The Roles of NILIM and Perspectives for the Future

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1. Introduction: Roles and Stance of NILIM

The National Institute for Land and Infrastructure Management (NILIM) conducts research and development based on the philosophy that "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." This is the first item in NILIM's "Research Policy," and it is our basic role and "Mission."

The objects of research and development by NILIM include a diverse range of fields related to social infrastructure and housing. Our organization, as a system, consists of 10 research departments and 2 research centers, as well as 3 administrative departments. Our staff includes approximately 250 researchers and 100 administrative personnel who are involved in practical support business. The necessary themes that we are grappling with on a priority basis are Disaster Prevention and Mitigation, Maintenance, Green Society Realization and Digital Transformation (DX) of Infrastructure. We have set up committees to promote research in each of these 4 fields, and are conducting activities with the cooperation of related research departments and research divisions.

NILIM is currently studying about 300 research subjects. Based on some of those results, we provide technical support for the policies of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and, in turn, the government, for example, reflecting our research outcomes in technical standards. In activities other than research, to support recovery efforts when a disaster occurs, we dispatch experts with advanced technical capabilities at the request of the disaster-stricken area after the disaster, and provide recommendations on recovery and reconstruction and other assistance.

In 2023, a revision of the Basic Act for National Resilience and the establishment of a Fundamental Plan for National Resilience were decided. Although NILIM has also carried out research and activities contributing to national resilience until now, we have taken a hard look at the effects caused by the recent 2024 Noto Peninsula Earthquake, and intend to further strengthen this particular role of NILIM.

2. Perspectives for Fulfilling NILIM's Roles

Next, the perspectives that I think are important for fulfilling the roles of NILIM are as follows.

(1) Continuing efforts

- Digital transformation of infrastructure: Example of "digital twins" –

For national resilience and disaster prevention and mitigation, research on maintenance and upkeep of specific facilities, structures, etc. continues to be important. At the same time, I think it is necessary to carefully consider methods of use based on social conditions including the future, also including existing facilities. As we advance toward the realization of digital twins through the creation of the MLIT Data Platform, Plateau and other initiatives, it is necessary to analyze data in connection with facility use and make predictions based on the results. In digital twins, data analysis is performed in a digital world, and predictions are made with simulation technologies (analytical techniques).

Although this was some time ago, at an international conference in the dam field, I made a presentation on 3-dimensional nonlinear analysis techniques and examples of Japanese dams. However, at the time, there was little response from the world's experts. This suggests that, while the advanced level of analytical techniques as such is recognized, it is difficult to gather all input data suitable to support their accuracy. Information on the external shapes of structures, ground and the like has been converted to data with high accuracy by the latest surveying technologies, but, for example, the accuracy and resolution of information on the physical properties of the foundation ground is

comparatively low at present. Thus, depending on the object of analysis, high uncertainty is still unavoidable in some simulations.

Therefore, in light of the increasing "new" role of improving the foundation of data that can contribute to digital twins, a renewed recognition of the importance of the roles that "we have carried out until now" is needed. Those roles include studying advanced analytical techniques, that is, collecting and organizing data, improving their performance and making appropriate selections of analytical techniques, evaluation of analytical results, and careful consideration of how we should proceed in the future.

(2) Understanding the direction and utilization of new technologies

- Digital transformation of infrastructure: Example of satellite technology use –

"BRIDGE" refers to various programs for Bridging the gap between R&d and the IDeal society (Society 5.0) and Generating Economic and social value, which the Cabinet Office launched in April 2023. As part of that initiative, NILIM is implementing a policy called "Social implementation of remote monitoring technology in the social infrastructure/housing fields using satellites." With the rapid progress of satellite observation technology in recent years, the need to use of satellite data, etc. has also increased. Among remote sensing technologies, in particular, SAR satellites (radar satellites), which enable observation at night and in any kind of weather, and technologies employing constellations of small satellites, which support high frequency observation, are expected to be used in various fields.

To return to my own specialty of dams, NILIM began research on techniques for measuring dam displacement by using a SAR satellite in FY 2014. This was shortly after the launch of the ALOS-2 (Daichi No. 2) satellite, but from among the many satellites available in the world, we constructed the dam displacement measurement technique centering on the use of ALOS-2 data. This was because we judged that ALOS-2 was the optimum choice at the time, considering the observation frequency, accuracy and measurability conditions necessary for operation and maintenance (O&M) of dams. However, rapid changes occur in dams and other facilities during an earthquake or other disaster. In order to understand those changes, a different perspective from routine O&M of facilities is needed. This includes, for example, full utilization of multiple satellites that can be used immediately whenever a disaster strikes. Remarkable progress is occurring in the development of satellite technology, and by grasping that progress, we can also ensure progress in the development of our own technologies.

Although this is an example of satellite technology, here, in order to accurately understand information from other fields and reflect it in our research, it is necessary to create and continue the systems necessary for cooperation with external organizations so as to grasp that information.

(3) Integrity of laboratories

- Example of the Green Society Realization Research Promotion Committee –

In 2023, NILIM launched the Green Society Realization Research Promotion Committee in a form that integrates and expands the previous Climate Change Response Research Committee and Environment Research Committee. Although the Climate Change Response Research Committee had led NILIM's internal research on "climate change response," the importance of responding to "climate change mitigation measures" such as carbon neutrality has also increased. Since it is necessary to promote climate change responses from both directions, the new Green Society Committee was organized to broadly include perspectives such as "a society that coexists with nature" and "a recycling (circular) society." The aims of this move were to invigorate research by encouraging closer information sharing in NILIM, and to ensure a response without delay in all fields of research at this institute.

In the future as well, it will be necessary to accurately understand conditions (changes) related to important issues, both inside and outside NILIM, to actively use the systems of the coordinating departments and others, and to stimulate activities by NILIM as a whole.

3. Conclusion

In order to fulfill the roles of NILIM, I believe we need to have a stance of continuing to "reflect" on how to use developed technologies, guidelines and the like in the field, how they will influence the country and society, and their connections with the goals of our "Mission," which I mentioned at the outset. Moreover, in the future, I hope to carry out research in close cooperation with the field, while striving for foresight based on an accurate understanding of both internal and external technical information and social conditions.

What is Expected from NILIM

FUKUDA Yukihiro, Executive Director for Research Affairs

(Keywords) Research evaluation, National resilience, Big-boned policy, Noto Peninsula Earthquake

1. Mission of NILIM

Since the National Institute for Land and Infrastructure Management (NILIM) was established in 2001, it has conducted research activities in accordance with its Research Policy as a common recognition shared by all individual researchers.

As the Mission of NILIM, the revision of NILIM's Research Policy in 2017 states that, "as the only national research organization in the field of housing and social infrastructure, the NILIM aims to realize a safe, secure, dynamic and attractive land and society now and in the future by using technology as the driving force," and describes the "Basic attitude" of NILIM as "participating in the policy development of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) as a technical expert taking into account the administrative perspective," "returning the advanced and comprehensive technical capabilities cultivated through research activities to the actual field of work" and "leading the insight of the future vision of land and society and the promotion of technological development to the creation of new policies."

2. External Evaluation of NILIM

To evaluate these efforts, evaluations of research and development organizations are conducted every 5 years from the two aspects of implementation and promotion of research and development and organizational operation based on "General Guidelines for Evaluating Government Funded R&D," "MLIT Guidelines for Evaluating R&D," and the like. The evaluation criteria for evaluations of organizations are shown in the **Figure**. In 2023, the condition of activities in the preceding 5-year period (FY 2018-Fy 2022) was summarized, and an evaluation by external experts and others at a meeting of the NILIM Research Evaluation Committee was held in December of 2023 [1].

This committee expressed the opinion that NILIM's activities could be evaluated as "fully appropriate" in terms of both implementation and promotion of research and development and organizational operation, as MLIT had achieved remarkable results through R&D supporting MLIT's policies and response during disasters and support for improvement of technical capabilities in actual fields of work, etc., and had also implemented cross-sectional initiatives and promoted human resource training for young persons and strengthening of experimental facilities, etc.

[I. Implementation and promotion of research and development]
①Research and development supporting planning, drafting and dissemination of MLIT policies
② Technical support for disaster/accident response and development of advanced countermeasure technologies
③Support for improvement of field technology capabilities of MLIT Regional Development Bureaus
④Collection, analysis and management of data that form the technical basis for planning and drafting policies, and return to society

[II. Organization operation]
⑤Construction of management systems supporting high-quality research
⑥ Training, etc. of human resources anticipating policy development from both the research side and the administrative/field side, with technology as a foundation
⑦Possession and strengthening of the functions of experimental facilities, etc., and technology research and development in the fields of housing and social infrastructure
⑧Effective recommendations on research outcomes and research activities

Figure Criteria for organizational evaluation

Particularly in recent years, the needs for disaster response and readiness required from NILIM have become more advanced and diverse, and it is thought that those efforts were highly evaluated. Among the 8 evaluation criteria in the above-mentioned organizational evaluation, NILIM contributed directly to disaster prevention and mitigation, and the institute also supported improvement in ② Technical support for disaster/accident response and development of advanced countermeasure technologies and ③ Support for improvement of field technology capabilities of MLIT Regional Development Bureaus.

Where ② is concerned, one evaluator expressed an opinion to the effect that "NILIM responded using new technologies corresponding to the conditions at the actual site, and utilized and accumulated knowledge without delay. In particular, promotion of activities in the form of local support, and the fact that NILIM has a system that allows national engineers themselves to judge, evaluate and give recommendations on disposal/repair measures for structures damaged by disasters and accidents could be highly evaluated."

Regarding ③, we received an opinion that "The one-stop system for responding to consultation requests from the local community can be highly evaluated. In addition, it can be judged that the PDCA cycle, including improvement of field technical capabilities and improvement of standards, is being practiced with the staffs of Regional Development

Bureaus, etc. so as to enable an initial response in the field, which is critical when a disaster occurs. I hope that NILIM will continue these activities in the future. Furthermore, the point that persons loaned to NILIM and the staff of Regional Development Bureaus, etc. who receive training are analyzing research outcomes could be highly evaluated.

We are happy that NILIM's efforts to date have been highly evaluated, and we believe this will also increase our motivation in the future.

3. Expectations for NILIM

Japan's Basic Act for National Resilience was revised in June of 2023, and the Cabinet Office approved the Fundamental Plan for National Resilience in July of the same year. Together with promotion of research and development on disaster prevention and mitigation, the Plan called for strengthening of research institutes related to national resilience.

In addition, the "Basic Policy for Economic and Fiscal Management and Reform 2023" (Basic Policy, the so-called "big-boned policy"), which was approved by a Cabinet resolution in June 2023, proposed expansion and strengthening of the TEC-Force and other disaster-prevention systems and functions to further strengthen the initiatives of the Fundamental Plan for National Resilience. This "TEC-Force, etc." denotes not only the Regional Development Bureaus, but also "research organizations that conduct field surveys which require advanced technical capabilities during disasters, and also provide support for emergency measures and other activities," and we recognize that this means NILIM and other research institutes. We believe that the fact that the role played by NILIM during disasters is positioned are part of the Fundamental Plan for National Resilience and the above-mentioned "Basic Policy" is deeply significant, as it indicates the high evaluation of our support activities to date, as well as the magnitude of the expectations placed on NILIM.

4. Looking Back on 2023

The trend toward increasingly severe disasters was unchanged in 2023, as could be seen in Typhoon No. 2 in June and the heavy rains caused by activation of the weather front accompanying that storm, torrential rains at the end of the rainy season, and the nationwide damage caused by Typhoon No. 13. After each of these disasters, experts from NILIM were dispatched to the stricken areas.

Among earthquakes, a strong earthquake with its epicenter in southeast Turkey occurred in February. In response, NILIM dispatched experts in the road, urban, and housing fields as members of the Japan Disaster Relief Team and expert teams. In Japan, an earthquake with a seismic intensity of 6 upper (on a scale of 7) occurred in the Noto district of Ishikawa Prefecture occurred in May, and an earthquake with seismic intensity of 5 upper also occurred in the Tokyo Metropolitan area during the same month. In all, 6 earthquakes with seismic intensities of 5 lower or more occurred during May.

Moreover, 2023 was also the 100th anniversary of the Great Kanto Earthquake, which struck the Tokyo area in 1923. Events and news reports in connection with that earthquake in a variety of fields commemorated that disaster. NILIM actively participated in these events, and the FY 2023 NILIM Conference was held on the theme of "Challenges of NILIM for Earthquake Disasters – 100 Years Since the Great Kanto Earthquake –." NILIM also cooperated in the preparation of an NHK special entitled "The Great Kanto Earthquake – Three Days of Ruin in Tokyo –," which was presented by Japan's national television broadcaster, NHK, and experts from NILIM appeared and provided commentary [2].

The Chinese character for "tax" was selected to symbolize the year 2023, but for civil engineers and persons involved in architecture and construction, it was a year of "tremors." Moreover, because the Noto Peninsula Earthquake occurred on January 1, 2024, continuing this series of disaster, 2024 will also be remembered are a year of "tremors" by those concerned. During the 2 months following the Noto Peninsula Earthquake, NILIM dispatched 86 experts to the disaster sites, local countermeasures headquarters, etc. for a total of 447 man-days (as of March 1), and compiled the results of the surveys and analysis. Information on these activities is available on the NILIM website [3].

5. Toward 2024

Support activities for the Noto Peninsula Earthquake subsequently transitioned to the next phase, which includes participation in recovery/reconstruction study committees. Beginning in 2024, waterworks administration will be transferred to MILT, and based on this, a new Water Supply System Division will be established in NILIM. Because unified research activities and disaster response are required, including both waterworks and sewerage, this is considered to be a new expectation for NILIM.

The third round of periodic inspections of highway structures also begins in 2024, and a more advanced management cycle is demanded.

The entire organization will continue to grapple with these issues as one in order to fulfill the roles expected of NILIM.

☞For more information:

1) Research evaluation for FY 2023:
https://www.nilim.go.jp/lab/bcg/hyouka/R5/r5index.htm

2) Efforts of NILIM in connection with the 100th anniversary of the Great Kanto Earthquake:
https://www.nilim.go.jp/lab/bcg/shinsai100/index.html

3) Status of activities by NILIM in the 2024 Noto Peninsula Earthquake:
http://wwwdisaster.nilim.go.jp/saigaitaiou/R601jishin/saigai_R601jishin.html

Expanded Use of Sewage Sludge Resources as Fertilizer as Part of Food Security

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(Keywords) composting, phosphorus recovery, recycling society

1. Introduction

Among the three elements (nitrogen, phosphorus, potassium) which are indispensable for raising agricultural products, Japan depends almost entirely on imports for phosphorus (ammonium phosphate), and production is unevenly distributed to China and certain other countries. In addition, the price of those imports has also fluctuated violently in recent years [1]. Against the background of import price fluctuations, competition to procure supplies has intensified as a result of the global destabilization of food production accompanying climate change, the ongoing crisis in the Russia-Ukraine situation, etc., as well as growing demand for food, and it is also recognized that there are large challenges in the Japanese government's basic policies of strengthening domestic food security and promoting the sustained growth of the agricultural, forestry and fisheries industry.

At the first meeting of the Headquarters on Measures to Secure Stable Supply of Food and Strengthen the Agriculture, Forestry and Fisheries Industries (Prime Minister's Office of Japan) in September 2022, one instruction given by the Prime Minister was to draw up an emergency package to respond to the urgent issue of rapidly rising food prices, to be led by the Minister of Agriculture, Forestry and Fisheries. This is an effort to achieve domestic production and a stable supply of fertilizer by expanding the use of the unused resources of sewage sludge, compost, etc., in cooperation with the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), etc.

2. Current Status and Issues for Use of Sewage Sludge in Fertilizer

Until now, the uses of sewage sludge have included use of the ash remaining after incineration in construction materials, use as energy, either as biogas generated by the digestion process or solid fuels produced by drying or carbonization, and use as a fertilizer or soil conditioner at green farms. Sewage sludge has high contents of phosphorus, nitrogen, and other elements, and the amount of phosphorus contained in sewage sludge in Japan is thought to be approximately 50 000 tons [2]. Although this is seen as a phosphorus source that can be procured domestically, only about 10 % of the sewage sludge generated in Japan is currently being used in fertilizer.

To promote use, it will be necessary to overcome technical issues and issues related to distribution. Use of sewage sludge in fertilizer can be broadly divided into composting to produce fertilizer and phosphorus recovery methods, in which phosphorus is recovered from the sludge treatment process (MAP method for obtaining magnesium ammonium phosphate, HAP method for obtaining calcium hydroxyapatite, etc., referred to hereinafter as "phosphorus recovery.") The composting method accounts for the majority of sewage sludge used in fertilizer. Issues for composting include the risk that compost may be contaminated with heavy metals, a negative image (which includes those contaminants), and the difficulty of securing distribution channels owing to a lack of know-how regarding spreading and fertilizer application methods. On the other hand, the issues for phosphorus recovery include high facility control costs and large variations in the recovered phosphorus content.

Fig.-1 Uses of sewage sludge (clockwise from upper left: a phosphorus recovery facility (Kobe City), fertilizer using recovered phosphorus, sewage sludge compost, and a sewage sludge composting facility (Saga City) [2]

3. Demonstration Research of Fertilizer Use Technologies for Sewage Sludge

Based on the fact that technologies for producing fertilizer from sewage sludge were included in the Supplementary Budget for FY 2022, and were selected as a B-DASH Project (Breakthrough by Dynamic Approach in Sewage High Technology Project) for FY 2023, the

National Institute for Land and Infrastructure Management (NILIM) is conducting demonstrations, evaluations, etc. of technologies as research commissioned by the B-DASH Project, [3] focusing mainly on solving technical problems.

For use of sewage sludge as fertilizer, a joint research group consisting of Kubota Corporation, Mitsubishi UBE Cement Corporation, Chubu Ecotec Co., Ltd., Shimane Prefecture and the Japan Sewage Works Agency is carrying out demonstration research on high-speed fermentation and drying, also blending biomass other than sewage sludge as submaterials, using a vertical closed fermentation technology which has a proven track record in composting up to the present. In this technology, adjustment of the charging rate, control of the air supply rate, etc. are controlled corresponding to the condition in the fermenter, aiming at stable treatment and labor-saving. As features of the technology, since the material is fermented in a closed, heat-insulated vessel, thermal efficiency is high, an external heat source is not necessary for drying, and countermeasures for odor can be implemented easily (**Fig.-2**).

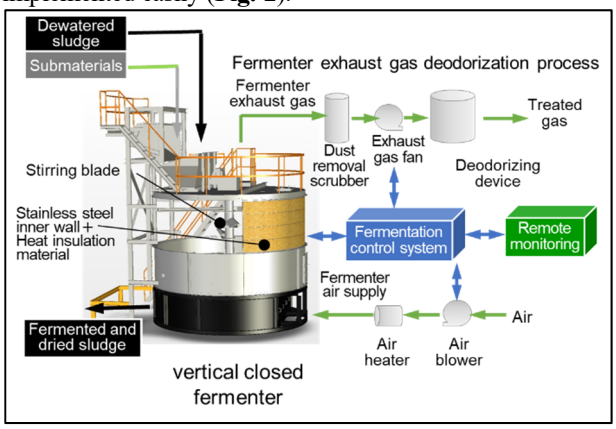

Fig.-2 Technology for production of fertilizer from sewage sludge by vertical closed fermenter[3)]

For phosphorus removal, demonstration research on a technology for recovering magnesium ammonium phosphorus (MAP) from digestion sludge (joint research group of Swing Engineering Corporation and Kobe City) is being carried out with the aim of stably achieving higher recovery efficiency than is possible with the conventional technology. Demonstration research on a technology for recovering MAP from the separated liquid when digestion sludge is dewatered (joint research group of JFE Engineering Corporation and Yokohama City), considering labor-saving and energy-saving by utilizing measurement and control technology, is also underway. For a technology for recovery of calcium phosphate from the separated liquid when dewatering is performed without a digestion process (joint research group of Taiheiyo Cement Corporation, Metawater Co., Ltd, and the Bureau of Sewerage, Tokyo Metropolitan Government), demonstration research on optimum control for securing stable quality through the four seasons is being conducted by following changes in the water quality of the separated dewatering liquid with addition of phosphorus recovery materials just the right amount.

To use sewage sludge incineration ash as a raw material, a joint research group of SANKI ENGINEERING CO., LTD., Akita Prefecture, and the above-mentioned Tokyo Metropolitan Bureau of Sewerage is carrying out a study on a technology for reducing heavy metals from sewage sludge incineration ash and granulating the ash in an easy-to-use form.

On completion of this demonstration research, we will prepare guidelines for each of the technologies, and hope that sewage treatment plants will use the technology best suited to their individual needs.

4. Conclusion

Use of sewage sludge, a domestically-available resource, in fertilizer will contribute to building a sustainable resource-recycling society, and since Japan depends on imports for the majority of its fertilizer, it is also attractive for obtaining a raw material that is easily affected by international market conditions and trends in exports by producing nations. As targets for 2030, the “Food Security Reinforcement Policy Framework,” which was approved by the government in December 2022, mentions doubling the use of compost and sewage sludge resources and increasing the share of domestic resources in total fertilizer use (phosphorus base) from 25 % in 2021 to 40 %.

Distribution is one major challenge for achieving these goals. In this area, the Ministry of Agriculture, Forestry and Fisheries, MLIT and other related parties are working to improve consumer understanding. As one concrete move, in December of 2023, the Tokyo Metropolitan Government and JA ZEN-NOH (National Federation of Agricultural Cooperative Associations) signed a partnership agreement to use phosphorus extracted from sewage sludge in Tokyo as fertilizer.

Since the mission of NILIM includes policy support and technology management for MLIT, we also intend to play an active role in these moves without delay.

☞ For more information:

1) Ministry of Agriculture, Forestry and Fisheries (MAFF): Situation Surrounding Fertilizer, May 11, 2023: https://www.maff.go.jp/j/seisan/sien/sizai/s_hiryo/attach/pdf/HiryouMegujiR5-5b.pdf
2) Ministry of Land, Infrastructure, Transport and Tourism (MLIT): Expansion of the Use of Sewage Sludge as Fertilizer: https://www.mlit.go.jp/mizukokudo/sewerage/mizukokudo_sewerage_tk_000555.html
3) National Institute for Land and Infrastructure Management, MLIT: https://www.nilim.go.jp/lab/ecg/bdash/bdash.htm

From the Great East Japan Earthquake and Tsunami to the Sendai Framework for Disaster Risk Reduction and River Basin Resilience and Sustainability by All

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(Keywords) Great East Japan Earthquake and Tsunami, Sendai Framework for Disaster Risk Reduction, River Basin Disaster Resilience and Sustainability by All, participation of all members

1. The Road to River Basin Disaster Resilience and Sustainability by All

"River basin disaster resilience and sustainability by all" means "sustainable flood control measures carried out by all stakeholders in an entire river basin." This is not a new concept, but rather, the traditional thinking on countermeasures for flood disasters in Japan, and it has been shared internationally as a philosophy of disaster risk prevention and mitigation.

Photo-1 Condition of disaster damage in the East Japan tsunami (2011)

1. Understanding of disaster risk;
2. Strengthening of disaster risk governance that controls disaster risk;
3. Investment in disaster risk reduction for resilience;
4. Improvement of readiness for effective disaster response, and "build back better" in the recovery and reconstruction process

Table-1 Four priority fields of the Sendai Framework for Disaster Risk Reduction (2015)

Photo-2 Condition of inundation in the Kinu River Flood (2015)

The Great East Japan Earthquake and Tsunami (**Photo-1**) occurred on March 11, 2011. The total number of dead and missing persons exceeded 22 000, and more than 90 % of the dead drowned as a result of being caught up in the tsunami. This was the largest human casualty due to a water-related disaster since 1959.

Although the Sanriku coastline where the tsunami occurred was protected by breakwaters and seawalls, the external force of the tsunami exceeded their capacity. Were there no lives that could have been saved in spite of this? This regret was shared by everyone in Japan, and in response, the Law Concerning the Creation of Tsunami Disaster Prevention Areas was enacted in 2011. The basic stance is "to aim to mitigate disasters by a total mobilization of hardware and software measures based on the concept of protecting human life by all possible means, assuming a large-scale disaster exceeding expectations." The law also notes that "disaster mitigation means reducing damage as far as possible while continuing to protect human life," and adopts the concept of "continuing efforts for disaster prevention and mitigation."

This concept was shared internationally through the Third United Nations World Conference on Disaster Risk Prevention, which was held in Sendai, Japan in March 2015, and is the "Sendai Framework for Disaster Risk Reduction 2015-2030." Japan shared its experiences, and the world's countries recognized that the primary responsibility for disaster prevention resides in each country, and the participation and cooperation of the society as a whole is necessary for risk reduction. The framework laid out the four priority fields of understanding disasters, risk governance, investment in disaster prevention and "build back better" after a disaster occurs (**Table-1**).

In September of the same year, the Kinu River flooded as a result of torrential rains caused by linear precipitation rainbands (**Photo-2**). Following that event, conditions where unprecedented damage occurs due to external forces exceeding the capacity of disaster prevention infrastructure have become an annual occurrence. Because countermeasures for disaster prevention and mitigation for frequently-occurring large-scale disasters were urgently needed, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) formulated "River Basin Disaster Resilience and Sustainability by All," and proposed

community development, housing development, and improvement of the storage and permeation function based on water damage-related risk with the cooperation of all stakeholders in addition to hastening the development of hardware.

2. Efforts of the River Department

In promoting River Basin Disaster Resilience and Sustainability by All, the roles of the River Department are to recognize and assess risks, study countermeasures, build a consensus among all stakeholders, and carry out social implementation. Research and development of both the hardware aspect and the software aspect are demanded in order to support the decision-making of the stakeholders of diverse projects.

As a concrete example, the River Department conducted model experiments on levee structures that tenaciously resist even overtopping and provided technical guidance on the recovery policies after a disaster (**Photo-3**). In the hardware aspect, support for facility administrators continues to be an important mission (**Photo-4**). In the future as well, we will continue research for improvement, including both functions and sustainability.

In the software aspect, we put great effort into supporting local stakeholders such as residents and companies. The department predicts the water level rise due to flooding in advance and provides the water level predictions to contribute to evacuation action during floods (**Fig.-1**) and supports the chain of command of Flood Prevention Groups (**Fig.-2**). Along coastlines, we also predict the wave runup height to prevent wave damage. We will carry out social implementation of information dissemination to protect human life when a disaster occurs.

In combination with this, we will also make efforts to improve the capabilities of not only researchers, but also persons engaged in practical work in the field.

3. Future Outlook

At present, when the effects of climate change are becoming increasingly apparent, it is indispensable to pursue reliability in infrastructure facilities. At the same time, in order to promote “River Basin Disaster Resilience and Sustainability by All,” effective techniques for building disaster prevention areas “by all” are also demanded. From this viewpoint, it is important to envision a wide range of research targets, from civil engineering to the social sciences and humanities.

Furthermore, as the Sendai Framework shows, disaster countermeasures are a challenge for all the world’s countries. Thus, the knowledge gained by this challenge in Japan, which has an abundance of experience in disasters and reconstruction, must be shared with all countries.

In the River Department, we will steadily continue the research activities demanded of us, and we will also take on the challenge of new issues and provide those results to all stakeholders, both inside and outside of Japan.

Photo-3 Actual-size overtopping experiment using large-scale experimental facility

Photo-4 Survey of a dam damaged by the Noto Peninsula Earthquake

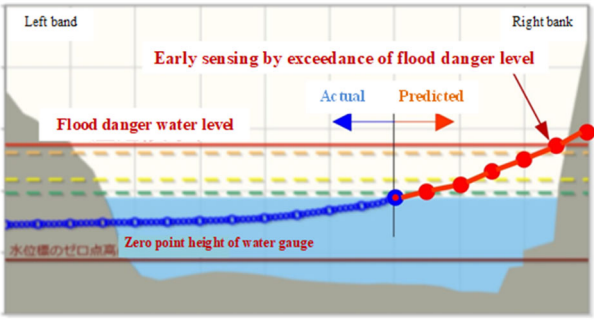

Fig.-1 Prediction of the future water level based on the risk line during flooding

Fig.-2 Display of the Flood Prevention Group activity information-sharing support system

Technology Development and Human Resources Training Supporting Crisis Management in Large-Scale Landslide Disasters

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(Keywords) crisis management of large-scale landslide disasters, river channel blockage (natural damming), UAV photogrammetry, BIM/CIM model, training support program

1. Introduction

Based on the changes in the natural environment and social conditions and the actual situation of landslide disasters in recent years, it is thought that the current conditions surrounding research on landslide disasters can be characterized by three environmental changes: 1) More frequent and more intense disasters and changes in the phenomena of their occurrence accompanying climate change, 2) Increased imminence of giant earthquakes, such as the Nankai Trough earthquake, and volcanic eruptions, which are thought to recur with a regular cycle, and 3) Society with a progressively declining population and workstyle reform. I feel that we must conduct our research activities based on these environmental changes.

On the other hand, the 2024 Noto Peninsula Earthquake, which occurred on January 1, 2024, caused a large number of slope collapses and landslides, as well as multiple cases of natural damming of rivers by landslides, and in responding with the cooperation of related organizations, including the Sabo Department, there was a re-recognition of the importance of "efforts to support crisis management for large-scale landslide disasters."

In other words, as efforts to support crisis management carried out by the national government and prefecture-level governments after landslide disasters caused by an earthquake, torrential rainfall, a volcanic eruption, etc. that it would be difficult to respond to with the normal system (i.e., large-scale landslide disasters), a certain effect of efforts by related organizations, including the Sabo Department, was recognized, and the importance of continuing efforts was recognized anew. However, there is also a continuing re-recognition of issues that require continuing study based on the changes in the above-mentioned 2) Increasing imminence of a Nankai Trough earthquake, etc. and 3) Society with a progressively declining population.

This article introduces the efforts of the Sabo Department in connection with large-scale landslide disaster crisis management, the importance of which was recognized anew in the recent Noto Peninsula Earthquake, based on the environmental changes mentioned at the outset.

2. Policy of Research and Development Efforts, Etc. Related to Large-Scale Landslide Disaster Crisis Management

There are considered to be several factors that make crisis management by national and prefectural governments difficult when a large-scale landslide disaster occurs. The policy of research and development efforts, etc. by the Sabo Department in response to those factors is shown in the following ① to ④.

① When a large earthquake or other disaster occurs, it is necessary to determine whether serious events have occurred or not quickly over a wide region, including mountainous areas; therefore, the Sabo Department conducts technology development which makes it possible to grasp the condition over a wide region, even at night and in bad weather, for example, by utilizing satellite SAR.

② Because large-scale earthquakes and other disasters are frequently complex disasters, and it is necessary to respond under severe manpower and equipment constraints, the department conducts development of technologies for estimating damage, such as the risk of slope collapse due to an earthquake, etc., so as to develop response plans and arrange the response system in advance.

③ Due to Japan's progressively declining population, it is necessary to respond to disasters with inadequate manpower while also promoting workstyle reform; to address this problem, the department conducts technology development to enable "faster, more accurate and safer" surveys by utilizing DX.

④ Since there are few opportunities to experience actual large-scale landslide disasters, which have a low frequency of occurrence, and it is difficult to secure personnel in a society with a declining population, the department conducts development of technologies for efficiently transferring knowledge and technologies to inexperienced persons by using digital technologies, etc., and conducts human resources training to transfer knowledge and technologies widely, for example, by conducting the Support Program for Training Regional Development Bureau Officials, etc.

3. Grasping the Scale of Natural Damming Locations by UAV

This is a concrete example of an effort in connection with the above 2.③.

In emergency surveys based on the Act on Sediment Disaster Countermeasures for Sediment Disaster Prone Areas, the Sabo Department conducts surveys of the position, relative elevation, length of flooding, etc. of natural dams caused by landslides in order to estimate the hazardous area and period of landslide disasters originating from natural damming. As an

alternative or complementary technique to conventional surveys using a laser rangefinder from the ground or a helicopter, we verified a survey technique using a UAV (drone).

When the accuracy of the 3-dimensional point group data measured by UAV photogrammetry (photographic surveying) was checked by comparison with the LP (Laser Profiler) data surveyed in the past fiscal year, it was found that topographical maps showing collapsed slopes and blocked river channels can also be created with high overall accuracy by UAV photogrammetry.

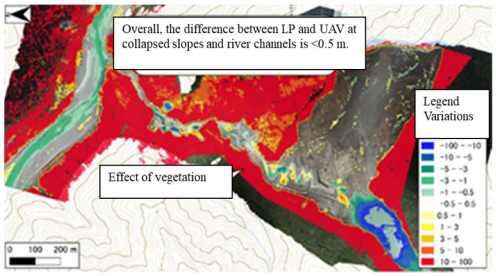


Fig.-1 Difference of UAV photogrammetry and LP data

4. Transfer of Disaster Response Technology Utilizing BIM/CIM Models

This is a concrete example of effort in 2.④.

As will be described below in 5., in practical training in measurement of natural dams in the training support program for staff of Regional Development Bureau Officials, Etc., the trainees could easily and visually understand the points to note in natural dam measurements when staff who had actually participated in emergencies surveys provided guidance on those points by displaying the results of natural dams measured by the trainees on 3-dimensional BIM/CIM models.

As this example demonstrates, 3-dimensional visualization of actual disaster sites by BIM/CIM models is also effective for transfer of disaster response technologies.

Photo-1 Measurement of a natural dam
(Left: measurement from helicopter,
right: measurement by UAV)

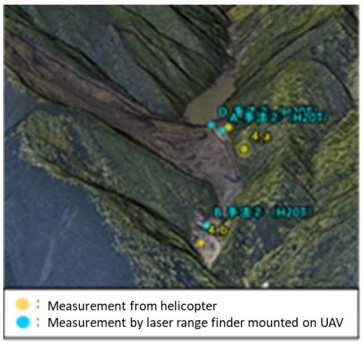


Photo-2 BIM/CIM model displaying results of natural dam measurement

5. Support Program for Training Regional Development Bureau Officials, Etc.

This is a concrete example of efforts in 2.④.

Since FY 2013, the Sabo Department has conducted this program in cooperation with the Public Works Research Institute (PWRI) and the Technical Center for Large-Scale Landslide Disaster Countermeasures of the Kinki Regional Development Bureau for staffs of the River Departments of all Regional Development Bureaus, etc. (including the Hokkaido Regional Development Bureau). (Since FY 2018, the objects of part of the program have been expanded to include the staffs of Road Departments).

The period of the program during each fiscal year is April to December. Under curriculum established for this program, trainees normally gather 4 times, and staff members who have mastered the response to crisis management of large-scale landslide disasters are trained through acquisition of landslide disaster emergency survey techniques, mainly for natural dams, and knowledge and research results that can be used in TEC-FORCE dispatches, and exercises related to emergency surveys and emergency countermeasures, etc.

6. Progress of Technology by Accumulation of Cases

Since the object of countermeasures for landslide disasters is nature, there are many cases where new techniques and knowledge are born from verification and experience of the actual phenomena.

