. Here, "exit" indicates an vehicle directly behind an exiting vehicle and "entry" indicates a vehicle directly behind an entering vehicle. For both exits and entries, vehicles travel at a speed close to the free flow speed until 100 m upstream, but a decrease in speed is observed from 50 m upstream to the entry or exit point (0 m), and recovery to close to the free flow speed is observed at the point 150 m downstream. Exits tend to have a greater decrease in speed, but this demonstrated the possibility that vehicles traveling on arterial roads may suffer delays due to entries, as well as exits.

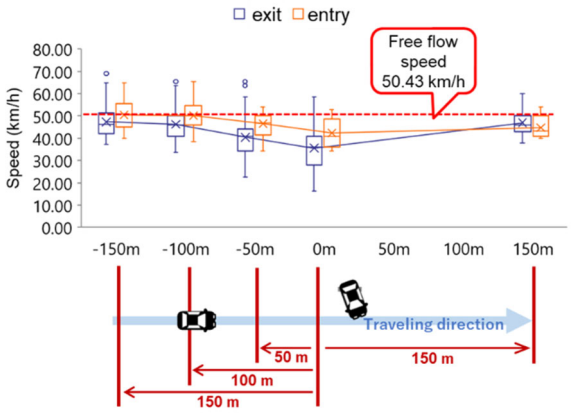

Fig. 2. Change in speed in vehicles directly behind entering and exiting vehicles

Next, we considered the delay in a vehicle traveling on the arterial road due to an exiting or entering vehicle to be the difference between the actual travel time of the vehicle directly behind an exit or entry and the free flow travel time, and computed it as 0 when the actual travel time was shorter. The delay at each unsignalized intersection is shown in table 1, aggregated by the exit or entry behavior of the car in front. It was confirmed that delay arose for both exits and entries. On the other hand, the delay varies depending on the point, and it appears necessary to examine differences due to the point and differences due to the route.

Table 1. Mean delay

Point no.	Exiting (sec)	Entering (sec)	Overall: exiting and entering (sec)
1 (Nat. Hwy 21)	2.19 (110)	1.44 (4)	2.16 (114)
2 (Nat. Hwy 21)	3.27 (100)	2.01 (15)	3.10 (115)
3 (Nat. Hwy 21)	2.18 (56)	1.33 (7)	2.09 (63)
4 (Nat. Hwy 21)	1.89 (194)	1.17 (49)	1.74 (243)
5 (Nat. Hwy 274)	1.79 (60)	1.48 (14)	1.73 (74)
6 (Nat. Hwy 274)	0.95 (357)	1.19 (28)	0.97 (385)

Parentheses indicate number of samples

(3) Analysis of influence in sections

We examined the influence from exiting and entering vehicles in a given section of an art erial road using traffic simulations. As the thr ee points connected to National Highway 21 w here we conducted the survey are on the sam e route and proximate, we set up a road secti on as in figure 3 in a simulation using the po sitional relationships and observed results of t hese points. We thought that the arterial road traffic volume, exiting and entering traffic vol ume, and number of unsignalized intersections would have an effect and conducted simulatio ns changing these conditions.

We found the delay and travel speed for all vehicles traveling on the arterial road and con verted them into values per vehicle. In additio n to the vehicles traveling on the entire arteri al road in the section under analysis, we inclu ded in the analysis the effects exerted on exiti ng and entering vehicles by other exiting and entering vehicles in arterial road sections that the vehicles traveled on.

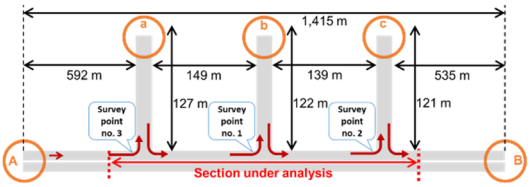

Fig. 3. Road section image

First, figure 4 shows the delay and travel speed when the arterial road traffic volume was changed. When converted to a delay per vehicle, the results were less than 2 seconds even with the highest traffic volume and were smaller than the observed delay when looking only at vehicles directly behind exits and entries as shown in table 1 (approx. 2–3 seconds). In addition, the delay increased and the mean travel speed decreased with an increase in traffic volume. The same also applied when the exiting and entering traffic volume was changed.

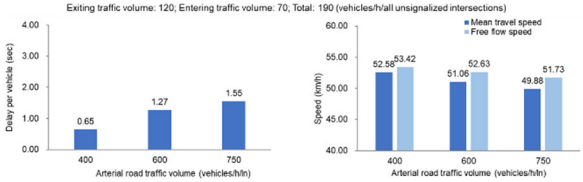

Fig. 4. Arterial road traffic volume and delay and travel speed

Next, figure 5 shows the delay and travel speed when the number of unsignalized intersections was changed. The total exiting and entering traffic volume was not changed, notwithstanding the change in the number of unsignalized intersections, but the delay per vehicle decreased and the travel speed increased with a decrease in the number of unsignalized intersections. It means an increased exiting and entering traffic volume per unsignalized intersection when the number of unsignalized intersections decreases and a longer time for entering vehicles to enter, as they do not have the right of way. Because of this, reducing the number of unsignalized intersections may contribute to improving travel speeds on arterial roads, but may have adverse effects on the road sections outside of arterial roads.

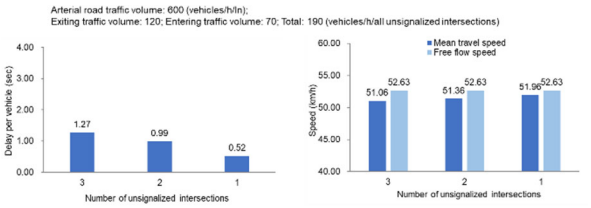

Fig. 5. Number of unsignalized intersections and delay and travel speed

3. Conclusion

We found that vehicles entering and exiting at unsignalized intersections connected to arterial roads may reduce the speed of vehicles traveling on the arterial road directly behind them and also lead to the occurrence of delay and decreases in travel speed in a certain section. It appears necessary to examine the factors causing decreases in arterial road travel speed, including signalized intersections, and to expand the examination to the network including roads connecting to arterial roads.

☞See here for detailed information

1) Effect for Travel Speed on Arterial Roads by Unsignalized Intersections Access, Proceedings of the 66th Infrastructure Planning Conference

Examination of Method for Gaining Information on Traffic Safety in Bicycle Traffic Spaces Through On-Site Travel and Surveys

(Research period: FY2021–FY2023)

Road Safety Division, Road Traffic Department
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(Keywords) bicycle traffic space, traffic safety, travel experiment

1. Introduction

While the total number of bicycle accidents has fallen by half over the past 10 years, there are still issues, such as the flat trend in the number of bicycle-pedestrian accidents, and calls for the development of bicycle traffic spaces have increased. In relation to the development of bicycle traffic spaces, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and the National Police Agency drafted Guidelines on Creating Safe, Comfortable Environments for Bicycle Usage in November 2012 and demonstrated design thinking in line with the road traffic situation, based on the perspective that bicycles should travel on roadways as a main principle. However, although bicycle traffic spaces have been developed until now, the total developed length remains at approximately 2,900 km as of the end of March 2020, and about 70% has been developed in the form of a mixed-use roadway.

One factor preventing further development of bicycle traffic spaces is the difficulty in forming agreement and the lack of clarity in the effects of developing bicycle traffic spaces, but visualizing the effects of development is necessary for promoting development.

This paper examines indicators for gaining information about the effects of development from the perspective of traffic safety in bicycle traffic spaces and reports on observation results from travel experiments.

2. Considering indicators based on a literature survey

We collected domestic and international papers, guidelines, and other literature pertaining to gaining information on safety relating to bicycle traffic.

As indicators, the domestic literature used statistical data and observed values, such as the number of bicycle-related accidents, the rate of bicycles driving in the correct direction on roadways, and bicycle speed and traffic volume, and also questionnaire survey-based objective evaluation values, such as the sense of danger, and heart rate to indicate the degree of physical effect. By contrast, the international literature used data relating to the structure of the bicycle traffic spaces and traffic regulations, such as the width composition, road surface state, and speed regulations.

Next, we selected the indicators and influencing factors for the organized data, based on ease of measurement and data acquisition and their generality as indicators (table 1). Incidentally, we defined the indicators as those that may allow us to directly gain information on safety relating to bicycle traffic, and the influencing factors as those that may influence safety.

Table 1. Results of consideration of indicators

Indicators used in literature		Suited for adoption in this study/survey method		
Subjective value	Sense of danger	Adopted	"Evaluation indicator" directly representing safety	Questionnaire survey
	Comfort			
	Times danger was felt			
Accidents, behavior	No. of bicycle-related accidents			Statistical data
	Behavior changes (times)			Video survey
Road structure traffic conditions	Rate of correct driving direction			
	Mean speed		"Influencing factor" indirectly influencing safety	
	Traffic volume			
	Large vehicle inclusion rate			
	No. of vehicles parked on street			On-site check
	Width			
	Road surface conditions, etc.			
Physical effects	Heart rate fluctuations	Not adopted	Issues with ease of measurement	
Integrated indicators	Bicycle service level		Not yet established as suitable model	
	Sense of safety assessment model		Model at research stage	

3. Verifying indicator validity by travel experiments

We conducted travel experiments with 10–11 subjects on four routes with contiguous sections (fig. 1) that had been developed in different forms (path for bicycles alone, mixed-use roadway, no development) and summarized the indicators and influencing factors selected in section 2 through video and questionnaire surveys. We verified the validity of these indicators and influencing factors through a comparative analysis of the different routes and development forms and a correlative analysis between indicators. The results concerning the indicators are discussed here.

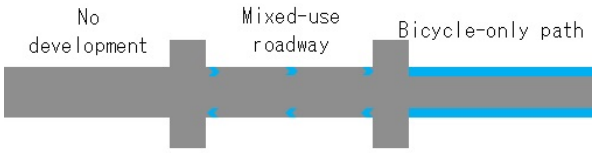

Fig. 1. Image of the surveyed routes

For the comparative analysis between development forms, the comparison results for sense of danger, rate of correct driving direction, and and number of bicycle-related accidents are shown as representative indicators among those shown in table 1.

For the comparative results for the sense of danger, the five-point scale evaluation by the subjects have been scored (with lower scores indicating greater danger), and the average for each of the routes and development form have been used for comparison, with bicycle-only path, mixed-use roadway, and no development having the lowest to highest sense of danger for all routes (fig. 2).

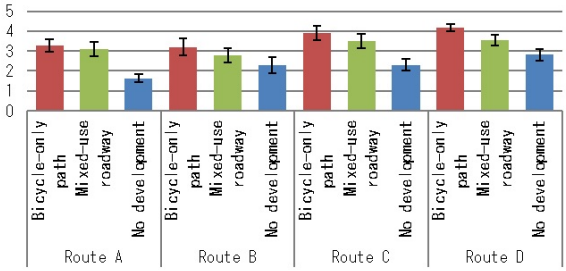

Fig. 2. Sense of danger by route and development form

For the rate of correct driving direction (the proportion of the total bicycle travelers who drive in the correct direction on a roadway or bicycle traffic space), the size relationship of the indicator between development forms is reversed for some routes (fig. 3). As it was confirmed from video footage showing actual travel on routes where the size relationship of the indicator was reversed that riders were traveling on the footpath to avoid parked cars, it is possible that the presence or absence of on-street parking may influence the indicator.

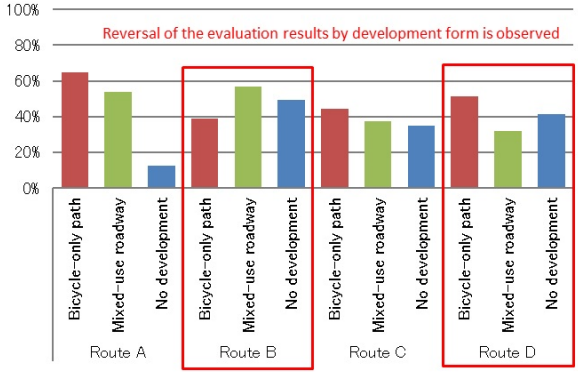

Fig. 3. Rate of correct driving direction by route

and development form

For the comparison results for the number of bicycle-related accidents, the indicators varied widely between routes and development forms (fig. 4).