In talking about large-scale landslide disasters, we use the single term “natural dam.” However, if the place, time, triggering factors, etc. are different, the characteristics in the phenomenological aspect and the response required in crisis management will also be different.

Accordingly, as the Sabo Department, in addition to promoting research, development, etc. which we have already begun, we hope to contribute to the progress of large-scale landslide disaster countermeasure by collecting not only knowledge gained by surveys and experience by our own staff when a new disaster occurs, and also the knowledge and experience by other organizations, and accumulating those cases.

☞For more information:

1) Website of the Technical Center for Large-Scale Landslide Disaster Countermeasures: https://www.kkr.mlit.go.jp/kiisankei/news/pdf/topic_20231107_02.pdf

2) Yamakoshi Takao: Support Program for Training Regional Bureau Officials Engaged in Advanced Landslide Countermeasures, Rivers, No. 910, pp. 53-55, 2023

Research and development toward the realization of road utilization that is wise, safe, and sustainable

Hidenori Yoshida, Director, Road Traffic Department

Key words: road traffic management, automated driving, zero traffic accidents, carbon neutral

1. Introduction

Roads form a network that constitutes the framework of national land and city blocks, etc. They are part of a vital social infrastructure that supports economic activities and people's lives by facilitating various functions including the movement of people and goods as well as retention and livelihood, disaster prevention, etc. Recent social transformation such as depopulation and aging, as well as the increased severity of disasters accentuated by climate change, highlights the need for further efforts toward the realization of a safe, secure, and flourishing society. That can be achieved by appropriately incorporating elements of the rapidly changing technological innovations, so that the roads function to the fullest extent.

Regarding mid- and long-term road policy, several discussions were held with the Council for Social Infrastructure Development, Road Subcommittee serving as the central platform. Proposals were made in June 2020 as the "Road Policy Vision 'Landscape of Roads Will Change in 2040'," and in August 2022 as "Now is the time to change the landscape of roads - Road Map to the 2040 Road Policy Vision -." Also, in order to define what the High Standard Highway network ought to be, an interim summary was made in October 2023, and it has been determined that the goal will be the realization of the "world's smartest, safest, and most sustainable infrastructure network system in 2050 (=WISENET2050)" .

This paper presents an overview and a trend of the efforts of the Road Traffic Department that is based on the attitude of a sustainable society that should be aimed at and the direction of the road policy that have been shown in these proposals.

2. Road traffic management utilizing ICT

After a period of high-growth, homogeneous road improvement projects have been enacted in an effort to meet the demands of increasing traffic and to connect regions. While the total length of the improved roads has increased, traffic jams still occur in various areas, and smooth mobility needs to be secured in order to increase productivity, vitalize the regions, and reduce environmental loads. In addition to the enlargement of traffic capacity by developing new roads and improving existing roads, the establishment of techniques to manage the demand and supply of road traffic by utilizing ICT and digital technologies is needed.

For this purpose, the first step is to observe the current condition of road traffic. The Road Traffic Department is currently developing traffic volume observation techniques by means of AI analysis of camera images for road management and techniques that estimate the traffic volume according to each of the starting and arrival points and the moving routes for each time zone based on the ETC2.0 probe information. Our department also conducts research on techniques for analyzing and predicting traffic jams, etc. on a real-time basis by using these various types of data. In the future, we will be engaged in research toward the realization of wise road utilization, through a study of measures for promoting changes in the actions of users, etc. using the provision of traffic jam information that has been predicted as well as other data.

3. Efforts toward the realization, dissemination and enhancement of automated driving

Through the realization of automated driving, we will realize automation and energy saving of the movement of humans and goods. It is also expected that traffic accidents will be reduced by preventing human errors as well as alleviating the problem of a shortage of drivers. The national government aims to make the automated driving of private cars on highways a reality (Level 4) by 2025.

Regarding automated driving, the development of autonomous vehicle control technologies is under way in which acceleration and deceleration, lane keep, etc. are performed by using the information collected by onboard sensors. On the other hand, support for automated driving is required by providing information from roads in situations such as those where it is difficult for the vehicle alone to avoid forward hazards on a highway and to detect information required for merging into a main roadway. The Road Traffic Department has been implementing technological development through joint research etc. with automotive and electric equipment manufacturers, etc., in which the provision of information, etc. on vehicles running on a main roadway is performed by mutual communications between a road and a vehicle when there is an obstacle ahead or during merging. Until the present, we have prepared technical specifications for passenger car systems related to the provision of merging assist information. Currently, we are preparing specifications for trucks, and it

verification experiments are scheduled to be performed on actual roads in FY 2024. (Fig. 1)

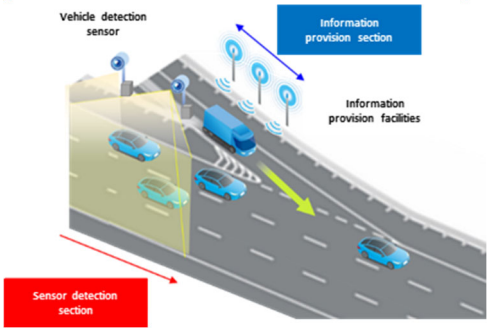


Fig. 1: Image of a verification experiment on the provision of merging assist information

4. Efforts toward "zero traffic accidents"

With the goal of realizing a safe and secure society, the national government is determined to aim at zero traffic accidents in the future. In Japan, among the deaths due to traffic accidents, the ratios of pedestrians and bicycles are relatively high, and it is important to promote traffic safety measures on sidewalks and residential roads in neighborhoods.

The Road Traffic Department is conducting research, in order to take measures effectively by obtaining an understanding of local residents, etc., on the efficient extraction of areas where measures need to be taken by means of analysis of various types of data including accident data, ETC2.0 probe information, running images, etc. as well as on the techniques for planning the measures appropriately. Specifically, research is conducted on the technique to explain the problems and the necessity of measures in an easy-to-understand manner by overlapping various types of data on a map (Fig. 2). In addition studies were done of effective shapes and arrangements as well as installation methods, of physical devices (humps, etc.) that contribute to the prevention of entry of vehicles and speed control. These are being installed by road administrators in conjunction with speed control on residential roads by the police.

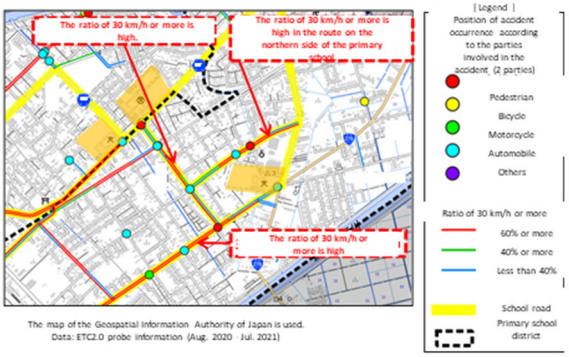


Fig.2: Example of a map to explain the problems in an easy-to-understand manner

5. Efforts toward low carbonization of road traffic

After the Paris Agreement that was adopted in 2015, it has become a world trend to set a goal of limiting the average temperature increase in the world to 1.5°C above pre-industrial levels, and in 2020 Japan also declared a policy to reduce greenhouse gas emissions to net-zero by 2050. After that, the Japanese government as a whole devised various plans, and the Ministry of Land, Infrastructure, Transport and Tourism devised the "MLIT's Green Challenge" in 2021.

In the road sector that accounts for about 16% of the total emissions in Japan, an interim summary of the carbon neutral promotion strategy was announced in September 2023, and it has been determined to promote efforts on the basis of 4 pillars: (1) Optimization of road traffic, (2) Converting to low-carbon flows of people and goods, (3) Greening of road traffic, and (4) Toward a low carbon life cycle for roads. Examples of the specific measures posted are as follows. (1) Measures to increase speed by means of traffic jam prevention measures and demand management, (2)Conversion to mobility with a reduced environmental load and automated driving of trucks, (3) Development and dissemination of the next-generation automobiles and improvement of electricity supply environments, and (4) Low carbonization of the plans, construction, and management of roads.

In order to effectively implement these policies, it is necessary to grasp the CO_2 emissions reductions accurately. The Road Traffic Department is examining the CO_2 emissions coefficient responding to the dissemination of EVs, etc. that substitute for conventional gasoline vehicles. In the future, we would like to aim for the development of techniques that enable the monitoring of CO_2 emissions and the evaluation of reduction effects achieved by each of the policies.

6. Conclusion

This paper has presented part of the efforts of the Road Traffic Department based on the direction of road policies in the future. The environments surrounding society and road traffic are changing at a pace exceeding our imagination, and as the Road Traffic Department, we would like to tackle the research that contributes to the solving of social problems and the creation of new values speedily and flexibly, in future. At the same time, we aim to ascertain what society will look like and what direction these new policies should take.

☞For detailed information, refer to the following:

1) Website of the Road Traffic Department
https://www.nilim.go.jp/japanese/organization/koutsu/jkoutsu.htm

Building a strategic management cycle for road structures

Junichi Hoshikuma (Ph. D.), Director, Road Structures Department

Key words: road structure, management cycle, regular inspection, ensuring quality, improvement of efficiency

1. Introduction

The Fundamental Plan for National Resilience that was determined by the Cabinet Decision in July 2023 has shown 4 fundamental goals and 5 basic policies. Among them, pillars that have intricate relationships with the technological policies in the road structure sector have also been launched, such as the strengthening of lifelines and the securing of substitutability as well as the improvement of capabilities to address disasters by the utilization of new technologies such as digital.

Among them, as one of the measures to increase the resilience of lifelines such as roads, it is shown that reduction of the life cycle cost will be pursued by full-fledged conversion to maintenance of the preventive maintenance type, and at the same time that infrastructure management will be implemented efficiently and strategically by grasping the infrastructure in multiple sectors as a group from the viewpoints of wide areas.

Based on this trend, this paper presents a plan for the strategic management of road structures as dealt with by the Road Structures Department. Also, since FY 2023 will be the final fiscal year in the second round of regular inspection of bridges and tunnels, we have organized the problems we will confront in the third round. We have also examined the review of regular inspection procedures (technical advice). Our efforts in this respect are outlined below.

2. Management cycle for road structures

The Road Structures Department conducts research on technological measures that enable the management cycle to be run strategically. Roads play a role of linear functions through the mutual configuration of road structures. This is not limited solely to point-like technological measures such as the maintenance cycle of individual road structures or disaster prevention inspection, etc.

The figure below shows an image of such cycle in its entirety. It aims at the improvement of technical standards that enable the design, inspection, and repair of each structure to be implemented based on the performance required for roads. It also aims at building a mechanism that will lead to efficient management by utilizing the data that will be obtained in the processes of this cycle.

3. Organizing problems in preparation for the 3rd round of regular inspection

In 2014, legally defined regular inspections were started, and in 2019 when the first round ended, the first review of the regular inspection procedures was implemented. At the time, it was shown that, when it is determined that sound diagnosis is equivalent to the diagnosis achieved by close visual inspection, other methods may also be considered equally viable where

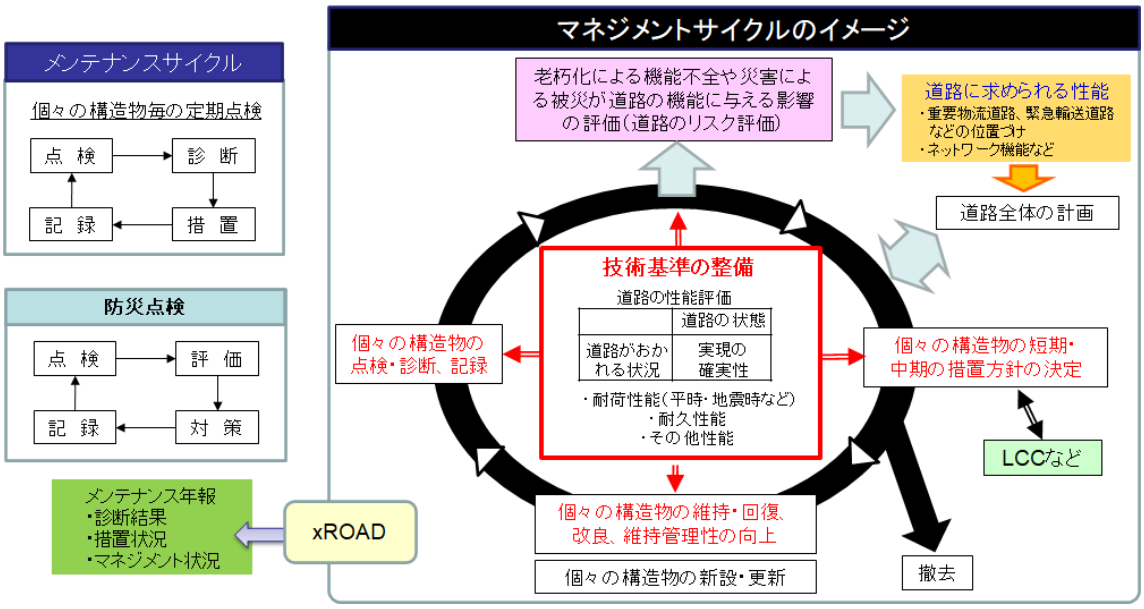


Figure: Image of the management cycle for road structures

close visual inspection is basically used. Now that the second regular inspection has ended, by taking a bird's-eye view of the results of such analysis, problems have been generally classified into 3 distinct categories.
The 1st category is one that shows an unevenness in the quality of regular inspections. This may have been caused by relative differences in the examination process of diagnosis and in the quantity or quality of information was obtained for diagnosis, depending on the manager of structures.
The 2nd category is one that shows the record of the diagnosis process that is the basis for the diagnosis was insufficient. This becomes a great obstacle in the promotion of the management of road structures based on data that will be taken into account by the road administrator.
The 3rd category is one that shows the problem of a burden of inspection. It also has reveals a deficiency of the lack of engineers. There is also the problem that records and data until the present have not been fully utilized effectively. The clarification of records that should be kept is necessary.
These problems all have aspects that are interrelated. It is considered to be important that, in the management cycle shown in the figure, diagnosis based on performance will be implemented in the inspection, thereby enabling the road administrator to evaluate the effects of malfunction due to aging degradation and damage caused by a disaster on the functions of roads. At the same time improvements will be made so that the basis for diagnosis is recorded reasonably.

4. To ensure regular inspection quality and increase efficiency

In the current regular inspection, the condition is grasped based on close visual inspection. Then a diagnosis of soundness is classified into 4 categories as required by laws and regulations, and the results are recorded. On the other hand, on the basis of the problems described above, in order to increase the reliability of ensuring quality of the regular inspection, not only the category on classification of soundness, but the basis of such diagnosis should also be kept on record. Namely, in the diagnosis of soundness, it is important that a person having knowledge and skills estimates how the current situation of road structures are, and how their condition will be in relation to the situations assumed by the time of next inspection, and keeps such estimation as a record.
For example, in the case of a road bridge, assumed situations include factors such as the situation where a live load acts, the situation where an earthquake occurs, what effects of torrential rains might have, and the like. In relation to these assumed situations, it is important that the state of the bridge as a whole and the state of each of the structures constituting the bridge (superstructure, substructure, and each structure when classifying the bridge into the units of connections from the top to the bottom parts) will be evaluated, and specific findings related to the estimation of performance will be recorded. After that, if a decline in the performance is estimated, the road administrator will determine short-term or mid-term measures and policies. However, if the repair method is examined based on the concept of performance recovery, a repair method other than simply returning the shape to its original one may also be considered in the broader picture. It is also considered possible that such an examination will lead to reasonable repair based on the shape and state of the structure.
Note that, from the viewpoint of increasing efficiency of regular inspections, there is also the need to systematize the inspection items and how records should be kept. Also, from the viewpoint of enabling the results of inspection to be utilized in asset management and risk evaluation, it is considered that data recording such as the estimation of performance should be standardized and codified, thereby organizing the environment in order to enable efficient quantitative analysis. The records that should be kept will be clarified, and no records beyond what is necessary will be required, thereby ensuring that the efficiency of inspections.

5. Conclusion

In the Road Structures Department, we would like to continually proceed with necessary research so that the management cycle of the performance required for roads will function appropriately. In so doing we will continue to make efforts to implement the research in the practical business of the plan, design, as well as maintenance and management of roads.

☞For detailed information, refer to the following:

1) FY 2023 NILIM Lecture Meeting, Making PDI infrastructure more resilient
https://www.nilim.go.jp/lab/bbg/koen2023.html
2) Council for Social Infrastructure Development, Road Subcommittee, Road Technology Subcommittee, 20th Road Technology Subcommittee, Jan. 2024
https://www.mlit.go.jp/policy/shingikai/road01_sg_000673.html

Toward Improvement of the Seismic Resilience Performance of RC Structures

HASEGAWA Hiroshi (Ph.D. (Eng.), Director, Building Department

(Keywords) RC structure, Seismic resilience performance, Degree of damage, Positioning satellite data, Continuity of use

1. Introduction

First, I would like to express my heartfelt condolences to all those who lost family members or loved one in the 2024 Noto Peninsula Earthquake.

This earthquake damaged approximately 99,000 structures in the three prefectures of Niigata, Toyama and Ishikawa (as of February 14, 2024). The majority of the damaged structures were wood-frame houses, but overturning, tilting and other damage were also seen in reinforced concrete (RC) structures.

When victims are forced to live as evacuees due to building damage, their quality of life is reduced, and disaster-related deaths are possible. For this reason, the Building Department is conducting research on improvement of "seismic resilience performance" from the viewpoint of the structural performance of RC structures to enable continuing use, even in the event of a large-scale earthquake. This report presents an overview of those efforts.

2. Damage of RC Structures in 2024 Noto Peninsula Earthquake

An RC structure with 7 above-ground stories in Wajima City overturned in the 2024 Noto Peninsula Earthquake (**Photo 1**). The Building Dept. conducted a damage survey of the RC structures in Wajima, including this building (Jan. 10, 2024) [1]. As a result, no conspicuous damage was seen in the superstructures of multistory RC structures, but tilting of entire buildings was observed. Therefore, we set up a joint expert committee with the Housing Bureau to analyze the causes of structural damage of buildings and study directions for countermeasures based on the results [2].

Photo 1 Overturned RC building (photographed from south side)

3. Framework for Evaluation of Seismic Resilience Performance

The framework for evaluation of seismic resilience performance is shown in **Fig. 1**. To enhance seismic resilience performance, first, it is necessary to encourage widespread adoption of buildings that secure earthquake-resistance performance, i.e., buildings that are damage-resistant and can easily be restored to use (in Fig. 1, reduce ① "Degree of functional decline" and shorten ③ "Recovery time"), and second, establish a method for quickly judging the continuing usability of buildings after an earthquake (shorten ② "Delay time.")

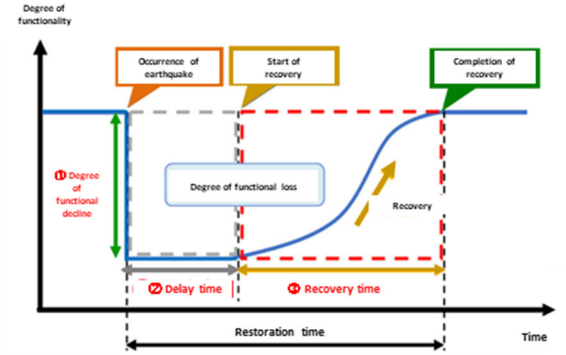


Fig. 1 Framework for evaluation of seismic resilience performance (conceptual diagram of degree of functional loss in a disaster)

4. Development of Method for Evaluation of Seismic Resilience Performance

(1) Development of evaluation method for degree of damage in large-scale earthquake

From the viewpoint of structural performance, the most important factor which makes continuing use difficult when an earthquake occurs is serious damage of the structural skeleton. Even if a building avoided collapse or overturning, there are cases where the building was demolished owing to extremely severe damage of its beam-column joints.

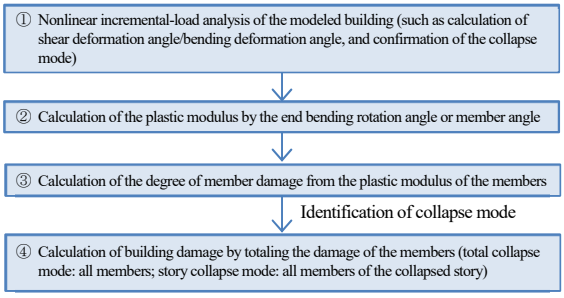


Fig. 2 Procedure for calculation and evaluation of building damage degree in an earthquake

Therefore, we will develop a technique for evaluating the damage of buildings assumed in a large-scale earthquake at the time of design (large-scale earthquake: earthquake that occurs extremely rarely (on the order of once in several hundred years)). Focusing on "damage" for judgment of the classification of the degree of damage, an evaluation by the procedure shown in **Fig. 2** is assumed [3], and the results will be made available as a "Damage evaluation Web program."

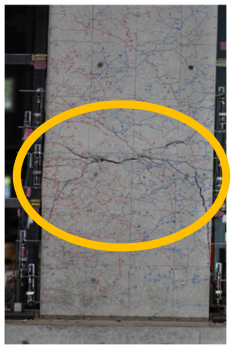
(2) Evaluation of the allowable degree of damage

In order to evaluate the allowable degree of damage related to seismic resilience performance, the Building Dept. is performing loading tests of techniques that are considered promising for damage mitigation and collecting data on damage properties, etc. The following **Table** shows ① Hinge relocation beam (technique in which the amount of main reinforcement of beam-column joints is increased, and the damage point is controlled to the central part of the beam; hereinafter, "HRC beam") and ② Unbonded precast prestressed concrete beam (technique in which damage is reduced by passing PC steel material through precast column-beam members and unifying the members by forming a prestressed joint by the tension of the PC steel; hereinafter, PcaPC beam). The following presents an example of the results of a loading test of the PcaPC beam (distortion angle: 1/50, 2nd cycle, negative side loading/unloading).

The HRC beam could control the damage position (plastic hinge). However, since the damage in that position was very large, it was found that a quite large reduction of deformation (horizontal displacement) was necessary in order to ensure seismic resilience. It was also found that the PCaPC beam was effective in controlling cracking of the tensioning system, but damage of the compressive system occurred instead.

Based on the damage characteristics identified in these loading tests, in the future, we plan to clarify the distortion angle needed to keep beam damage within the allowable range and study the degree of repairability corresponding to the damage characteristics.

Table Examples of results of loading tests of beams for RC structures

①HRC beam	② PcaPC beam
	
The damage position is controlled. However, the concentration of damage in the central part of the beam is severe.	Damage of the compressive system (concrete flaking) occurred.

5. Development of Method for Quick Judgment for Continuity of Use

To expand continuing use of buildings when a large-scale earthquake occurs, quick judgment for the continuity of use (integrity) of the damaged structures is demanded. Therefore, we are working to develop a quick and highly accurate judgment method utilizing positioning satellite data.

Fig. 3 shows an overview of the development. The aim is to develop ① a system that can directly measure the horizontal displacement of buildings during and after an earthquake by acquiring positioning satellite data at the building rooftop floor and ground surface, and combining it with seismographs installed in buildings, and ② a system that enables judgment of the degree of damage, etc. of buildings from a remote location based on the measured horizontal displacement.

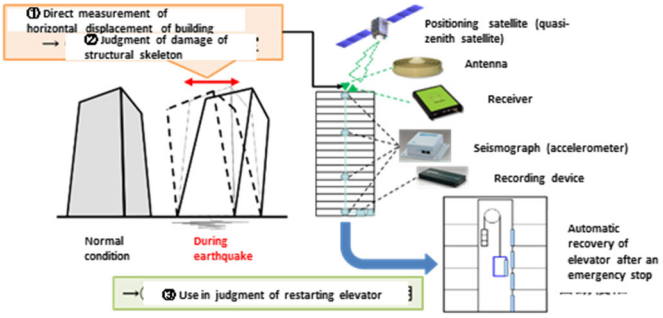


Fig. 3 Overview of development of quick judgment method for continuity of use of damaged structures utilizing positioning satellite data

6. Conclusion

Securing seismic resilience performance in large-scale earthquakes has become an important issue in the building earthquake-resistance field. While clarifying the causes of damage to RC structures in the 2024 Noto Peninsula Earthquake, the Building Dept. hopes to contribute to mitigating damage of buildings in large-scale earthquakes and speeding up post-disaster recovery through continuing research toward improvement of seismic resilience performance and social implementation of the results.

☞For more information

1) "Report of site survey of foundation and ground damage of structures by the 2024 Noto Peninsula Earthquake (bulletin)"
https://www.nilim.go.jp/lab/bbg/saigai/R5/notojishin04.pdf

2) Objects of study by the committee include wood-frame structures, etc. in addition to RC structures.
"Meeting of committee to analyze causes of building structural damage in 2024 Noto Peninsula Earthquake"
https://www.nilim.go.jp/lab/bcg/kisya/journal/kisya20240209.pdf

3) "Development of Method for Evaluating the Continuing Usability of RC Structures after a Large-Scale Earthquake," pp. ____

Research and Development Initiatives to Overcome Vulnerabilities of Housing in Large Modern Urban Areas in Disasters

KIUCHI Nozomu (Ph.D. (Eng.), Director, Housing Department

(Keywords) Life continuity during disaster, Securing electric power, Continuity of use of elevators, Evacuation support for elderly people and disabled persons

1. Introduction

This paper describes countermeasures against the vulnerabilities that are assumed to be possible when a large modern urban area such as Tokyo suffers a disaster, based on the 100 years since the Great Kanto Earthquake that struck Tokyo in 1923.

In the Great Kanto Earthquake, fires spread through wood-frame houses which had collapsed or were damaged by seismic motion (maximum seismic intensity: 6 on the Japanese scale), and about 90 % of the victims, totaling more than 100,000 persons, died in fires. Looking at more recent major earthquake disasters, in the Great Hanshin-Awaji earthquake (1995), collapsed buildings claimed the lives of approximately 80 % of the more than 6,000 victims, and in the Great East Japan Earthquake (2011), which claimed more than 18,000 lives (excluding disaster-related deaths of persons who died later), about 90 % of the victims drowned in the tsunami following the earthquake.

Thus, the types of damage differ greatly, depending not only on the scale and location of the earthquake, but also on the region and the characteristics of the society affected by the earthquake. When con sidering countermeasures for large-scale earthquake damage in large modern urban areas, it is necessary to implement measures based on the vulnerabilities of the infrastructure of daily life, which was highly developed in metropolitan areas.

The following mention several related efforts by the Housing Department in the past, and introduces the types of vulnerabilities to be addressed and the issues studied in connection with countermeasures.

2. Securing Power Necessary for Continuing Living

Since modern urban life is supported by various kinds of lifelines, even when a building does not suffer direct damage after a disaster, there is a high possibility that it will become difficult to continue living at home if lifelines stop, etc. In particular, power outages have a serious impact. For this reason, increasing the number of dwellings where people can continue living in their own homes after a disaster will lead to reductions in the number of evacuees who must be accommodated in evacuation shelters and the number of temporary housing units required, and will also contribute to quick recovery and improved resilience of the region.

Therefore, in "Study on Design Targets for Self-sustaining Energy Systems to Ensure Post-Disaster Residential Continuity" (FY2020-FY2022), first, the requirements for continued living during a power outage after a disaster were studied, focusing on energy-saving systems consisting of photovoltaic power (PV) generation and storage batteries for dwellings. Concretely, a method for calculating electric power demand (power consumption) reflecting the necessary minimum or priority equipment/devices for continued living and the condition of their use, and the power supply to cover that demand was constructed.

In this research, a questionnaire survey of households that had experienced a power outage for a period exceeding a half-day during a large-scale disaster [1] was conducted to clarify the electric power usage necessary for continued living after a disaster, and the equipment/devices necessary for continued living under the condition of a lifeline

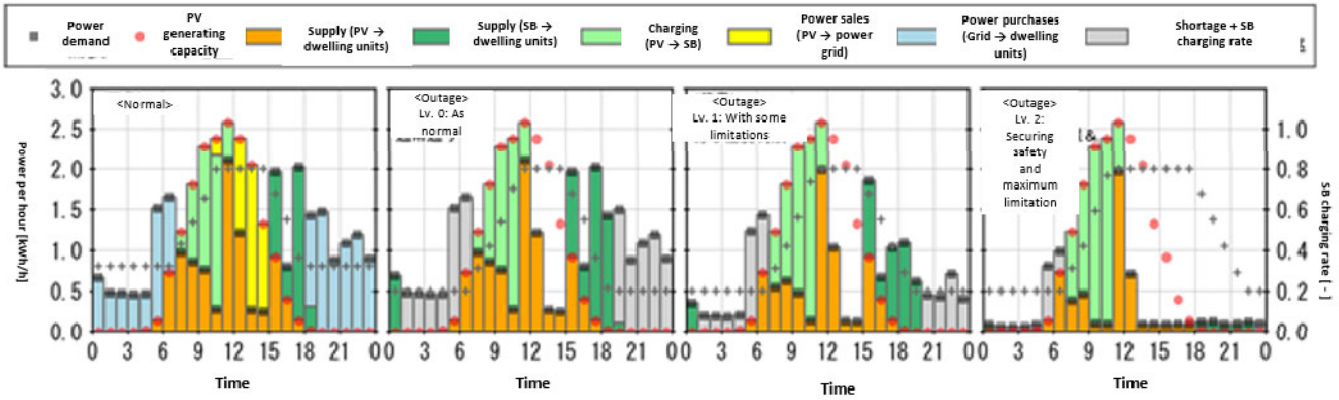


Fig. Example of calculation of power demand in 24 hours after a power outage occurs and power supply capacity by photovoltaic power generation (PV, 4.0 kWh) and storage batteries (SB, 12.0 kW)

stoppage were identified. A method for calculating the power supply of the above-mentioned energy-saving system was constructed corresponding to the conditions of the power outage and the use of devices by the family members, based on the method for calculating residential energy conservation standards, by setting or assuming two levels of equipment/device use patterns, in which power consumption was reduced by measures such as having the family gather and spend time in certain rooms (living-dining-kitchen and couple's bedroom). Together with this, technical information on cases of malfunction of the PV power generation and storage battery system, measures to avoid or minimize such problems, precautions during a disaster, etc. was also collected and arranged.

The results will be arranged and provided in the future so that they can also be applied to apartment houses and regional units.

3. Evaluation of Continuity of Use of Elevators after Large Earthquakes

The percentage of households living in high-rise multi-unit complexes in large cities is increasing, and it is essential to use elevators in order to live there continuously after a disaster. However, a method for evaluating the continuity of use of elevators has not been established. To enable continuous use of elevators after a disaster, verification from the following viewpoints is necessary: ① Safe stopping at the specified position during a disaster (to avoid passengers being trapped and prevent injury), ② Response to recovery by an automatic diagnosis and recovery system (also including remote response), ③ Response to disruptions of the lifeline (electric power), and ④ Response to disruptions of the maintenance network.

Research on these issues is being carried out in "Research on Performance Evaluation Technologies for Housing/Buildings Responding to Changes in the Social Environment" (FY 2022-FY 2026). For example, for ②, a survey of the effects of the inter-story drift angle of buildings on impaired functioning of elevators and the effectiveness of a system that detects that condition and performs automatic diagnosis and recovery are being studied.

4. Evacuation Support Technologies for Elderly People and Disabled Persons during Disasters

The number of elderly people and disabled persons living in medium- and high-rise multi-unit complexes in large cities is increasing, and it may be difficult for such persons to evacuate during a disaster that includes a power outage. On the other hand, while preparation of barrier-free technologies for everyday life is progressing, so-called "emergency barrier-free" still faces many issues.

As concrete examples, it is difficult to evacuate from upper floors using stairs, it is impossible to use elevators during power outages, there are limits (unusable) use elevators during fires, and the use of evacuation equipment assumes only use by able-bodied persons.

To address these issues, in "Development of Evaluation Standards for Evacuation Support Technologies for Elderly/Disabled Persons during Disasters in Apartment Houses, Etc." (FY 2015-FY 2017), evacuation plans and evacuation support technologies were systematically arranged, and ergonomic experiments were carried out toward the creation of evaluation standards for new evacuation support technologies, aiming at the establishment of a performance evaluation method and operation and maintenance techniques.

In this study, prototype of a new evacuation support device was developed and installed, and its effectiveness was compared with that of the existi ng evacuation ladders and escape chutes by operation experiments and psychological evaluation experiments. For example, in the operation experiments, the time required for evacuation by young subjects wearing and using the above-mentioned devices was measured, etc., assuming a person carrying an infant, an elderly person, and a person paralyzed on one side of the body.

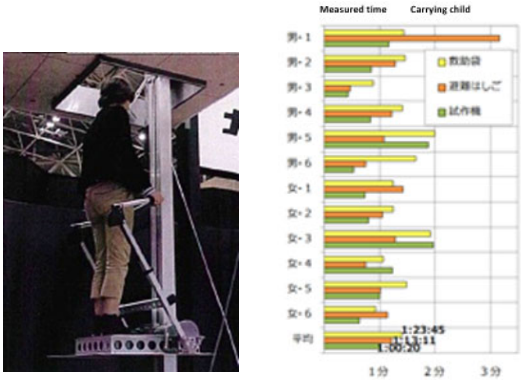


Fig. Condition of experiment using a prototype device and example of experimental results

5. Conclusion

Continuing progress is being made in the efforts of local public organization to encourage condominiums that enable "at-home evacuation" during disasters by certification systems such as the "'Mori no Miyako' Disaster Prevention Improvement Condominium Certification System" in Sendai City, "Tokyo 'Todomaru' Mansions" in Metropolitan Tokyo, and the "Yokohama Disaster Prevention Capability Improvement Condominium Certification System," and the Housing Department will also continue research and development to provide support to those efforts in the future.

☞For more information

1) TECHNICAL NOTE of the National Institute for Land and Infrastructure Management No. 1271,
" Online survey targeting households that have experienced power outages due to natural disasters"
https://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1271.htm

Improvement of Earthquake Disaster-Prevention Safety in Built-up Urban Areas

MURAKAMI Harunobu, Director, Urban Planning Department

(Keywords) Noto Peninsula Earthquake, Great Kanto Earthquake, Urban fire, Densely built-up urban area

1. Introduction

First of all, I wish to express my deepest condolences to all those who perished in the recent Noto Peninsula Earthquake, which occurred on January 1, 2024, and to their families. This earthquake caused a large-scale fire in the Kawaimachi district of Wajima City. The Great Kanto Earthquake, which occurred almost exactly 100 years ago, on September 1, 1923, also caused large-scale urban fires, particularly in Tokyo.

Since improvement of the safety of existing urban areas in earthquakes remains an important policy issue for Japan even today, in this paper, I would like to introduce the trends in national government policies in this connection and related research by the National Institute of Land and Infrastructure Management (NILIM).

2. Fire in 2024 Noto Peninsula Earthquake

According to a statement (issued at 9:00, Jan. 26, 2024) by the Disaster Response Headquarters of the Fire and Disaster Management Agency of Japan's Ministry of Internal Affairs and Communications, the 2024 Noto Peninsula Earthquake caused 17 fires in 10 cities and towns. Among these, NILIM and the Building Research Institute (National Research and Development Agency) dispatched researchers to Kawaimachi in Wajima City, where a large-scale fire developed, and released a damage survey report (quick report) [1] on January 12. According to that report, looking at the surroundings of the fire-devastated area, it appeared that the area contained many low-rise wood-frame dwellings, buildings that had collapsed as a result of seismic motion, and buildings where wood-and-mortar walls had fallen off, and the fire occurred under those urban conditions. It was estimated that the burnt-out area was approximately 50,800 m^2 and contained about 300 buildings, and the final scale of the damage is expected to be determined by the fire department.

3. Urban Fire in Great Kanto Earthquake

The Great Kanto Earthquake became an unprecedented conflagration, in which victims of the fires that occurred after the earthquake accounted for about 90 % of all deaths. As reasons for this kind of large-scale urban fire, it may be noted the Tokyo of that time was an easily-inflammable urban area, being a densely built-up city of wood-frame structures. Weather conditions were also conducive to fires, including a strong southerly wind that was blowing when the earthquake occurred, and firestorms and leaping fires further increased the damage.

The mechanism of these urban fires in the Great Kanto Earthquake was the subject of a television "NHK Special" that was broadcast on September 2-3, 2023, in which NILIM participated from the planning stage. Researchers from NILIM and the Building Research Institute commented on images from the period of the earthquake, which were prepared by high-definition color imaging, and performed an experiment reproducing the firestorms and leaping fire and provided commentary. Readers are invited to view a shorter version of this program, which NHK has made available on YouTube.

Fig. 1 Experiment reproducing a firestorm

4. Trends in National Government Policies

Built-up urban areas, and particularly densely inhabited areas of predominantly wood-frame structures, have various problems, including a lack of wide spaces that might serve as firebreaks, numerous narrow roads and sites with no access to roads, and difficult conditions for firefighting activities, and thus have a high risk of urban fires.

Development and improvement of densely inhabited urban areas are important issues in Japan for protecting the lives and property of the nation's citizens. The measures for achieving this are specified in the "Fundamental Plan for National Resilience" (approved by Cabinet resolution on July 28, 2023). The "Housing Basic Plan (National Plan)" (approved by Cabinet resolution on March 19, 2021) also stipulates that "the land area of densely inhabited areas that are conspicuously dangerous (dangerous densely inhabited areas) when earthquakes occur should be mostly eliminated (by FY 2030)" and calls for "strengthening of soft measures that contribute to the improvement of wide-area disaster prevention readiness (100 % by FY 2025)".

Based on these Cabinet resolutions, the national government and local governments are cooperating in screening dangerous densely inhabited areas by disaster-prevention evaluation methods (danger of fire spread, difficulty of evacuation) developed with the support of NILIM, and are implementing various types of development and improvement measures, as shown in **Fig. 2**, centering on those urban areas.

However, dangerous densely inhabited urban areas still remain, particularly in cities built on hilly land, such as Yokohama and Nagasaki, and historic cities like Kyoto. Thus, in addition to the hard measures taken to date, it has become necessary to minimize the occurrence of urban fires and the ensuing damage by new measures and improvement of wide-area disaster prevention readiness.

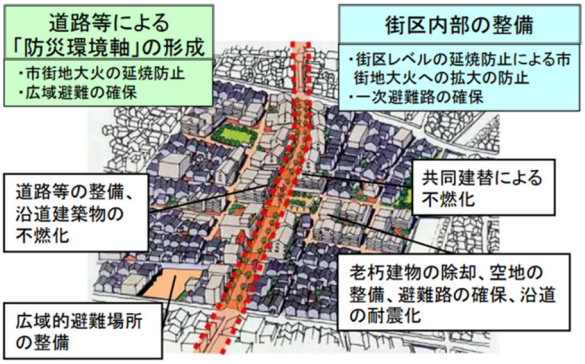


Fig. 2 National government development and improvement measures for densely inhabited urban areas

5. Research by NILIM

Based on the above-mentioned issues, the Urban Planning Department, in cooperation with experts, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), the Building Research Institute and internal support (Building Department, NILIM), began a comprehensive technology development project, "Development of Effective Earthquake Disaster Prevention/Mitigation Technologies for Built-up Urban Areas Using New Technologies, Etc." as a 4-year plan beginning from this year (FY 2023). In this technology development, blockage of roads by fires or collapsed buildings when an earthquake or other disaster strikes a built-up urban area will be detected by drones, AI cameras installed at high locations, etc., and will be incorporated into a plateau or other 3D city model, a fire spread simulation will be conducted, for example, for 24 hours in the future, and the results of an evaluation of the evacuation risk based on the simulation will be visualized by a digital twin. This will then be shared with local residents by using digital devices such as LINE and other social media, leading to early firefighting activities and evacuation activities by residents. Technologies for reevaluation of the disaster mitigation performance of dangerous densely inhabited urban areas will also be carried out, considering the use of these new technologies and improvement of wide-area disaster prevention readiness.

In addition, under the Cabinet Office's BRIDGE Program (for "bridging" the gap between research and development results and social implementation), the Urban Planning Dept., in cooperation with related organizations, is carrying out a 2-year research project, beginning in FY 2023, in which it will attempt to detect urban fires by infrared and SAR observation from a satellite, and link this to a quick, accurate response when a fire occurs by providing the results of predictions of fire spread after detection to local governments and others.

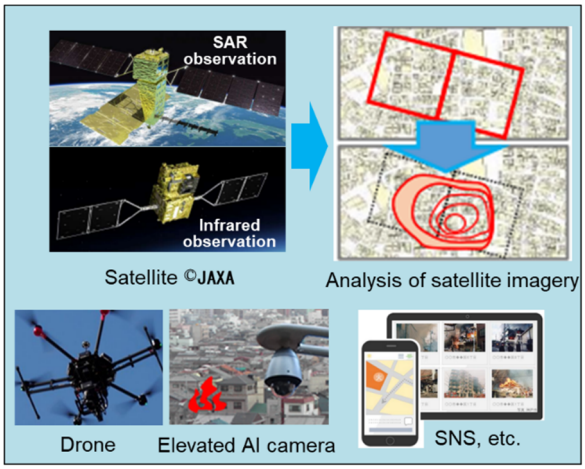


Fig.-3 Image of research using satellite, etc.

6. Conclusion

In today's Tokyo, the number of bare wood-frame houses and other buildings has decreased in comparison with the time of the Great Kanto Earthquake. As a result, the speed of fire spread has decreased to 1/3 to 1/4 of that 100 years ago, and the possibility of an urban fire of the scale of the fire following the Great Kanto Earthquake is also smaller. The scale of fires is also smaller compared to that time, and the danger of "giant" firestorms has also decreased. Nevertheless, even if it is not a giant firestorm, the occurrence of a firestorm as such is still quite conceivable, and large-scale damage is possible if a firestorm encourages the spread of a fire.

It is also possible that fires in urban areas may expand due to unforeseen conditions. In the future, together with further fireproofing, flame-resistance measures and earthquake-resistance measures for built-up urban areas, it will also be important to share the results of predictions of damage in urban fires and other disasters with residents, and to ensure their awareness of advance disaster prevention measures and early evacuation when a fire occurs. The Urban Planning Department is also conscious of the importance of these points, and would like to continue its research efforts and return the results to society.

☞For more information:

1) "Report of survey of fire damage of buildings, etc. by 2024 Noto Peninsula Earthquake (Quick report)"
https://www.nilim.go.jp/lab/bbg/saigai/R5/notojishin02.pdf

Initiative to Study Climate Change Adaptation Actions for Ports and Harbors

SAKAI Koji, Director, Port, Coastal and Marine Department

(Keywords) climate change, Technical Standards for Port and Harbor Facilities, advance adaptation actions, adjusting adaptation actions

1. Introduction

Climate change is a urgent global challenge, which requires concrete and concerted action. Port facilities in Japan are an essential infrastructure that supports people's lives and economic activities. Furthermore, being located on the waterfront, they are inevitably susceptible to the effects of changes in sea levels and ocean waves resulting from climate change. In consideration of the importance of port facilities, the Transport Policy Council released a report in August 2020 entitled "Future Direction for Comprehensive Disaster Prevention and Mitigation Measures for Ports which Combine Hard and Soft Measures." In the meantime, scientific insights on climate change have accumulated, as represented by the report "Climate Change in Japan 2020" released in December 2020 by the Japan Meteorological Agency and the Ministry of Education, Culture, Sports, Science and Technology. Against this backdrop, the "Technical Committee on Climate Change Adaptation Implementation for Ports and Harbors," which is chaired by Dr. ISOBE Masahiko, professor emeritus at Kochi University of Technology and the University of Tokyo, has been studying the implementation of measures to cope with climate change at port facilities. Following the deliberations of this committee, a partial revision is to be made in April 2024 on the Technical Standards for Port and Harbor Facilities to integrate adaptation measures to address climate change. This paper is intended to introduce adaptation measures for climate change at ports and harbors.

2. Assessment of climate change impact on high-water levels and ocean waves

(1) Growing severity of the impacts of climate change

In September 2021, the Intergovernmental Panel on Climate Change (IPCC) released a summary of its Sixth Assessment Report for policymakers. The report recognized that human activities had unequivocally caused the warming of air, ocean, and land areas, and it points out that even if net zero emissions is achieved in the future, further global warming is inevitable due to past greenhouse gas emissions. In particular, CO2 emissions are still rapidly increasing, and current progress and timeframes for achieving global net zero emissions are not clear. Therefore, countermeasures for climate change must include both mitigation and adaptation measures.

(2) Forecasts for high-water levels and ocean waves at port facilities which take into account the effects of climate change

Forecasts for high-water levels and ocean waves that take into account climate change are vital for designing adaptation measures at port facilities. To this end, prediction calculations for future climate patterns were made according to the two scenarios of global warming of 2°C and global warming of 4°C using the Database for Policy Decision-Making for Future Climate Change (d4PDF). The respective calculations were made according to the six cases of the model sea surface temperature (SST). The calculation method used an

empirical typhoon model that incorporated atmospheric pressure and wind velocity, with these two factors being corrected for pressure bias via a quantile mapping method. Based on these, a nonlinear long-wave equation was used to calculate high-water levels, and the third-generation wave model Wave Watch 3 was used to calculate ocean waves.

Figure 1 presents examples of probable sea level deviations under the present climate (past testing) and in the future (future testing) for Tokyo Bay in the warming scenario of 2°C (given as an average of the 6 SSTs).

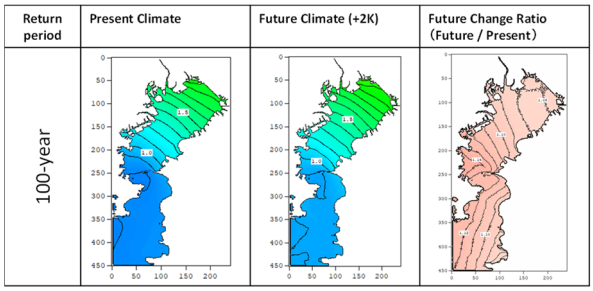


Fig. 1: Examples of probable sea level deviations (Tokyo Bay, under the 2°C warming case)

Calculations were also made for Ise Bay and Osaka Bay[1], to summarize the spatial average of the probability of sea level deviations in each sea area (see **Table 1**), and the probable wave height indicated as an average of representative points (see **Table 2**).

In addition to these sea areas, efforts are being made to calculate future change ratios for sea level deviations and wave heights for all sea areas in Japan. These results are to be released once they have been completed.

Table 1: Spatial average of future change ratio in sea level deviations

Bay	100-year Return Period			50-year Return Period
	Mean	10%tile	90%tile	Mean
Tokyo Bay	1.10	1.03	1.15	1.09
Ise Bay	1.07	1.03	1.10	1.03
Osaka Bay	1.06	0.99	1.13	1.05

Table 2: Future change ratio in wave heights indicated as an average of representative points

Bay	50-year Return Period		
	Mean	10%tile	90%tile
Tokyo Bay	1.02	0.98	1.06
Ise Bay	1.00	0.98	1.03
Osaka Bay	1.04	0.97	1.08

3. Partial revision of the Technical Standards for Port and Harbor Facilities

(1) Revision of notification

As climate change adaptation measures, the clause "in consideration of meteorological conditions and future prospects" for wind, sea levels and waves has been newly incorporated in the notification that specifies the details of the Technical Standards for Port and Harbor Facilities.

(2) Two approaches to ensure required performance

The Standards and Guide to the Standards propose two different approaches to ensure required performances[2] as a specific design approach for addressing the impacts of future climate change.

Conditions, including various water levels (such as average sea level and abnormal water level), high-water level, and residual water level, should be set in consideration of anticipated changes that may occur over time during the design working life of the facilities subject to the Technical Standards to ensure their required performance during their working life. Also, the facilities subject to the Technical Standards must be designed to factor in such changes so that they can fulfill their required performance during their design working life. In consideration of these requirements, "proactive adaptation measures," which address changes at an early stage of the design working life and "flexible adaptation measures," which address changes in a step by step manner within the design working life, have been presented as ways for handling anticipated temporal changes during the design working life. In applying adaptation measures to facilities subject to the Standard, or other port facilities, it is not the

case that only a single approach can be used. The two approaches can be applied in combination as needed, according to the usage situation and structural characteristics, etc., of each facility.

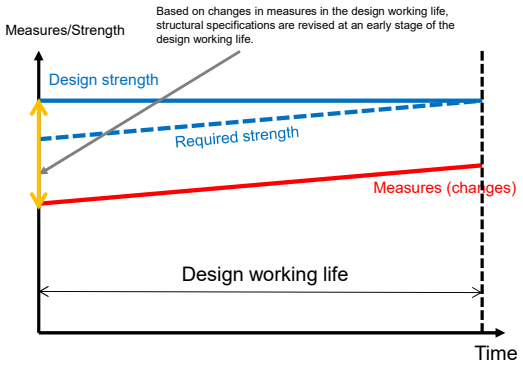


Fig. 2: Proactive adaptation measures

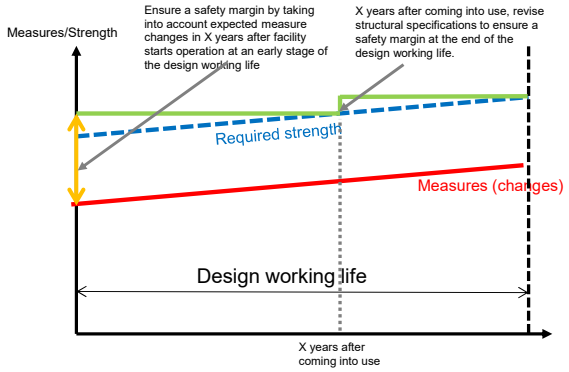


Fig. 3: Flexible adaptation measures

4. Conclusion

The 2024 fiscal year marks the first year of specific efforts being implemented to address climate change issues at ports and harbors. NILIM intends to properly address technical issues that are ports and harbors are being confronted with.

☞For more information:

1) Technical Note of NILIM, No. 1266, p 132
https://www.ysk.nilim.go.jp/kenkyuseika/pdf/ks1266.pdf
2) Technical Note of NILIM, No. 1281, p 24
https://www.ysk.nilim.go.jp/kenkyuseika/pdf/ks1281.pdf

On-site and Social Issues

Airport Department Director-General INOUE, Keiji

Keywords: Airports, Maintenance and management, Improved productivity, Inbound, Automation and labor saving, Noto Peninsula Earthquake

1. Introduction

Airports are essential and fundamental infrastructure that supports civic life and economic activity.

The major development of airports is said to be largely complete in Japan, but given strong inbound demand, etc., there is a need to strengthen the functions of airports in major metropolitan areas and regional hub airports, and the maintenance of previously developed facilities will also be an important issue.

Given recent social changes such as from labor shortages due to the declining birthrate, there is a need to address issues such as improving the efficiency and sophistication of airport facility construction and maintenance and management and increasing the productivity of airport operations.

The Airport Department has supported the planning, construction, maintenance and management of airports, through the development of methods for demand forecasting and project evaluation, the development of design and construction methods and the establishment of related standards, and the development of inspection systems and construction cost estimation systems, etc.

The Department will continue making efforts using the knowledge accumulated through activities so far, in order to resolve issues on site related to airport construction and maintenance and management, and social issues in light of recent circumstances.

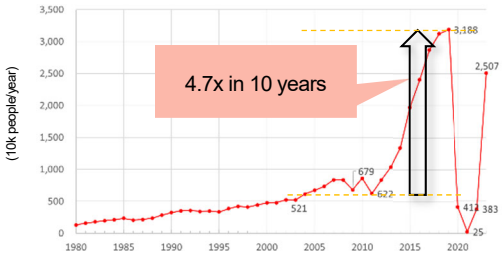
Here, some of these major initiatives will be introduced.

2. Development of Methods and Standards as a Basis for Airport Planning, Construction and Maintenance and Management

(1) Development and improvement of demand forecasting methods

Methods have been developed for the forecasting of air transportation demand (“NILIM Model”), contributing to the formulation of aviation/airport policy and airport planning, and this know-how has been broadly disseminated and the results of demand forecasts have been reported to the Aviation Subcommittee of the Transport Policy Council as needed.

Efforts are being made to improve methods to appropriately reflect social changes in recent years including increases in inbound demand, such as through modeling the trips of foreign visitors in Japan.



Increase in foreign visitors to Japan and Post-COVID-19 recovery

(Source: JNTO, “No. of Foreign Visitors to Japan”)

(2) Revision of airport facility design manuals, etc.

The Airport Department has been conducting research on technical standards for essential airport facilities (runways, taxiways and aprons) and the development of design manuals (pavement design, earthquake-resistant design, and structural design), etc.

Research is being conducted into needed revisions to

design manuals to contribute to the resolution of on-site problem in airport construction, maintenance and management.

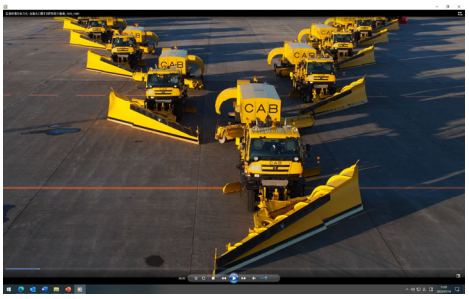
3. Initiatives for the Resolution of Various Issues

(1) Improvement of airport operation through the introduction of automated driving technologies

Research is being conducted to promote automation and labor-saving through the introduction of automated driving technologies for airport snow removal and GSE (ground support equipment: airport operation support vehicles).

Please see the NILIM YouTube channel for more information about research on airport snow removal vehicles.

https://www.nilim.go.jp/lab/bcg/nilim-youtube/index.html



From the NILIM YouTube channel
"Research on automation and labor-saving for airport snow removal vehicles"

(2) Improvement of the efficiency and productivity of airport construction and maintenance and management

Research will be conducted into the advancement of airport pavement survey and design methods from the perspective of preventing the sudden failure of airport pavement and improving the efficiency of nighttime construction, etc.

Efforts will also be advanced to standardize airport precast concrete structures (box culverts, pipes, etc.) and to build data platforms for the introduction of BIM/CIM.

(3) Support for airport construction, maintenance and management, and disaster response

Support is provided to resolve on-site issues based on knowledge of airport facility design and construction methods, in response to technical inquiries from construction, maintenance and management entities such as Regional Development Bureaus and Regional Civil Aviation Bureaus.

The Airport Department also prepared a draft "Manual for the Inspection and Emergency Restoration of Airport Pavements after Earthquakes," which was formulated by the Civil Aviation Bureau in March 2022, to support airport administrators in quickly determining whether runways, taxiways and other airport pavements can be used and considering emergency restoration methods in the event of an earthquake.

In addition, researchers are dispatched to local airports as needed in the event of an actual earthquake to provide technical knowledge and to support airport administrators in determining whether airports can be used and to provide support for emergency restoration work.

[Topic: Support for the restoration of the Noto Airport]

Following the recent Noto Peninsula Earthquake on January 1, 2024, two staff members, the Head of the Airport Facilities Division and a Senior Researcher, were dispatched to the site between January 6 and 9 to provide technical support to the airport administrator, Ishikawa Prefecture, for the early recovery of Noto Airport.

Thanks to strong efforts to carry out emergency restoration work under the unfavorable conditions in which access to the airport by car was poor, there was a lack of material supply for restoration works due to the damage to surrounding asphalt plants, and the need to remove accumulated snow by continuous fall, etc., takeoffs and landings resumed for Self-Defense Force fixed-wing aircraft on January 12, and for civilian aircraft on January 27.

Resumption of civilian aircraft operations at Noto Airport after emergency recovery work

4. Conclusion

When conducting the above research, it is required to foster a common understanding of issues by closely sharing information and exchanging opinions with relevant government agencies, airport administrators, other airport stakeholders and academics, etc. In addition it is necessary to understand and share information on the content of research on each issue and the division of roles among relevant parties, as well as the results of research and the path to implementation, etc., to ensure that results are implemented and new research topics are identified.

The Department will conduct and manage such research, based on the new Basic Airport Technology Plan formulated by the Civil Aviation Bureau.

The Department will also continue to actively participate in the activities of academic societies, develop research capabilities, including for paper-writing skills, and disseminate research results to the public.

☞ See here for more details

NILIM Airport Department website

https://www.ysk.nilim.go.jp/kenkyujosyoukai/kukou.html

Efforts of the Research Center for Infrastructure Management to promote DX and GX in the infrastructure sector

Naohiko Shioi, Director, Research Center for Infrastructure Management

Key words: DX, GX, BIM/CIM, ICT construction, CN, construction production process

1. Introduction

The Research Center for Infrastructure Management (hereinafter called the "Center") has been conducting research and development, as an organization that carries out research on all the construction production processes, including the design, construction, supervision and inspection, as well as maintenance and management up to renewal of social capital, the Center focuses on interdisciplinary matters while cooperating with relevant institutions.

In particular, in recent years, with the onset of a digital society, we have been preparing manuals for the purpose of a smooth introduction of ICT construction and BIM/CIM into the site. The Ministry of Land, Infrastructure, Transport and Tourism as a whole have been promoting efforts based on the "DX Action Plan in the Infrastructure Field". In addition, the NILIM has established the "Infrastructure Sector DX Promotion Headquarters" as an interdisciplinary organization, to help promote research and development.

2. Efforts related to BIM/CIM

(1) Enhancement of the utilization of 3-dimensional data

We have worked to introduce BIM/CIM as a 3-dimensional model to facilitate the sharing of information among the parties concerned over the entire project and to help increase the efficiency and sophistication of the construction production processes. The Center has been involved in the preparation of the "3-dimensional Model Deliverables Preparation Procedures (Plan)". Based on the fact that the application of BIM/CIM has been started as a standard for all the detailed designs and construction work of the projects implemented by MLIT since FY 2023, we will deal with the amendments of the standard procedures.

When exchanging 3-dimensional data between the provider and the receiving party, a "DX Data Center" has been built that functions to perform browsing and storage of data as well as preparation, editing. Its operation was started in January 2022. By utilizing a virtual PC server, the DX Data Center has a mechanism that can be used from a personal computer on which no dedicated software is installed, and we anticipate that 3-dimensional data will be utilized proactively among concerned parties.

(2) Efforts at the bidding and contractual stages

Including the viewpoints, that seek the smooth introduction of BIM/CIM the technical proposal and negotiation method (ECI method) is utilized at the bidding and contractual stages. As of January 2023, the method has been applied to 32 cases of construction work implemented by MLIT. It is a method, through the involvement of the construction executor from the design stage, that enables the smooth succession of data during the period from design to construction work, by making a detailed design of a 3-dimensional model according to the needs in each construction work step. The Center analyzes the effects and problems, etc. of this method, and is involved in the preparation of guidelines.

In addition, we are proceeding with the development of the next period cost estimation system, concerning the construction cost estimation. The system is being built such that the quantities are automatically calculated from the BIM/CIM data in the design stage, and the import of such data into the cost estimation system enables the construction work cost to be calculated efficiently (see Fig. 1).

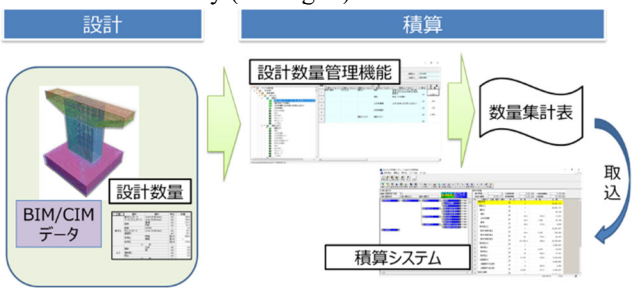


Fig. 1: Image of the next period cost estimation system

(3) MLIT Data Platform

The MLIT has made the "MLIT Data Platform" open to the public over the Internet since April 2020, aiming at increasing the efficiency of work and the advancement of MLIT measures, by integrating the data it possesses with the data of private entities. The platform enables various data to be downloaded through the same interface, such as information on social capital and basic construction work information, point group data, etc. It also enables the downloaded data to be displayed on a 3-dimensional map. The Center seeks to enhance data and to continually improve the operating functions. It believes that the platform will contribute to increased efficiency and the advancement of the construction production processes as well.

3. Efforts in the construction stage such as ICT construction

The number of cases of ICT construction in civil engineering work implemented by MLIT is increasing year after year, and in FY 2022 ICT construction is implemented in nearly 90% of the entire civil engineering work.

Also, the work time has been reduced by more than 30% owing to the ICT construction. In the future, we will endeavor to improve the standards such as procedures for as-built management, towards the goal of the further expansion of its use for small-scale construction types and construction work ordered by local governments.

In addition, as Stage II of the ICT construction (see Fig. 2), we are promoting the development and improvement of automation and remote control technologies for construction machinery.

We are promoting research that seeks to increase the efficiency of construction work plans, by grasping the situation of work based on the utilization data of construction machinery. We are promoting our efforts toward automation and autonomous construction work, by utilizing the "Construction DX Experimental Field" located in the NILIM as well as cooperating with the Public Works Research Institute.

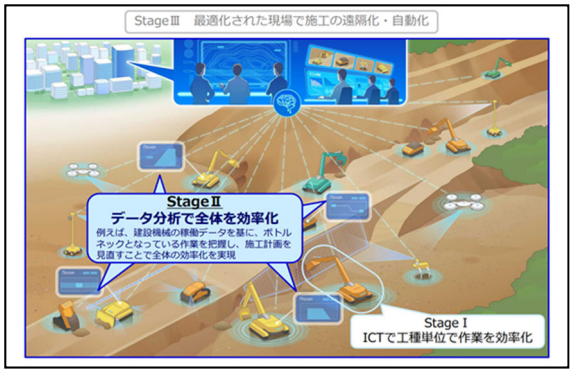


Fig. 2: Direction of ICT construction

4. Promotion of GX in the infrastructure field

The CO2 emissions in the construction work field are estimated to be about 1.4% of those in the industrial field and about 0.5% of those in Japan as a whole. Furthermore, if those in the supply chain are included, such as the emissions from construction materials and construction-related by products, the emissions from the construction field as a whole are estimated to be slightly more than 10% (see Fig. 3). Considering the declaration of carbon neutral in 2050, in an effort to reduce CO2 emissions in the construction field, and in order to promote technological development, that contributes to low carbonization, it is necessary to set evaluation criteria to ascertain the effects of such reduction. The Center is proceeding with the preparation of a CO2 emissions calculation manual in the construction work stage.

Also, as our efforts for GX Promotion, it is also necessary to evaluate the functions of green infrastructure. The Center has been conducting research on the evaluation method as well as the maintenance and management method for the greening of public roadsides, and will continue to conduct the research on road greening management, etc.

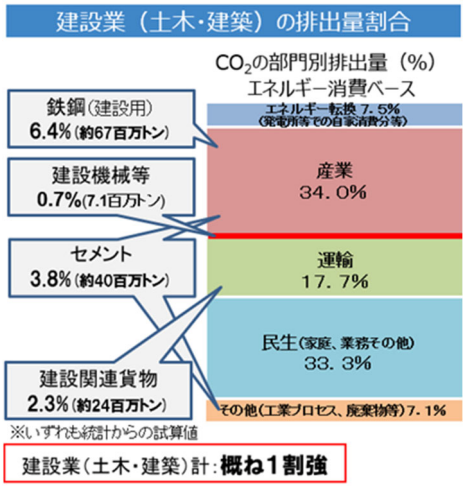


Fig. 3: Ratio of CO2 emissions from the construction industry

5. Conclusion

We consider that the construction production processes will be deployed including viewpoints, such as transformation into 3D as well as cost, process plan, and CN. To achieve this, the Center is determined to make continued efforts in the improvements of necessary standards and systems. However, the increase in efficiency and advancement of the processes and revision of the way work is carried out is indispensable. In the "DX Action Plan 2 in the Infrastructure Field" summarized by MLIT, as one of such approaches, the "accumulation and sharing of work reform" is advocated. We would like to endeavor to improve the environment as well so that the relevant personnel will be able to take such an approach with greater understanding and awareness.

Establishment of Support Center for Port and Harbor Advanced Information Technology

KOZAWA Keiji, Director, Support Center for Port and Harbor Advanced Information Technology

(Keywords) infrastructure DX, Cyber Port, improvement of productivity, informatization, computerization

1. Introduction

The Ports and Harbours Bureau of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), has been promoting Cyber Port[1] as one of its key policy measures. Cyber Port is an initiative that the government intends to improve and strengthen under government programs such as the comprehensive strategy for the Vision for a Digital Garden City Nation. Cyber Port is a data platform to integrally handle information by computerizing and linking data. Relevant information includes port logistics procedures between private entities; administrative procedures followed by port managers; investigation and statistical services; and information on infrastructure across every stage of its life, from port planning to maintenance and management. This platform is aimed at achieving a remarkable improvement in productivity for Japan's port sector, and the establishment of a business environment where information relevant to ports and harbors is organically connected.

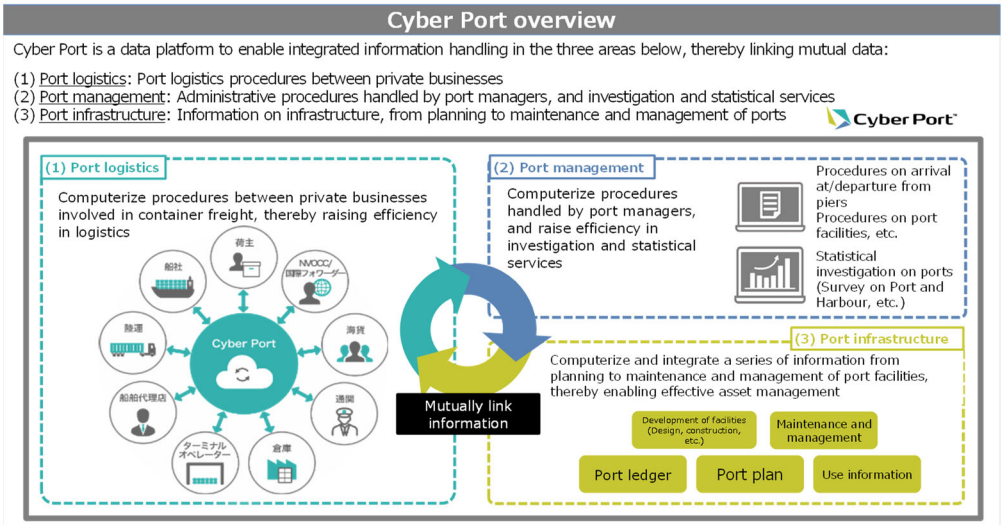


Fig. 1 Outline of the Cyber Port program

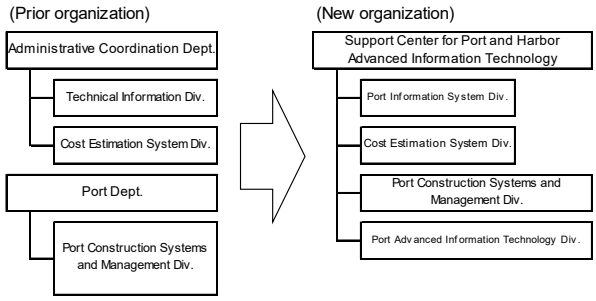


Fig. 2 Organization of Support Center for Port and Harbor Advanced Information Technology

This platform particularly emphasizes the use of ICT technologies at port construction sites and the promotion of i-Construction[2] through the introduction of 3D data, etc., to enhance port productivity development programs. These efforts are being made as a way to accelerate infrastructure DX as established in the Basic Policy on Economic and Fiscal Management and Reform 2023.

As one of the initiatives to strengthen organizational structures to implement these key measures, the Support Center for Port and Harbor Advanced Information Technology was established by the National Institute for Land and Infrastructure Management in April 2023. The Center was established by reorganizing part of the

functions of the existing Administrative Coordination Department and Port Department. With a focus on specific areas of research and development policies based on key policy measures, the Center is operated in line with a business promotion policy that takes into consideration characteristics of the business support system to promote key policy measures.

Even though each division of the Center has taken over tasks from prior organizations to a certain extent, the Center has gradually begun to make its own achievements. These achievements include consideration and preparation of draft implementation plans for introducing new technologies; putting into operation a new business support system; enhancing functions and data thereof and other activities. The Center will remain engaged in research and development and supporting tasks in close cooperation with the MLIT and the Port and Airport Research Institute, as well as in collaboration with each Regional Development Bureau, port managers, business entities related to the port sector, and other stakeholders in order to pursue the goal of promoting key policy measures to improve productivity in the port sector, and of applying research results and business achievements to society.

This paper introduces the focal points of the aforementioned research and development policy, as well as an overview of the business promotion policy.

2. Focal points of research and development policy

(1) Infrastructure DX

In the field of infrastructure DX, intensive efforts have been made systematically to work on technological verification for the adoption of new technologies which are needed to enable the use of ICT technologies in the port sector. More specifically, based on a roadmap[3] created by the Ports and Harbours Bureau (MLIT), with the prerequisite of implementing testing work, on-site verification tests are being conducted to examine the effectiveness of new technologies. The results of these verification tests are being reflected in testing operating plans in sequence[4].

Fig. 3 Cyber Port web portal

In addition, in considering ICT technologies in the port sector there is a need for access to 3D data at work sites in order to achieve automatic and independent construction by work vessels. Against this backdrop, we are implementing research and development into the latest technological trends in 3D data, including supporting the establishment and introduction of BIM/CIM in the port sector.

(2) Cyber Port

Cyber Port aims to upgrade asset management[1] to ensure functional and efficient maintenance, management, and protection of port and coastal facilities through data linkage attained via the integrated operation of logistics, management, and infrastructure field in the port sector. We have been conducting research and development tasks to maintain, manage, and protect facilities using a more sophisticated methods than those used conventionally.

3. Business promotion policy

In collaboration with the Ports and Harbours Bureau of MLIT, NILIM has been engaged in the establishment, improvement, operation, and maintenance of Port CALS[5], a cost estimation support system, and other programs. We take these initiatives in response to the computerization and informatization of operations related to port and coastal facilities development projects undertaken by regional development bureaus of MLIT. NILIM has been continuously working on updating systems as needed and enhancing their functions to improve efficiency.