The factor leading to this is thought to be the low number of bicycle accidents. Moreover, if the year under evaluation is less than a certain period of time after the development of the bicycle traffic space, it may not be evaluated appropriately.

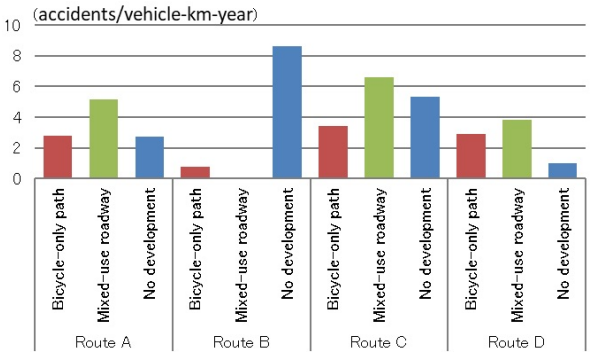

Fig. 4. Number of bicycle-related accidents by route and development form

Furthermore, table 2 shows the results of the correlative analysis between indicators.

We confirmed that there was a “strong to fairly strong correlation” between sense of danger, comfort, number of times danger was felt, number of changes in behavior (wobbling and weaving), and rate of correct driving direction, thus obtaining the expected result representing safety with regard to bicycle traffic.

The above suggests that sense of danger, comfort, number of times danger was felt, number of changes in behavior, and rate of correct driving direction are likely to be valid as indicators for evaluating safety with regard to bicycle traffic.

Incidentally, the number of bicycle accidents did not necessarily show a strong correlation with any of the indicators, but as discussed above, this is thought to be caused by the low number of bicycle accidents.

Table 2. Correlative analysis between indicators

	Sense of danger	Comfort	Times danger was felt	No. of behavior changes	Rate of correct driving direction	No. of bicycle-related accidents
Sense of danger	–	0.966	-0.743	-0.659	0.447	-0.117
Comfort	–	–	-0.592	-0.646	0.492	-0.313
Times danger was felt	–	–	–	0.628	-0.128	-0.302
No. of behavior changes	–	–	–	–	-0.538	-0.026
Rate of correct driving direction	–	–	–	–	–	-0.040
No. of bicycle-related accidents	–	–	–	–	–	–

4. Conclusion

This paper presented efforts in visualizing the effects of development of bicycle traffic spaces.

By clarifying the effects of developing bicycle traffic spaces and sharing these between the people involved, we hope to link to the promotion of developing bicycle traffic spaces.

☞See here for detailed information

1) 66th Proceedings of Infrastructure Planning (29-01)
Examination of Method for Gaining Information on Traffic Safety in Bicycle Traffic Spaces Through On-Site Travel and Surveys

Study on Ways of Smoothly Consensus Building in Utility Pole Removal Projects

(Research period: FY2019-)

Road Environment Division, Road Traffic Department

Head ŌSHIRO Nodoka Senior Researcher FUSE Jun Researcher ŌKŌCHI Keiko

(Keywords) utility pole removal, consensus building, project acceleration

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) formulated a new Plan to Promote Utility Pole Removal[1)] in May 2021, pursuant to Article 7 of the Act on the Promotion of Utility Pole Removal, and has been moving forward with utility pole removal.

Based on this, NILIM created a Guide to Consensus Building in Utility Pole Removal Projects (draft), which gives commentary on basic knowledge about utility pole removal projects, matters relating to consultation between those involved, etc., for the people in charge of this in local government, who may have little or no experience of involvement in utility pole removal projects, and it published this guide in April 2022.

2. Background and objectives of creating the guide

In carrying out a utility pole removal project, it is essential to build consensus with residents, shops, companies, and others along the roads, not just with companies such as the road administrator and the power line administrator. This is because when electric lines and other equipment are buried or moved under eaves or off major streets, it is necessary to relocate the lead-in equipment for power and communication lines leading to residences, shops, and others along the road, and in addition, to obtain the understanding of roadside residents and others about aboveground devices that will be newly installed on sidewalks, etc. in conjunction with the utility pole removal and about the plan and construction schedule for interconnection equipment.

Thus, utility pole removal projects involve coordinating a wide range of items with a large number of associated people and require knowledge of power and communications technologies, not to mention roads, and they therefore present a high level of difficulty for personnel in charge of the practical work who have little experience in utility pole removal projects. Moreover, according to a 2020 questionnaire survey of local governments throughout Japan, approximately 80% had “no experience of conducting utility pole removal projects in the past five years.” This created a demand for easily understood materials for the personnel in charge of practical work to understand the items to coordinate at each stage of a utility pole removal project and the matters to note in consensus formation.

3. Outline of the guide

The guide is divided into a fundamentals volume and the main volume (fig. 1).

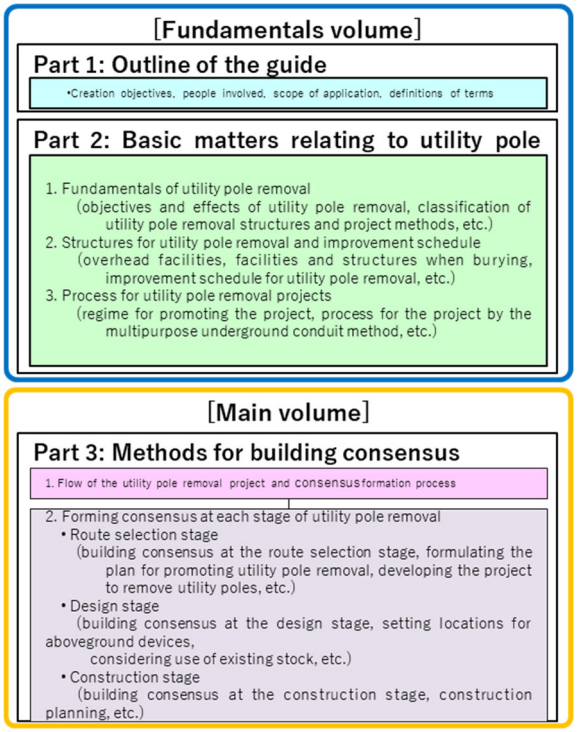

Fig. 1. Composition of the guide

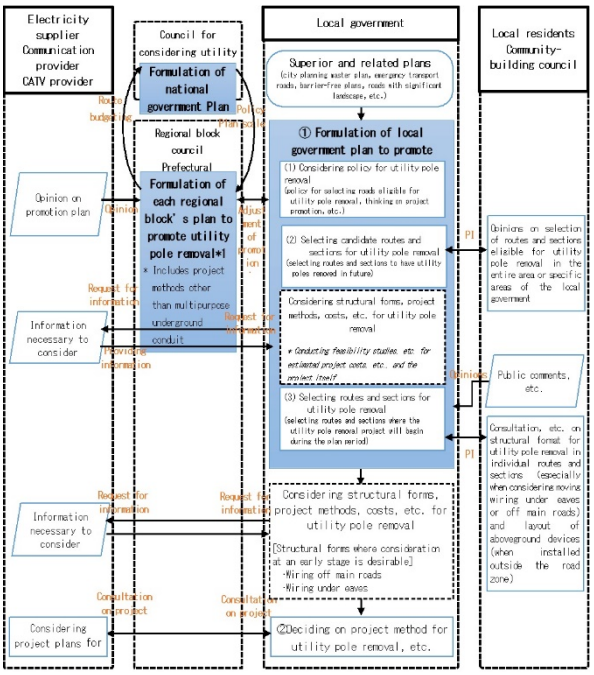

Fig. 2. Image of the basic flow of the route selection stage

(1) Fundamentals volume

The fundamentals volume explains the public works, electricity, and communications technologies concerning utility pole removal and how to proceed with a utility pole removal project, to give the reader the knowledge needed to carry out the project.

(2) Main volume

The main volume explains the many matters for coordination with the people involved in a utility pole removal project and the points to note in order to build consensus smoothly. For example, for the matters for coordination with people involved, by showing the basic flows of the overall project and the project stages (route selection stage, design stage, construction stage) as in figure 2, it gives a bird's-eye view of the operations to be performed and the contents to be coordinated between people involved.

(i) Building consensus at the route selection stage

This section describes the significance of building consensus for the route selection stage, key points when formulating the local government plan for promoting utility pole removal, and things to be considered when developing the project to remove utility poles, among other items. Key points listed for when the local government formulates its plan for promoting utility pole removal include considering the utility pole removal policy based on superior and related plans, such as the national government's utility pole removal promotion plan and city planning master plans, and selecting candidate routes for utility pole removal as the foundation for the utility pole removal policy, and this section explains matters to note in relation to these. Things that the local government should consider when developing the project to remove utility poles

include considering the possibility of adopting low-cost methods, such as adopting wiring off main roads or under eaves and making use of existing stock. The points to note when considering explain that consensus with residents is essential if the local government will adopt wiring off main roads or under eaves.

(ii) Building consensus at the design stage

This section describes the key points in building consensus in each of the practical operations at the design stage. It is particularly detailed with regard to the installation of aboveground devices, which can have a wide range of contents that need to be coordinated at the design stage, and the use of existing stock. In relation to the installation of aboveground devices, in addition to explaining traffic safety above footpaths and ways to handle cases needing care to ensure smooth traffic, it explains matters to note like considering design schemes that allow for the surrounding landscape, as in figure 3, in utility pole removal aimed at building a better landscape.

Example of hiding an aboveground device with board fences (Kanazawa City)

Example of using an aboveground device as a tourist information board (Osaka City)

Fig. 3. Design schemes allowing for the surrounding landscape, etc.

(iii) Building consensus at the construction stage

This section describes methods of explaining to residents before the works, matters to consider in the construction plans, and other matters. For the pre-works explanation to residents, it gives such matters to note as that the road administrator and the power line administrator should cooperate to explain the overall image of the works relating to utility pole removal.

4. Conclusion

The guide is published on the NILIM website for download[2] to be widely used. Furthermore, we plan to continue to collect examples and conduct investigations and to update and enrich the contents of the guide.

In preparing the guide, we benefited from the opinions and advice of the working group (WG) consisting of people with expertise and experience and related businesses. We take this opportunity to sincerely thank every WG member.

☞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) Guide to Consensus Building in Utility Pole Removal Projects (draft)
https://www.nilim.go.jp/lab/dcg/kadai6-mudenchu-guide.html

A Study on Standard Floor Section Specifications for Wooden Buildings in Consideration of Sound insulation Performance and Cost-effectiveness

(Research period: FY2022 - FY2023)
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HIRAKAWA Susumu (Ph.D. in Engineering), Senior Researcher,
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Key words: green, decarbonization, sound insulation, heavy floor impact noise

1. Introduction

The New Basic Plan for Housing and Living (Cabinet decision on March 19, 2021) by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), prioritises the integration of sustainable practices and materials in urban development. A key focus is on augmenting carbon storage in urban environments and endorsing the use of innovative construction materials specifically Cross-laminated Timber (CLT). The initiative encourages the application of wooden construction techniques in the development of medium and high-rise buildings[1].

Further, the analysis conducted on the 2018 Comprehensive Survey of Housing and Living data identified a direct correlation between building construction material and residents' satisfaction with sound insulation performance. **Fig. 1** indicates a lower satisfaction among occupants of wooden construction buildings in comparison to those residing in concrete structures. It highlighting an urgent need for enhancements in sound insulation within wooden constructions to improve their living quality[2].