In addition, Port CALS has built and is operating a

maintenance management information database that adds maintenance and management information to an integrated port facility database as a measure for upgrading facility maintenance, management, and protection. In this manner, the Port CALS provides business support for relevant port managers and private entities.

Furthermore, on the premise that a systemic link will be established between these business support systems, NILIM has been focusing on the creation, operation, and maintenance of Cyber Port in collaboration with the Ports and Harbours Bureau of MLIT. In addition to MLIT officials, a wide variety of parties are expected as potential Cyber Port users, including port and facility managers, research institutes, construction companies, port logistics businesses, and the general public. NILIM therefore has been making efforts to further enhance the credibility and stability of the system, and to maintain and advance security measures.

4. Conclusion

We will be continuously engaged in research and development and undertake related tasks to steadily apply various technologies and methodologies to society. We intend to proceed with these tasks on the basis of the latest developments in information technology and practical business operation, thereby aiming to remain responsive to the requirements from organizations and business entities in the field of the infrastructure DX or related to the Cyber Port policies.

☞**See here for detailed information**

1) Cyber Port
https://www.mlit.go.jp/kowan/kowan_00002.htm2)
2) i-Construction in ports and harbors
https://www.mlit.go.jp/kowan/kowan_fr5_000061.html
3) A material from the 8th meeting of the i-Construction Promotion Committee for Ports, P8
https://www.mlit.go.jp/kowan/content/04_shiryou.pdf
4) Research on the advancement of infrastructure DX, NILIM report 2024, p*
5) Port CALS (Construction Acquisition Life-cycle Support)
https://www.ysk.nilim.go.jp/cals/index.htm

Considering a Coastal Dike Structure Resistant to High Waves
– Toward Implementation at Actual Sites –

(Research period: FY 2021 – FY 2023)

River Department, Coast Division

Researcher (Ph.D. in Eng.) FUKUHARA Naoki Senior Researcher HIMENO Kazuki Head (Ph.D. in Eng.) KATO Fuminori

(Keywords) coastal dike, high waves, resilient structure, scouring

1. Background and Purpose of Research

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is promoting improvement of coastal dikes and other facilities to a structure (resilient structure) that reduces damage even in the event of a tsunami or waves exceeding the planned scale. Since an early date, NILIM has carried out studies on resilient structures for waves that exceed the design wave, and confirmed the effectiveness of multiple improvement methods by small-scale experiments in the past. However, concrete design methods (e.g., a method for setting the embedded length of steel sheet piles, etc.) are needed for implementation at actual sites. In the research described here, we conducted a large-scale hydraulic model experiment to clarify the process from scouring of the front (seaward) side of a dike until failure and the relationship between the scour depth and the necessary embedded length of steel sheet piles, whose effectiveness was confirmed in the past small-scale experiments, and also confirmed the estimation accuracy of the scour depth obtained using a calculation model.

2. Large-Scale Hydraulic Model Experiment

In this research, we conducted a large-scale hydraulic model experiment (**Fig.-1**) [1], in which waves acted on a model of a coastal dike, and confirmed the process by which the function of the dike was reduced and lost as a result of wave overtopping, and also acquired data on the scour depth and scour profile on the seaward side of the dike. As a result, it was found that the backflow of withdrawing waves that have run up on the outer slope shielding on the seaward slope of the dike generates a vortex on the front side of the dike, and scouring proceeds because that vortex picks up the sand in front of the dike (**Photo-1**).

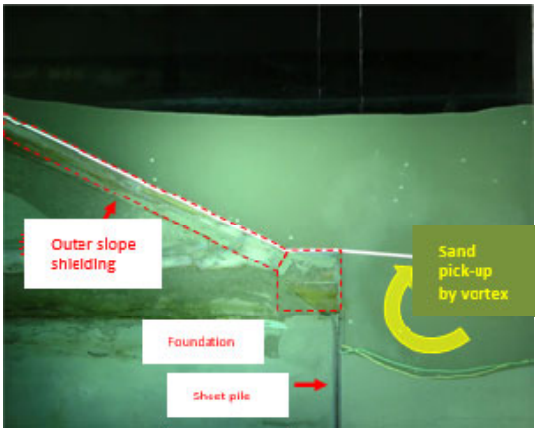


Photo-1 Condition of scouring at seaward side of dike

If scouring proceeds, it was also found that a crevice forms between the crown shielding and the outer slope shielding (**Fig.-2**). In this case, water penetrates from that crevice and causes large-scale deformation of the structure within a short time, and the dike transitions to a state in which it cannot maintain its function.

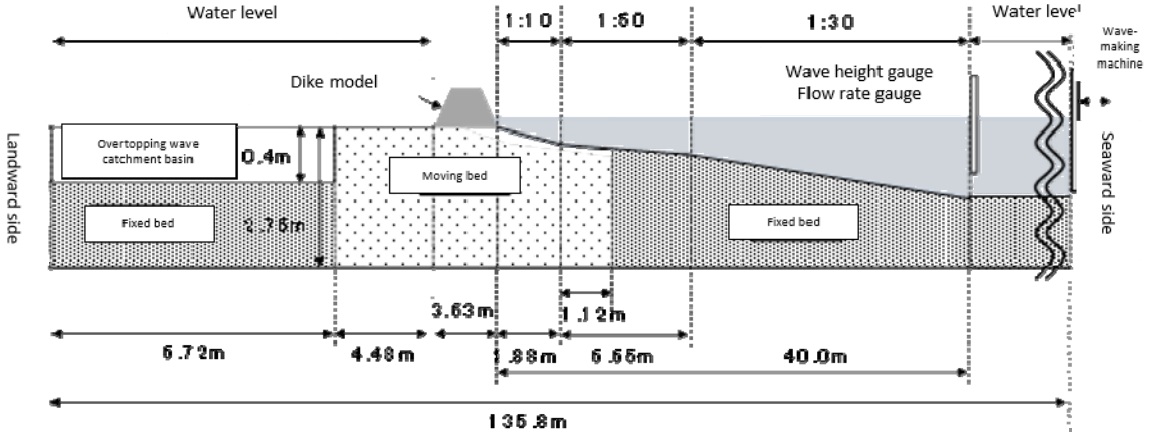


Fig.-1 Water channel and topographical conditions of large-scale hydraulic model experiment

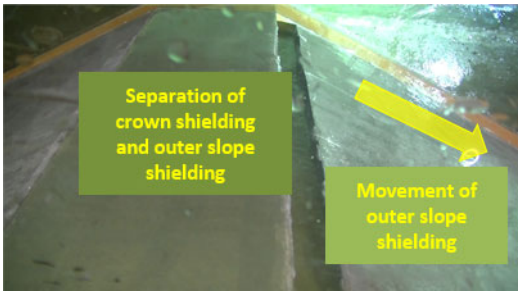


Photo-2 Crevice between crown shielding and outer slope shielding

Since the large-scale hydraulic model experiment confirmed that the main cause of failure of coastal dikes is scouring of the seaward side of the dike, an understanding of the scour depth on the dike front side is considered essential for the implementation of resilient coastal dikes at actual sites. However, there are limitations on large-scale hydraulic model experiments due to the constraints of cost and time, and no technique for estimating the scour depth at the front side of dikes has been established. Therefore, for implementation at actual sites, it is necessary to develop a technique that enables easy estimation of the scour depth in the field by a calculation model or a simple formula.

3. Estimation of Scour Depth by Calculation Model

Based on the situation in 2., the key point for resilient structures is the scour depth at the front side of a dike. Therefore, a model [2] for calculating the scour depth at the front side of a dike was studied. **Fig.-2** shows the velocity vector during wave-making obtained by the calculation model, and **Fig.-3** shows the overlay of the large-scale hydraulic model experiment and the waveform at the dike front side after wave-making. These results confirmed that the model is capable of reproducing the vortex which is the primary factor in the progress of scouring at the dike front side. Although it was not possible to reproduce the sediment zone at distances of more than 1 meter from the dike, the difference between the maximum scour depth in the experiment and the calculation was less than 3 cm, indicating that the scouring that occurs at the dike front side can be roughly reproduced by the model.

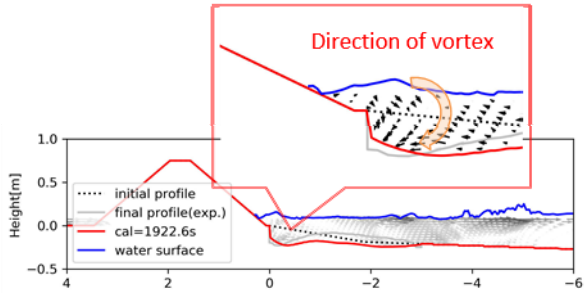


Fig.-2 Example of reproduction by calculation

4. Future Development

If the calculation model that successfully reproduced the large-scale hydraulic model experiment can be constructed, application to diverse bottom sediment conditions and dike structures will be possible, and it will become possible to design resilient structures for coastal dikes with various coastal conditions. At present, the model has only been verified in experiments under limited conditions, but in the future, we intend to confirm its validity through large-scale hydraulic model experiments to examine the effects of differences in the sediment particle size and type of dike structure on the condition of scouring, carry out a study on methods for setting the parameters of the calculation model, and confirm its reproducibility as research toward the implementation of resilient coastal dikes throughout Japan.

☞For more information:

1) Fukuhara, Himeno, Kato et al.: Experimental Study on Resilient Structures Using Steel Sheet-Pile for Coastal Dikes Against Unexpected High Waves, Journal of the Japan Society of Civil Engineers, Vol. 79 No. 17, 23-17128, 2023.

2) Tomoaki Nakamura and Norimi Mizutani: Numerical Analysis of Tsunami Overflow Over a Coastal Dike and Local Scouring at the Toe of its Landward Slope, Journal of the Japan Society of Civil Engineers Ser. B3 (Ocean Engineering), Vol. 70, No. 2, I_516-I_521, 2014.

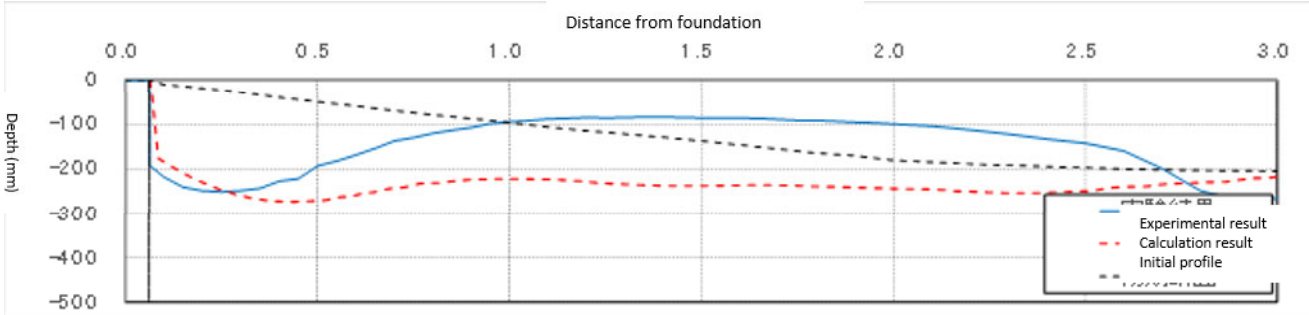


Fig.-3 Results of topographical change in large-scale hydraulic model experiment (solid blue line) and calculation (dotted red line)

Study on a Technique for Analysis of the Spatiotemporal Distribution of Rainfall in Flood Control Planning Based on Climate Change

(Research period: FY 2022 -)

River Department, Water Cycle Division

Senior Researcher YAMAJI Hideyuki Head (Ph.D. in Eng.) TAKESHITA Tetsuya

(Keywords) climate change, flood control planning, self-organizing map, pattern classification

1. Introduction

Based on concern that increased rainfall due to the effects of climate change may cause increase of rainfall and intensification of flood damage, NILIM calculated the ratio of rainfall under the present climate and future climate (hereinafter, the rate of change in heavy rainfall intensity [1]) using ensemble climate prediction data as 1.1 (1.15 in Hokkaido) at a 2 °C temperature rise. This value was used in the revision of the MLIT's Basic River Management Policy.

The rate of change in heavy rainfall intensity is an index that focuses on the total amount of rainfall in 1 rainfall event. However, even if the total amount of rainfall is approximately the same, there is concern that it may cause larger flooding damage in large rivers, along tributaries and in downstream flood plain areas, depending on the spatiotemporal distribution of the rainfall in cases such as concentrated rain in a short period or local concentrated rain. Moreover, because the spatiotemporal distribution of rainfall experienced in the past will not necessarily be the same in the future climate, work to compare the actual rainfall data from the past and the ensemble climate prediction data and confirm various spatiotemporal distributions of rainfall was carried out in the above-mentioned revision of the Basic River Management Policy. Nevertheless, analysis of the enormous volume of rainfall data in terms of the three dimensions of temporal changes, spatial changes and changes in total rainfall has resulted in an increased degree of difficulty in the work of studying flood control planning in the Basic River Management Policy, etc. In addition, from the viewpoint of river basin flood control, disaster prevention urban planning, etc., including measures to prevent outflow from rice field dams, etc. and land use, is being studied for a range of rainfall events from high frequency to low frequency, but in this, it is important to understand the future changes in the spatiotemporal distribution in the entire basin, and not simply in rivers.

Against this backdrop, in this research, pattern classification by self-organizing maps was carried out using the ensemble climate prediction data [2] (**Table-1**) in order to grasp the future changes in the spatiotemporal distribution of rainfall.

Table-1 Ensemble climate prediction database

Data name	Yesrs	No. of members	Sea surface water temp.	Time resolution	Space resolution
Past experiment	31 years	12	1 pattern	1 hr	5 km
2 ℃ temp. rise experiment	31 years	2	6 pattern	1 hr	5 km

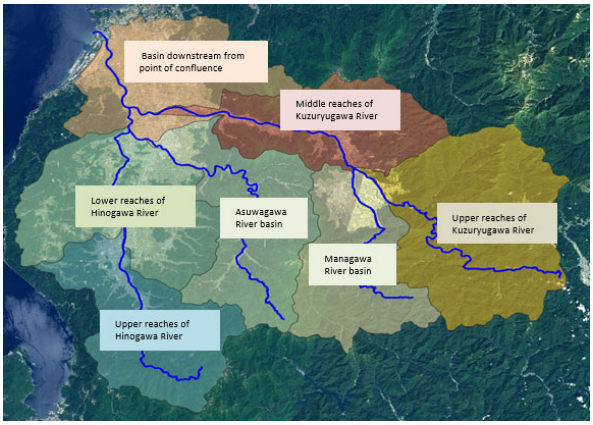


Fig.-1 Kuzuryu River Basin

2. Pattern Classification by Self-Organized Map

Self-organized maps are one type of machine learning which has many examples of use as a classification method for weather patterns and can map high-dimensional data on low-dimensional space. In this research, we extracted rainfall events that cause the annual maximum basin average rainfall for the present climate and future climate, and visualized and classified the spatiotemporal distribution (3-dimensional data of time x space x amount of rainfall) of each of the rainfall events on a 2-dimensional space.

The target was the Kuzuryu River basin shown in **Fig.-1**. The results of pattern classification of the spatiotemporal distribution of rainfall in the present climate are shown in **Fig.-2**. **Fig.-2** shows the "time-series diagrams of the average rainfall in the basin" (left) as diagrams showing the temporal distribution of the rainfall events, and "average value diagrams of the cumulative rainfall for each middle reaches of the basin"

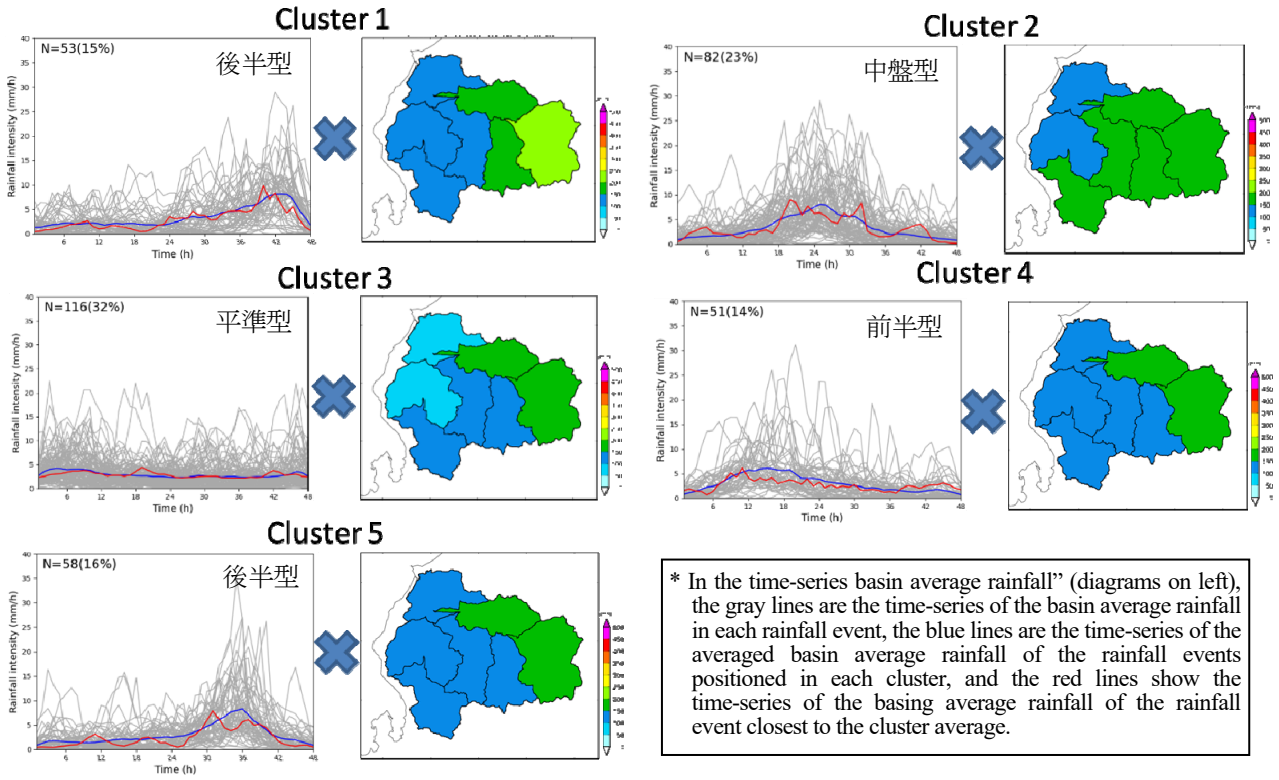


Fig.-2 Results of pattern classification of the spatiotemporal distribution of rainfall (present climate)

Table-2 Rainfall patterns of each cluster, number of rainfall events, and percentage of the total (present climate)

Cluster	Rainfall pattern (temporal direction x spatial direction)	No.	%
1	Later period x Main river upstream	53	15%
2	Middle period x Main river/tributary upper reaches	82	23%
3	Level x Main river middle reaches	116	32%
4	Early period x Main river/middle reaches	51	14%
5	Later period x Main river/middle reaches	58	16%

Table-3 Rainfall patterns of each cluster, number of rainfall events, and percentage of the total (future climate)

Cluster	Rainfall pattern (temporal direction x spatial direction)	No.	%
1	Later period x Main river upstream	106	29%
2	Middle period x Main river/tributary upper reaches	86	24%
3	Level x Main river middle reaches	89	25%
4	Middle period x Main river upper reaches	79	22%

(right) as diagrams show the spatial distribution of the rainfall events. However, it can be understood that the rainfall events have been classified into 5 patterns with similar temporal or spatial ch aracteristics.

Table-2 and **Table-3** show the results when percentage in the total of the rainfall patterns, number of rainfall events and percentage in total under the present and future climates were arranged in each cluster. Looking at these two tables, it was found that the rainfall pattern of the "latter period type x river upstream type" (Cluster 1), in which a large amount of rain falls in the Kuzuryu River Basin in the latter part of rainfall events, shows an increasing tendency from the present climate to the future climate.

3. Conclusion

In the future, we plan to analyze the spatiotemporal distribution of rainfall of other river systems with different basin characteristics by the technique described here as part of a study of possibility of applying this technique and methods for improvement.

☞For more information:

1) TECHNICAL NOTE of the National Institute for Land and Infrastructure Management No. 1205, Technical Note on the Rate of Change in Heavy Rainfall Intensity for Flood Control Planning to Cope with Climate Change
https://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1205.htm

2) Social Implementation of Climate Change Adaptation Technology Program (SI-CAT)
https://www.restec.or.jp/si-cat/_public/202003b/SI-CAT%20DDS5TK%E6%A6%82%E8%A6%81_200228.pdf

Toward Social Implementation of DX for Flood Disaster Prevention Activities

(Research period: FY 2020 –)

River Department, Flood Disaster Prevention Division

Chief Researcher YUASA Ryu Researcher EBIHARA Yuki Head TAKEUCHI Yoshinori

(Keywords) support for flood disaster prevention activities, DX, social implementation

1. Background of Research

As of April 2023, Flood Prevention Groups had a total membership of approximately 765,000 persons, or about 60 % of the number of approximately 1.22 million in 1971. The increasing age of the members is also a serious issue, and in particular, about half of the full-time members are 60 years old or over.

On the other hand, flood damage has intensified in recent years, the role of Flood Prevention Groups organized in local communities in reducing that damage is becoming increasingly important.

Under these difficult social conditions, the Flood Disaster Prevention Division conducted interviews with Flood Prevention Groups throughout Japan to understand the problems they are facing and study support measures for achieving higher efficiency in their activities. Based on the interview results, we arranged the issues as follows, focusing especially on “exchanges of information.”

1)Coping with a huge volume of information (higher efficiency in information processing)

Because the flood disaster prevention activities that must be carried out in times of disaster are diverse and the location of activities has a wide spatiotemporal range, there were numerous opinions that excessive time is required to process diverse information because it is necessary to judge which activities are to be carried out next.

2)Speeding up individual information transmission

Although there are also some Flood Prevention Groups that use SNS message transmission functions for mutual contact within the group, many groups use telephone or wireless communication networks. Many expressed the opinion that transmission of status reports and instructions by telephone or wireless communications requires excessive time.

3)Centralized aggregation of information

Information on water levels, the amount of rainfall, etc. is necessary for understanding the situation and making judgments about instructions. However, because those various types of information are posted on separate websites, the task of switching between various websites and comparing information is a factor in the excess time required to collection information.

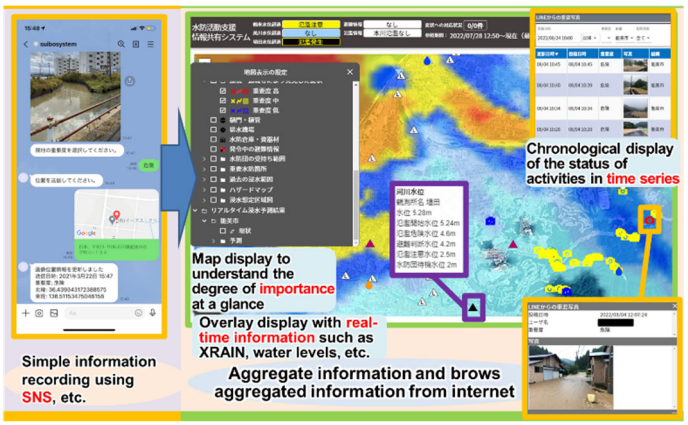


Fig.-1 Overview of the system

2. Overview of the Developed System

As a response to the issues arranged in the previous section, incorporation of ICT technology, which enables real-time, centralized aggregation and sharing of various types of information collected by those involved in diverse activities in the existing flood disaster prevention activities was considered effective. Therefore, in FY 2020, we constructed a “Flood disaster prevention activity support information sharing system” (hereinafter, “the system”). An overview of the system is shown in **Fig.-1**. The system can be broadly divided into the following functions.

1) Simple information recording using SNS

Simple recording and reporting of the condition at the site to the system in a dialogue format is possible from the SNS (LINE©) screen. Recorded information can also be browsed by Flood Prevention Groups and related organizations from the system website.

2) Map display to understand high-importance locations at a glance

It is possible to display reported information on a map on the system website and instantly share it with related organizations. Since screening and selection of information is easy, this function is expected to result in improved efficiency when processing large volumes of information.

3) Concentrated display of information necessary in flood disaster prevention activities on map

Dynamic information such as the condition of rain

(XRAIN), the level of rivers, etc. and static information such as the range of inundation in the past and critical

locations for flood disaster, which have been recorded in advance, can be displayed overlaid on maps. Centralized aggregation of the information necessary for flood disaster preventions is possible on the system screen.

Photo-1 Condition of demonstration experiment

3. Knowledge Gained from Demonstration Experiments

To verify the effectiveness of the developed system, demonstration experiments were carried out by 7 local governments over a 3-year period from FY 2021 to FY 2023 (**Photo-1**), and many opinions were obtained (**Table-1**). Based on these opinions, the functions of the system are being improved each year. **Table-1** also shows examples of the functions implemented to reflect opinions up to the present.

Thus, while continuing to reflect the opinions from the field in the functions of the system, we gained the following knowledge through this 3-year demonstration experiment.

1) Depending on the area, the information required in flood disaster prevention activities and the perspective on information and the content of activities differ, and various functions are required in the system.

2) For that reason, it is estimated that aiming at an all-purpose system that can be used in all regions has the opposite effect of making the system more complicated and difficult to use.

3) Based on the above, a combination of a basic system, which enables information transmission of items that are essential regardless of the region, and compatible supplementary packages suited to the way the system is used, corresponding to the region, is an effective approach. In addition, study of concrete methods of using the system and scenes of use, including its relationship with the existing telecommunication methods that are widely used in each region, is an important issue when envisioning future social implementation.

Where these points are concerned, further arrangement of the characteristics of each region, based on demonstration experiments in other regions, is demanded.

Table-1 Representative opinions and examples of functional improvement

Opinions on improvement	Improvements based on opinions
• In case inundation extends over a large area or scattered abnormalities exist in a series of districts, it should be possible to report for certain designated areas, and not a single point.	• The system was improved to allow reporting about locations not only as "points," but also as "areas" and "lines."
• To accumulate response histories of single disaster locations i.e., "Report"⇒ "Judgment/instructions"⇒"Start of countermeasures"⇒"Completion of countermeasures," it should be possible to arrange the condition of response at each location following the time series.	• A time-series aggregation function was added.
• In flood disaster prevention measurements, a large amount of information is recorded, so important information may be buried. This should be avoided.	• A function to prevent overlooking newly arrived information was added. • Function for changing the degree of importance.
• The large number of buttons on the screen makes it difficult to understand what I can do by pushing what button. Even assuming the system has many functions, it's meaningless if they are hard to understand.	• The menu composition was simplified.
• It should be possible to reload the information being displayed with the latest information at an optional timing.	• An update button was added.

4. Initiatives for Social Implementation

These initiatives using the system can be arranged with the following positioning.

The first is reducing the flood damage in the areas where activities of Flood Prevention Groups are carried out by making those activities more efficient. The second is stimulating to desire to conduct software development by the private sector related to support for flood disaster prevention activities. Although information sharing had not attracted attention until now, private-sector software development could be stimulated by identifying the needs in the field for information sharing support for flood disaster prevention activities by experiments, etc. using the system, and presenting those needs to society. This is expected to enable a free selection of software that suits the needs of each area by making software with various distinctive features available to the public.

The conceivable means for achieving the goals outlined above are considered to include ① Determining needs through demonstration experiments, etc. and presenting the functions required in the system in a collection of cases studies, guidelines or the like, so that they function as requirements based on the needs of the field in software development by private-sector companies, and ② Returning the know-how of system development and improvement widely to society by making the system available as open-source software, tie-ups between private companies and local governments, etc. In the future, the Flood Disaster Prevention Division will study the optimum measures for achieving this.

☞ For more information:

1) "Flood Disaster Prevention Support Information Sharing System" Wins the 24th Infrastructure Technology Development Award" (JICE/CDIT)
https://www.nilim.go.jp/lab/bbg/20220803_JICEhyousyou.pdf

Study on Method for Prediction of Sediment Yield during Torrential Rain by Physical Model

(Research period: FY 2022 – FY 2023)

Sabo Department, Sabo Planning Division

Head (Ph.D. in Agricultural Science) YAMAKOSHI Takao, Senior Researcher TANAKA Yasutaka, Guest Research Engineer YOSHIDA Takumi

(Keywords) sediment and flood damage, numerical simulation, prediction of sediment yield

1. Introduction

MLIT has promoted research on prediction of areas at risk of surface collapse by physical models. It is considered possible to predict the amount of sediment yield necessary in sabo projects by using a technology for identifying slopes at risk of surface collapse called H-SLIDER ("Hillslope scale shallow landslide-induced debris flow risk evaluation method"). Therefore, the amount of sediment yield predicted by the physical model and the sediment yield actually produced by ground surface collapses during the Heavy Rain Event of July 2018 were compared, and the usefulness of prediction of sediment yield by the physical model was examined.

2. Method

The object of this study was four river basin areas (Fuchuokawa, Misoogawa, Hatakakagawa and Yaguchigawa Rivers) in the eastern part of Hiroshima City where collapses occurred as a result of the torrential rain in July 2018. Slopes at risk of surface collapse were identified by using H-SLIDER, and the existing results of soil tests and cone penetration tests were used as parameters of the calculations. For the amount of rainfall, the X-band radar rainfall amount was given as the input condition. Rainfall was also given by probability scale, and the reproducibility of sediment yield in small river basin units and the characteristics of increased sediment yield by rainfall scale were arranged.

3. Results and Discussion

In the case of secondary watersheds, when the physical model and actual data were compared, sediment yields of approximately the same order were estimated by the model. However, it cannot be said that compatibility in calculation mesh units was satisfactory.

When rainfall was given by probability scale, the results of the sediment yield generated by surface failure changed corresponding to the scale of rainfall. Because this was an estimate by a physical model, and not an empirical formula, the technique used in this study is considered to be effective for analyzing the impacts of climate change in the future. In addition, these results showed a tendency to reach a peak. In case a physical model is used, it is suggested that the upper limit value of sediment yield is decided by the distribution of site conditions such as the thickness of the soil layer, etc., even if the amount of rainfall increases. This indicates that is also necessary to take site conditions into account when considering the increase in sediment yield due to climate change.

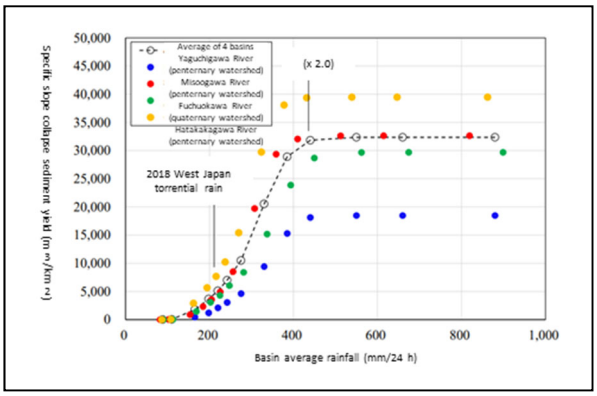


Fig. Relationship of cumulative rainfall and specific slope collapse sediment yield

4. Conclusion

Although the possibility of predicting sediment yield by the physical model also depends on the accuracy of estimations of the distribution of site conditions in the target river basin, this research confirmed the possibility of such predictions. Issues for the future include improvement of accuracy in setting site conditions and the possibility of application when drafting sabo plans.

☞For more information:

1) TECHNICAL NOTE of the National Institute for Land and Infrastructure Management No. 1048
https://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1048.htm

Estimation of Rainfall Amount from Images Toward Strengthening River Basin Monitoring

(Research period: FY 2020 – FY 2022)

Sabo Department, Sediment Disaster Risk Management Division (Sabo Risk-Management Division)

Head TAKIGUCHI Shigetaka Senior Researcher (Ph.D. in Environmental Science) KANAZAWA Akito

(Keywords) river basin monitoring technology, rainfall intensity, image analysis

1. Introduction

In order to construct an effective warning and evacuation system for sediment disasters, it is important to monitor the condition of mountain river basins, which are sites where slope failure, mudslides and other sediment movement phenomena occur. Because interval cameras, which are installed outdoors to monitor the surrounding area, can be obtained at a comparatively low cost, in recent years, research has been carried out in an attempt to detect changes in the flow condition of rivers and rainfall, and to detect sediment movement by analyzing images obtained by interval cameras. NILIM is studying a technology for the estimated amount of rain in mountain river basins by analyzing images obtained by interval cameras by image processing technology.

2. Study of Technology for Estimating Rainfall Amount from Images

Images acquired during rainfall have features which are different from those taken when it is not raining. For example, the background appears whitish and hazy, and white lines which are the tracks of raindrops are superimposed on the background.

The characteristics that appear in images taken during rainfall also change depending on the intensity of the rain. Therefore, in this research, we examined a technology for estimating the amount of rainfall from the degree of haziness that appears in images by quantifying the haziness of the background. In this study, 3 interval cameras (A, B, C) were installed at observation points in a mountain river basin, and image processing was performed using the images captured by the cameras. As the degree of white haze, here, transmittance, which expresses the degree of transmission of light in the atmosphere, was used as an index, and was calculated by an image processing program. The results of estimations of rainfall intensity using the transmittance showed similar intensities and time-series changes to those observed with tipping-bucket rain gauges installed at the same points (**Fig.-1**), demonstrating the possibility of estimating the amount of rain by using images captured with cameras.

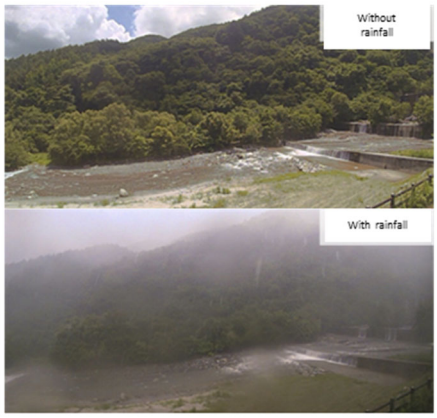


Photo-1 Example of images without and with rainfall

3. Conclusions

This study is still in the initial stage, and errors caused by various factors have also been discovered in the estimated values. Therefore, in the future, we will work to improve estimation accuracy, for example, by factor analysis, etc.

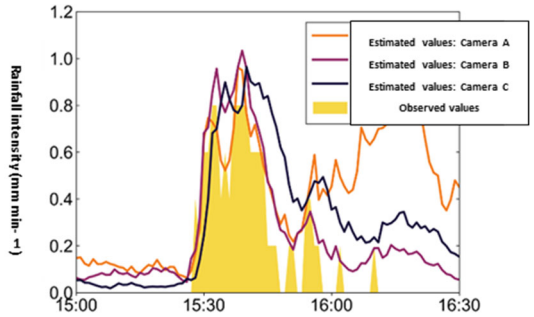


Fig.-1 Time-series fluctuations of estimated values and observed values of rainfall intensity

Analysis of the features of rust on weathering steel by means of AI

(Research period: FY 2023)

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Road Structures Department, Bridge and Structures Division

Key words: AI, weathering steel, life extension of road bridges

1. Introduction

Weathering steel is a steel made by adding alloy elements to an ordinary steel, thereby forming a minute rust layer (called protective rust) on the surface of the steel and suppressing the progression of rust thereafter, to suppress the amount of decrease of the plate thickness during a long period. It is widely used in the construction of road bridges as well, and depending on the conditions of bridge construction, a reduction of the life cycle cost is expected by implementing maintenance and management appropriately.

However, in cases where the steel is put in a wet state, or the like, no minute rust is formed, and flaky rust (E) and swelling and laminated layers of rust (F) occur as shown in Photo 1, and the progression of rust is not suppressed. Even if the rust does not become flaky, protective rust may remain in an ungrown state for a long period in some cases, and attention needs to be paid to the maintenance and management in such a case as well. Therefore, during inspection, etc., the minuteness of rust and the speed of corrosion should be distinguished from appearance to a certain extent. Therefore, in this study, it was investigated first based on what kinds of features AI grasps the appearance of rust, by making AI learn the images of multiple types of rust using the AI technology that is widely used in the classification of images. As compared to the observation of rust by a human and the consideration of its features, AI might characterize the appearance of rust from different viewpoints, and the classification of rust obtained as a result of such characterization may also provide more appropriate association with the speed of corrosion. The investigation was carried out in anticipation of such possibility.

2. Classification of rust that is used in current inspection

Studies that classify the features of rust from appearance and provide association with the speed of corrosion thereafter have also been conducted heretofore, and the results of such studies are used in actual inspection as well. It is stated that the condition of rust can be evaluated in 3 to 7 stages, by focusing on the fact that there are differences in rust particle size and differences in color tone and color unevenness according to the minuteness of rust. However, the ways of occurrence of individual types of rust on weathering steel that is used under various conditions are actually varied. Therefore, in this study, the features of the appearance of rust will be classified by the deep learning model based on the architecture called the Residual Network (ResNet).

Photo 1: Types of rust

3. Classification of images by means of AI technology

The deep learning model enables, when an image has been given, the features of such image to be learnt, to be extracted, and classification to be done based on the extracted features. The images of the appearance of rust to be learnt by the model are the 120 sets of anaglyph images contained in Technical Note of NILIM No.828[1)]. An anaglyph image is to produce a stereoscopic effect when viewed with glasses pasted with a red film on the left and a blue film on the right, and is a two-dimensional image in which the dents and projections as well as height of rust are reflected. Making the model learn a simple photo may also be acceptable on the precondition that the features of rust shall be capable of being classified properly by the particle size and color tone. However, in this study, from the standpoint that there could be useful appearance information besides the particle size and color tone, it has been determined that images in which information on three-dimensional shape is also reflected shall be learnt by the model.

4. Results

Firstly, AI was made to learn an image data set and the results of classification by a human in the existing method of classification (7 stages) for each image. It is

the so-called learning with teachers. Fig. 1 shows the results of classification by AI of different types of rust that appear to have no conspicuous difference in shape or dents and projections of rust within the range visible to the human eye, although the color tones are obviously different. Of the rust images that were input during such classification, which points were focused on by AI are shown in pairs, by creating a heat map (redder areas are focused on more strongly by AI) of the points by means of a technique called the Grad-CAM. The orange and brown rusts on the left in **Fig. 1** are classified into ungrown rust, and the heat map has sparse warm-colored (red, etc.) portions, and they are mixed with cold-colored (blue, etc.) portions as well. The dark brown and light brown rusts on the right in Fig. 1 are classified into protective rust, and they have been classified differently from the rusts on the left, but the heat map shows wide warm-colored (red, etc.) portions in the entire image. It is suggested that if there are no great features in the particle size, the color tone may have affected the classification by AI as well.

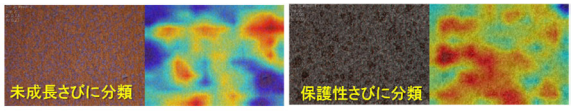

Fig. 1: Analysis of the effects of color tone of ungrown rust and protective rust

Fig. 2 shows the results of classification of rust in the same place classified by a human as protective rust, by inputting an anaglyph image and a simple two-dimensional image before synthesizing the anaglyph image (which shall be called a non-anaglyph image herein), which was done by AI, respectively. The anaglyph image in which the height information is reflected (Fig. 2, left) is classified correctly by AI as protective rust, and it appears from the heat map as well that the entire image is focused on without omission, and that the image is regarded as an image having homogeneous characteristics. On the other hand, the non-anaglyph image (Fig. 2, right) was classified erroneously as flaky rust. From the heat map on the right in Fig. 2, it can be seen that AI focuses on specific areas. A photo showing an enlargement of such areas is also shown in the figure. When a human looks at the photo as well, the areas appear as though there are dents and projections from the shade and others. Based on the foregoing, the analysis by AI shows the possibility that dents and projections should be taken into account when a human characterizes rust as well.

Secondly, AI was also made to learn the same data set consisting of 120 sets of images without teachers. In the first place, it was investigated, by classifying rust into several patterns, whether the features are reflected well in the classification. As a result, interestingly it appeared that classification into 6 types or so was good, with the result being close to the classification of the features of rust by a human into 3 to 7 types.

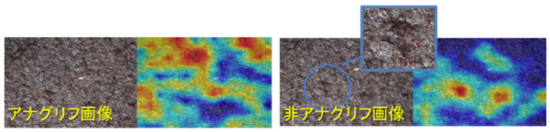

Fig. 2: Example of distinction by means of AI of an anaglyph image (left) and a non-anaglyph image (right) of the same protective rust

Actually, AI was made to classify the learning data set of 120 sets of images into 6 by learning without teachers. The rust considered to be representative of each classification is shown in Fig. 3. When the classified results are viewed by human eyes, it appears that information on the color tone and the dents and projections of rust is reflected in the classification. In future, we plan to look for the possibility of advancement of the inspection method for weathering steel by taking measures such as conducting an analysis of a certain rust by associating the classification by AI with the chemical components of rust and the speed of degradation thereafter.

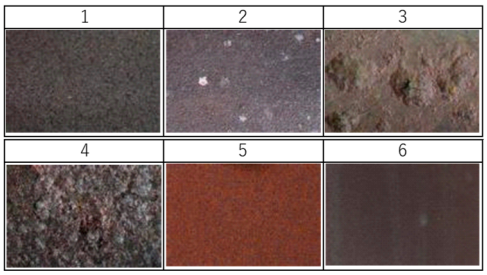

Fig. 3: Example of distinction of rust by learning without teachers

5. Conclusion

Although the Bridge and Structures Division has been conducting studies of the method of inspection concerning the functions of corrosion prevention for weathering steel until the present, it appears that a new development of studies can be expected by utilizing AI technologies as well. In future, we would like to make efforts in the advancement and speedup of studies by utilizing the cutting-edge technologies in various studies.

Note that an app for classifying the anaglyph images of any rust is available on the website[2)] that uses a model that underwent learning with teachers, which has been created in this study. Although its accuracy is not clear, readers having interest in it are welcome to test it.

☞For detailed information, refer to the following:

1) Technical Note of NILIM No. 828 Study on Evaluation of Rust by Appearance Properties for Weathering Steel Bridge (February 2015)
https://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0828.htm
2) https://www.nilim.go.jp/lab/ubg/index.htm

Analytical study toward the building of an evaluation technique for local scour around a highway bridge foundation

(Research period: FY 2021 -)

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Key words: highway bridge foundation, scour, bed protection works, semi-three-dimensional flow analysis

1. Introduction

Situations often occurred where torrential rains with intensifying severity and increasing frequency in recent years caused scour damage to piers and the road functions were lost for a long period (Photo 1). The effects on a bridge associated with scour are considered to be dependent on the structural conditions of the bridge as well as on the conditions of a river shape, etc. in the location of bridge construction as well, e.g. such as a bent river channel[1)].

On the other hand, in hydraulic model experiments conducted by our Division in the past, it was clarified that the local scour shape, etc. around piers were affected by the mode of installation of the piers themselves and the bed protection works[2)] used as the protective measures against the scour of a riverbed or bank protection works in association with the installation of the piers.

This paper reports the applicability of the method of evaluation for scour by using semi-three-dimensional flow analysis, toward the establishment of techniques for risk evaluation and verification of effects in order to proceed with scour protection measures more effectively for existing bridges.

2. Effects of bed protection works on local scour around piers

(1) Overview of existing experiments subject to analysis

Fig. 1 shows an experimental model for hydraulic model experiments subject to reproduction analysis. In this experimental model, bed protection works are arranged adjacent to the pier, by referring to actual examples of scour damage. Note that in the case of this experiment, the pier model is secured to the bottom surface of the waterway, for the purpose of grasping the situation of scour around the pier depending on the conditions of installation of the bed protection works, thereby ensuring that no subsidence or fall by leaning will occur as a result of the progression of scour. Also, the experimental flow rate is set to 5 L/s, assuming the situation of the river in ordinary times (static scour flow rate).

Fig. 2 shows, as the experimental result, a contour diagram of the riverbed shape after completion of the passing of water. An overall tendency can be confirmed that the riverbed degradation ranges are connected from the front surface of the bed protection works to the front surface of the pier, as though crossing the waterway obliquely. Among other things, in the range in the vicinity of the pier (front surface and both sides), great riverbed degradation occurred to the point equivalent to the footing lower end (29 cm).

Photo 1: Pier damaged by scour

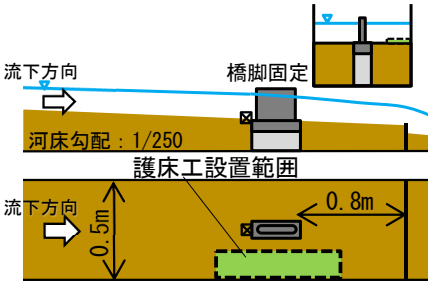

Fig. 1: Overview of an experimental model

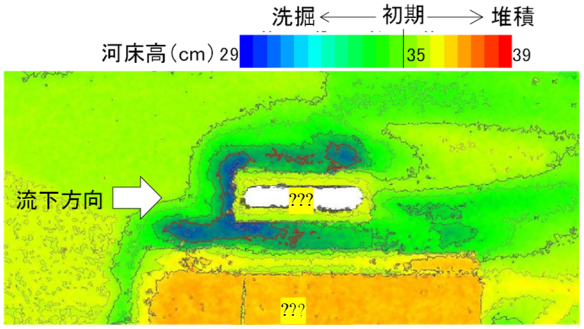

Fig. 2: Riverbed shape after completion of the passing of water

(2) Reproduction by means of semi-three-dimensional flow analysis

In order to grasp the scour depth of a pier and its range by means of an analytical technique, an analytical model is required that enables reproduction of three-dimensional and complex hydraulic phenomena

around the pier such as downward flow and horseshoe vortex (Fig. 3). However, three-dimensional flow analysis involves a large computation load, and there are few examples of its application to actual rivers extending over a wide range[4]. Therefore, in this study, considering deployment to the practical work of road management in future as well, it has been determined that semi-three-dimensional flow analysis shall be used that considers the three dimensionality of flow, by expanding the planar (longitudinal/transversal) two-dimensional flow analysis that is frequently used in the practical work of river management.

Various proposals have been made to the method of evaluation of the three dimensionality of flow. In this study, an analytical method[5] has been used, that can consider the vertical distribution of the flow velocities in the longitudinal and transversal directions (differences in the flow velocities on the water surface and bottom surface) and the flow in the vertical direction (upward flow, downward flow), by solving the vorticity equation and the equation of flow velocity in the vertical direction. Note that, for the sake of comparison, we have also carried out an analysis in the case of an assumption of hydrostatic approximation (general assumption that is applied in the flow regime analysis in the practical work of river management) without considering the flow in the vertical direction by using the analytical method as it is.

Here, the pier and bed protection works have been expressed by setting the fluid occupation rate[6] instead of an obstacle cell, and to express riverbed fluctuations, a general planar two-dimensional riverbed fluctuation analytical technique has been applied[7], which uses the equilibrium sediment transport formula, etc.

The result of analysis is shown in Fig. 4. As compared with the experimental result (Fig. 2), the magnitude of the depth of scour that occurs on the front surface side of each of the pier and bed protection works is slightly excessive. However, the result that roughly reproduces the experimental result has been obtained, such as the tendency of riverbed degradation in the direction from the front surface of the bed protection works to the front surface of the pier (oblique direction) and the large local scour in the range in the vicinity of the pier (front surface and both sides).

Note that, in the case of the assumption of hydrostatic approximation, the result was significantly different from the experimental result, in terms of the scour depth and scour range.

3. Conclusion

By means of the non-hydrostatic semi-three-dimensional flow analysis that enables the three dimensionality of flow to be expressed reasonably by expanding the planar two-dimensional technique, the existing experimental result could roughly be reproduced. In future, we plan to verify the applicability in the case of changing the river channel shape or the

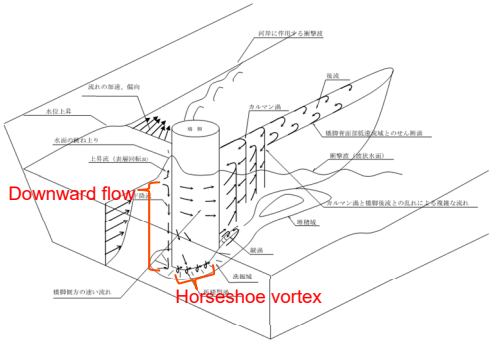

Fig. 3: Hydraulic phenomena that are caused by the pier with additions to 4)

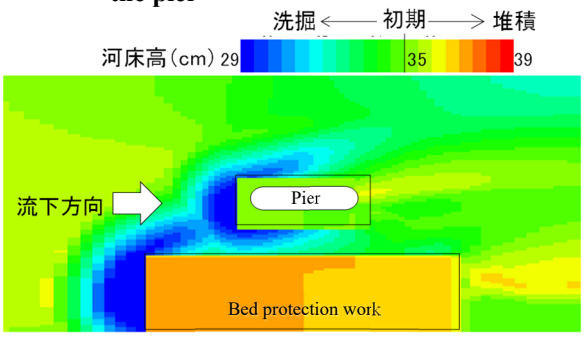

Fig. 4: Result of reproduction by means of riverbed fluctuation analysis

conditions of arrangement of the pier and bed protection works, thereby clarifying the conditions of road bridges having a high risk of sour damage and elucidating the mechanisms of scouring, etc., and at the same time to summarize the findings, etc. that will serve as a reference when the road administrator takes scour protection measures by means of analytical techniques.

References

1) Technical Note of NILIM No. 1202
2) Japan Institute of Country-ology and Engineering: Revision Explanations - Cabinet Order on Structure of River Management Facilities etc., 2000
3) Japan Institute of Country-ology and Engineering: Guidance on Plans for Bridges That Cross a River (draft), 2009
4) Japan Riverfront Research Center: Guidance on the Introduction of a Three-dimensional Design Tool for River Channels Aiming at the Advancement of River Making with Rich Nature (rough draft), 2023
5) Tatsuhiko Uchida, Shoji Fukuoka: A Bottom Velocity Computation Method for Estimating Bed Variation in a Channel with Submerged Groins, 2010
6) Tatsuhiko Uchida, Yoshihisa Kawahara: Development of an Explicit Conservative CIP Scheme for Shallow Water Flows, 2006
7) Ministry of Land, Infrastructure, Transport and Tourism, Water and Disaster Management Bureau, Technical Standards for River Works, practical guideline for Method of Investigation, Chapter 6, 2014

Study of Alternative Method for Gas Toxicity Test of Noncombustible Building Materials

(Research period: FY 2023-FY 2024)

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(Keywords) Gas toxicity test, Gas component analysis, Performance evaluation for certification by Minister of MLIT, Fire-preventive material

1. Introduction

At present, in addition to the heat generation test, etc., the gas toxicity test (ISO/TR 16312-2; Rotative cages smoke toxicity test) is also specified in performance evaluations of fire-preventive materials for certification by the Minister of Land, Infrastructure, Transport and Tourism (MLIT). In the gas toxicity test, a mouse is exposed to the combustion gas generated when a 22 cm square material test piece is heated, and toxicity is evaluated by comparing the time to behavioral incapacitation of the animal with a standard value of 6.8 minutes.

However, it has been noted that this gas toxicity test has various problems, including the fact that the formed gas cannot be quantified. Since this test is also undesirable from the viewpoint of animal welfare, an alternative evaluation method to the gas toxicity test is required.

In this research, the Fire Standards Division conducted a smoke density chamber test[1] (ISO 5659-2; Smoke Density Chamber Test; hereinafter, SDC test), which is used in evaluations of toxic gas in Europe, while analyzing the gas composition. The results of the SDC test were compared with those of the conventional gas toxicity test, and their correlation was examined.

2. Overview of Research

An outline of the SDC test system is shown in **Figs. 1** and **2**. Using the SDC test system, the test specimen is heated in accordance with ISO 19021 "Test method for determination of gas concentrations in ISO 5659-2 using Fourier transform infrared spectroscopy," and a quantitative analysis of the gas sampled from the center of the chamber ceiling is performed using Fourier transform infrared spectroscopy (FTIR). Among the heating conditions specified in ISO 19021, "25 kW/m^2 with pilot flame" and "50 kW/m^2 without pilot flame" were adopted in these tests. In addition, the Conventional Index of Toxicity CIT_G value[2] (G: general products) was calculated from the measured gas concentration in accordance with EN 17084-2018.

As test samples, rubber, wallpaper, medium-density fiberboard (MDF) and others were selected as materials that are generally used as building interior materials.

The obtained CIT_G values were compared with the time to behavioral incapacitation of mice when gas toxicity tests were performed using the same test samples, and a certain correlation between the two was confirmed.

Fig.-1 Appearance of SDC test system[2]

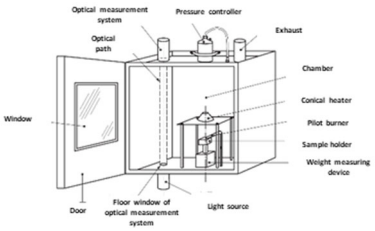

Fig.-2 Device diagram of SDC main unit[2]

3. Conclusion

In the future, we plan to publish more detailed study results in connection with the correlation between the gas toxicity test and the SDC test in conference presentations, technical materials, etc. when the occasion arises. In the future, we also plan to propose an alternative technique to the gas toxicity test using these research results.

☞For more information:

1) ISO 5659-2:2017, Plastics -- Smoke generation -- Part 2: Determination of optical density by a single-chamber test.

2) EN 17084-2018, Railway applications -Fire protection on railway vehicles – Toxicity test of materials and components.

Trial of Soil Survey Behind Retaining Wall by Cone Penetration Test

(Research period: FY 2020-FY 2023)

Urban Planning Department, Urban Disaster Mitigation Division Head IWAMI Tatsuya
Urban Planning Department Research Coordinator for Quality Control of Building (Dr. Eng.) INOUE Namihiko
Building Department, Standards and Accreditation System Division Head TAKEMURA Yoshifumi

(Keywords) Retaining wall, Seismic reinforcement, CPT

1. Introduction

To acquire knowledge related to "advance" survey methods for retaining walls for residential land and soundness evaluations of residential retaining walls, electric cone penetration tests (JGS 1435-2012; hereinafter CPT), which are one ground survey method, were carried out in the vertical and inclined directions at a residential retaining wall which had suffered earthquake damage.

2. Survey Method

The retaining wall (**Fig. 1**) that is the object of the survey is a concrete masonry retaining wall located in Soma City, Fukushima Prefecture, and was damaged in the 2011 Off the Pacific Coast of Tohoku Earthquake (Great East Japan Earthquake). After repairs in 2013, it was damaged again in earthquakes that occurred in 2021 and 2022 with epicenters off the coast of Fukushima Prefecture.

Fig. 1 Retaining wall surveyed in this study

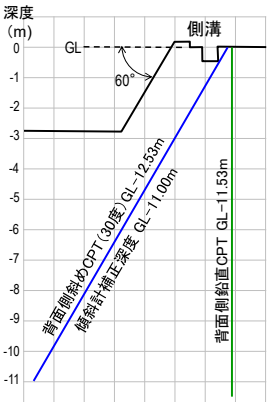

Fig. 2 Diagram of surveyed section

The CPT is normally performed in the vertical direction. However, if the probe is penetrated from above the back side of a retaining wall, the distance between the wall and the probe will increase as the probe descends to the underside of the wall, and it will not be possible to investigate the ground adjacent to the wall. Therefore, in addition to the vertical CPT, a CPT is also performed at an inclined angle of 30 ° (hereinafter, inclined CPT) in parallel to the inclination of the retaining wall surface (**Fig. 2**).

3. Results and Conclusion

The ground composition at the penetration position could be understood by the vertical and inclined CPT survey behind the retaining wall. Because there was no clear difference between the strata detected by the two tests except at GL–5.0 m to GL–6.5 m, the inclined CPT can obtain almost the same results as the vertical CPT (**Fig. 3, Fig. 4**). Based on this, the ground conditions behind a retaining wall and directly under the wall, which are related to wall damage, can be understood by performing an inclined CPT. This is expected to contribute to rationalization of earthquake-resistance diagnosis and seismic reinforcing design. In the future, however, it will be necessary to accumulate examples of points where the inclined CPT method was applied under conditions other than flat land (rear side of retaining walls).

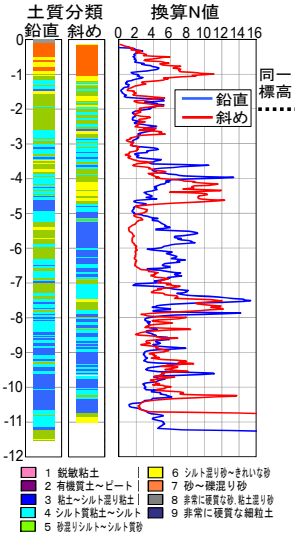

Fig. 3 Comparison of survey results by vertical and inclined CPT

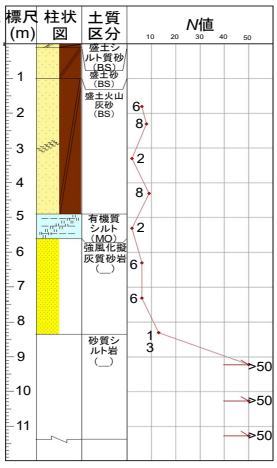

Fig. 4 Columnar section of road embankment near the survey site

☞For more information:

1) Shuichi Takeya et al., On-site Survey of a Retaining Wall Damaged by the 2022 Off Fukushima Earthquake: Part 1: Trial of soil survey behind retaining wall by cone penetration test, Summaries of technical papers of annual meeting, Architectural Institute of Japan, July 2023
2) Overview of "Technology Development Contributing to Revitalization and Resilience of Cities by Rationalization of Structural Regulations Related to Buildings and Ground" https://www.nilim.go.jp/lab/hcg/kisojiban_hp/kisojiban.htm

Development of stochastic typhoon model

(Research period: FY2022–FY2024)

Port, Coastal and Marine Department, Port and Coastal Disaster Prevention Division

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(Keywords) Stochastic typhoon model, typhoon classes, climate change

1. Introduction

Japanese ports, located along the country's coastal areas, often suffer damage from storm surges and high waves when typhoons approach or make landfall. Recent examples of damage to ports caused by storm surges and high waves include the damage to the Osaka Bay coast wrought by Typhoon Jebi (T1821) in 2018, and the damage to the Tokyo Bay coast inflicted by Typhoon Faxai (T1915) in 2019. In studying port disaster prevention, it is necessary to evaluate storm surges and high waves caused by typhoons. However, actual typhoon data (typhoon best track data) is only available for the roughly 70-year-period since the 1950s, and this is not sufficient to evaluate storm surges with a return period of 100 years or more. To address this problem, developing a stochastic typhoon model that uses statistical data derived from typhoon best track data to simulate hypothetical typhoons over tens of thousands of years, is an effective approach.

2. Stochastic typhoon model

While various research studies on stochastic typhoon models have been conducted, we have opted to use an autoregressive (AR) model that can take into account previous time-varying processes of typhoon attributes such as central pressure, for our research, as such a model has been proven to be effective.

To determine the distribution of the mean temporal variation of the central pressure of typhoons, Figure 1 (left) compares actual typhoon data with the stochastic typhoon model used in our research, using all best-track typhoon data. In a comparison with the actual data for areas surrounding Japan, we find that the stochastic typhoon model shows a small increase in the temporal variation of central pressure, as well as a weak typhoon attenuation trend, resulting in poor reproducibility. To address this, we improved our model to enhance the reproducibility of typhoon attenuation in areas surrounding Japan.

3. Improvements based on typhoon class

Typhoon best track data includes characteristics of storms other than typhoons, such as information on typhoons that change into extratropical cyclones and information on tropical cyclones and other storms before they develop into typhoons. With this in mind, we developed a new stochastic typhoon model based on data that excludes this information from the typhoon best track data. Figure 1 (right) displays the comparison of this improved stochastic typhoon model with actual data without this information. It shows the increase in the temporal variation of central pressure in the areas surrounding Japan is on par with the actual data, confirming the reproducibility of typhoon attenuation

has increased.

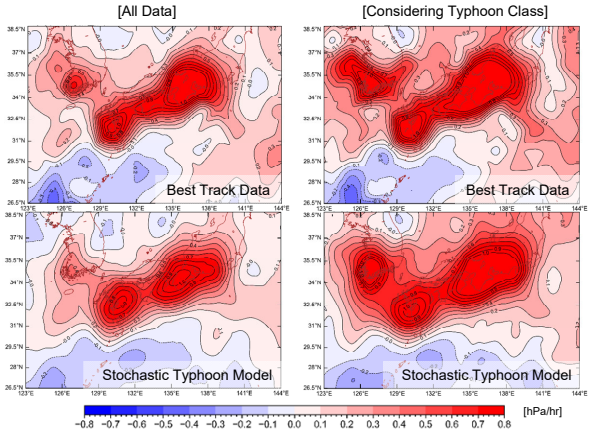

Figure 1: Mean temporal variation of central pressure of typhoons

4. In closing

In this research, we developed a stochastic typhoon model based on an AR model that takes into accounts typhoon classes, and improved the reproducibility of typhoon attenuation in areas surrounding Japan. However, the reproducibility of the typhoon occurrence area is not sufficient, so we plan to make further improvements to our model in the future. Finally, we intend to consider using our stochastic typhoon model to study the impact of climate change on storm surges with an extremely long return period.

Creation of a Simple Evaluation Model (Draft) for the Effects of Smart Cities

(Research period: FY 2020-FY 2023)

Urban Planning Department, Urban Planning Division Researcher (Ph.D.(Eng.)) ANDO Ryosuke Senior Researcher (Ph.D. (Eng.)) KUMAKURA Eiko
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Urban Facilities Division Head SHINGAI Hiroyasu

(Keywords) Smart city, Simple plan evaluation, KPI

1. Introduction

NILIM created a "Simple Plan Evaluation Model (Draft)" (hereinafter, "Evaluation Model (Draft)") as a tool that provides a reference for staff of local governments and others who will be engaged in "smart cities" in the future, when those persons predict the effects of introducing new technologies, that is, the effects of the smart city. The purpose of this tool is to make quantitative rough calculations of the expected effects of solving urban problems when local governments, etc. study directions for solving urban problems by introducing new technologies, and to support decisions on the types and quantities of new technologies to be introduced. This article presents an outline of the "Evaluation Model (Draft)".

2. Background and Purpose of Evaluation Model (Draft)

Efforts to realize "smart cities" that utilize IoT and other new technologies to solve urban problems by promoting national government model projects, etc. and sharing know-how on the Smart City Public-Private Partnership Platform are steadily increasing in all areas. However, many local governments still are not carrying out initiatives, and nationwide horizontal development has become an issue.

The results of a questionnaire survey [1)] of local governments and companies that NILIM carried out to grasp the issues for implementing smart cities revealed that the cost (initial cost, operational cost, profit structure) is the largest obstacle to the introduction of new technologies, for both local governments and companies, and this is common problem regardless of which new technology is to be introduced. When a local government that has not yet embarked on a smart city initiative decides to start one, it must be able to quantitatively predict and evaluate the cost-effectiveness of new technologies during both the planning and implementation stages. This ensures that the benefits gained from resolving specific urban issues are appropriately balanced against the initial and operational costs of those technologies. To support this process, NILIM created the "Evaluation Model (Draft)."

3. Overview of the Evaluation Model (Draft)

(1) Features

While there are various examples of smart city projects, in the Evaluation Model (Draft), the applicable new technologies for the 6 main urban problems shown in the following **table** were set considering the following two points: "Many needs have been expressed by local governments, and the technology has high general applicability" and "Existing efforts are comparatively advanced, and information on their effects is easily available." Information on each of these combinations of urban problems and applicable technologies was collected by interviews on advanced initiatives of local governments, etc.

Table: Targeted "Urban problems" and "Applicable technologies," and "Examples of Key Performance Indicators (KPI)"

Urban problem	Applicable new technologies	Examples of KPI
Support for persons with transportation/shopping difficulties	Self-driving car, on-demand transportation, delivery drone	Service coverage rate, amount of shopping cost reduction
Supply of tourism/central city information	Digital signage, integrated app	Daily number of views, visitor increase rate
Promotion of citizens' health activities	Incentives and provision of health data via app	Daily use frequency, increase in number of steps taken
Protection of elderly people/children	Camera network, BLE tag, GPS tag	Reduction of search time, area coverage rate
Supply of disaster information	Integrated app, dashboard	Daily number of views
Real-time grasp of river/water channel condition	Water level sensor, river camera	Reduction of time required for on-site checks

Based on information on the effects, etc. obtained by initiatives, examples of the Key Performance Indicators (KPIs) for the effects of introduction were set, and the Evaluation Model (Draft) was created. The concepts of the Evaluation Model (Draft), cases that form its basis, points to note, etc. were arranged as "Commentary." In addition, the unit effects for the number of units of the new technologies (e.g., number of vehicles, drones, etc.) were estimated, and a "Simple Calculation Sheet" was prepared as a tool that enables a rough calculation of the effects of introducing new technologies using those unit effects.

(2) Composition and content of the Commentary and Simple Calculation Sheet

① Commentary (see figure)

In the Commentary, "Method of evaluating introduction effects," "Examples of evaluations for examples of initiative," "Points that affect the appearance of effects," etc. are arranged for the items in the **table** on the preceding page, and reference information for the selection of the new technologies to be used in solving urban problems is provided.

For example, when assessing how to reduce the burden of routine shopping on citizens, we created a model that evaluates cost savings achieved through self-driving cars, on-demand transportation, and drone delivery services. The model assumes that, before these services were introduced, citizens relied on taxis to reach the nearest supermarket.

② Simple Calculation Sheet

Using the unit effects estimated based on the information on typical initiatives provided by localgovernments, we prepared a Microsoft Excel sheet that allows users to make rough calculations of the expected effects (KPI) by inputting local information, assumed conditions, and the amount of introduction of the new technology which the user is considering introducing.

However, please note that results of calculations using this sheet are ultimately only reference values, because the sheet was created using data on a small number of cases, including some that are still in the demonstration experiment stage.

4. Conclusion

This Evaluation Model (Draft) ("Commentary" and "Simple Calculation Sheet") will be released to the public on the NILIM website, etc. in the future. In addition, the Evaluation Model (Draft) and the "Case Studies of Smart Cities(Introductory Volume)," [2] which has already been released, will be also revised when necessary due to the addition of case studies of initiatives and changes in the content in response to new technical innovations.

☞For more information

1) Wataru Katsumata, Eiko Kumakura and Hiroyasu Shingai (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

2) "Case Studies of Smart Cities – Introductory Volume," available as aa PDF file at the public URL (website of the Urban Planning Department, NILIM)
https://www.nilim.go.jp/lab/jbg/smart.html

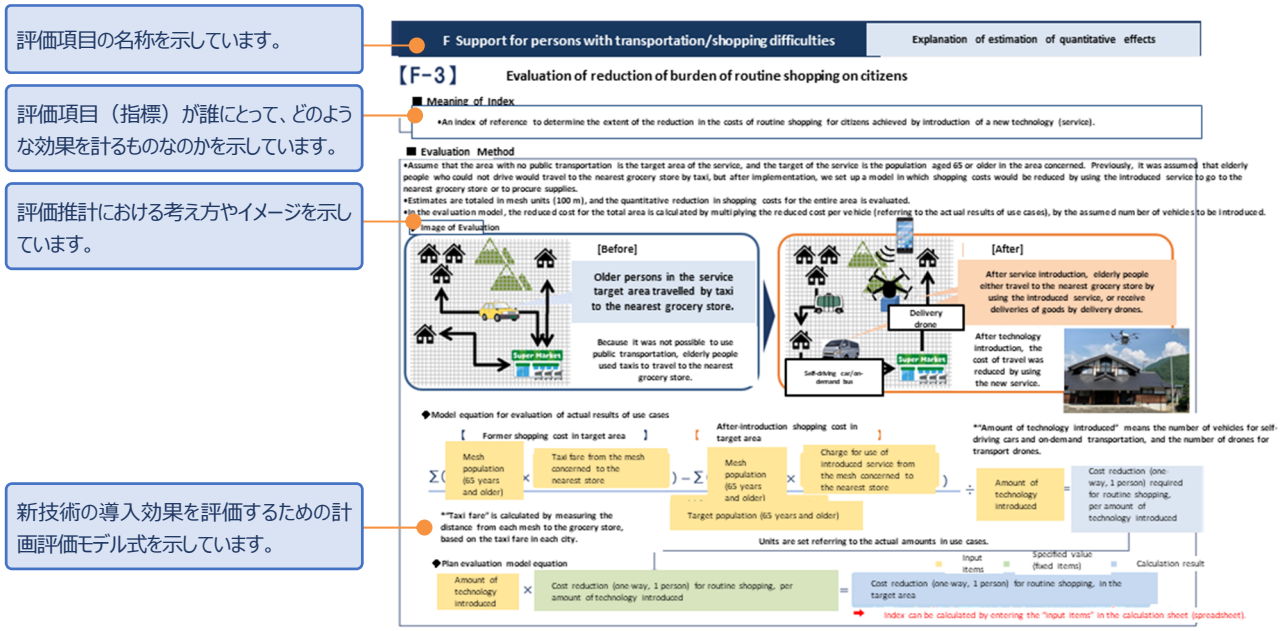

Fig. Image and use of the Commentary (partially excerpts from Commentary)

Study on how to expand the application of business promotion PPP

(Research period: FY 2021 -)

Naoko Matsuda, Head, Takashi Tajima, Senior Researcher, Yasushi Kimura, Researcher, Shuma Matsubayashi, Guest Research Engineer, Research Center for Infrastructure Management, Construction and Maintenance Management Division

Key words: project promotion PPP, guidelines, project supervision work, management, public private partnership

1. Introduction

The project promotion PPP is to implement efficient project management by merging varied knowledge and abundant experience of engineers from both public and private sectors from the upstream stages of the project such as survey and design (Fig. 1). We introduced the project promotion PPP in FY 2012 after the 2011 off the Pacific coast of Tohoku Earthquake in March 2011. The purpose was to smoothly and speedily implement the project that extended over about 380 km such as the Sanriku Coast Expressway, the Tohoku Regional Development Bureau. Later on in March 2019 the Guidelines for the Project Promotion PPP were established under the Jurisdiction of the Ministry of Land, Infrastructure, Transport and Tourism (hereinafter called the "Guidelines") and the application of the guidelines has been widened to projects for recovery from large-scale disasters as well as large-scale projects in ordinary times in each of the regional development bureaus.