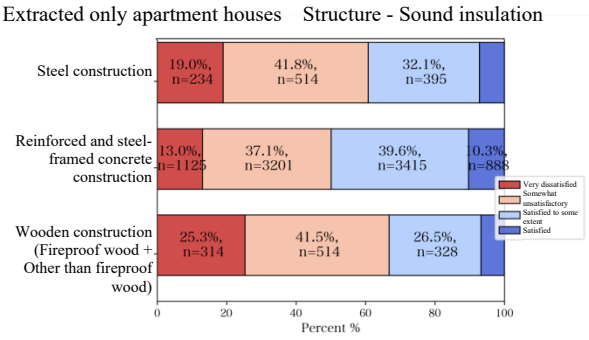

Fig. 1: Cross-tabulation results on building structures and satisfaction with sound insulation performance in the 2018 Comprehensive Survey of Housing and Living

The success in promoting mid and high-rise wooden houses relies on effectively optimizing design and enhancing resident satisfaction. The Public-Private R&D Investment Strategic Expansion PrograM (PRISM) has been dedicated to researching standard cross-sectional specifications that balance sound insulation performance with cost efficiency. The aim is to formulate cross-sectional specification guidelines for inclusion in the public notice of the Japan Housing Performance Indication Standards.

2. Description of the study in the current fiscal year

This year's study involved the construction of a new floor structure as illustrated in **Fig. 2** on the second floor of a six-story full-scale 2 × 4 experimental building at the Building Research Institute. This effort aimed to achieve optimal performance in heavy-weight floor impact sound insulation at a cost lower than or equal to traditional concrete structures utilizing CLT, etc.

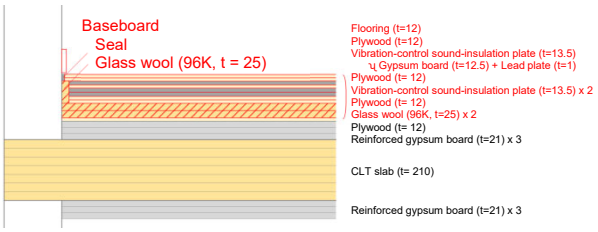

Fig. 2: Example of measured floor section specifications[3]

3. Conclusion

The results of the study will be made public through conference presentations and technical documents as needed.

☞See the following for details.

1) Outline of the New Basic Plan for Housing and Living (Cabinet Decision on March 19, 2021) (Reference: Jan. 24, 2022)
2) Housing Bureau, MLIT: Results of the 2018 Comprehensive Survey on Housing and Living, Aug. 2020
3) Architectural Institute of Japan (ed.), Floor Impact Noise Prevention Design of Buildings (Gihodo Shuppan, Tokyo, 2009)

Research on Quantification of the Cost and Effect of Vacant House Management and Measures

(Research period: FY2020 to FY2022)

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Key words: vacant house, vacant house management, prevention of mismanagement, cost estimation

1. Introduction

In recent years, the number of vacant houses in Japan has been increasing. Accordingly, there is a concern about the future increase in the number of "unmaintained vacant houses" that are not properly managed. In addition, an increase in the burden of municipalities and owners has been observed, and it is required to strengthening the measures to prevent vacant houses from becoming unmaintained through appropriate management and various types of support.
In response, the NILIM, in its "Research on Quantification of the Effective of Preventive Measures against Mismanagement of Vacant Houses," clarified "the minimum level of management required to prevent mismanagement," and aims to develop "a method for quantifying the effect of preventive measures against mismanagement." In other words, the goal is to show in an easy-to-understand manner how much "loss" is incurred when a vacant house is "dilapidated" and how much "gain" is achieved when it is properly managed.
In this issue, as preventive measures, we position the provision of information and advice on proper management and various support measures, as well as assistance projects for utilization and removal, and as responses to vacant houses, position owner surveys by the municipal department in charge, actions based on the Vacant House Act, etc.

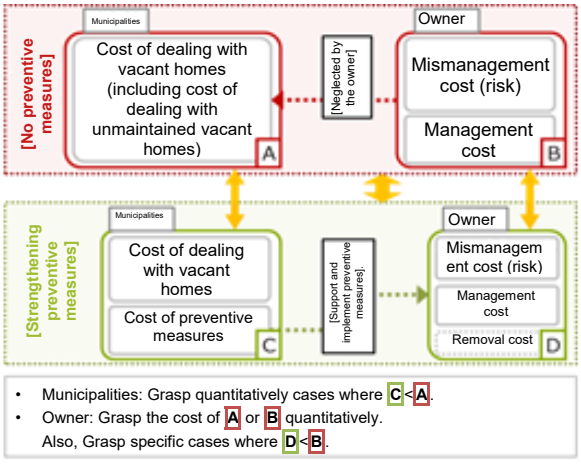

Fig. 1: Image of cost comparison by preventive measure

The basic approach to the quantification of the effect of preventive measures is to compare the costs when preventive measures are taken and when not taken (**Fig. 1**).
In FY2022, we 1) developed a "Quantification Tool for the Effect of Preventive Measures for Mismanagement of Vacant Houses" (the "Quantification Tool") to estimate the costs, and 2) conducted case studies targeting municipalities, etc. and mainly improved the Quantification Tool.

2. Development of quantification tools

Two types of the quantification tools were developed: municipal version and owner version. The municipal version of the tool uses the population, number of houses, and number of vacant houses as inputs, and estimates for a certain period based on assumed scenarios according to population size, etc.
Specifically, the following are estimated: "cost of preventive measures," "cost of responding to vacant houses," "effect of preventive measures," and "effect of responding to vacant houses" for each year. The "effect" is calculated by the number of dwelling units with improved management, etc., and is expressed in the form of a decrease in costs required for response, etc., due to a decrease in the number of vacant houses requiring response at the next point in the estimation process (**Fig. 2**). This allows a quantitative grasp of the effect of preventive measures when they are taken,

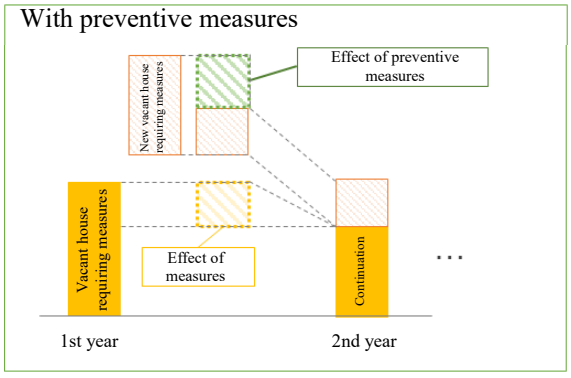

Fig. 2: Image of estimated effect of vacant house measures (by municipalities)

for example, the tool can be used to examine preventive measures to be specifically implemented, personnel arrangement, etc. in considering future measures for vacant houses in municipalities.
The owner version of the tool calculates the "cost of management," "cost of response required due to mismanagement," and "risk of accidents, etc. resulting from mismanagement" for a certain period of time each year. The cumulative cost over the period and the assumed cost of removal can also be calculated (**Fig. 3**). By comparing these data, it is possible to quantitatively demonstrate that it is advantageous for the owner to implement proper management, or that in some cases, removal is a realistic option.

3. Case study focused on municipalities, etc.

Fig. 4 shows the results of estimation made by the quantification tool for a municipality. In this example, decrease in the number of vacant house was limited to a certain level when preventive measures are not implemented.
On the other hand, when preventive measures were implemented, a constant decrease was observed, which indicates the effect of preventive measures on the utilization and removal of vacant houses.

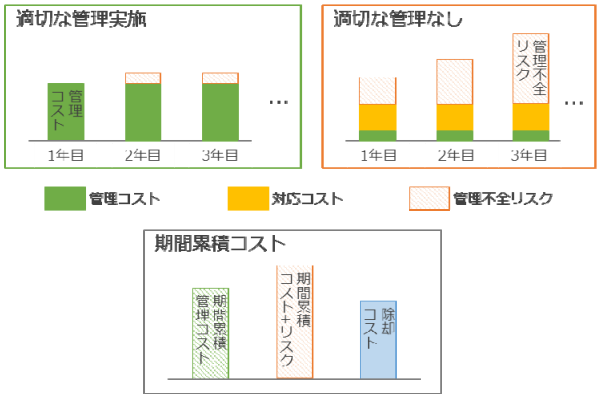

Fig. 3: Image of the estimation of vacant house management cost (owner)

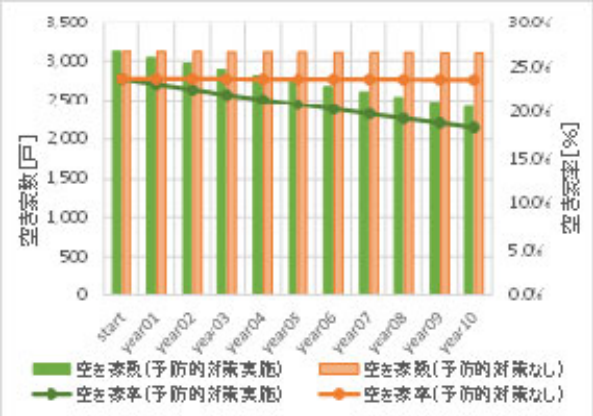

Fig. 4: Example of the estimation of the number of vacant houses in the future according to preventive measures

The analysis results also showed that the effect of preventive measures is likely to support the utilization and removal of vacant houses that are in relatively good management condition, while the effect of measures taken by the department in charge of vacant houses, including the Vacant House Act, are likely to raise the management condition of vacant houses that are in relatively poor management condition.
Based on these results, we conducted a hearing survey of five cities and towns (including prefectural capitals and municipalities with small populations) selected considering their housing and population characteristics, and interviewed them about the results of their calculations using the quantification tool and their measures for vacant houses, etc. Specifically, we asked for opinions on the extent to which there are differences between the results of cost and effect estimation using the quantification tool and actual results in light of usual operations, and on the appropriateness of unit cost data[1] such as the unit cost required to address vacant houses in municipalities, which is necessary for the estimation.
As matters that should be improved, we found the identification of items that tend to cause large differences between actual and estimated values, and the clarification of the display of estimation results, etc. Also, as matters to be well evaluated, we found that the results of estimation have a certain validity and that specific situations of use can be expected. These opinions were organized and improvements were made in the form of feedback to the quantification tool.

4. Conclusion

Since FY2022 is the final year of the research, after making revisions based on the results of municipal hearings, etc., we will promptly compile as a method for quantifying the effect of preventive measures against mismanagement in a manner that includes the minimum required management level and quantification tools to prevent mismanagement. We also plan to publish the quantification tool on the NILIM website[2] as soon as it is ready for use by municipalities and property owners in their future study of vacant house measures and management policies.

1) The basic unit cost data needed to create the quantification tool, such as the unit cost for municipalities to address vacant houses and the unit cost for owners to manage them, were collected from the 2020 and 2021 surveys.
2) Housing Planning Division website
http://www.nilim.go.jp/lab/ibg/index.htm

Actual Conditions Related to Human Adaptation to Heat Using Mobile Phone Location Data

(Research period: FY2021 to FY2023)

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Key words: heat island, human flow big data, heat stress index

1. Introduction

Urban heat island countermeasures are being promoted by relevant ministries and agencies in cooperation with each other based on the "Outline of Heat Island Countermeasures" (revised in 2013) and the "Climate Change Adaptation Plan" (2018). In recent years, data-driven city planning has been promoted through the widespread use of measurement devices utilizing new technologies, such as ICT, and the use of big data, AI, etc.

Therefore, the NILIM is engaged in research that utilizes big data on mobile phone location data to grasp urban residents' exposure to heat, and contributes to the study of soft measures (life styles that avoid heat) and the introduction of priority hard measures in appropriate places and time zones where the measures can be more effective.

2. Mobile phone location data big data used

In this research, point-type mobile phone location data were used[1]. This is GPS location information, etc., collected from a specific application which can track the movement history of people on a street-by-street basis. A way correction needs to be devised for the data acquired because it is limited to locations that are easily located by GPS, there is a user bias, and the area around residences, etc., is confidential. The data is however considered suitable for making relative comparisons on outdoor active persons exposed to heat, which is the subject of this research.