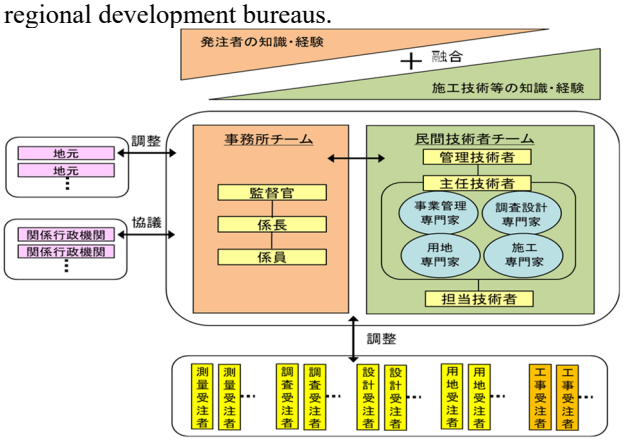

Fig. 1: Overview of the project promotion PPP

In addition, the project promotion PPP has various stages of work such as survey, design, land, and construction. It is necessary to secure and educate personnel who have capabilities required for the project management work to obtain high quality work results. Also, since there are varied needs of utilization depending on the purpose of introduction of the project promotion PPP and each project stage, it is necessary to revise the Guidelines to address such needs, in order to expand the application of project promotion PPP.

Under such background, the NILIM held hearings and conducted questionnaire surveys about the project promotion PPP work ordered by each of the regional development bureaus, etc., as surveys of the situation of implementation of the project promotion PPP management work. Based on the results of those surveys, the NILIM conducted a study to consider revisions to the Guidelines. This paper reports the results of the surveys and the contents of the study.

2. Survey results

Of the project promotion PPP work ordered by each of the regional development bureaus, concerning the projects on which hearings were held by the NILIM, the contents of implementation, systems, etc. of such projects have been summarized as shown in Fig. 2.

対象業務		指導・調整、協議の有無		事業段階			実施体制		
		業務の指導・調整	地元・関係機関協議	調査設計	用地	施工	管理技術者	主任技術者	担当技術者
事業促進PPP	PPP ①	－	●	●	●	－	◎	－	○'
	PPP ②	●	●	●	●	●	○	◎	△
	PPP ③	●	●	●	●	－	○	◎	△
	PPP ④	●	●	●	●	－	○	◎	－
	PPP ⑤	－	●	●	－	－	◎	－	○'
	PPP ⑥	●	●	●	－	－	○	◎	－
	PPP ⑦	●	●	●	●	－	◎	◎	－
	PPP ⑧	●	●	●	－	－	○	◎	－
	PPP ⑨	●	●	●	●	－	○	◎	○
	PPP ⑩	●	●	●	●	－	◎	◎	－

凡例 ●：実施 ◎：資格・実績要件有 ○：資格要件無・実績要件有
○'：資格要件有・実績要件無 △：必要に応じて資格・実績要件有

Fig. 2: Summary of the implementation system, etc. of the project promotion PPP work

Regarding the project promotion PPP, a type such as PPP (ii) is set in the Guidelines, which is intended for all the project stages from survey to construction, but it was often utilized in each individual project stage. Also, as to the engineers in charge, the Guidelines specify a system of 3 layers: managing engineer, chief engineer, and engineer in charge. However, when the system was utilized in each individual project stage, a system of 2 layers was employed.

In addition, the results of the questionnaire surveys, showed that the parties placing and receiving orders expressed the following opinions and requested improvements.

- If work such as the project promotion PPP is performed for both maintenance and management, it will solve the personnel shortage problem.
- Engineers will be needed who understand the both intention and that policy of the party placing the order and who can smoothly collaborate with the

party placing the order.

With regards to the second point, many people's opinions stated that among the roles of the managing engineer, chief engineer, and engineer in charge, when it comes to project promotion PPP, the managing engineer is required to have a wide field of vision and leadership. Many opinions stated that the chief engineer is required to have both expertise as well as the wideness of the range of response, communication skills, and that the engineer in charge should have the ability to understand and coordinate skills.

Based on these opinions, we have conducted a study of the contents of the proposal to revise the Guidelines and summarized them as described below.

3. Drafts of the revised contents

On the basis of the above surveys, we have conducted a study of the revision drafts of the Guidelines. The two major revision drafts are described below.

(1) Addressing the varied project stages and classification, etc. according to the purpose (Fig. 3)

The project promotion PPP must to be capable of being selected and set in each of the stages of the project, according to the phase in which it is introduced and the purpose, contents, etc. of the work. Therefore, in addition to the type (comprehensive type) of all applicable project stages from survey to construction that have already been decided on, the project stage selection type has been chosen.

区分		指導・調整、協議の有無		事業段階					体制（資格、専任・常駐）		
		業務の指導・調整	地元・関係機関協議	調査	設計	用地	施工	維持管理	管理技術者	主任技術者	担当技術者
事業促進PPP（災害時）	総合型	●	●	●	●	●	●		○	◎	△
	事業段階選択型（複数段階、単独段階）	●	●	各課題に応じ、複数または単独段階で適切に選択					○	◎	－
									◎	－	△
事業促進PPP（平常時）	総合型	●	●	●	●	●	●		○	◎	△
	事業段階選択型（複数段階、単独段階）	●	●	各課題に応じ、複数または単独段階で適切に選択（管理も含む）					○	◎	－
									◎	－	△

2or3階層※

凡例 ●：実施 ◎：資格・実績要件有 ○：資格要件無・実績要件有 △：必要に応じて資格・実績要件有
■…常駐・専任の必要あり ■……必要に応じ常駐、専任を設定
※業務の特性、規模、難易度等を勘案し、業務体制の選定を行っていくことが考えられる

Fig. 3: Systematic summary of the Guidelines

Also, in recent years, the amount of work such as inspection and diagnosis as well as repair work, has been increasing in the stage of maintenance and management, and it is required that the work be performed more efficiently. For this reason, when placing orders at ordinary times, the item in the stage of maintenance and management has been added, in consideration of the expansion of the application of the project promotion PPP to the stage of maintenance and management.

Regarding the engineer who has been scheduled to be deployed, they must be the comprehensive type and their deployment will be in 3 layers. The engineers who are scheduled to be deployed for the project stage selection type shall be of 2 layers or more. In addition, regarding the selection of the engineers planned to be deployed in the case of 2 layers, it has been enabled to set the selection according to the characteristics, scale, degree of difficulty, etc. of the work.

(2) Clarification of the capabilities required of the engineers to be deployed

In order to ensure that the project promotion PPP work will be implemented, it is of vital importance that a common understanding is shared about the capabilities of each layer of the party receiving the order as required by the party placing the order and about the personnel fit for deployment in each layer as considered by the party wishing to participate in the tender. Based on the replies, obtained in the hearing surveys, the required roles have been summarized in Fig. 4 according to the class of engineers.

管理技術者	主任技術者	担当技術者
■事業全体の俯瞰 ・事業全体計画を俯瞰し、個々の業務・工事の目的や内容を理解し、主任・担当技術者が的確に業務を行えるよう指導する。	■事業全体の流れの把握 ・事業全体の流れ、個々の業務・工事の目的や内容を理解し、管理技術者の指導を踏まえ、的確に業務を行う、又は、担当技術者を指導する。	■目的に応じた遂行 ・管理・主任技術者の指導を踏まえ、目的に応じて、的確に業務を行う。
■必要な手続等の理解 ・業務遂行にあたり、必要な行政手続、協議等の流れ、目的、内容を理解し、主任・担当技術者を指導する。	■必要な手続等の理解・遂行 ・管理技術者の指導を踏まえ、必要な手続、協議の目的や内容を理解し、的確に手続、協議等を行う、又は、担当技術者を指導する。	■必要な手続等の遂行 ・管理・主任技術者の指導を踏まえ、的確に手続、協議等を行う。
■信頼関係の構築 ・事業の関係者を想定し、関係者と信頼関係を構築しながら、行動するとともに、主任・担当技術者を指導する。	■信頼関係の構築 ・管理技術者の指導を踏まえ、事業の関係者と信頼関係を構築できるよう、業務を行うとともに、担当技術者を指導する。	■協調的な行動 ・管理・主任技術者の指導を踏まえ、事業の関係者と信頼関係を構築できるよう、協調的に行動する。
■柔軟性のある行動 ・基準やマニュアルだけでは解決できない関係者の意見を聞きながら、計画へ反映できるよう、柔軟に行動するとともに、主任・担当技術者を指導する。	■柔軟性のある行動 ・管理技術者の指導を踏まえ、基準やマニュアルだけでは解決できない関係者の意見を聞きながら、柔軟に計画に反映するとともに、担当技術者を指導する。	■協調的な行動 ・管理・主任技術者の指導を踏まえ、関係者の意見が計画に反映されるよう、協調的に行動する。

Fig. 4: Capabilities required of the engineers to be deployed

4. Conclusion

The above results of the study have been reflected in the Guidelines, after deliberation in the Council of Experts of the MLIT. As a result of the incorporation of the results of the study that have been indicated herein, it is expected that the project promotion PPP work will be carried out more smoothly by utilizing the project promotion PPP in a wide variety of projects, and that both the parties placing and receiving orders will share a common understanding. In the future, we plan to carry out follow-up work to review the situation of implementation of project promotion PPP, its effects, problems, etc.

☞For detailed information, refer to the following:

1) Study on the systematization of various types of management work and ability evaluation of the project promotion PPP, etc. (Proceedings of the 40th Research Presentation and Discussion Meeting on Construction Management)
https://www.nilim.go.jp/lab/peg/img/file2006.pdf

2) Basic survey on the classification of the work of management and ability evaluation of the project promotion PPP, etc. (Civil Engineering Journal, Vol. 64 No. 9)
https://www.nilim.go.jp/lab/peg/img/file1995.pdf

Maintaining and improving the efficiency of hinterland transport for international maritime containers

(Research period: FY2021–FY2023)

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(Keywords) Hinterland transport, driver shortages, container round use

1. Introduction

To address truck driver shortages and help realize carbon neutrality, we have conducted research on the improvements in the efficiency of hinterland transport for international maritime containers since FY2021. This paper presents the findings of the research to date, as well as future issues and challenges based on those findings.

2. Hinterland transport functions for international maritime containers: Current state and challenges

Figure 1 illustrates the shipping process for a container (export scenario)—a common form of hinterland transport—through steps (1) to (8). In this process, trailers specialized for the transport of international maritime containers ("maritime trailers") are used. Because empty containers are sent in one direction in both export and import transactions, these containers are sometimes reused in hinterland areas using a "container round use" system intended to improve transport efficiency. From April 2024, work style reform legislation was enacted that tightens regulations governing work hours for drivers who transport maritime containers (giving rise to the so-called "2024 Problem"). To maintain hinterland transport functions in such an environment, transport efficiency needs to be improved. This may also contribute to a reduction in CO_2 emissions, and confer other benefits.

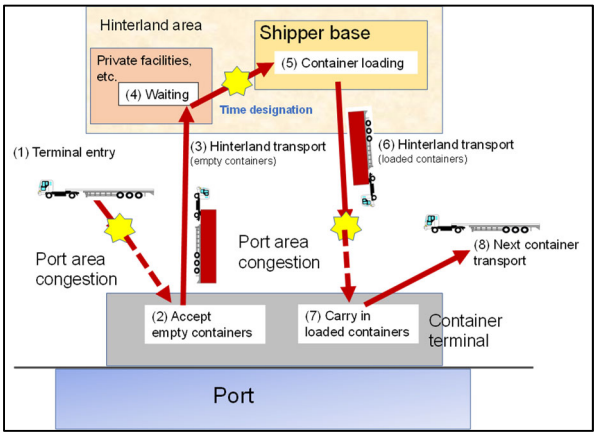


Figure 1: Current state of hinterland transport

3. Outlook for driver surpluses/shortages

We have estimated the outlook for driver surpluses/shortages in 2030. Under present conditions, demand and supply appear to be closely matched, but our estimates indicate that driver shortages will emerge for hinterland transport from East Japan to the Keihin ports in 2030 (**Figure 2**). In this scenario, our estimates also show that shortening waiting times (assumed 20-minute reduction at ports, and 10-minute reduction at shipper bases) at transportation hubs (shipper bases at ports and in hinterland areas) would alleviate the shortage ratio.

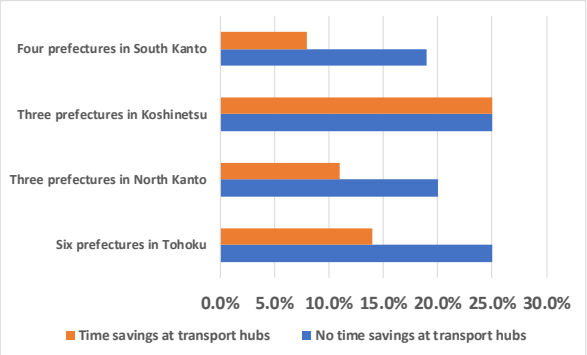
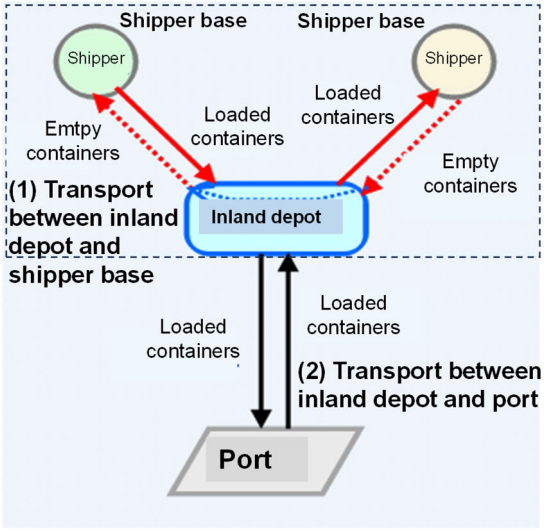


Figure 2: Results of driver shortage ratio estimates (2030)

4. Measures to improve hinterland transport efficiency and results

In this research, we divided the hinterland into three areas based on distance from Keihin ports, and studied various measures to improve efficiency and their results. In this paper, we present our research on medium-distance locations. These include the North Kanto area (Gunma Prefecture, Tochigi Prefecture, and Ibaraki Prefecture) and Fukushima Prefecture, all of which are located at a certain distance from Keihin ports and have a concentration of export companies. This makes them suitable candidates for improvements in transport efficiency. As a measure to increase transport efficiency, we envision the use of inland facilities that handle containers (inland depots), as illustrated in **Figure 3**. These inland depots serve as container round use hubs. Furthermore, through the inland depots, we assume functions can be divided into (1) transport between inland depots and shipper bases, and (2) transport between inland depots and ports (Keihin ports).



・Using container round use system between shippers through an inland depot
・Division of functions: (1) transport between inland depot and shipper base, and (2) transport between inland depot and port

Figure 3: Improving transport efficiency through the use of inland depots

Under (1), goods are transported short distances in the area surrounding the inland depot, making it possible to increase the daily turnover per driver. Furthermore, the time restraints per transport shorten, facilitating flexible work styles and enabling support for the promotion of employment of female and elderly staff. **Table 1** shows estimated results of the implementation of measures to improve efficiency. The results confirm improvements in both CO_2 emissions and productivity of maritime container operators. While the aforementioned measures are expected to significantly alleviate shortages of drivers that transport maritime containers, they will not entirely eliminate the problem. Therefore, we are also studying other measures such as automated driving.

Table 1: Estimated results of implementation of efficiency improvement measures (example)

Item	Estimated item	Estimated result of efficiency improvement measures
Improvement in shortage of truckers who transport maritime containers	Contribution to reduction in shortages of drivers of maritime container trucks	Shortages to improve by 10% or more, but not be eliminated fully
Improvement in transport times	Time required per round use transport and number of rotations in working hours after tightened regulations	Driver operational efficiency can be improved by allowing 2–3 rotations per day
Reductions in CO2 emissions	CO2 emissions generated through required hinterland transport	Potential improvement of 5% or more
Transport costs	Transport costs shouldered by shippers (including depot usage fees)	Expected to increase
Business productivity	Productivity of maritime container transport companies	Expected to improve
Profitability of inland depots	Profitability of establishment and operation of inland depots	Additional cost of roughly 2,000 yen per container per time is required

Assuming the inland depot establishment and operating costs are shouldered by shippers, improvements in transport efficiency through the container round use system can be confirmed, but there will be a slight increase in overall costs. As to the question of how this cost burden should be borne, there is room to explore measures such as the use of carbon credits.

5. Toward the implementation of efficiency improvement measures for hinterland transportation

Conventional hinterland transport takes the form of separate round trips for each import/export transaction, but society demands solutions to driver shortages and other related problems. Consequently, hinterland transport can be regarded as an essential social system. Another conceivable option is to improve efficiency under a collaboration of stakeholders, including through public-private partnerships. Below, we present challenges that will be faced in implementing improvement measures for hinterland transportation.

First, to improve shortages of drivers who transport maritime containers, it is necessary to reduce waiting time that does not add value. To shorten loading and unloading times at port terminals, information systems are being rolled out, and there are also calls for reductions in waiting times at shipper bases in hinterland areas. Second, the participation or collaboration of stakeholders plays an important role. For example, when establishing and operating inland depots, it is worth considering support from public institutions (there are already cases of inland depots that have been set up by local governments). Furthermore, when implementing a container round use system, it is necessary to monitor the locations of empty containers in real time and share them among stakeholders. Another requirement is to introduce a mechanism to share information and collaborate among maritime container operators and shipping companies who own containers, while considering the transportation-related procedures among shippers. Third, the applications of new technologies can also be assumed to be effective—particularly, the introduction of automated platooning, and the development of information systems that support the operation of a hinterland transport system.

6. In closing

In the foregoing, we have introduced the current status of hinterland transport for international maritime containers, measures to improve related efficiency, and other information. Going forward, we intend to continue studying measures to improve efficiency with an eye toward the application of new technologies and digital transformation (DX), starting with the monitoring of the impact of the 2024 Problem.

☞For more details, please refer to the following.

1) National Institute for Land and Infrastructure Management Technical Note No.1239
https://www.ysk.nilim.go.jp/kenkyuseika/pdf/ks1239.pdf

Draft template (individual article, one-page draft)

Research on the impact of domestic excursions by international visitors to Japan on domestic air traffic demand

(Research period: From FY2020)

Airport Department, Airport Planning Division

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(Keywords) Air traffic demand forecasting, domestic excursions by international visitors to Japan, usage of domestic air routes, big data

1. Purpose and background of research

In recent years, inbound travel demand in Japan has seen a sharp decline attributable to the impact of the COVID-19 pandemic, followed by a rapid recovery (**Figure**). Going forward, the domestic flow of international visitors to Japan is expected to pick up strongly. This will raise the need for air traffic demand forecasting to consider strengthening airport functions, and accordingly enhance the environment to welcome international visitors to Japan. Meanwhile, at present, the usage of domestic air routes by international visitors to Japan, which is required data for air traffic demand forecasting, is estimated from existing statistics for domestic and international passenger volume. We have attempted to improve the accuracy by using big data, which offers benefits such as a large number of samples.

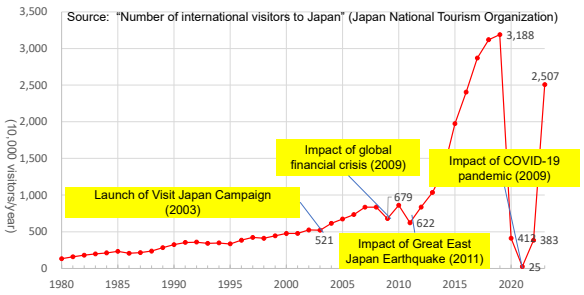

Figure: Trends in the number of international visitors to Japan

2. Analysis of current state of domestic air route usage by international visitors to Japan

Below, we show the results of our estimates of domestic air route usage by international visitors to Japan using two methods: (1) method based on existing statistics (estimated number of passengers by route based on passenger nationality ratios in the "Annual Report of Air Transportation Statistics" and the "Air Passenger Movement Survey"), and (2) method using big data for air route use (**Table**). Compared to the method based on existing statistics, the method using big data shows a trend to be small in the number of international visitors to Japan. Big data has large numbers of samples, and can obtain data on the flow of people mechanically rather than relying on interviews with people as existing statistics do. As a result, there is a high likelihood this method can ascertain movement patterns that are not detected in existing data methods, and this is believed to be the likely cause behind the differences with existing statistics.

Table: Number of international visitors to Japan by major domestic air routes (comparison of both methods)

Ranking	Top 30 routes			A: All purposes	B: International visitors		C = B/A: Ratio of international visitors	
				CY2019 passengers [1]	(1) Existing data method [2]	(2) Using big data [3]	(1) Existing data method	(2) Using big data
1	Haneda	-	Shin-Chitose	9,416,816	80,215	144,325	0.90%	1.50%
2	Haneda	-	Fukuoka	8,811,944	68,216	42,211	0.80%	0.50%
3	Haneda	-	Naha	6,108,917	90,616	37,061	1.50%	0.60%
4	Haneda	-	Itami	5,541,344	77,133	54,962	1.40%	1.00%
5	Haneda	-	Kagoshima	2,466,061	20,827	7,237	0.80%	0.30%
6	Haneda	-	Hiroshima	1,957,044	32,238	12,944	1.60%	0.70%
7	Haneda	-	Kumamoto	1,954,387	13,392	5,737	0.70%	0.30%
8	Fukuoka	-	Naha	1,922,691	27,160	8,154	1.40%	0.40%
9	Narita	-	Shin-Chitose	1,915,466	90,776	107,701	4.70%	5.60%
10	Haneda	-	Nagasaki	1,803,440	22,668	3,896	1.30%	0.20%
11	Haneda	-	Matsuyama	1,554,158	11,164	12,998	0.70%	0.80%
12	Haneda	-	Miyazaki	1,429,297	10,059	9,235	0.70%	0.60%
13	Haneda	-	Kansai	1,344,748	52,319	60,589	3.90%	4.50%
14	Narita	-	Fukuoka	1,211,540	57,586	24,877	4.80%	2.10%
15	Kansai	-	Shin-Chitose	1,194,391	25,665	47,887	2.10%	4.00%
16	Kansai	-	Naha	1,190,152	51,531	15,591	4.30%	1.30%
17	Itami	-	Naha	1,168,963	13,224	4,274	1.10%	0.40%
18	Naha	-	Miyako	1,123,516	11,719	11,388	1.00%	1.00%
19	Naha	-	Ishigaki	1,116,294	22,918	18,517	2.10%	1.70%
20	Haneda	-	Komatsu	1,090,239	13,176	8,476	1.20%	0.80%
21	Haneda	-	Hakodate	1,082,874	12,667	22,025	1.20%	2.00%
22	Shin-Chitose	-	Sendai	872,283	14,859	1,452	1.70%	0.20%
23	Narita	-	Naha	681,592	89,951	22,504	13.20%	3.30%
24	Kansai	-	Narita	680,064	45,516	49,998	6.70%	7.40%
25	Narita	-	Itami	476,001	59,753	47,346	12.60%	9.90%
26	Kansai	-	Fukuoka	469,050	10,333	8,700	2.20%	1.90%
27	Chubu	-	Narita	373,346	40,331	31,797	10.80%	8.50%
28	Haneda	-	Chubu	252,965	15,296	16,053	6.00%	6.30%
29	Haneda	-	Misawa	223,492	12,516	4,634	5.60%	2.10%
30	Naha	-	Minami-Daito	34,062	11,568	-	34.00%	-
Total for 30 routes				59,467,137	1,105,393	842,569	1.90%	1.40%
Total for all covered routes				93,618,678	1,429,500	1,105,326	1.50%	1.20%

Source) *1: Annual Report of Air Transportation Statistics (2019); 2: *1 and the FY2017 Air Passenger Survey; *3: Mobile Spatial Statistics (2019)

3. Future outlook

Based on this research, we aim to determine the effectiveness of using big data in air traffic demand forecasting models, and study concrete application methods. Furthermore, since air traffic demand forecasting requires estimates of transportation choices, we will study to improve forecasting using big data not only with regard to use of air routes, but also in connection with analysis of domestic destinations visited through all modes of transportation. In this way, we will aim to improve the accuracy of our forecasting.

ACR-PCR method for airport pavement applicable from 2024

(Research period: FY 2021-2023)
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Key Words: PCR, ACR, ICAO

1. Introduction

Annex 14 established by the ICAO (International Civil Aviation Organization) sets out various items that airport authorities must comply with, one of which is the public notice of bearing strength of airport pavement using the ACN-PCN (Aircraft Classification Number – Pavement Classification Number) method.

ACN is a number expressing the relative effect of an aircraft on airport pavement and is found in "Airplane Characteristics" published by the aircraft manufacturer that described the characteristics of each aircraft. PCN is a number expressing the bearing strength of airport pavement, and airport authorities around the world are required to publish the PCN of their airport in AIP (Aeronautical Information Publication).

By comparing ACN with PCN, it is easy to determine whether the aircraft can be operated or not. As shown in Figure, if PCN is equal or greater than ACN, normal operation is allowed, and if PCN is smaller than ACN, the airport authority decides to allow the overload operation, to allow the operation with weight restriction, or not to allow the operation.

ACN calculation method is established by the ICAO, but PCN calculation method is left to each airport authority. PCN calculation method in Japan is shown in the document "Manual for Public Notice of Airport Pavement Bearing Strength" by the Japan Civil Aviation Bureau of the Ministry of Land, Infrastructure Transport and Tourism.

Annex 14 was revised in 2022, and the ACN-PCN method used since November 26, 1981, will be abolished on November 27, 2024, and the new ACR-PCR (Aircraft Classification Rating – Pavement Classification Rating) method will be applied from November 28, 2024. When Japan Civil Aviation Bureau revises the document "Manual for Public Notice of Airport Pavement Bearing Strength" in response to the revision of Annex 14, the author conducted research to establish the standard PCR calculation method in Japan considering the ACR calculation method established by the ICAO and the airport pavement design method in Japan.

2. Overview of ACR calculation method

The ACR calculation method established by the ICAO is as follows (F and R are for flexible pavement and rigid pavement, respectively). Unlike ACN, multilayer elastic analysis is used for ACR calculation.

- In the pavement structure shown in Table-1 and Table-2, base course thickness (F) / concrete slab thickness (R) is determined so that the vertical strain on the surface of subgrade is 1325 μ (F) / the load stress on the underside of the concrete slab is 2.75 MPa (R) by the landing gear load (multiple wheels) of the aircraft.
- Derived single wheel load is calculated for the determined pavement structure. Specifically, a single wheel load with a tire contact pressure of 1.50 MPa is determined so that the vertical strain on the surface of subgrade is 1325 μ (F) / the load stress on the underside of the concrete slab is 2.75 MPa (R).
- ACR is the calculated derived single wheel load (in 100 kgf unit) multiplied by two.

3. Consideration of PCR calculation method

Various studies were conducted to reflect the airport pavement design method in Japan, and the PCR calculation method was developed with some modifications to the ACR calculation method. For flexible pavement, elastic modulus of base course was set with no upper limit in the ACR calculation, while that was set with the upper limit in the PCR calculation. For rigid pavement, the allowable stress design method was used in the ACR calculation, while the fatigue design method was used in the PCR calculation.

4. Conclusion

This PCR calculation method is described in the document "Manual for Public Notice of Airport Pavement Bearing Strength" published by Japan Civil Aviation Bureau in October 2, 2023.

☞ Reference

1) Y. Tsubokawa: Research on PCR Calculation Method for Airport Pavement, 2023 (in Japanese) https://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1256.htm

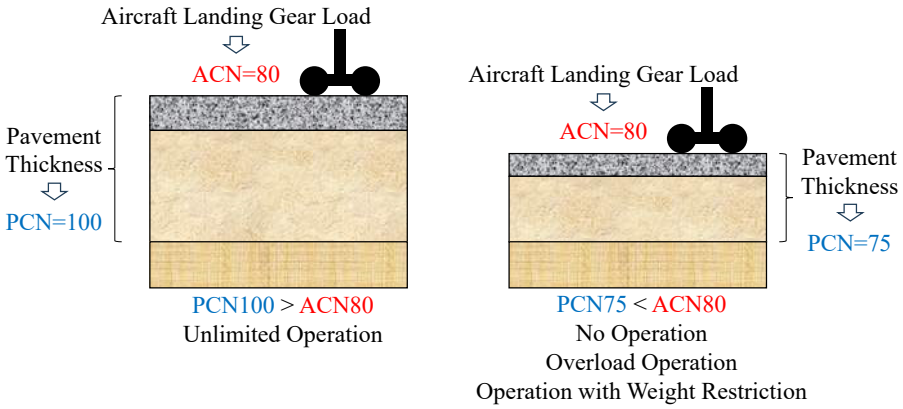

Fig: Determination of aircraft operation by using ACN-PCN method

Table-1: Flexible pavement structure for ACR calculation

Layer	Thickness (mm)	Elastic Modulus (MPa)
Surface Course	76 or 127 (Depending on the number of wheels)	1,379
Base Course	Variable	Set by equation
Subgrade	Infinite	50, 80, 120 or 200 (Depending on the subgrade strength categories)

Table-2: Rigid pavement structure for ACR calculation

Layer	Thickness (mm)	Elastic modulus (MPa)
Surface Course	Variable	27,579
Base Course	200	500
Subgrade	Infinite	50, 80, 120 or 200 (Depending on the subgrade strength categories)

BIM/CIM Generating Methods for the Efficient Maintenance and Management of Existing Port Facilities

(Study period: From FY 2022)

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Keywords: Productivity improvement, BIM/CIM, maintenance and management

1. Introduction

BIM and CIM (Building/Construction Information Modeling/Management) are expected to be effective in improving the efficiency of maintenance and management, such as in the visualization of inspection and diagnosis records, the centralized management of maintenance-related data, and as an information platform function in connection with measuring equipment. However, current guidelines for BIM/CIM are mainly aimed at new port facilities, and if applied as is to existing port facilities is a risk of creating unnecessarily high-precision 3D models. This study examines the minimum requirements for 3D models needed for maintenance and management and proposes a method for generating 3D models for existing port facilities.

2. Procedure for Examining the Requirements of 3D Models for Existing Port Facilities

The method for generating 3D models for existing port facilities adopts a method which uses the cross-sections and plan views that accompany maintenance and management plans which are available for most port facilities. Also, the maintenance and management plan and the results of inspections and diagnosis were directly or indirectly (by external reference) assigned as attribute information for the 3D model, depending on the content.

In this study, we first created a detailed 3D model of open-type wharves on vertical piles similar to that for a new port facility construction. We then conducted interview surveys with facility personnel, etc., considered the minimum requirements for 3D models needed for maintenance and management, and recreated a 3D model that met these minimum requirements.

3. Main Conclusions

The left of Fig. 1 shows a detailed 3D model similar to that for a new port facility construction, with a 3D level of detail (hereinafter “LOD”) of about 300. On the other hand, the right of Fig. 1 shows the minimum 3D model needed for maintenance and management as considered in this study.

From the interviews with facility personnel, it was learned that it was important that 3D models needed for maintenance and management be capable of allowing the visualization of the degree of performance degradation and deterioration and allowing the efficient searching of past inspection and diagnosis results, so the LOD was lowered to 200. The right side doesn’t accurately reproduce the haunch on the underside of the superstructure and the pile heads, etc., but the type of components, location of installation and number of components can be identified, so this is considered sufficient for maintenance and management BIM/CIM. The lowering of the LOD to 200 also reduced the creation time by about 50%.

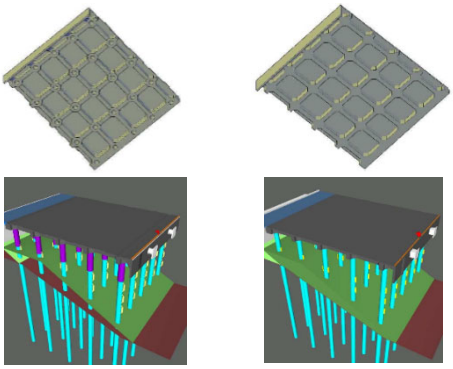

Fig. 1 Existing port facility BIM/CIM 3D model
(Top: superstructure; Bottom: Entire wharf)

4. Future Issues

In the future, it will be important to consider the most efficient methods for generating 3D models and adding attribute information based on the results of setting the requirements for existing port facility 3D models.

Study of techniques for detecting near-miss images by utilizing AI image recognition technologies

(Research period: FY 2022 -)

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Key words: AI image recognition technologies, roadside camera, near-miss

1. Introduction

When implementing traffic safety measures in areas where traffic accidents occur frequently, etc., in order to select effective measures, it is necessary to properly grasp the process of occurrence of an accident and the factors of the accident that are inferred from such process. If image data that have been obtained on roadside cameras can be utilized, as compared with the accident statistics data and accident occurrence status drawings, etc. that have conventionally been used, the situation of surrounding areas and behavior leading to the occurrence of the accident can directly be grasped, and besides samples of latent hazards that do not lead to an accident (near-miss) can also be obtained, and it is considered that the accuracy of inference of the factors of the accident will increase. On the other hand, there is a problem that time and efforts are required to check the images visually and to extract the near-miss only. If the extracted images are only those of the near-miss, the above problem can be solved, and an increase in the efficiency of accident factory analysis can be achieved. Therefore, the NILIM is conducting a study of techniques for mechanically detecting near-miss images, and this paper presents the results of such study.

2. Detection of near-miss images by utilizing AI image recognition technologies

A near-miss has been defined to be a "phenomenon in which two parties come close to each other," and from the images of roadside cameras that were installed in two intersections on national highways, 60 events each of "image data including those of a near-miss" and "image data not including those of a near-miss" were extracted in advance by visual checks. By applying the AI image recognition technology (YOLO) to the continuous images of these phenomena, objects such as vehicles and bicycles, pedestrians, etc. in the images were detected (the rectangular frames surrounding the vehicles in the figure). Then, the near-miss was detected by means of the method shown in Table 1, by using as indexes the "distance between the parties" and "speed change (with or without deceleration)" based on the position of the detected object.

In order to verify the accuracy of detection, the accuracy verification indexes shown in Table 2 were calculated, assuming the results of distinction by visual checks were accurate. Consequently, the accuracy rate was about 70 to 80%, thus achieving a certain level of accuracy, but the rate of precision was around 30% in both of the intersections, and the highest rate of reproduction was around 45% at intersection A. The "distance" was used as the detection index as the major factor of erroneous detection or overlooking, but the directions of travel of the parties are not considered by the index, and phenomena with no possibility of crossing could have been detected.