3. Relationship between the percentage of pedestrians and the heat stress index (WBGT)

Through the expanded estimation of point-type mobile phone location data based on mobile spatial statistics[2], we calculated the population according to means of transportation, taking into account the travel speed of each user, distance from railroads and roads, GPS accuracy, etc. (**Fig. 1**). We studied the relationship between the percentage of people within a 5-km radius around a major station in Tokyo by means of transportation and WBGT distribution data[3] at 14:00 August 2019 (**Fig. 2**). On holidays, "stay" increased and "walk" decreased as WBGT becomes higher. On the other hand, on weekdays, the slope of both "stay" and "walk" against WBGT is smaller than on weekends. It was estimated that the respondents were forced to travel "on foot" even when WBGT was high, due to the influence of their employment on weekday travel.

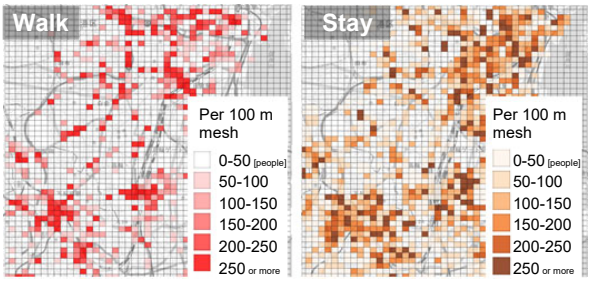

Fig. 1: Estimated population according to means of transportation (example between 14:00 and 15:00)

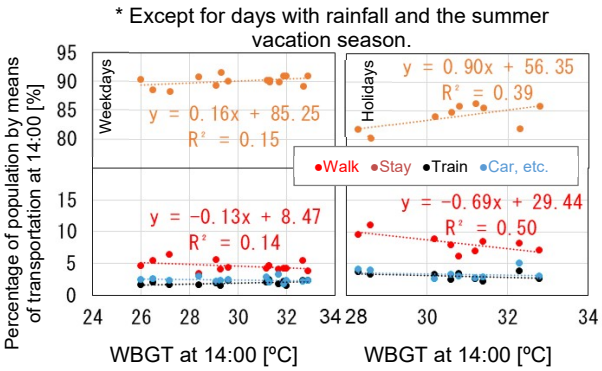

Fig. 2: Relationship between WBGT and the percentage of population by means of transportation

4. Conclusion

We have grasped the actual exposure of people to heat using mobile phone location data. In the future, we will study Heat risk assessment.

☞Citations, etc.

1) Agoop Corp. point-type current population data
2) Registered trademark of NTT DOCOMO, INC.
3) Ministry of the Environment, Japan "Heat Illness Prevention Information
4) This research was funded by the Comprehensive Environmental Research Promotion Fund of the Ministry of the Environment and the Japan Environmental Restoration and Conservation Agency (JPMEERF20212006).

Research on Urban Functions and Public Spaces Based on New Lifestyles

(Research period: FY2021 to FY2023)

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Urban Planning Department, Urban Facilities Division,

Key words: new lifestyle, urban function, public space, Interaction effects of public spaces

1. Background and purpose of research

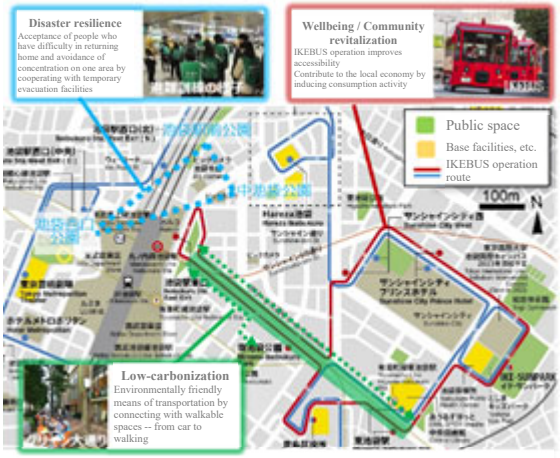

Image source: Toshima Ward HP, Tokyo Metropolitan Government Disaster Prevention HP

Fig. 1: Image of PS interactions (Ikebukuro Subcenter area)

In keeping with diversification of lifestyles, functions required of cities are also diversifying, and it is now important that urban policies reflect these changes. In response, there are urban functional open spaces in various regions that implement various initiatives such as walkable space formation. However, in order to increase the effectiveness of these initiatives, mutual synergy between multiple open spaces is required. Thus, we have organized the functions required of cities based on new lifestyles, etc., and focus on public spaces ("PS") that serve as hubs for people's activities, aiming to establish a method to grasp the effect of their interaction.

2. Organization of functions required of cities

Through the organization of existing literature, etc., we have organized the basic urban functions, the functions required of cities based on new lifestyles, etc., and the functions to be performed by PS. Among these, we categorized them into several types based on the expected effects of PS interactions("Interaction effects of PS"). It is categorized into four categories: well-being, community revitalization, disaster resilience, and low carbon emissions (**Fig. 1**). We decided to investigate the manifestation of these effects.

3. Get an understanding of the effect of PS interactions through interview surveys, etc.

From the aforementioned perspective, in order to verify the existence of PS interaction effect and their factors, etc., we conducted on-site interviews with approximately 200 people in each city, including weekdays and holidays, in the central areas of Yokohama, Kanazawa, and Okazaki. As a result, it became clear that for city dwellers, the presence of multiple PSs is expected to have an impact on wellbeing and community revitalization, such as improvement in the living environment and life satisfaction and expansion of the scope of behaviors and content of activities, and that behavior and consciousness that vary are different depending on the urban spatial characteristics (**Fig. 2**).

4. Conclusion

In the future, we plan to continue the aforementioned analysis, clarify evaluation items and indicators, etc. to grasp the effect of interaction, and compile the results as a Technical Note of NILIM.

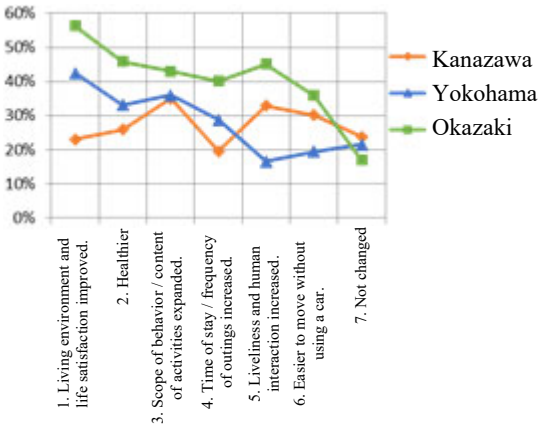

Fig. 2: Changes in behavior and awareness perceived as a result of the connection of the entire survey areas (answers by city dwellers)

Development of Network Visualization Technique for Habitat Regeneration to Make Organisms in an Inner Bay Prosper in the Long Term

(Study period: FY2020 to FY2022)

Marine Environment and Emergency Management Division, Coastal and Marine Disaster Prevention Department

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(Keywords) *Microsatellite analysis, Relatedness, network analysis*

1. Introduction

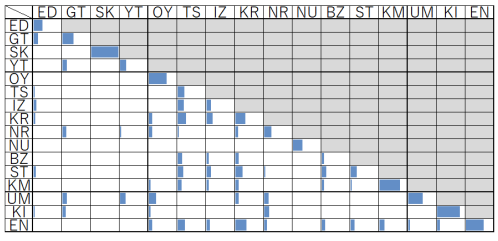
When regenerating habitats due to the decline of various organisms in port areas, spatial arrangement of habitats is required in consideration of the network among habitats formed by the movement of organisms instead of only increasing habitats. The network is an important system for organisms that maintain population persistence by moving between habitats for reproduction, growth, or adaptation to environmental disturbances (such as blue tides).

Here, we introduce a technique for estimating and visualizing the habitat networks based on the kinship of common snails (the Japanese mud snail *Batillaria attramentaria*) in the inner bay.

2. Estimation of Kinship in Snails

Microsatellite analysis (analysis to estimate the number of repeated DNA units) was performed on Japanese mud snails at 16 sites (15 individuals per site) inside and outside Tokyo Bay to estimate the degree of relatedness based on the concordance rate of genetic types (Table).

Table: Mean degree of relatedness of habitat pairs (the longer the blue bar (relatedness > 0), the more likely the network is to form)



3. Network Visualization

On the assumption that a network will be formed between habitats with a degree of relatedness exceeding 0, the network structure was visualized by depicting the results of the network analysis on a map together with information on the population size of snails forming the networks and the grouping of habitats based on network characteristics by community analysis (Figure).

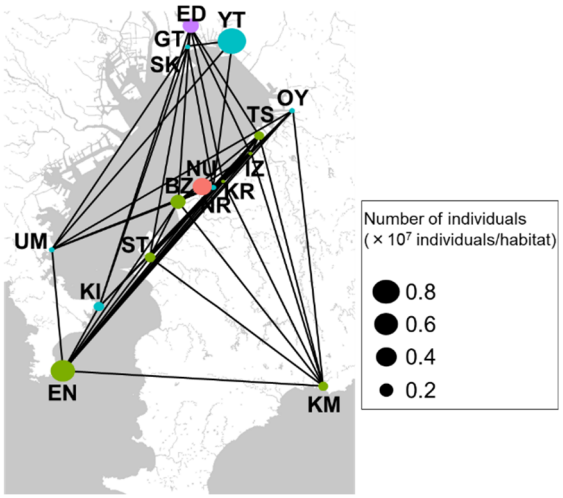


Figure: Network structure of Japanese mud snails inside and outside Tokyo Bay. (The circle size represents the total population of the snails per habitat, and the color represents the grouping.)

4. Conclusion

Results in the present study will be used in the future to identify the features of seascape (coastal habitats composed of various environmental types) that contribute to the enhancement of habitat networks of diverse organisms ecologically similar to Japanese mud snails. Based on the identified seascape features, it is expected that habitat-regenerating sites will be extracted, and this is effective in improving the persistence of organisms in an inner bay.

Grasp of Current State and Issues of Spatial Development in Coastal Areas

(Study period: FY2020–)

Coastal and Marine Disaster Prevention Department

Research Coordinator for Coastal and Marine Affairs OKAMOTO Osamu

(Keywords) *Restructuring of coastal areas, manufacturing industry, and return of manufacturing to Japan*

1. Introduction

The recent depreciation of the yen, reduction of labor costs in Japan, rapid economic growth in Asia, and spread of the novel coronavirus have caused changes in the coastal areas of Japan. The purpose of this study is to identify the trends that are remarkable in relation to the coastal areas of Japan, and to identify and organize issues.

2. Trends in return of manufacturing to Japan

In Japan's manufacturing industry, factories had been relocated to China and Southeast Asian countries since the 1990s in search of cheaper labor costs. However, in light of the current situation, there are new developments such as reshoring (returning manufacturing to Japan). Typical examples are shown in Table 1. Some industries have switched their production bases to Japan due to the COVID-19 pandemic (e.g., textiles). Others are located in coastal areas.

Table 1: Trends in return of manufacturing to Japan

Industry	Summary
Cosmetics	Establishment of overseas export bases
Sanitary goods	Located in coastal industrial parks
Industrial machine	Establishment of overseas export bases
Fiber	Strengthening the production of non-woven fabrics
Toothpaste	Migration and export base formation
Air conditioner	Enhancement of production function

Next, the impact on logistics is shown in Table 2. It can be seen that the shift from overseas production to domestic production has had a considerable impact on global distribution networks, such as the type of packing and quantity of imports and exports.

Table 2: Effects on logistics

Industry	Impact on logistics
Motorcycle component	Shift 1/4 of Thai production to Japanese production
Household goods	Cost reduction by 20% on average
Apparel	Increase domestic production ratio to 90% from 40%
Car navigation system	Increase the domestic production scale to five times the conventional scale
Large household electrical appliance	Double the exports from the previous level

3. Summary and Discussion of Factors Such as Reshoring

First, it is assumed that one factor on the corporate side is that the countries where the factories were previously relocated have achieved economic growth and labor costs have increased while Japan's labor costs have not grown during that period. From the viewpoint of economic security, it is also assumed that there is a trend to avoid areas that are affected by production stoppages due to wars, conflicts or urban lockdowns.

In addition, this may be due in part to the fact that the Ministry of Economy, Trade and Industry's policy currently provides assistance for reshoring of production sites with regard to the reinforcement of supply chains. At the same time, ASEAN countries are increasing their procurement bases for important products and supporting the diversification of overseas supply chains. We will keep an eye on both sides of this issue.

4. Future Issues to Be Considered

As a future consideration, we will identify issues by collecting additional examples, having appropriate interviews with business operators, and collecting examples of coastal realignment. Measures to be taken in the coastal areas in the future will also be discussed.

Developing and Implementing APIs in Road-Related Systems

(Research period: FY2021-)

Information Platform Division, Research Center for Infrastructure Management

Researcher NIIKURA Isaya Senior researcher ŌTE Masayuki Head NISHIMURA Tōru

(Keywords), xROAD, road maintenance, API linkage

1. Introduction

The Road Bureau of the Ministry of Land, Infrastructure, Transport and Tourism (the Road Bureau) is moving forward with construction of a road data platform (xROAD) to promote the use of data in road management, etc., by linking the various road-related data through API linkage.

Specifically, this initiative aims to link data on traffic volume, structure specifications, and the like and build a 3D platform that uses and benefits from the data necessary for road management, on top of platform data centered on 3D point group data from mobile mapping systems (MMS), digital road

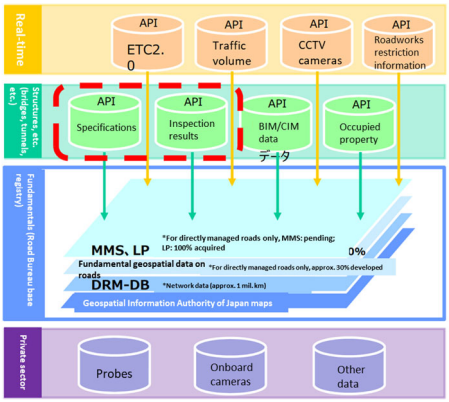


Fig. 1. Concept diagram for xROAD

map databases (DRM-DB), fundamental geospatial data on roads, and other data (fig. 1).

Our division is also improving the functions of and developing new systems as part of the construction of xROAD, so this paper presents the systems that we are in charge of developing and improving, using APIs as an entry point.

2. What is an API?

An API (application programming interface) is a set of rules (or a program to transmit data using the rules) that define shared methods for exchanging data and other information so that the functions and data held by a certain system can be made available for use by another external system. Then, API linkage refers to the mechanisms whereby the system passing the data and the system receiving the data can exchange data by communicating to each other according to the API.

Due to its nature of having each system communicate based on shared rules, API linkage makes it possible to link data in new ways without significantly altering existing systems, so it enables cost and time savings in development and improvement and is being used in various settings.

At the Road Bureau, too, API linkage is an important technology in xROAD to build an environment that allows the effective use of data that was previously held disparately by several systems.

Our division is improving functions and conducting new development in three systems—the fundamental geospatial management system

for roads, the point group storage, management, and processing system, and the road sign database—and the following sections present these systems and the APIs being (or to be) used in them.

3. Fundamental geospatial management system for roads

The fundamental geospatial management system for roads is broadly composed of three functions: the data conversion and storage function, the browsing function, and the data provision function.

When paving works, etc. for a road are completed, the contractor is required to create a CAD drawing known as a "roadwork completion drawing" and deliver it to the Electronic Delivery Storage and Management System, and "fundamental geospatial data on roads" (fig. 2), which is GIS data with the structures in the road zone divided into 30

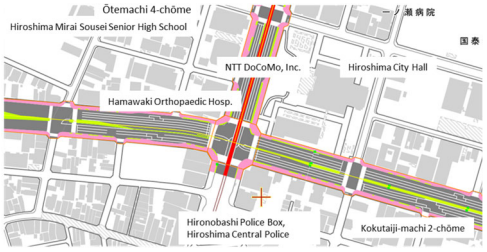


Fig. 2. Image of fundamental geospatial data

layers, is created from this roadwork completion drawing. Because the fundamental geospatial management system for roads has a specification that acquires CAD data from the Electronic Delivery Storage and Management System by an exclusive line and automatically creates GIS data, the data is developed without human involvement.

The fundamental geospatial data on roads thus created is accumulated in the system as a database, and not only can MLIT employees use the browsing function to check them over the Internet, but they can also check works information and download CAD data by clicking points on the map.

In addition, we have also implemented API linkage functions to provide fundamental road maps to external systems and are currently able to provide image data in PNG format through the Web Map Service (WMS) (fig. 3). WMS is a standard specification when providing map images online, an out system has a mechanism that outputs map image data within the

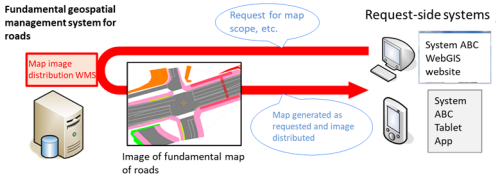


Fig. 3. Image of data linkage through WMS

specified scope when a rectangular scope is designated by two arbitrary coordinates.

Moreover, we are considering system improvements to enable API linkages through outputs of CAD data and CSV format for roadwork completion drawings and works specification data, among others.

4. Road sign database and MMS data storage, management, and processing system

The Information Platform Division, under the direction of the Road Bureau, has just built a road sign database to make use of MMS data to create a database of all road signs under MLIT management in Japan. In future, we intend to consider API specifications for API linkages with the National Road Facility Inspection Database,(*) for example (fig. 4).

* A database composed from a group of several databases on road facilities. Built in the cloud.

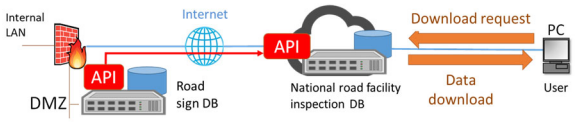


Fig. 4. Image of linkage with the road sign database

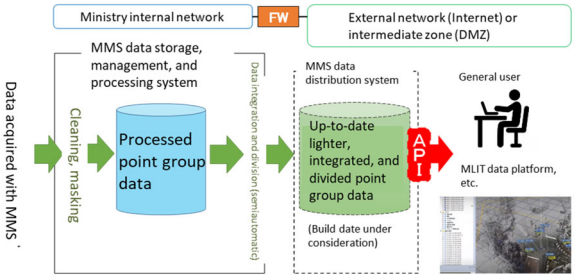


Fig. 5. Image of MMS data linkage

Furthermore, under the guidance of the Road Bureau, we are moving forward with 3D point group data and image data acquisition through MMS for roads directly managed by the national government, and these data are stored in the MMS data storage, management, and processing system developed by our division (fig. 5). As the MMS data itself has a large file size and cannot be transmitted easily over a network, we are considering making the data lighter and distributing it through API linkages.

5. Conclusion

Our division is also making improvements to systems through API linkages with the aim of advanced usage of the various data. We hope to work on xROAD through the above initiatives to promote greater work efficiency and the use of new technologies in the maintenance and management fields, for example.

☞See here for detailed information

1) Research Institute for Road and Street, "What Is the National Road Facility Inspection Database?"
http://rirs.or.jp/tenken-db/

Preventive Measures for and Utilization of Parks Based on Preventive Measures Against COVID-19

(Research period: FY2021-FY2022)

Landscape and Ecology Division, Research Center for Infrastructure Management

Senior Researcher YAMAGISHI Yutaka Head MATSUMOTO Hiroshi

(Keywords) COVID-19, city parks, questionnaire surveys, infection preventive measures, utilization

1. Introduction

While COVID-19 is not yet settled, parks and other public spaces require measures to prevent its spread, as well as utilization corresponding to the new normal.

"The Use of Parks Corresponding to the New Normal," published by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) on August 7, 2020, summarizes basic points regarding park use, while taking into account secondary health damage from the COVID pandemic due to long-term restrictions on activities and lack of exercise because of measures against the infectious disease. It further notes the need to make determinations on specific use according to the situation in each location and to check cautions and other information from park administrators, and points to the possibility of successive reviews as knowledge accumulates and the infection situation changes in the future.

Amid these circumstances, the National Institute for Land and Infrastructure Management (NILIM) seeks to record infection preventive measures from a long-term perspective and to organize technical notes for park administrators that summarize key points and matters to note based on infection preventive measures regarding the planning, design, management, and operation of city parks and their utilization corresponding to the new normal, with the aim of contributing to effectively promoting projects in the future.

Below, we present the contents of research we have conducted from FY2021 to FY2022.

2. Questionnaire surveys on responses in city parks

In order to gain information on the realities of responding according to the conditions of the spread of infection in January and February 2022 (under a state-of-emergency declaration, during priority measures to prevent the spread of the disease, when these are lifted, etc.),

Table 1. Period covered by questionnaire surveys

Period	Period A	Period B	Period C
Dates	Period of 1st state-of-emergency declaration •Nationwide (Apr. 16–May 14, 2020) •Saitama, Chiba, Tokyo, Kanagawa (Apr. 7–May 25, 2020)	Infection expansion period (Jun.–Oct. 2021)	Response date (Jan. 2022)
State of infection and measures	Period when the first state-of-emergency declaration was issued across the nation with the first wave and infection preventive measures were implemented amid a dearth of knowledge about measures against infectious disease.	Period when infection preventive measures were implemented based on the experiences from the first state-of-emergency declaration, amid the spread of infection and the issuance of state-of-emergency declarations and priority measures to prevent the spread of the disease in various regions. On August 7, 2021, the Parks, Green Spaces and Landscape Division, MLIT published key points for park use, etc., based on the "new normal"	As of January 2022, when infections decreased with the progress of vaccinations, long-term state-of-emergency declarations and priority measures to prevent the spread of the disease were lifted, and infections temporarily abated, but concerns of expanding infections arose because of the prevalence of the Omicron variant (response date: January 2022)

Table 2. Implementation of measures relating to prevention of infectious disease (by period and by park type (all periods); multiple answers allowed)

Implemented measures	Period A		Period B		Period C		Paid-entry parks (any type)		Parks in cities・Large-sized parks n=87		Parks in residential districts n=72		Green buffer spaces, etc. (excluding Special parks) n=74		Special parks n=69	
(1) Fully closed	27	64%	17	40%	3	7%	27	64%	18	21%	4	6%	2	3%	7	10%
(2) Partially closed	26	62%	20	48%	8	19%	27	64%	68	78%	37	51%	26	35%	29	42%
(3) Call for caution	32	76%	38	90%	38	90%	42	100%	87	100%	66	92%	52	70%	57	83%
(4) Open with restricted use ((5)–(8))	14	33%	22	52%	11	26%	29	69%	56	64%	33	46%	20	27%	20	29%
(5) Restricted numbers	10	24%	19	45%	12	29%	21	50%	37	43%	13	18%	10	14%	11	16%
(6) Restricted times	5	12%	13	31%	5	12%	14	33%	36	41%	17	24%	8	11%	10	14%
(7) Limits on usage methods	6	14%	7	17%	7	17%	13	31%	24	28%	15	21%	10	14%	8	12%
(8) Other	7	17%	6	14%	5	12%	12	29%	31	36%	19	26%	11	15%	14	20%

we conducted questionnaire surveys to departments in charge of parks in local government (47 prefectures, 20 ordinance-designated cities, 62 core cities) using an Excel response sheet and attained a recovery rate of 74% (96 local governments). In creating the questionnaire, we set survey periods as shown in table 1 to investigate changes over time.

Excerpts from the survey results are shown below. In the questions in (1) and (2), “implemented” means that measures were used in at least one of all the parks managed by that local government.