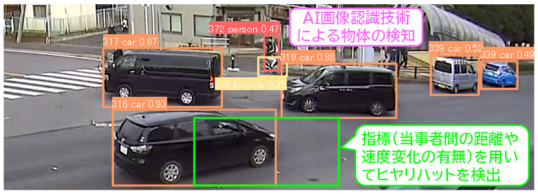

Figure: Image of near-miss detection

Table 1: Near-miss detection method

当事者	ヒヤリハット検出指標・閾値
歩行者・自転車対自動車	当事者間の距離が6m以下（①）
自動車対自動車	①かつ減速があり、直前1秒間の移動距離が4m以下

Table 2: Results of verification of the near-miss detection accuracy

交差点	精度検証指標			
	正解率	適合率	再現率	F値
交差点A	67.0%	30.6%	45.6%	36.7%
交差点B	80.3%	35.5%	29.6%	32.3%

正解率：指標による判定結果のうち、正しかったものの割合
適合率：指標によってヒヤリハットと判定したケースのうち、本当にヒヤリハットである割合（誤検出の少なさ）
再現率：全てのヒヤリハットケースのうち、指標によってヒヤリハットと判定できた割合（見逃しの少なさ）
F値：適合率と再現率の調和平均（バランス）

3. Conclusion

We would like to review the detection indexes and threshold so that no specific near-miss phenomena will be overlooked (for example, only the near-miss involving bicycles will be overlooked, or the like), while aiming at an increase in the rate of precision so that extraction of non-near-miss images will be suppressed, in order to increase the efficiency of work at the site, and to enable the technologies to be applied at the site.

Support for the introduction of green infrastructure in road space- by using road greening as an example-

(Research period: FY 2021 to FY 2023)

Yoshiki Nezu, Senior Researcher, Keiko Ohkouchi, Researcher,
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Key words: green infrastructure, road greening, road administrator, collaboration

1. Introduction

Green infrastructure that utilizes the functions of nature is efforts to promote the making of national land, cities and areas that are sustainable and attractive, and its introduction can be seen in various fields.

In the road sector, efforts that have been made conventionally such as road greening are re-evaluated as green infrastructure. In particular, it is expected that road greening that contributes to the formation of space integrated with facilities along the road and surrounding areas will form comfortable time-spending space, thereby contributing to the realization of human-centered road space that is crowded with people. It is expected that the utilization of road space by residents and businesses along the road will lead to the improvement of the environment and attraction of the road space as well as surrounding areas.

At the time of implementation of road greening that contributes to the formation of space integrated with facilities along the road and surrounding areas, it is important that the road administrator devises a plan and carries out maintenance and management in collaboration with relevant parties along the road, etc., on the basis of the needs of the areas.

Therefore, we have conducted a survey of measures concerning collaboration with relevant parties along the road, from the examples of the formation of space integrated with facilities along the road and surrounding areas by the greening of road space, etc., and have summarized the points to be noted that will serve a reference for the road administrator.

2. Survey of examples of greening that contribute to the formation of space integrated with surrounding space

We have conducted a survey of about 20 examples where the formation of space integrated with facilities along the road and surrounding areas by the greening of road space, etc. (for example, Saitama City (Photo 1), Asaka City (Photo 2), and Kawasaki City (Photo 3)), and have summarized the measures related to efforts made by the road administrator in collaboration with the relevant parties along the road from the stage of devising the plan. Examples are presented below for reference purposes.

In the OMIYA STREET PLANTS PROJECT (Saitama City), which is one of the examples surveyed, private businesses exclusively use the planting portion of the road space, and install the planting and sell the installed planting to road users (reposted: Photo 1). Private businesses are engaged in planting improvement according to the needs, based on the situation of sale and the situation of stay of road users, etc. The road administrator shares the duties in the districts with private businesses and carries out maintenance and management in collaboration with the private businesses. By the collaborative efforts in road greening, the formation of green shade in the road space and the improvement of landscape in the entire areas are pursued. In addition, the open terrace such as shops along the road and the road space can integrally be utilized, comfortable time-spending space is formed, and crowded space is created. In this example, at the time of implementation of road greening, measures are taken such that the planting space will be improved based on the needs of the areas, and that the road administrator will be engage in maintenance and management by shares the duties with private businesses.

Photo 1: Road greening in road space assuming its utilization integrated with surrounding areas (Saitama City)

3. Points to be noted in road greening that contributes to the formation of space integrated with facilities along the road and surrounding area

From the measures related to efforts that have been obtained from the survey of examples, the points to be noted by the road administrator have been summarized when implementing road greening that contributes to the formation of space integrated with the facilities along the road and the areas. Examples of such points are presented below.

Firstly, the points to be noted when devising a plan are the arrangement of trees and the selection of tree types, it is important for the road administrator to examine a plan in collaboration with citizens and private businesses, etc., and to devise an improvement plan by assuming that maintenance and management will be done by the road administrator in collaboration with the relevant parties along the road such as residents after improvement by the road administrator (Asaka City, Kawasaki City, etc.), and to devise a plan assuming that improvement, maintenance and management of the greening portion such as planting will be done by private businesses by exclusively using the road, etc. (Saitama City). By noting the points such as these, it is expected that the planting improvement will reflect the needs of the areas and will contribute to the improvement of space integrated with the areas along the road.

Secondly, the points to be noted when preparing a maintenance and management plan are those when the road administrator carries out maintenance and management by sharing the duties with relevant parties. The basic practice of ordinary road greening is the maintenance and management done by the road administrator. Whereas, when implementing road greening that contributes to the formation of space integrated with the facilities along the road and the surrounding areas including the improvement of landscape and the improvement of road functions such as traffic safety as well as the improvement of attraction of the surrounding areas, the road administrator is required to share the roles with the areas and the relevant parties along the road such as private businesses. It is important that the framework of cooperative systems between the road administrator and the relevant parties along the road for the maintenance and management cost and for the implementation of maintenance and management will be established beforehand (Saitama City, Kawasaki City, etc.). It is expected that, by noting the points such as these, a system will be built in the stage of devising the plan, and that smooth and sustainable maintenance and management will be in place in the stage of maintenance and management after the improvement.

The points to be noted as described above have been summarized by referring to the basic flow of the planting plan in the Road Greening Standard and Its Explanations (March 2016) (Fig. 1).

4. Conclusion

We plan to provide support for the smooth introduction of green infrastructure such as road greening, by creating detailed explanations in which specific examples, etc. have been added to the points to be noted that have been summarized in this paper, as a material that serves as a reference for the road administrator, and by familiarizing the relevant parties with such material.

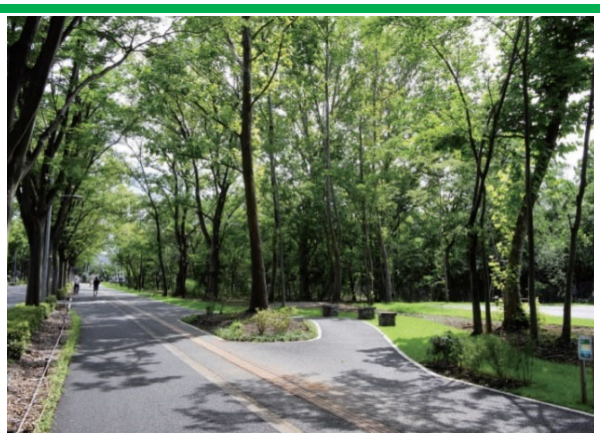

Photo 2: Creation of crowded space and space for rest, by improving the road space and surrounding areas integrally by road greening (Asaka City)

Photo 3: Space created by planting installed along the road (operation as well as maintenance and management implemented by residents, etc. in the surrounding areas) (Kawasaki City)

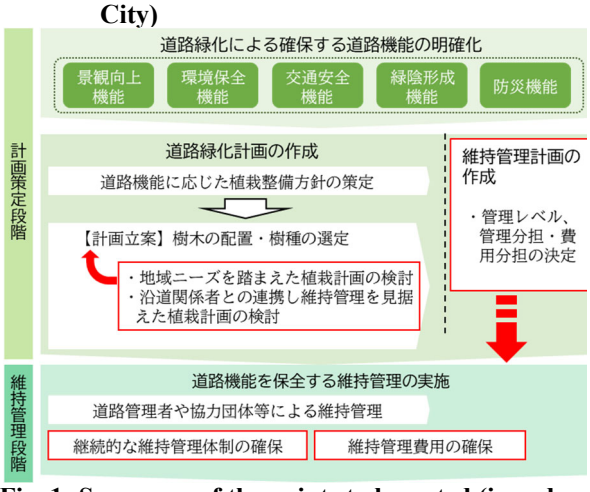

Fig. 1: Summary of the points to be noted (in red frames) that have been presented in this paper in each of the stages of road greening

☞For detailed information, refer to the following:

1) Website of the Road Environment Division https://www.nilim.go.jp/lab/dcg/kadai10-greeninfra.html

Development of a Rational Evaluation Method for the Daylighting Performance of Residential Environments

(Research period: FY 2022-2026)

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(Keywords) Housing performance indication system, daylighting, comfort, resident's evaluation

1. Introduction

One system for evaluation of the quality of houses is the housing performance indication system, which was based on the Housing Quality Assurance Act. The evaluation items for light and visual environment performance in this system specify the simple opening ratio and the ratio of openings by orientation as indexes related to daylighting from windows. However, the relationship between these indexes and light and visual environment performance is difficult for residents to understand, and the correspondence to the ratings used as target values for design has not been adequately established. Therefore, the purpose of this research is to improve the evaluation method for light and visual environments based on the diversifying needs of recent years. First, this report explains the results of a survey of residents concerning windows and the light and visual environment from windows.

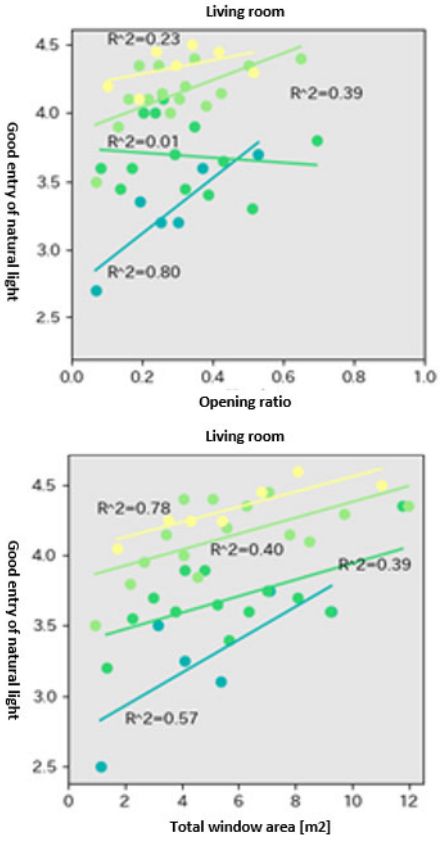
2. Questionnaire Survey on Daylighting and View of Housing

The survey method was an online survey, in which replies were received via the internet. The survey was conducted in January 2023. The survey regions were three areas with different annual hours of daylight and sunrise/sunset times (Tohoku region: Akita Prefecture, Yamagata Prefecture; Kanto region: Chiba Prefecture, Ibaraki Prefecture; Kyushu region: Kumamoto Prefecture, Kagoshima Prefecture). The respondents were 1,000 persons assigned by age and gender from 10,000 persons who participated in a preliminary survey. The main survey items were items related to "Room and window specifications" (size of rooms and windows), "External conditions" (spaciousness of outdoor space, visibility of the sky) and "Evaluation of light and visual environment" (degree of satisfaction with daylight from windows and the view from windows).

Among the questionnaire items, **Figure** shows the relationship between the results of an evaluation of "Good entry of natural light," which is related to daylighting, in 5 levels (5: I think so, 3: Not particularly good or bad, 1: Don't think so.) and the size of windows. As indexes of window size, the figure shows two cases, the opening ratio (ratio of the window area to the room floor area) and the total window area. The degree of daylighting can be explained more convincingly by the total window area. Moreover, as the visibility of the sky from windows increases (larger values), the evaluation of daylighting also improves, and the degree of that effect could be confirmed.

3. Future Outlook

In the future, we plan to study inclusion of the effect of the view from windows in the housing performance indication system, in addition to the evaluation of daylighting, and will work to improve the evaluation method for the light and visual environment in response to diverse needs.



*The points in the figure were rearranged so that the data are shown in ascending order by the values on the respective horizontal axes, and the averages of the values on the horizontal and vertical axes were then plotted for each 20 respondents.

Fig. Relationship of window opening ratio and area and evaluation of daylighting

Actual Condition and Trends in Retrofitting of Condominium External Thermal Insulation

(Research period: FY 2023-2025)

Housing Department, Housing Planning Division

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(Keywords) Condominium, Energy conservation, External wall insulation, Performance improvement, Life prolongation

1. Introduction

The total stock of condominiums in Japan has reached approximately 6.943 million units (as of the end of 2022). Because many older condominium buildings also have low frame insulation performance, etc., promotion of retrofitting to improve energy conservation performance is required in order to respond to life prolongation and realize carbon neutrality. However, there are challenges when attempting to implement plans to install external wall insulation on external walls, which are considered "common parts" of condominium buildings, as the hurdles to consensus-building are high, including the positioning of the construction work in the long-term repair plan, the possibility of increases in the building's reserve fund for repairs, etc., and experts in management and repair are not be able to present the effects of repairs in an appealing form.

This report introduces the actual condition and trends in this field as a basic survey of retrofitting of condominium external thermal insulation.

2. Actual Condition and Trends in Retrofitting of Condominium External Thermal Insulation

Based on information on examples of retrofitting available on the internet, in books, etc., the Housing Planning Division conducted an interview survey of various types of groups, persons engaged in actual work and others, and collected and organized examples of retrofitting of condominium frame external insulation. As a result, at least 41 cases (totaling 212 buildings with 5,897 units) could be understood as examples of implementation (as of the end of January 2024).

Arranging the trends in these cases, the largest number of sites, comprising 20 cases, was in Japan's northern island of Hokkaido, followed by 18 cases concentrated in the Tokyo Metropolitan area (**Fig. 1**). As the period of construction, the oldest were two cases in housing complexes consisting of staircase-type buildings completed in 1968, where retrofitting started more than 50 years after the original construction. The largest number of cases, 19 (totaling 121 buildings with 3,734 units), was condominiums built during or before the 1970s, including those mentioned above. Although the total number of retrofitted units increases as the buildings become older, we also found two examples (totaling 2 buildings with 47 units) from after the year 2000 (**Fig. 2**). Among condominiums constructed from the 1990s onward, there were some cases in which frame repairs were carried out at a comparatively early stage with a view to improving interior-environment performance or prolonging the life of the structure by protecting the frame with external thermal insulation. Cases of this type can be seen in Hokkaido, where retrofitting of external thermal insulation was carried out simultaneously with the first large-scale repair 13 to 16 years after construction.

Photo. External thermal insulation retrofitting

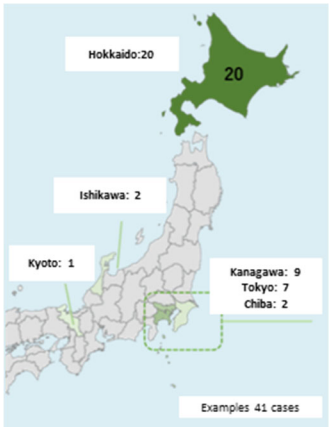

Fig.-1 Sites of examples

3. Future Outlook

In the future, we plan to collect and analyze data on the cost and effects of external thermal insulation retrofitting and develop a technique for quantifying its cost effectiveness. Based on that work, we intend to summarize the results in a handbook, bearing in mind the need to present information that can contribute to supporting the experts who will study and plan performance improvement retrofitting for energy conservation, etc. and planned implementation by the condominium management associations.

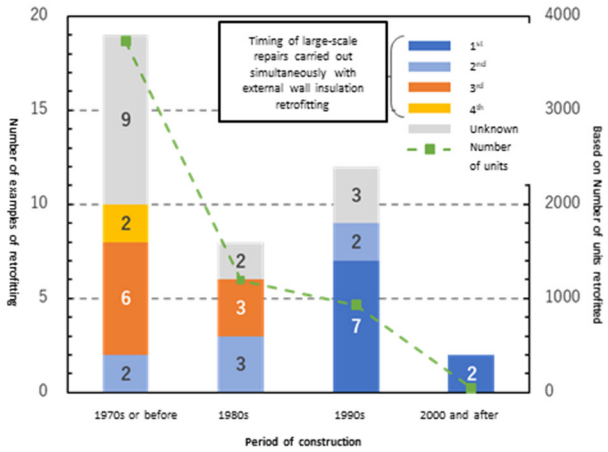

Fig.-2 Relationship of number of cases of retrofitting by construction period and large-scale repairs

Research on Standards for Barrier-free Tubless Bathrooms

(Research period: FY 2021-2023)

Housing Department, Housing Production Division

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(Keywords) Elderly people living at home, Accidental drowning, Tubless bathroom, Barrier-free standards

1. Introduction

In recent years, deaths of elderly people living at home due to accidental drowning while bathing have occurred frequently and are increasing in Japan. On the other hand, assistance in which a helper places the bather in a bathtub imposes a heavy burden on helpers, and is accompanied by risk for both the bather and the helper. Although the Japanese are still not accustomed to bathing without a bathtub, it is possible to prevent drowning accidents and reduce the burden on helpers by eliminating the tub from the bathroom and bathing without soaking in a bathtub. In addition, as a result of this reduction in the burden on helpers, family members in the home will be able to assist elderly people safely and easily. Since this will increase the opportunities for bathing, it can also be expected to contribute to an improved quality-of-life (QOL) for the bather.

The Housing Production Department conducted "Research on Standards for Barrier-free Tubless Bathrooms (FY 2021-2023) on bathrooms without a bathtub," in other words, "tubless bathrooms," to arrange design concepts that give appropriate consideration to the needs of elderly people ("elderly-friendly design"), as well as technical standards that can be applied to judgments of safety, etc.

2. Study Items

The main study items in this research are as follows. The following sections present an outline of the respective items. Table 1 gives the definition of a "tubless bathroom," and **Fig. 1** shows an image of remodeling from an existing bathroom with a bathtub to a tubless bathroom.

① Study and arrangement of the range of bathers
② Experimental verification of the safety, ease-of-use, etc. of tubless bathrooms
③ Development of technical standards, etc. for barrier-free design of tubless bathrooms

3. Study and Arrangement of Range of Bathers

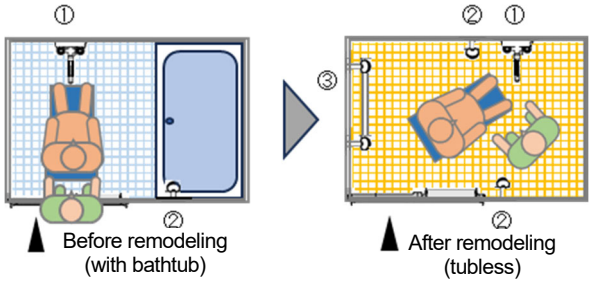
In studying the size, etc. of tubless bathrooms and planning the related experiments, firstly, because the method of bathing differs depending on the physical condition of the user of a tubless bathroom, and the necessary dimensions of the bathroom will also differ accordingly, the relationship between the assumptions about the physical condition of the bather and the nursing care certification class were arranged, as shown in **Fig. 2**. As shown in the figure, the experimental conditions of the bathroom size were specified assuming that persons having physical characteristics that fall within the gray ellipse will be the users of the tubless bathrooms.

【1】Independent bather capable of walking (with bathing helper)
【2】Use wheelchair in room, use bath chair in bathroom (with bathing helper)
【3】Use assistive-type wheelchair in room, use shower carrier in bathroom (with bathing helper)

Table 1 Definition of tubless bathroom

・ A bathroom with no bathtub, a space for bathing that does not need a bathtub.
・ Activities such as washing the bather's hair and body and warming the bather's body can be performed with the bather seated on a bath chair or by using a shower carrier (or a wheelchair and bath chair)
・ A helper can also enter the bathroom and help with bathing.

*In principle, a bathroom with no bathtub is defined those which satisfy the above 3 requirements.



① Faucet hardware (water faucet) ② Vertical handrail for use in standing and sitting ③ Handrail for moving
* The size of bathrooms are the same.

Fig. 1 Image of remodeling from an existing bathroom to a tubless bathroom

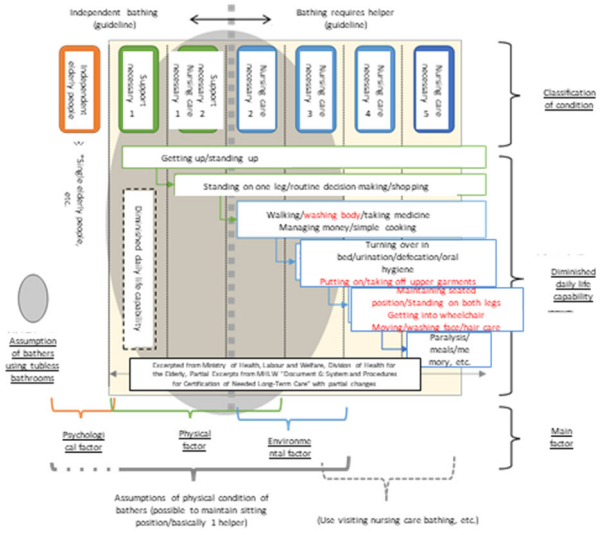


Fig. 2 Relationship of assumptions about physical condition of bather and nursing care certification class

4. Experimental Verification of Tubless Bathroom Safety and Ease-of-Use, Etc.

Experiments were carried out for verification of the necessary spatial dimensions, handrail positions, etc. of tubless bathrooms and verification of the safety, burden, etc. of actions of the bather and helper. For these experiments, actual-size mockups simulating the tubless bathrooms were installed, and human-subject experiments were conducted using a total of 17 general males and females as the subjects (conducted in December 2022). The outline of the experiments is summarized in **Table-2**. For further details, please refer to the reference literature.

Table2 Outline of experiments

*The lower rows show the data obtained.

[Experiment 1] Position, height, etc. of handrails installed in tubless bathroom
Position and height of handrails to make it possible for the bather and helper to move in the washing space, prevent falling when standing up or sitting down, and maintain posture while bathing.
[Experiment 2] Minimum size of tubless bathroom required for bathing
Inner dimensions of the tubless bathroom that enable bathing actions, separately for the cases of independent walking and assisted walking.
[Experiment 3] Size of tubless bathroom in case a wheelchair, etc. is to be used
Dimensions of the tubless bathroom that enable movement and bathing actions when using a wheelchair or shower carrier, assuming the presence of a helper, as in the above [Experiment 2]

5. Development of Technical Standards, Etc. for Barrier-free Tubless Bathrooms

(1) Required size levels of "tubless bathrooms" (draft)

Based on the results of the verification experiments described above, the required performance levels of tubless bathrooms were studied by following procedure.

① Each of the experimental cases of the human-subject experiments is evaluated by experts from the viewpoint of "whether bathing and bathing assistance can be regarded as possible," based on the data obtained by videorecording the experiments, etc.

② Whether the actions and movements of the subjects assuming the bather and helper are realistic under the spatial constraints of the bathroom size (inner dimensions W x D) and layout is evaluated in four levels (◎, ○, △, ×), and a primary evaluation is made.

③ The evaluation results are summarized and discussed, and based on the results, the evaluators finalize the evaluation.

④ Based on the summary of the expert evaluation, the required levels (draft) of the "Bathroom size (length of short side, area)" are arranged corresponding to the characteristics of the bathers and bathing methods.

The results (examples) of this arrangement are shown in **Fig. 3**.

◎ Recommended ○ Guidance △ Standard × Not possible

Experiment No. 実験No.	Bathroom type 浴室タイプ	Bathroom size (W x D) 浴室サイズ（幅×奥行）	Area (m2) 面積（㎡）	Opening 開口	◎ 推奨 ○ 誘導 △ 標準 × 困難 Wheelchair 車いす	Shower carrier シャワーキャリー	Walk/helper 歩行・介助者
b16	Existing UB type	1,700 × 1,800	3.06	800	◎	◎	
b4	Existing UB type	1,600 × 1,800	2.88	800	◎	◎	
b1		1,600 × 1,600	2.56	800	○	◎	
a1		1,600 × 1,200	1.92	800		△	◎
c9		1,500 × 1,600	2.40	800		◎	
a18		1,500 × 1,200	1.80	800	×	×	◎
b18	Existing UB type	1,400 × 1,800	2.52	800	○-	◎	
b2		1,400 × 1,600	2.24	800	△	○	
c18		1,400 × 1,500	2.10	800	△	△	
c19		1,400 × 1,400	1.96	800	△	×	
a19		1,400 × 1,200	1.68	800	×	×	◎

Fig.-3 Arrangement of evaluation results (example)

(2) Design Guideline for Tubless Bathrooms for New Construction and Remodeling of Existing Housing (Draft)

Based on the content of the study up to this point, the captioned Guideline was compiled with the aim of popularizing tubless bathrooms. Since the main assumed readers are residents and designers who are studying the installation of a tubless bathroom, the concept of the tubless bathroom, its required functions and their levels, and examples that may provide hints for design are introduced (a draft of the Table of Contents is shown in **Table-3**).

Table-3 Table of Contents of Guideline (Draft)

Chapter 1 Introduction
Purpose, composition of Guideline, definitions of terms
Chapter 2 What is a Tubless Bathroom?
Definition and features of tubless bathroom, image of use, characteristics of assumed users
Chapter 3 Functions and Performance of Tubless Bathrooms
Functions of tubless bathrooms, required levels of tubless bathrooms and their concepts, dimensional standards for tubless bathrooms
Chapter 4 Tubless Bathrooms Considering Ease-of-Use, Safety and Peace of Mind
Response to characteristics of users, introduction of examples for remodeling to a tubless bathroom
Chapter 5 Conclusion
Proposal of the tubless bathroom as a new bathing style, future outlook and issues

6. Conclusion

A summary of these research results, the required levels of tubless bathrooms, and a draft of the Guideline will be compiled as a TECHNICAL NOTE of the National Institute of Land and Infrastructure Management (NILIM). The results are scheduled to be released during FY 2024.

☞For more information

1) Research on Technical Standards for Barrier-free Tubless Bathrooms Part 1 – Outline of Human-Subject Experiments Related to Size and Dimensions, Etc., Summaries of technical papers of the FY 2023 Annual Meeting (Kinki) of the Architectural Institute of Japan, pp. 1255-1256, Aug. 2023
2) Research on Technical Standards for Barrier-free Tubless Bathrooms Part 2 – Trial of Use of 3-Dimensional Measuring System in Human-Subject Experiments, Summaries of technical papers of the FY 2023 Annual Meeting (Kinki) of the Architectural Institute of Japan, pp. 1257-1258, Aug. 2023

Trial of Creation of ZEB Retrofitting Plan for Existing Government Office Building

(Research period: FY 2022-2024)

Housing Department, Building Environment Division

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(*Keywords*) *Existing building, Decarbonization, Energy saving, Retrofitting, ZEB, Simulation*

1. Background and Purpose of Research

To realize decarbonization, further energy conservation is necessary and indispensable, not only in new construction, but also in existing buildings (**Fig. 1**). In nonresidential buildings (office buildings, etc.), air-conditioning, lighting and other equipment and devices are renewed (renovated) every 10 to 20 years, but in many cases, this renovation work is limited to easy equipment exchanges at present. When undertaking repairs, it may be possible to achieve substantial energy saving effects at a rational additional investment cost if the equipment is redesigned based on a survey of the existing conditions (**Fig. 2**). However, because concrete methods have not been established, the current situation is that surveys and redesign work are almost never carried out, and as a result, opportunities for energy saving are missed.

To address this problem, NILIM is developing technical guidelines (current condition diagnosis method, retrofitting design method) aimed at maximizing the energy-saving and CO_2 reduction effects of retrofitting, as well as evaluation tools for evaluating their cost-effectiveness. This report describes the results when a concrete "ZEB retrofitting plan" (ZEB: net Zero Energy Building) was created on a trial basis for an actually-existing government office building (NILIM Tachihara Office; completed in March 1978, 7 above-ground floors, 1 basement, total floor area: 13,467 m^2) to obtain concrete knowledge concerning retrofitting design.

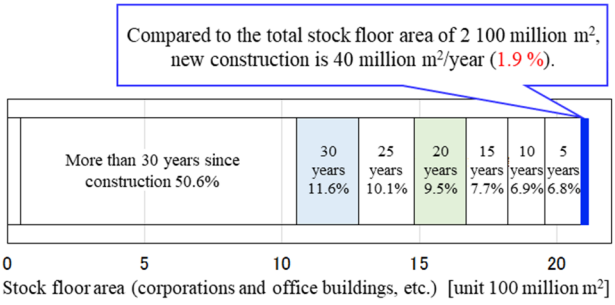

Fig. 1 Stock floor area by building age

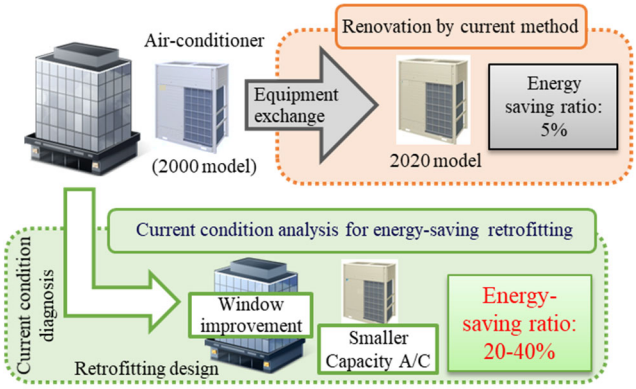

Fig. 2 Energy-saving retrofitting based on current condition diagnosis

2. Setting the Retrofitting Level

In this trial, the three retrofitting levels (1, 2, 2+) shown below were set, and retrofitting plans were created.

- (Level 0) Current condition as-is
- (Level 1) Standard equipment renovation:
  The type of air-conditioning system is not changed from the current "Central air-conditioning system using a direct-fired absorption water heating and cooling machine," and are only upgraded to the most recent machine of the same type. The building envelope is not changed, and equipment other than the air-conditioning system is simply upgraded to the general equipment specification which is currently in use.
- (Level 2) Retrofitting targeting ZEB:
  Retrofitting is carried out, aiming at a condition in which its energy consumption after the retrofit is equivalent to "ZEB Ready (building with energy consumption reduced to no more than one-half of the standard value, without considering energy creation by solar power generation)." Improvement of the building envelope is also included in the study targets, and changing the type of air-conditioning system, introduction of an automatic control system, etc. are also included in the study targets.
- (Level 2+) Level 2 + introduction of solar power generation:
  In addition to Level 2, introduction of solar power generation is studied.

Table 1 Procedure for creation of ZEB retrofitting plan

No	Item	Content
STEP-1) Determine current energy consumption performance		
1-1	Check and arrange existing drawings	• Check whether drawings and materials exist or not. (Architectural drawings, equipment ledgers, structural calculation sheets) • In the existing drawings, check the insulation performance and types and positions of fixtures and equipment.
1-2	Field survey	• Visit the building, and check and record the current arrangement, number of units, serial Nos., etc. of the equipment. • Interview the equipment manager regarding the condition of the equipment.
1-3	Evaluation of energy consumption performance	• Using a building energy consumption performance calculation program (non-residential), calculate primary energy consumption.
STEP-2) Perform standard equipment renovation design		
2-1	Perform renovation design	• Perform standard equipment renovation design (equipment updating).
2-2	Evaluate energy consumption performance	• Using the building energy consumption performance calculation program (non-residential), calculate primary energy consumption.
2-3	Calculate renovation cost	• Calculate the estimated cost.
STEP-3) Perform retrofitting design aiming at ZEB		
3-1	Perform retrofitting design	• Create a ZEB proposal.
3-2	Evaluate energy consumption performance	• Using the building energy consumption performance calculation program (non-residential), calculate primary energy consumption.
3-3	Calculate the retrofitting cost	• Calculate the estimated cost.
STEP 4) Analyze energy-saving performance and economics		
4-1	Analysis of energy-saving performance	• Calculate and compare the results of general energy-saving improvements and the energy-saving and CO2 reduction effects, etc. of the ZEB retrofit.
4-2	Analysis of economics	• Using the cost of the general energy-saving improvements and cost of the ZEB retrofit, and the monetary effect of energy-saving under the two scenarios, compare the payback periods (years to recover investment).
STEP 5) Create the ZEB retrofitting plan		
5-1	Summarize the content, cost-effectiveness, etc. of retrofitting	• Summarize the content, cost-effectiveness, etc. of the retrofitting proposal so that the study results are easy to understand. • If it is possible to use a financial support project, calculate the actual cost in case that financial support is used.
5-2	Create the retrofitting schedule	• Create an implementation schedule for all processes from retrofitting design to completion of construction.

3. Creation of ZEB Retrofitting Plan

Table-1 shows the procedure used to create the ZEB retrofitting plan in this trial. First, as STEP-1, the energy consumption performance in the current condition (Level 0) was determined. Because the target government office building has undergone repeated renovations, and drawings were only prepared of the parts necessary in the work at the time, the transition over time was understood by combining multiple drawings. The current condition of parts that were unclear in the drawings was determined by a field survey. Based on the survey results, the primary energy consumption was calculated by using a program for judging compliance with building energy standards (Web program, standard inputting method).[1)] The result was 2,655.5 MJ/m^2/year (BEI = 2.08).

Next, as STEP-2, standard equipment renovation design (Level 1) was carried out. The equipment was selected using Building Equipment Design Standards, and the equipment efficiency was set based on a market survey. Primary energy consumption was reduced to 2,377.5 MJ/m^2/year (BEI = 1.87), for a reduction of about 10 % compared with Level 0.

In STEP-3, retrofitting design targeting ZEB (Level 2) was carried out. The air-conditioning equipment was changed to the individual distributed type using packaged air-conditioning units, and improvements (strengthening of heat insulation of openings, introduction of total heat exchangers, adjustment of precooling time, etc.) were introduced to keep the peak load to within 150 W/m^2 by utilizing dynamic load calculations by BEST (Expert Ed.). As a result, primary energy consumption was reduced to 517.5 MJ/m^2/year (BEI = 0.41). At Level 2+, based on the current roof area, etc., it was judged that 236 kW of solar power generation capacity can be introduced. In this case, primary energy consumption is 349.6 MJ/m^2/year (BEI = 0.28).

In STEP-4, the utility expenses before and after retrofitting and the cost of the retrofitting work were calculated. The calculation results are shown in **Fig. 3**. Utility expenses were calculated assuming prices of ¥32.29/kWh for electricity, ¥193.8/m^3 for gas, and ¥120/L for kerosene. A rough calculation of the cost of retrofitting work was made using Life Cycle Cost of Buildings, 2nd Ed. (2019), published by the Building Maintenance and Management Center.