(1) Implementation of measures relating to prevention of infectious disease (by period)

The proportion of both full and partial closures decreases as we move from period A to period C, and we inferred the reason as follows. Because period B contained the point approximately one year from the origin of the infectious disease, local governments opened parks with restrictions on use, and they shifted towards merely calling for caution in period C. The reason that calling for caution increased from period A to period B but remained steady in periods B and C is inferred to be that the contents of the calls for caution were mostly fixed. (table 2)

(2) Implementation of measures relating to prevention of infectious disease (by park type)

The majority of parks that were closed were paid-entry parks, which are thought to allow closure by locking entry gates, etc., at 64%, followed by parks in cities and large-sized parks at 21%.

For partial closures, parks in cities and large-sized parks accounted for the majority at 78%. (table 2)

3. Preventive measures against infection in city parks and future utilization of city parks

From the results of the above-mentioned questionnaire survey conducted in FY2021 and other sources, we extracted specific cases of preventive measures against infection in city parks during the COVID pandemic and future utilization of city parks and conducted interview surveys. Cases excerpted from the results of these surveys are presented below.

(1) Specific cases of the preventive measures against infection in city parks

To respond to cherry blossom-viewing, an event characteristic of city parks, preventive measures were put in place from the beginning because many people gather and the event is accompanied by eating, drinking and parties.

Photo 1 shows the case of Ueno Park in Tokyo. When the flowers were in bloom in 2020 to 2022, planted areas were closed off to restrict parties. In addition, Sakura-dōri was closed during the 2020 flowering season and was opened during the 2021 season, but it was limited to one-way traffic, the measure was also implemented in the 2022 season.

(2) Specific case of the future utilization of city parks

Forms of future utilization responding to the new normal that were seen in city parks include use of parks as a venue for remote work, introduction of cashless transactions to avoid the Three C's and increase park user convenience (photo 2), online transmission of event programs and park information, utilization of grassed plazas for day camps, etc., drive-in theaters and other public viewing events using parking lots, etc., holding indoor programs, etc. outdoors, and adding or expanding dining offerings located outdoors (food trucks, takeout, etc.).

Photo 2. Cashless transaction for entry fees (Showa Kinen Park)

4. Conclusion

From the results of this research, we intend to organize technical notes for park administrators that summarize key points and matters to note regarding the planning, design, management, and operation of city parks and their future utilization, with the aim of contributing to effectively promoting projects in the future.

☞See here for detailed information

1) Tech. Note of NILIM, No.1230, pp.27-32
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1230.htm

2020-2022: Planted areas closed to restrict parties

2020: Sakura-dōri closed

2021-2022: Sakura-dōri limited to one-way traffic

Photo 1. Trends in preventive measures during cherry blossom-viewing (photo provided by Tokyo Metropolitan Government)

Development of an AI-Based Tool to Enhance Dam Safety Management Decision-Making

(Research period: FY 2020–2022)

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Keywords: Dam, safety management, manager support, AI, LSTM

1. Introduction

The basic and essential method to ensure safety in dam maintenance and management for detecting abnormalities includes monitoring a range of measurement data, such as water leakage, deformation (displacement), and pumping pressure, along with visual inspections. During Japan's rapid economic growth period from the mid-1950s to the early 1970s, numerous dams were constructed. Many of these dams have been in operation for a long period and are now showing signs of aging. Consequently, there is growing concern about the shortage of experienced safety staff responsible for monitoring dam conditions through patrols and measurements to detect any abnormalities in the dams. Given this situation, it is crucial to develop methods that allow for accurate assessment of dam abnormalities, even when individuals with limited experience in dam management are appointed as dam managers.

Hence, the Large-Scale Hydraulic Structure Division conducted a study on artificial intelligence (AI) technology designed to assist dam managers in making accurate decisions regarding the presence of abnormalities. We then developed a tool named the Dam Safety Decision Support Tool, hereinafter referred to as the Decision Support Tool.

2. Purpose of the Decision Support Tool

As illustrated in Figure 1, AI technology is employed in the various aspects of dam maintenance and management. This includes the assessment of operational elements, such as rainfall forecasting, inflow prediction, and operational support. It is also utilized to evaluate dam robustness,

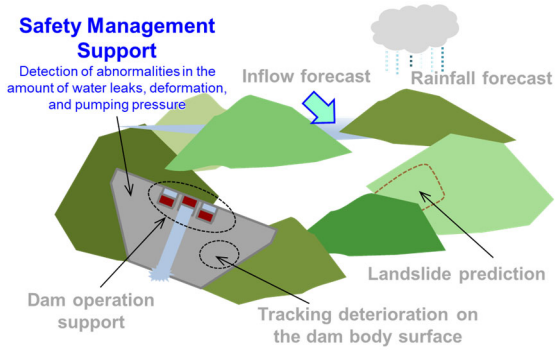

Figure 1. Example of AI use in dam maintenance and management

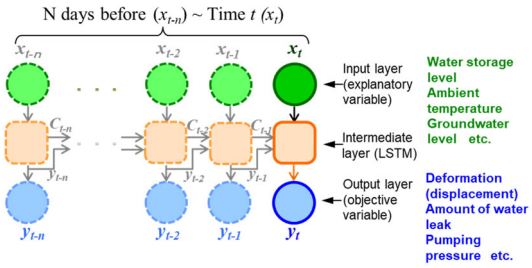

Figure 2. Outline of the LSTM model

covering aspects, such as landslide forecasting and the detection of deterioration in the dam wall surface. The Decision Support Tool is designed to assist dam managers in ensuring the safety of dam embankments. By providing information on measurements like the amount of water leakage, deformation (displacement), and pumping pressure, the tool enables dam managers to assess any abnormalities.

3. AI technologies used in Decision Support Tool

It is known that the deformation (displacement) of a concrete dam's embankment is influenced by water storage levels and temperature, and these factors undergo repeated

cyclic changes. Likewise, the amount of leakage and pumping pressures fluctuate repeatedly because of various factors, including ambient temperature, groundwater levels in the surrounding mountains, and the water storage level. Based on these factors, the system needs to identify abnormalities by comparing forecasted values, which consider factors like water storage level and ambient temperature, with actual measurements. To achieve this, we utilized Long Short-Term Memory (LSTM, shown in Figure 2), a deep-learning algorithm suitable for time-series data regression problems. LSTM takes past time-series data into account as long-term memory to produce forecasts.

The following is an example of a trial calculation for the deformation (both upstream and downstream components) of a gravity-type concrete dam embankment (with a height of approximately 120 meters) learned using LSTM. In the model depicted in Figure 2, time-series data, including water storage level and temperature (both ambient and embankment temperature), were input as explanatory variables in the input layer, while the output layer is the embankment deformation (displacement). Figure 3 illustrates a comparison between the forecasted (estimated) embankment displacement generated through the learning and the actual measurements. The figure also displays the outcomes of multiple regression analysis, a traditional method. It is evident that the forecast produced by LSTM closely matches the actual measured values.

Since LSTM can generate highly accurate forecasts, we believe that dam managers can employ the system for early abnormality detection by establishing appropriate thresholds for deviations from actual measurements.

4. Decision Support Tool

We designed the Decision Support Tool to allow officials from the dam management office to input and output data, as well as set parameters, effortlessly using Microsoft Excel, a spreadsheet software. The Decision Support Tool analyzes time-series data, including the

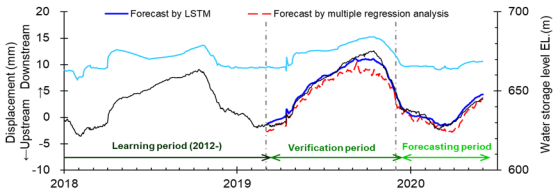

Figure 3. Example of trial calculation (forecast of embankment deformation (displacement))

Table: Applications of the Decision Support Tool

Scenes in which Decision Support Tool can be used	Purpose
Checking past behavior	Assess the likelihood of abnormalities by analyzing trend changes
Confirmation of the day's behavior	Detect abnormality by comparing deviations from past trends
Prediction of future behavior	The system predicts cases when dam conditions remain stable despite anomalies by analyzing historical trends. This prediction serves as a safety management indicator.

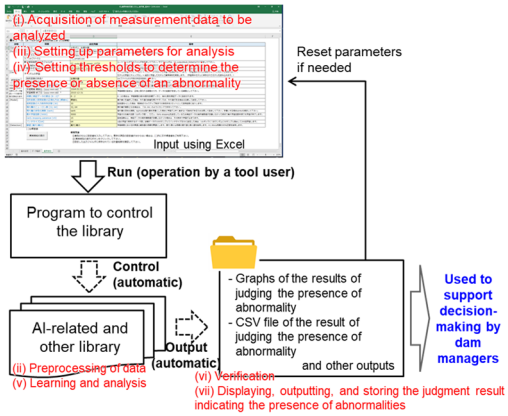

Figure 4. Functions of Decision Support Tool

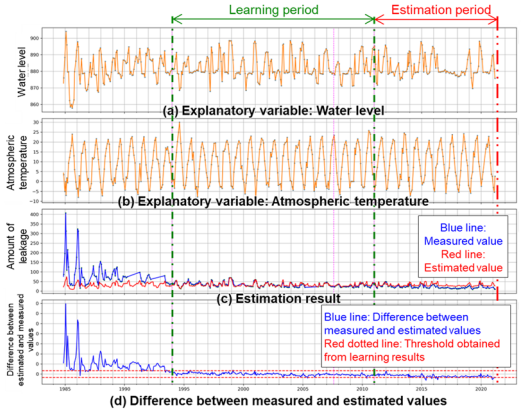

Figure 5 Output example (confirmation of past behavior (amount of leakage))

amount of leakage, deformation (displacement), and pumping pressure. It identifies a condition as "abnormal" when its forecast, derived from the learning of past data, deviates from actual measurements.

(1) Scenes in which the tool can be used

The Decision Support Tool is designed for the following situations: checking past behavior, checking behavior of the day, and predicting future behavior as outlined in the table.

(2) Function

Figure 4 outlines the functions of the Decision Support Tool. The Decision Support Tool first generates time-series data for the analysis subject in a CSV file format. It then automatically executes processing steps (i) to (vii) outlined in Figure 4 within its system.

(3) Output example

As an example of the Decision Support Tool's output, we present the results obtained from examining the past behavior of water leakage in the embankment of a gravity concrete dam (with an approximate embankment height of 110 meters). The total leakage served as the objective variable, while the explanatory variables included water storage level and temperature. Figure 5 displays the output results, which is the diagrams generated in step (vii) of Figure 4.

Figure 5 (d) illustrates the threshold used by dam managers as an indicator for their decisions. The dam manager can use this threshold to assess any abnormalities.

5. Conclusion

We utilized LSTM, an AI technology, to create the Decision Support Tool designed specifically for dam managers' use. In the future, we intend to continue trial implementation of the Decision Support Tool with dam managers. Based on the trial findings, we will enhance the tool and create operational manuals.

An Analysis of the Results of Regular Road Tunnel Inspections

(Research period: FY2021-)

Foundation, Tunnel and Substructures Division, Road Structures Department

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Head NISHIDA Hideaki

(Keywords) tunnel, regular inspection, deformation trend

1. Introduction

In order to respond to issues with road structures, such as aging, statutory inspections have been carried out once every five years since FY2014 on tunnels and other road structures with the aim of preventative maintenance.

This paper presents the state of occurrence of deformation and trends therein as obtained from the results of the first (five years) and second (three years from FY2019 to FY2021) rounds of regular inspections of nationally administered road tunnels.

2. Summary of results of first round of regular inspections

Of the 1,553 national administered road tunnels that were inspected in the first round (FY2014-2018), the diagnostic results of the health of 1,421 tunnels constructed by mountain construction methods (sheet piling, mountain tunnel method) found approximately 3% in assessment class I (healthy), approximately 63% in class II (preventative maintenance stage), approximately 34% in class III (early measures stage), and approximately 0.2% in class IV (urgent measures stage), with the majority of tunnels requiring some sort of measures. Reorganizing this by span (where one span is approx. 10 m), the proportion in class I (healthy) is approximately 46% and the proportion in classes III and IV is approximately 5% (fig. 1). This difference is due to diagnoses of tunnel health being represented by the class of the least healthy span.

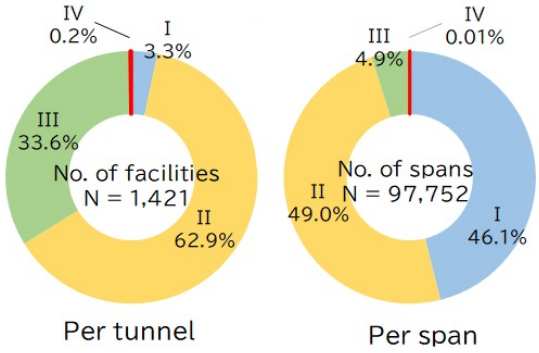

Fig. 1. Proportions of health assessment classes

Looking at the 1,421 facilities by deformation class, approximately 30% of deformations due to material deterioration fall into class III or IV, which tends to be greater than deformations due to external forces or leaking water (fig. 2).

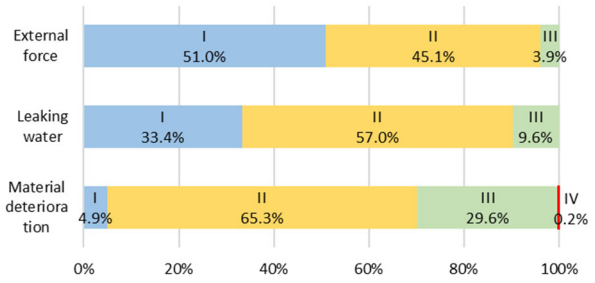

Fig. 2. Proportions of deformation classes

In addition, figure 3 shows the proportions organized by deformation class for the 503 tunnels that were diagnosed with class III or IV health, among the 1,421 facilities. The proportion where external forces were a factor is comparatively small at approximately 11%, while the proportion where material deterioration alone or both material deformation and leaking water were a factor is larger at approximately 78%.

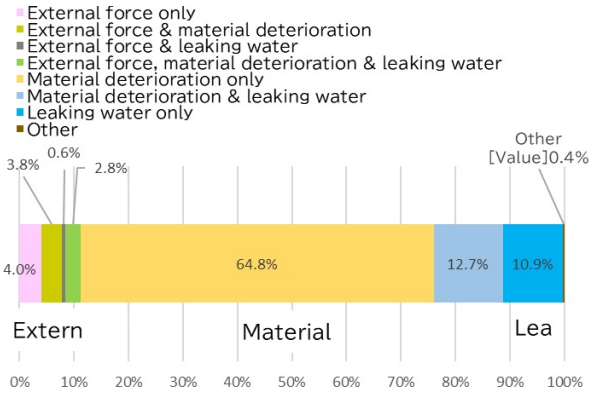

Fig. 3. Breakdown by deformation class in tunnels with class III or IV health

Among the deformation classes, looking at the locations of lining deformation that were assessed as measure class III or IV with “material deterioration” (5,460 locations) by the type of deformation, “bubbling and peeling,” which is a factor in flaking that leads to user harm, accounts for the majority at 92%, and bubbling and peeling that was not completely removed by beating at inspection is a major issue in the preservation of tunnels.

An analysis of the positions where this bubbling and peeling occurs has revealed that most occurs in two locations: joint sections and their surrounds (65%) and locations where deformation has occurred or repairs have been made in the past and their surrounds (34%). Based on these analysis results, the inspections from the second round basically used a proximal visual inspection of the entire lining surface, while performing hammering tests of joint sections and repair locations was reflected in the revision of the regular inspection guidelines (2019), leading to more streamlined and efficient inspections (fig. 4).

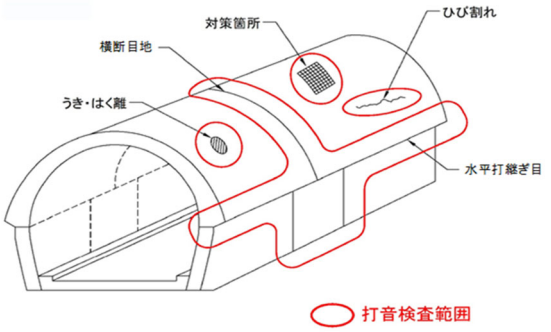

Fig. 4. Image of hammering test scope from second round

3. Comparison of results of first and second rounds of regular inspections

Comparing changes in the number of bubbling and peeling locations due to material deterioration in the 927 tunnels that underwent a regular inspection in the second round (FY2019-2021) and also had data from the first round of inspections did not show a major change in the number of locations of deformation by measure class between the first and second rounds (fig. 3).

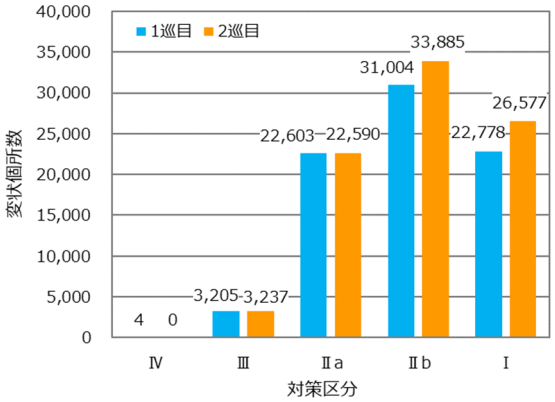

Fig. 5. Changes in the number of bubbling and peeling deformation locations

Figure 6 shows the measure classes for deformations by material deterioration in the second round of inspections (the degree of progress from the first round of inspections). Looking at the number of deformations where repairs or measures were performed after the previous inspection, there were very few deformations in measure class III and most were in measure class I.

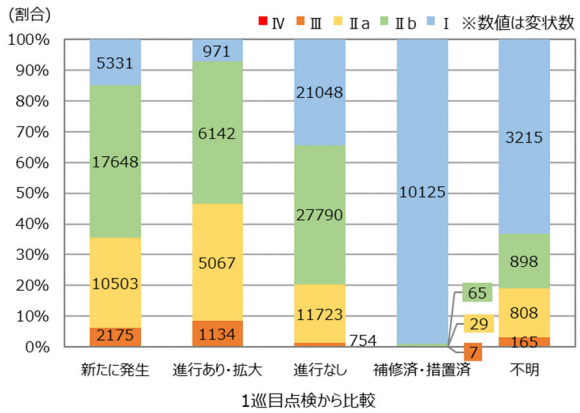

Fig. 6. Proportion of measure classes in second round of inspections (material deterioration)

This shows that the repairs or measures were performed appropriately. Conversely, with regard to deformations by material deterioration that had "newly arisen" or "progressed or expanded" since the previous inspection, the proportion of deformations in measures class IIa or III tended to be higher.

4. Conclusion

Based on the results of regular tunnel inspections to date, we prepared a casebook[2] with brief commentary using photographs and explanations for cases of deformation in repair and reinforcing materials, in addition to deformations in lining concrete like cracking, bubbling and peeling, and published it in 2022.

We intend to continue comparing the results of the first and second rounds of regular inspections, organizing the data from the time of construction, and conduct analyses to find trends in structural conditions, environmental conditions, deformations by part, and the like, which we will connect to proposals for greater streamlining and efficient in inspections, including considering applying new technologies, such as making use of inspection assistance technologies.

☞See here for detailed information

1) Tech. Note of NILIM, No. 1175, "Data Collection of Regular Inspection Results for Road Tunnels (FY2014-2018)"
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1175.htm
2) Tech. Note of NILIM, No. 1206, "Reference to Inspection Manual for Road Tunnels (2021): Casebook of Damage of Road Tunnels"
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1206.htm

Analysis of Utilization Trends of International Transport Infrastructure such as Canals, Ports and Harbors against the Background of the Impact of Social and Economic Environmental Changes and Geopolitical Risks to International Logistics

(Study period: FY2016–)

International Coordination Division, Administrative Coordination Department

Researcher TERANISHI Hiroyuki Former Director SANO Toru

(Keywords) *New Panama Canal, Suez Canal, route selection, potential demand, food and energy security*

1. Introduction

Trade and transport trends in each country are rapidly changing due to changes in industrial trends in each country, economic partnerships in each country associated with the development of free trade, economic friction, and emerging geopolitical risks.

In light of these changes in the environment surrounding international logistics, we will comprehensively analyze ship movement data and various statistics such as trade, and analyze the utilization trends of canals and important ports and harbors, which are bottlenecks in international transportation.

In this material, we present research that analyzed the impact of the opening of the Panama Canal (New Panama Canal), which was expanded in 2016, and utilization trends of the canal during the ongoing U.S. shale revolution.

2. Shale Revolution and American Energy Exports

The shale revolution has made the United States one of the world's largest energy producers. In addition to being the world's largest exporter of liquefied petroleum gas (LPG), the production and exports of unconventional shale-derived liquefied natural gas (LNG) have increased, which in turn increased the exports of surplus coal in the U.S.

Exports of energy resources and other resources to Japan from the coast of the Gulf of Mexico and the East Coast of the United States, and Colombia where large coal ports are established along the Caribbean coast, etc. are handicapped due to the ocean transport cost over longer distances than other regions. Passage through the Panama Canal makes it possible to shorten transportation distances.

3. Opening of the New Panama Canal

Traditionally, the largest vessel that can pass through the Panama Canal is called a Panamax (ship length: 294.1 m, draft: 12 m, ship width: 32.3 m), and this has been a standard for vessel size. However, with the increase in the size of ships, it became a bottleneck on the route network. In addition to the existing lock gates (former Panama Canal), the canal expansion project provided a third access channel and lock gates and in June 2016, the new Panama Canal, which allows transit of Neopanamax ships (ship length: 366 m, draft: 15.2 m, ship width: 49 m, 51.2 m since June 2018) and new LNG carriers, was opened.

In about two years from its opening to 2018, the cumulated total number of transits in the New Panama Canal reached 4,000, of which about half were container vessels, 30% LPG vessels, 10% LNG vessels, and the rest dry bulk carriers. This time, against the backdrop of the shale revolution, the analysis focused on LPG and LNG carriers whose exports from the United States have increased, and dry bulk carriers that transport resources such as coal and food (grain).

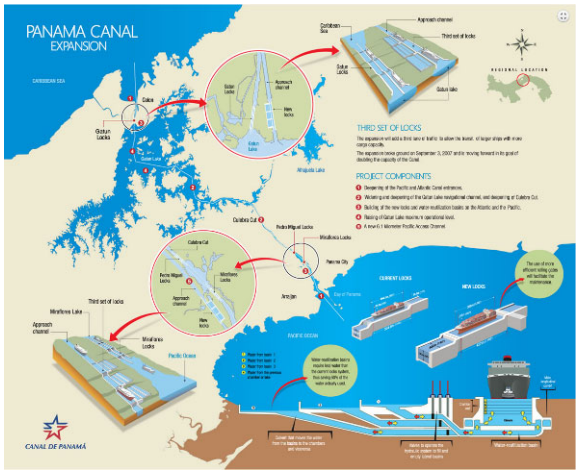

Figure 1: Overview of Panama Canal Expansion Project

4. Ships Using the New Panama Canal

For each type of ship, it was suggested that the opening of the New Panama Canal contributed to improved efficiency in transporting energy resources from the United States and Colombia, where the shale revolution has progressed, to Northeast Asia including Japan. The drawings are based on the results of analysis of vessel movement data for 2018.

- LPG vessels (Neopanamax class)

Figure 2: Utilization trends of LPG vessels in the New Panama Canal

- LNG vessels

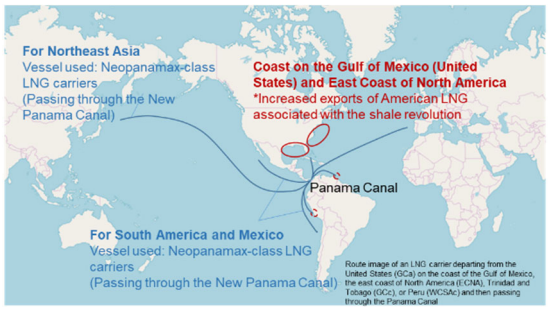

Figure 3: Utilization trends of LNG vessels in the New Panama Canal

- Dry bulk vessels (Neopanamax Class)

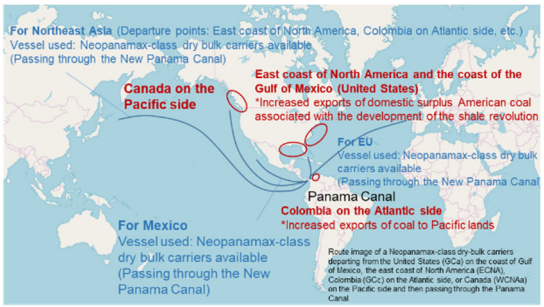

Figure 4: Utilization trends of dry bulk carriers in the New Panama Canal

5. Potential Demand for the Panama Canal and the Suez Canal

Panamax-plus and Neopanamax dry-bulk vessels, which find it difficult to pass through the Panama Canal from the Atlantic side of the United States and Canada to the Northeast Asia area from the viewpoint of draft and loading efficiency, have chosen the Suez Canal route as well as the Panama Canal route whose navigation distance is shorter, even after the opening of the New Panama Canal (2018). This suggests a competitive relationship between the Panama Canal and the Suez Canal and a potential demand for transit through the New Panama Canal. The Panamax-plus is a vessel that can pass through the former Panama Canal if the load is sufficiently reduced, and it is probable that the transit through the new Panama Canal was limited, and the load was sufficiently reduced to pass through the former Panama Canal.

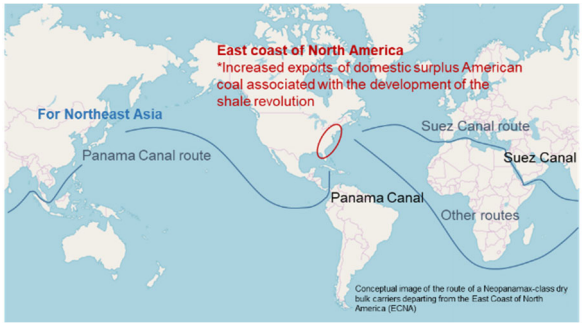

Figure 5: Conceptual image of route selection of dry bulk vessels

Figure 6: Departure points of dry bulk vessels (Neopanamax class) heading for Northeast Asia

6. Conclusion

This analysis shows the relationship with Japan and other countries in international logistics such as the Panama and Suez canals, the impact on Northeast Asia and other countries, and the potential demand for canals. The findings can be used to help design strategies for the development of import environments that contribute to the diversification of Japan's procurement of resources, energy, food, etc., and to examine the role of the Panama and Suez canals, etc. in trade from a geopolitical perspective.

Against the backdrop of the growing tension in Ukraine such as the destabilization of global food production due to climate changes and the intensification of procurement competition resulting from the expansion of global food demand, further assuring the safe supply of energy and food has become an urgent and paramount issue for the nation. In light of social and economic environmental changes and geopolitical risks, we will continue to analyze trends in the use and transportation of overseas ports, harbors and canals.

✓ Click here for more information.

1) NILIM material No. 1180
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1180.htm

Research to Promote DX in the Infrastructure Field

(Research period: FY2021-)

Digital Transformation of Infrastructure Systems Research Committee

Construction management research officer OGAWA Tomohiro

Head, Advanced Construction Technology Division YAMASHITA Hisashi

(Keywords) digital transformation (DX), ICT construction, BIM/CIM, improvement of productivity

1. Introduction

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

2. Development of the DX Data Center

DX Data Center stores BIM/CIM models, point group data, and other 3D data for searching, displaying, and providing. From January 2023, it is available not only to MLIT employees, but also over the Internet for private-sector companies that have been awarded contracts for MLIT operations and works (fig. 1).

This will enable us to promote the use of the BIM/CIM models created at the stages of surveying, investigation, design, and construction in other works and operations, as well as in maintenance.

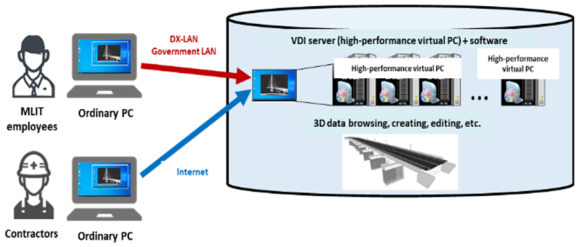

Fig. 1. Outline of DX Data Center system

3. Development of Construction DX experimental field

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

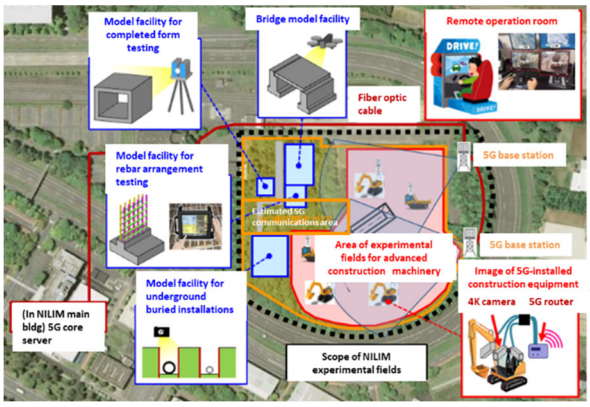

Fig. 2. Outline of Construction DX experimental field

4. Conclusion

MLIT has declared 2023 to be a "year to leap ahead," when it will further accelerate innovations through DX, and in addition to conducting research and development with a view to improving productivity, 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.

International Research Activities

1. International research activities at the NILIM

In accordance with the relevant policies of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), the NILIM is enhancing collaboration with foreign government agencies and research institutions funded by governments. Meanwhile, the NILIM is promoting international research activities based on the following three key perspectives.

(1) Supporting policy formulation in Japan with technical expertise:

We will establish networks with foreign government agencies by leveraging the bilateral agreements initiated by the NILIM and agreements concluded by the MLIT. Through this network, we will gather information on advanced initiatives and disaster damage scenarios. We will then use this collected data and knowledge to enhance domestic policy recommendations and technical standards.

(2) Technical support for developing nations:

We have gathered valuable knowledge from hands-on experience in maintaining public facilities and responding to disasters in Japan, often from the perspective of facility managers. Additionally, we have research findings on advanced disaster preparedness measures that incorporate these insights. Leveraging this expertise, we aid developing nations and their local governments in addressing complex technical challenges, establishing technical standards, and enhancing the abilities and skills of technical government officials.

(3) Sharing infrastructure systems internationally:

We use our expertise in developing technical standards that aid policy implementation in Japan to customize Japanese technical standards according to the specific requirements and conditions of partner countries. At the same time, we offer technical support to facilitate the international sharing of infrastructure systems knowledge. We do this by actively engaging in committees that establish international standards. In certain areas, we take a leading role in globalizing technical standards, ensuring alignment between domestic and international standards for consistency.

2. International Research Activities in FY 2022

In FY 2022, border restrictions were slowly eased despite ongoing COVID-19 infections. This relaxation resulted in a rise in international travel, allowing the world to slowly return to a state of the pre-COVID era. During this period, some international conferences and meetings were either delayed or held online. However, a few of them proceeded in the traditional face-to-face format, involving participants traveling internationally to attend.

The following section outlines the key international research initiatives we implemented in FY 2022 under the ongoing influence of the COVID-19 pandemic.

2.1 LandAware: Activities in the international network on landslide early warning systems

At LandAware, the international network for landslide early warning systems established in 2020, we consistently work on standardizing technical standards from different countries regarding landslide early warning systems, which are increasingly adopted globally. We also exchange best practices and collaborate on producing summary papers. Our Sabo Department, as a founding member of the network, is actively reviewing landslide early warning systems worldwide and drafting glossaries and catalogs related to these systems. In October 2022, a workshop was held in Zurich, Switzerland, to develop a prototype for the

next-generation landslide early warning system. Participants engaged in discussions about the operational methods of warning systems and the necessary review steps. This was accomplished by sharing examples of conducting comparative assessments of warning systems currently in operation in the various countries based on their specifications. Additionally, we shared our accumulated experiences, information, and insights related to models and data.

2.2 Participation in the 26th FHWA/MLIT Intergovernmental Meeting

A meeting took place between the United States and Japan to discuss the maintenance and management of road bridges and earthquake-resistant technologies. This meeting was held in accordance with the Japan-US Memorandum of Cooperation on Japan-US Traffic Infrastructure Development, which was signed by the US Department of Transportation and the MLIT of Japan. We acquired information on the latest trends and policies in road bridge management by sharing information on road bridge management trends in Japan and engaging in discussions and exchanging opinions with the US Federal Highway Administration. We anticipate using these insights to streamline and refine future road bridge management efforts, improve management technologies, and reduce the workload associated with maintenance and management tasks.

2.3 Holding joint seminars with Vietnam-Japan University

On November 25, the NILIM held an online joint seminar with Vietnam-Japan University, Vietnam National University, Hanoi (referred to as "Vietnam Japan University"). The Vietnam-Japan University was established with support from the Japanese government. The NILIM collaborated in organizing the seminar to foster relationships between the university and Japanese companies. During the seminar, both the NILIM and Vietnam-Japan University presented their respective road technologies and policies. The NILIM also presented information on road structure maintenance and management in Japan and methods for preventing and mitigating landslide disasters. Nearly over 100 participants, including those from outside Japan and Vietnam, took part in the joint seminar. Their active participation in the Q&A sessions contributed to the success of the event.

Figure 1. The joint seminar with Vietnam-Japan University

2.4 Interactive Meeting on Urban Research with Korea Research Institute for Human Settlements

In November 2012, the NILIM and the Korea Research Institute for Human Settlements signed a memorandum of cooperation for urban research. Since then, we have conducted collaborative research meetings and field trips together. In fiscal year 2023, a joint workshop took place in Japan, marking the first such event in five years. During this period, various meetings and field trips were conducted. During the joint research meeting, both institutions presented their research findings on smart cities. They also discussed strategic plans for the next five years and agreed to collaborate on a joint research project focused on digital transformation (DX) in urban areas during the first half of this period.

Figure 2. The seventh joint research meeting with Korea Research Institute for Human Settlements (December 1, 2022)

2.5 Our roles in PIANC WG213

The NILIM has been engaged in WG213, a group within the World Association for Waterborne Transport Infrastructure

(PIANC), focusing on creating guidelines for planning multipurpose terminals. As part of our involvement, we have developed draft reports on this topic. Our Port and Harbor Department has represented Japan as a member of the working group (WG). Specifically, we were responsible for drafting a chapter that explores the usage of multipurpose terminals other than cargo transportation and submitted scripts. In this chapter, we discussed our ideas on the use of multipurpose terminals for emergency transportation during natural disasters and information on procedures for accommodating cruise ships.

2.6 Activities related to ISO

Our Water Quality Control Department, serving as an expert committee member of WG16 (adaptation to climate change) within ISO TC224 (water supply and sewage service), participated in the meeting online. During the session, international standards related to water supply and sewage services, specifically addressing climate change challenges, were developed and discussed. Our Building Department contributed to the online working group of ISO TC92 (fire safety) SC2 (containment of fire). During the session, they gathered feedback on expanding the application of fire resistance test results as part of their role in drafting standards.

2.7 Cooperation with JICA projects and training

In response to JICA's request, the NILIM has been hosting trainees from overseas. These trainees attend lectures at our research facility and tour our experimental facilities every year. Additionally, we have started providing online training sessions in recent years. This year, we conducted the following training programs along with three others.

(1) Dam Safety Management (River Department) [Video lecture: 2 trainees]
(2) Training for Enhancing Public Construction Project Estimating Skills (Research Center for Infrastructure Management) [Face-to-face lecture: 11 trainees]