Finally, as STEP-5, cost-effectiveness was analyzed. Comparing Level 1 and Level 2+, the difference in utility costs was ¥42.8 million, and the difference in retrofitting costs was ¥614 million. This means that payback period of 14.3 years is required to recover the investment from Level 1 to Level 2+ (difference of retrofitting cost/annual difference of utility costs).

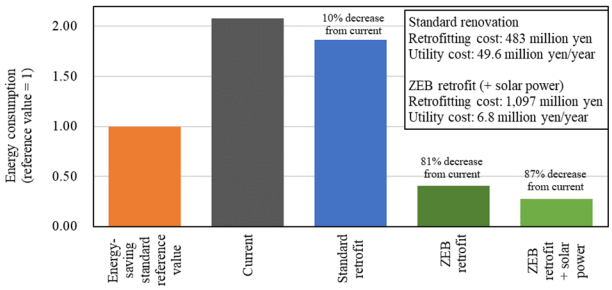

Fig. 3 Energy consumption reduction effect of retrofitting

4. Summary and Issues

A trial ZEB retrofitting plan was created for an actually-existing government office building. It was found ZEB Ready can be achieved even in an office building that was completed in 1978. On the other hand, the investment payback period was 14.3 years. Thus, it will be necessary to appeal to potential users based on benefits other than the reduction in utility costs, for example, improvement of the indoor thermal environment. This is an issue for future study.

☞For more information:

1) Building Research Institute: Technical Information on Energy Consumption Performance of Buildings (in cooperation with NILIM)
https://www.kenken.go.jp/becc/index.html

Development of Tools for Utilization of Organic Interaction Effects of Public Spaces in City Centers

(Research period: FY 2021-2024)

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(*Keywords*) *well-being, public-private cooperation, walkable, sensory evaluation (five senses), imageability, enhancement of area value*

1. Purpose and Background of Research

With the rapid progress of digitalization, diversification of individual lifestyles and orientation toward providing a more abundant life for all persons, including well-being, etc., in the post-COVID era, initiatives aimed at creating innovation through encounters and exchanges with diverse people and realizing more abundant humancentric lifestyles by the formation of walkable "comfortable town centers where people want to walk" through joint public-private efforts are progressing in city center areas throughout Japan. To enhance the effects of these efforts in spite of limited investment resources, it is important to develop and implement concepts that will have a ripple effect on the entire city center area, and thereby increase its value, by encouraging city streets, plazas, parks, rivers and other public spaces (hereinafter, PS), which are not only flow lines for people's everyday lives, but also hubs for a diverse range of activities, to form a complex, mutually-interrelated whole that demonstrates synergistic effects. On the other hand, because the elements and extent of those effects were unclear, there were problems when attempting to deploy urban revitalization programs in the community. Therefore, the aim of this research is to construct a methodology that will be useful in improving local programs by measuring and observing the elements of the organic interaction effects of PS and the modes in which they are expressed.

2. Urban Revitalization Based on Organic Interaction of PS

Fig. 1 represents the management cycle from planning and implementation of urban revitalization programs until realization of the outcomes required in the future, by evaluation and analysis of PS interaction effects and repeated improvement and implementation of plans.

The element items of these PS interaction effects were classified in a total of nine categories based on the 3 approaches of the physical aspect, activity aspect and the psychological and social aspect from the 3 viewpoints of users, facility administrators and community development organizations involved in urban activities. It is assumed that these will be used as axes for predicting the interaction effects of PS in the planning stage of urban revitalization programs, properly understanding the conditions at actual sites in the implementation stage, and continuously monitoring the manifestation of effects.

3. Results of Street Interview Survey of Users

Among the elements of PS interaction effects, the Urban Facilities Division conducted street interviews focusing on the perspective of users during FY 2022 (Nov.-Dec. 2022). Preconditioned on the establishment of a future vision for the area and the possibility of observing leading initiatives that display an awareness of PS interaction, three target areas (Katamachi, Korinbo and Hirosaka areas of central Kanazawa, Minato Mirai in Yokohama, and the Otogawa Riverfront area in Okazaki) were selected as three cases with different local characteristics, different availability of PS and different user characteristics and other features. The changes in behavior, awareness, etc. due to linkage between PS in these areas were investigated by interviewing PS users in each area. Interviews were conducted on two days (one weekday, one holiday) between 10:00 and 16:00, and the sample size was around 200 in each city (about 100 on each day).

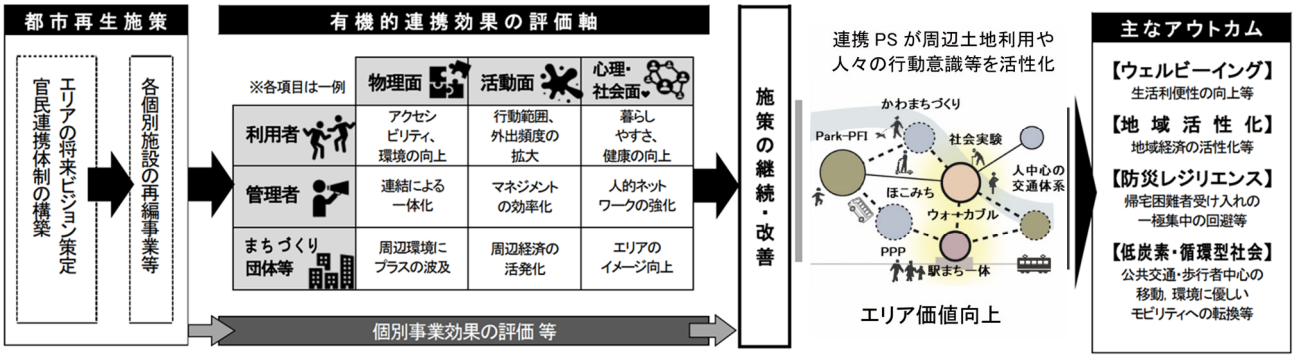

Fig. 1 Image of utilization of PS interactions of in the urban revitalization management cycle

The results clarified two types of effects, namely, improvement of the life satisfaction of the users in the area as a whole and an increase in the scope of behaviors and content of activities, etc., corresponding to the characteristics of the urban space and the purpose of visiting the area (**Fig. 2**).

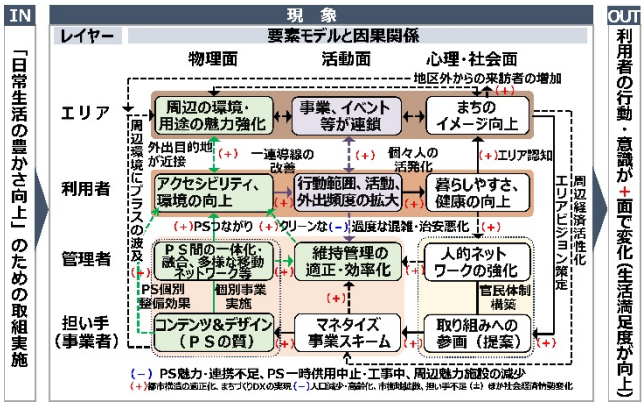

Fig. 2 Toward study in FY 2023: Consideration of the causes and effects of interaction

4. Sensory Survey of Modes of PS Interaction by Expert Investigators

In FY 2023, a composite study was conducted to understand the mutual spatial relationships at the micro-scale, rather than in area units. This was a multi-scale investigation of PS units, diverse transportation networks and the furniture scale, and was carried out by a mixed method involving quantitative and qualitative surveys. The feasibility of applying the 9 categories as a whole, also including the standpoints of administrators and community development organizations, and the extent and appropriateness of the element effect items, the mutual interrelationships between the items and other relevant issues were verified in a comprehensive and detailed manner by interviews with each of the entities concerned. From the perspective of users, a field survey of the modes of physical interaction between multiple PS and the condition of human activities, focusing on perception by the five human senses, was also carried out by five investigators with expertise in the urban field. To confirm the condition of each PS, the questionnaire prepared for this field survey included not only physical aspects such as the condition of stagnant and movement spaces, the physical outlook, etc., but also the activity aspect, that is, the types of human activities according to Jan Gehl and attributes of visitors, and the psychological/social aspect, in which spatial perception was understood by the SD method. In addition, the concept of "imageability" (legibility: ease-of-understanding, visibility: ease-of-seeing, etc.) was added to the indices used in evaluating PS interactions, and image maps and Link & Place maps expressed in terms of the 5 elements proposed by Kevin Lynch (Path, Landmark, Edge, Node, District) were created and visualized, and the relatedness between the PS was confirmed from these viewpoints (**Fig. 3**).

This survey was conducted in the central areas of 5 cities, Sumida Ward (Tokyo), Okazaki, Shizuoka, Osaka and Nagano. The results suggested the possibility that areas where interactive relationships, including the use of surrounding land, etc., i.e., linkage and wholeness, and the diversity of options for various kinds of static and dynamic activity spaces can be experienced physically as a comfortable chain through the five senses of sight, smell, sound, touch (+ somatic and deep sensation) and taste, are natural and comfortable areas that invite walking, which leads to vigorous walking, greater diversity of activities, and stimulation and heightening of sensitivity. On the other hand, even while individual PS spaces are well-designed, it was found that some organic interactions were clearly lacking in areas that were seldom used by people. The survey also suggested the importance of carefully excluding unpleasant factors that hinder interaction through the PS, such as continuous scattering of trash and soiling, the spread of bad odor and noise, traffic congestion and disruptions, uneven and rough road surfaces, and the impact of electrical wiring and various types of barriers on scenery, etc., and preventing negative interactions, for example, continuation of uninteresting, commonplace PS spaces due to homogenization.

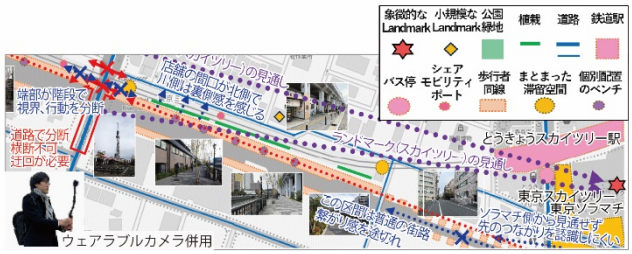

Fig. 3 Condition of imageability survey and mapping (framework)

5. Future Initiatives

It is assumed that the questionnaire and other tools prepared in this work will be used as common searchlight tools for sharing the conditions of various kinds of interactions and cooperation with stakeholders, and will be useful in study of the content of policies considering PS interactions and consensus-building when promoting initiatives for co-creation type urban development though workshops and other activities held under local government-private leadership. In the future, we plan to refine the indices through monitor surveys, etc. in the field and systematize the evaluation methodology. We also hope to study a flexible use methodology and present guidelines for appropriately customizing the evaluation items according to the local characteristics and purpose of policies in each area.

☞For more information

1) FY 2023 Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Proceedings of the National Land Technology Research Conference, pp. 22-27
https://www.mlit.go.jp/chosahokoku/giken/

Effective Use of Dredged Soil as a Base Material for Tidal Flats for Carbon Storage

(Study period: FY 2022-FY 2024)

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

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Senior Researcher (PhD (Earth Environmental Science) AKIYAMA Yoshihiro

Division Head (PhD (Engineering)) OKADA Tomonari

Keywords: Dredged soil, Artificial tidal flats, Carbon storage, Total organic carbon, Ignition loss

1. Introduction

The fixing of carbon in marine ecosystems in the ocean such as seaweed and algae is gaining attention as a means of absorbing greenhouse gases. Coastal areas are also considered locations for the storage of organic carbon since organic matter derived from phytoplankton production within coastal areas accumulates in the bottom mud. However, it is difficult to regard port areas as organic carbon storage sites because of the fact that dredging is regularly carried out in sea channels and anchorages within these areas to ensure the maintenance of port functions, making them unstable in terms of carbon fixing. Thus, it is believed that carbon could be stored by stably sealing off organic carbon as base material for tidal flats and seaweed beds.

Whether dredged sediment can be used effectively for carbon storage depends heavily on the residual trapped organic carbon rate. This study estimates the residual organic carbon rate in dredged sediment when using dredged sediment as the base material for the creation of tidal flats.

2. Study Methods

At the Hannan 2-ku tidal flats, which were completed 17 years ago, dredged soil was used as the base for the tidal flat foundation, and the residual organic carbon rate was then examined. The thickness of the sand cap layer on top of the dredged soil layer is about 50 cm.

Vertical samples were collected at two locations. A geo-slicer was used to collect the vertical samples, collecting a core of about 2 m. The vertical sample was then sliced at 10 cm intervals, and the samples were then analyzed in terms of the grain size composition, water content, soil particle density, ignition loss and total organic carbon.

3. Results

The obtained vertical sample consisted of an upper sand cap layer and a lower dredged sediment layer, and the sand cap layer had a median grain size distribution of 300-500 μm to a depth of 105 cm, and the dredged sediment layer had a grain size distribution of 9 μm from a depth of 145 cm. The ignition loss, indicating the amount of organic matter, was almost uniformly 7% in the dredged sediment layer (Fig. 1). The residual organic carbon rate was obtained from the difference between this ignition loss and the ignition loss during dredging, and the average residual organic carbon rate at the two sites was 82%. This showed that carbon could be effectively stored by using dredged soil as a base material for artificial tidal flats.

4. Future Study Issues

The quantification of residual organic carbon rates for various uses of dredged soil (seaweed beds, borrow pit,

landfill) remains an issue.

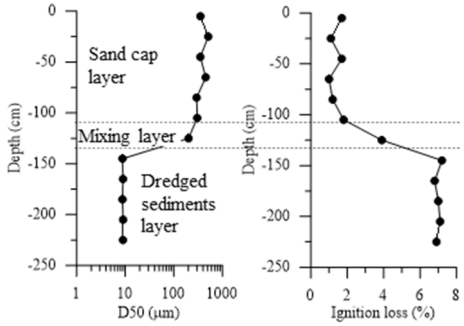


Fig. 1 Vertical Distribution of Median Particle Size and Ignition loss

☞ See here for more details

1) NILIM Materials, No.1242, pp.1-14
https://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1242.htm

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

(Study period: From FY 2020-)

Port, Coastal, Marine Department
Research Coordinator for Coastal and Marine Affairs OKAMOTO Osamu

Keywords: Restructuring of coastal areas, Plant location, ASEAN trends

1. Introduction

Changes are occurring in the coastal areas of Japan based on the recent trend of the weak yen, lower labor costs in Japan, rapid economic growth in Asia, the spread of COVID-19, various international conflicts, and various disasters, etc. This study aims to understand prominent trends in coastal areas and to extract and organize the issues.

2. New Locations of Plants, etc. in Coastal Areas

Table 1 shows examples of major new locations of plants, etc. after the spread of COVID-19. The features include locations for the building of new plants with an awareness of disaster business continuity plans (BCP), and plants that include disaster prevention measures themselves. Other examples include a few cases of creating vibrant spaces within port green spaces and the creation of recycling bases with environmental awareness.

Table 1 Examples of New Locations in Coastal Areas in Japan

Location Facilities	Facility Features
Machinery manufacturer logistics warehouse	Raising of ground level to prevent flood damage
Chemical product manufacturer plant	Consciousness of BCP and development of alternative manufacturing base
Craft beer plants and restaurants, etc.	Development of vibrant space within the port green space
Plasterboard recycling plant	Collection and recycling of waste materials from all over Hokkaido
Demonstration test facility	Expansion of development and manufacturing base

3. Expansion of Japanese Companies into the ASEAN Region, etc.

Along with the trend of Japanese manufacturing returning to Japan, which was introduced last year, there has also been a trend of companies expanding to the ASEAN region. This is expected to accelerate the trend within the ASEAN region towards local production for local consumption with the formation of production bases, etc., contributing to the strengthening of supply chains in countries into which companies are expanding. Major examples of this are shown in Table 2.

Table 2 Examples of Expansion into ASEAN Countries

Industry	Destination Country
Air conditioner manufacturer	Indonesia
Machinery manufacturer	Malaysia
Food manufacturer	Vietnam
Chemical products manufacturer	Thailand
Cement manufacturer	Philippines

In relation to this, some Japanese underwear

manufacturers and others have closed plants in China to consolidate their manufacturing bases in Japan, confirming this trend towards local production and local consumption in Japan as well.

4. Future Issues for Consideration

Future issues to be considered include the collection of additional cases (particularly those related to the use of former thermal power plant sites), interviewing appropriate business operators and port administrators, etc., the collection of cases of coastal area reorganization to identify and examine further issues, and the consideration and examination of measures to be taken in coastal areas going forward.

Strengthening Research System for Realization of Green Society

(Research period: FY 2023 –)
Green Society Realization Research Promotion Committee
Director (Ph.D. in Eng.) SASAKI Takashi
Secretariat Research Coordinator for DX OSHIRO Nodoka
Secretariat Construction Specialist MAEDA Yuta
Secretariat Researcher FUKUOKA Chiaki

(Keywords) global warming, climate change, green society, environmental action plan, cross-sectional research committee

1. Creation of the Green Society Realization Research Promotion Committee

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) established the "MLIT Green Society Realization Promotion Headquarters" in 2021 toward the realization of a green society, including realizing the Japanese government's aim of achieving carbon neutrality by 2050, responding to the climate crisis, etc., and revised the "MLIT Environmental Action Plan" as part of its efforts to realize a "carbon-neutral society," "society adapting to climate change," "nature-harmonious society" and "recycling society."

Until now, NILIM has promoted climate adaption measures in the "Climate Change Adaptation Research Group" and efforts to mitigate climate change in the "Environmental Research Promotion Group." However, it is necessary to concentrate our total capabilities more comprehensively to keep pace with the above-mentioned moves.

To achieve this, in July 2023, NILIM merged the two groups to create the Green Society Realization Research Promotion Committee, with the Director-General of NILIM as Director and the Deputy Director-General/Executive Director for Research Affairs as Deputy Director, and organized a cross-sectional research system in which all NILIM research department Heads and center Directors participate as members.

Table-1 Relationship of research fields of NILIM and "Four Pillars"

	Housing and buildings	Urban development and infrastructure	Flow of people and goods
Decarbonized society	・Measures for CO_2 absorption sources and carbon recycling ・Decarbonization in infrastructure development ・Energy-saving in housing, buildings and cities		・Smart transportation ・Green distribution
	・Diffusion of next-generation automobiles, etc.		
	・Introduction and use of renewable energy		
Society adapting to climate change	・Response in natural disaster field ・Adaptation in people's lives and city life		
		・Adaptation of water resources and water environment field	
Nature-harmonious society		・Utilization of green infrastructure, etc. ・Sound water circulation ・Sea conservation and restoration	
Recycling society	・Promotion of distribution and renovation of existing houses	・Construction recycling prioritizing quality	

2. Activities of the Green Society Realization Research Promotion Committee

In the Green Society Realization Research Promotion Committee, in order to promote environmental research based on the four pillars of environmental measures (**Table-1**) shown in the MLIT Environmental Action Plan, NILIM's Planning and Research Administration Department, which did not have a clear role until now, is positioned as the Secretariat, and efforts are made to strengthen cooperation and information sharing between research departments and centers.

3. Exchanges with Other Research Organizations in the Environmental Field

(1) 5th Research Exchange Seminar of the Environmental Research Institute Coordinating Council

At the "Research Exchange Seminar" hosted by the "Environmental Research Institute Coordinating Council," which is made up of research institutes involved in environmental research, the Research Coordinator for DX introduced NILIM research contributing to carbon neutrality and conducted exchanges of views with other organizations.

(2) FY 2023 Research Group Symposium on Climate Change Adaptation

The Research Coordinator for Integrated Water Disaster Management made a presentation on efforts for "Visualization of the Degree of Flood Risk in River Basins" for climate change at this symposium, which was held as an activity of the "Environmental Research Institute Coordinating Council for Climate Change Adaptation" to promote coordination and cooperation between related research institutes based on the Climate Change Adaptation Act and Plan.

☞For more information:

1) Website of the NILIM Green Society Realization Research Promotion Committee
https://www.nilim.go.jp/japanese/organization/gx_honbu/indexgx.htm

2) 5th Research Exchange Seminar of the Environmental Research Institute Coordinating Council
https://kankyorenrakukai.org/seminar_05/

3) FY 2023 Research Group Symposium on Climate Change Adaptation
https://adaptation-platform.nies.go.jp/archive/conference/2023/1221/

Dispatch of Experts to Earthquake with Epicenter in Southeastern Turkey

(Research period: FY 2022)

Evaluation System Division　Urban Facilities Division　Bridge and Structures Division
International Coordination Division
Head (Ph.D. in Eng.) MUKAI Tomohisa　Head SHINGAI Hiroyasu　Head (Ph.D. in Eng.) SHIRATO Masahiro
Head OSHIRO Nodoka

(Keywords) Republic of Türkiye (Turkey), earthquake, Japan Disaster Relief Team, disaster survey

1. Overview of Expert Dispatch

A large with its epicenter in southeastern Turkey occurred on February 6, 2023. Based on a request from the government of the Republic of Türkiye (Turkey) to the government of Japan, NILIM dispatched 3 of its researchers (in the fields of building planning and structures, urban planning, and civil engineering structures) to the site from March 6 to March 16 as members of an expert team of a Japan Disaster Relief Team dispatched by the Japan International Cooperation Agency (JICA) [1].

2. Activities at the Site

At the site, the NILIM researchers conducted field surveys in connection with the building planning and structure field and urban planning field in Hatay, Antakya, Gölbaşı, Kahramanmaraş, etc., where the effects of the earthquake were comparatively large, and exchanged views, etc. with knowledgeable persons on future recovery and reconstruction efforts in Istanbul and Ankara based on the survey results.

In the field of civil structures, after consultation with the Turkish General Directorate of Highways, (KGM) in Ankara, NILIM's representative surveyed the condition of damage of bridges and other structures in Gaziantep, Nurdağı and Malatya.

3. Activities after Dispatch

After completing their assigned missions, the three NILIM team members, together with other members of the Japan Disaster Relief Team, reported to Minister Saito of the Ministry of Land, Infrastructure, Transport and Tourism on March 24 after returning to Japan (**Photo-2**). [2]

Subsequently, on April 20, NILIM and the Public Works Research Institute (PWRI) jointly held a lecture meeting, featuring lectures by Dr. Shirato, Head of the Bridge and Structures Division at NILIM, and Chief Researcher Atsushi Kajiyama of the Geology and Geotechnical Research Group at the PWRI, a team member who was dispatched from the PWRI. In November, NILIM released a report containing examples of damage of the surveyed roads and bridges [3], and in a Turkish television station [4] program broadcast in January 2024, Dr. Mukai of the NILIM Evaluation System Division Head was interviewed, and introduced Japan's seismic standards for buildings, seismic countermeasures and experimental facilities.

☞For more information:

1) MLIT press release (March 3, 2023)
https://www.nilim.go.jp/lab/bcg/kisya/journal/kisya20230303.pdf
2) MLIT press release (March 27, 2023)
https://www.mlit.go.jp/report/press/sogo07_hh_000670.html
3) TECHNICAL NOTE of the National Institute for Land and Infrastructure Management
https://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1260.htm
4) "How Did Japan Succeed? No. 3 | NTV
https://www.youtube.com/watch?v=r-8Yp0N5YpQ

Photo-1 Technical recommendations by the expert on buildings

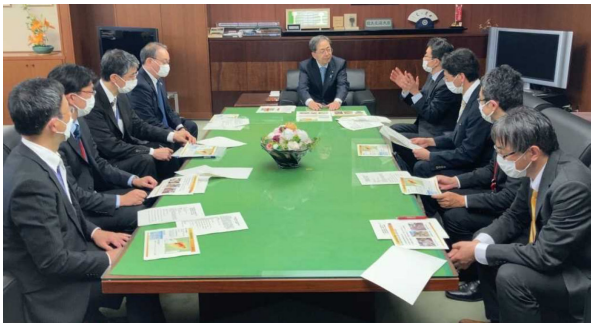


Photo-2 Debriefing report to Minister Saito of MLIT on returning to Japan

Development of Damage Estimation System Using Seismic Motion Data Measured at Dams

(Research period: FY 2022)

River Department, Large-scale Hydraulic Structure Division

Head SAKURAI Toshiyuki Chief Researcher (Ph.D. in Eng.) KOBORI Toshihide

(Keywords) dam, seismic motion, damage situation, estimation

1. Introduction

The probability that Nankai Trough earthquake will occur within the next 30 years is estimated to be 70 to 80 %, which has heightened the sense of urgency of a large-scale earthquake affecting a wide area. In the unlikely event that a dam suffers serious damage as the result of a large-scale earthquake, in addition to the direct damage to the dam, the effects on the flood control function and water supply will also continue for extended period. Therefore, when a large earthquake strikes, a grasp of the damage of multiple dams and early construction of the necessary support system are demanded.

At present, seismic motion data is collected at many dams, but in many cases, the maximum value of acceleration is used to judge the necessity of special inspections of the individual dams, and it has not been possible to use this data to predict damage or directly use the diverse data contained in the seismic motion data.

Therefore, the Large-scale Hydraulic Structure Division constructed a dam damage estimation system (hereinafter, instantaneous estimation system) for realizing early construction of the necessary support system, based on instantaneous predictions of the damage of multiple dams from seismic motion data and ranking of the dams in order of priority for inspections.

2. Overview of the System

The instantaneous estimation system can make judgments of whether anomalies have occurred or not, as shown in **Fig.-1** and ① to ③ below, and transmit the judgment results.

① Using a distance attenuation equation, the system estimates the acceleration of the dam foundation bedrock from information concerning the scale of the earthquake and location, depth, etc. of the epicenter, which can be obtained from the Japan Meteorological Agency immediately after an earthquake occurs, and judges the possibility of that anomalies have occurred based on the results of an advance analysis and the results of inspections conducted following earthquakes in the past.

②The system judges the possibility of anomalies based on the results of an advance analysis and results of inspections following past earthquakes from the maximum acceleration calculated from the seismic motion data observed at the dam, which is collected through the seismic motion data collection system.

③Using the data collected through the seismic motion data collection system, the system detects anomalies by using AI technology. The AI-based anomaly detection function was incorporated in the instantaneous estimation system after conducting the test described in the following section.

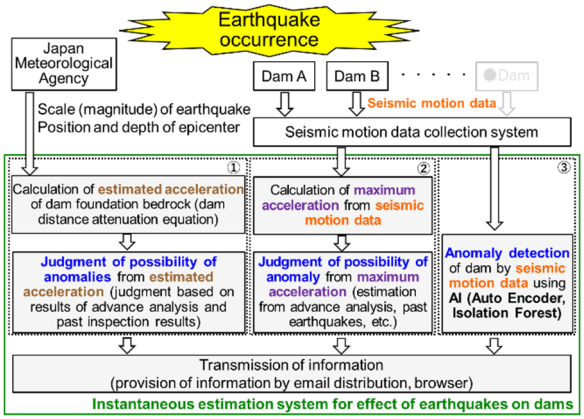


Fig.-1 Overview of the instantaneous estimation system

3. Trial of Judgment by AI

In dams, it is known that the eigenfrequency of the dam body changes when a dam is subjected to comparatively large seismic motion. Among various seismic records of dams, the dam crown reflects the response of the dam body. Therefore, based on the observation records of the dam crown, a trial of anomaly detection using AI technology was conducted. As the AI technologies used in the trial, various AI technologies were compared, and two technologies, Encoder and Isolation Forest, were selected.

Auto Encoder is a self-encoding system, and is one type of unsupervised learning using a neural network. The model first compresses (encodes) normal seismic data input, and after retaining feature values, reproduces the input decoded by restoration processing to its original dimension, (**Fig.-2**). Detection of anomalies is performed based on the difference in the reproducibility of the normal data and anomalous data when seismic motion data that appear to be anomalous are input to a model trained by learning using normal seismic motion data.

Isolation Forest is also a type of unsupervised learning

method, but uses a decision tree that classifies a large volume of data (Ⓐ to Ⓕ in the example in **Fig.-3 (a)**) by using a tree structure. In this process, Isolation Tree splits feature values by randomly setting the threshold value of randomly selected feature, and then performs splitting repeatedly until all the features have been isolated (**Fig.-3 (b)**). A large number of splitting operations is required for the feature values of normal data, which are difficult to isolate because their values are close, but the feature values of anomalous data can be isolated easily, with only a few reiterations of splitting, because of the difference between their values and those of the normal data.

As an example of the trial results, the two AI tools evaluated "data assuming a decrease in the eigenfrequency of a dam due to the occurrence of cracking in the dam or opening of crevices in the dam" as the anomalous data, and data in which 60 waveforms which did not correspond to that data were used as the normal data. Based on the learning results, the anomalous data and normal data were judged, as shown in **Table-1**. (Here, the normal data were not used as learning data.) As the result of this trial, the anomaly judgments by Auto Encoder had a higher detection rate than the judgments by Isolation Forest.

It should be noted that, at present, this is a trial only for certain designated dams. Therefore, it will be necessary to further improve the accuracy of anomaly detection by accumulating additional learning data, while continuing and expanding the trials.

3. Research Outcomes and Future Plans

When using the system developed through this research, in addition to email transmission of information, the system can also be accessed via the network system in MLIT (**Fig.-4**). As a result of this research, it has become possible to estimate the whether the damage assumed after an earthquake occurs or not, and if so, the degree of that damage, and to share information with those involved in dam management in MLIT at an early timing.

In the future, we plan to promote introduction of the seismic motion data collection system for transmission of seismic motion data from dam administration offices, which is necessary for wide dissemination of the instantaneous estimation system, and improve the accuracy of anomaly detection by collecting seismic motion data by the seismic motion data collection system and accumulating learning data.

☞For more information:

1) KOBORI Toshihide et al.: Initiatives for Collection and Effective Utilization of Seismic Motion Data Observed in the Dam Body, Civil Engineering Journal, Vol. 66, No. 6, pp. **-**, 2024.

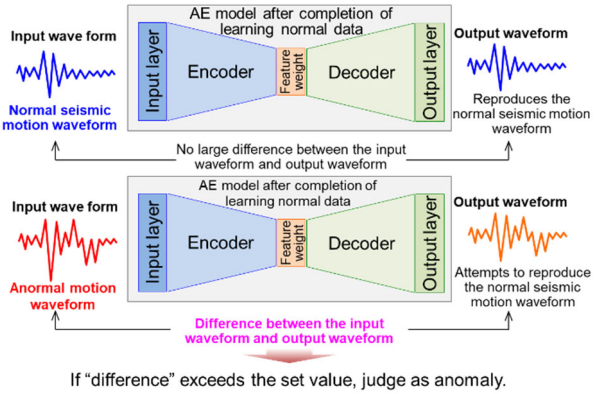
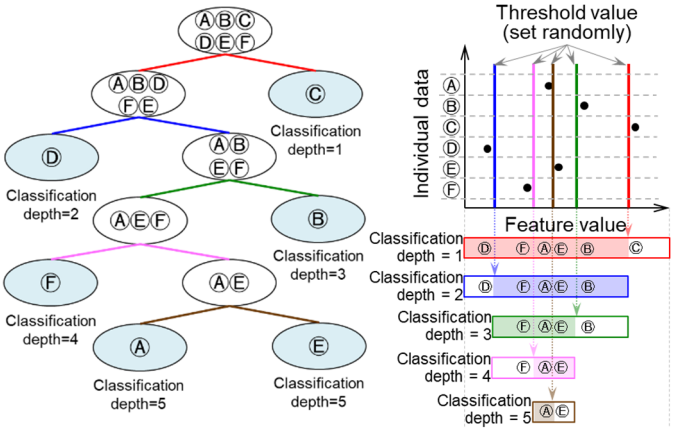


Fig.-2 Outline of Auto Encoder



(a) Isolation tree (b) Splitting by feature value

Fig.-3 Outline of Isolation Forest

Table-1 Example of trial results

AI method		Auto Encoder			Isolation Forest		
Item	Dam name	Frequency (actual)	Number of anomaly detections by AE	Detection rate	Frequency (actual)	Number of anomaly detections by AE	Detection rate
Abnormal data (eigenfrequency changes)	Dam A	5	5	100%	5	4	80%
	Dam B	4	3	75%	4	1	25%
	Dam C	0	0	-	0	0	100%
	Total	9	8	**88%**	9	5	**56%**
Normal data (no change in eigenfrequency)	Dam A	7	0	0%	7	0	0%
	Dam B	8	0	0%	8	0	0%
	Dam C	12	0	0%	17	0	0%
	Total	27	0	**0%**	27	0	**0%**

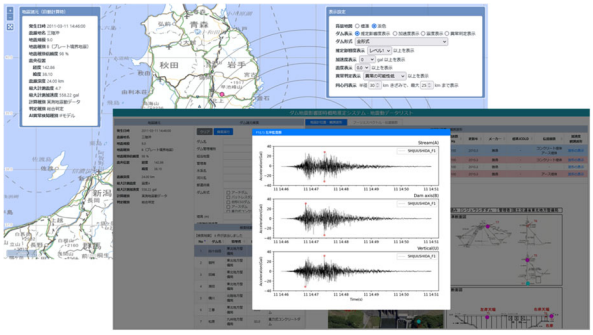


Fig.-4 Example of access of estimation results by web browser

Toward the promotion of increasing efficiency in traffic volume survey and introducing machine observation

(Research period: FY 2022 -)
Hideo Yamashita, Senior Researcher, Manabu Dohi, Head, Masamichi Takimoto, Researcher,
Shigeki Sugiyama, Guest Research Engineer, Road Traffic Department, Road Division

Key words: Road Traffic Census, traffic volume survey, machine observation

1. Situation of implementation of machine observation in general traffic volume survey

The Ministry of Land, Infrastructure, Transport and Tourism conducts the Road Traffic Census once roughly every 5 years. The most recent census was conducted in autumn in FY 2021, and the results of the general traffic volume survey therein were published in June 2023[1]. The ratio of the section length according to each observation method in the traffic volume survey in FY 2021 is shown in Fig.1. In the FY 2021 survey, the ratio of the section length where machine observation was made became about 26% as a whole, resulting in an increase of about 12 points over the result in the FY 2015 survey, and machine observation was promoted. On the other hand, such ratio was about 75% on ordinary national highways (under the jurisdiction of the national government), whereas it was about 15% on roads managed by local governments, etc. Therefore, we are conducting studies about the problems in the case of further facilitating machine observation, and about the measures to solve such problems.

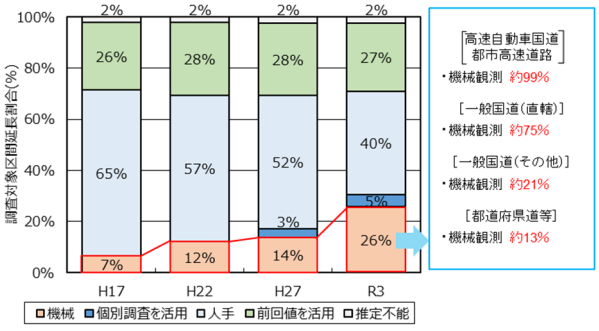


Fig.1: Ratio of the section length according to each observation method in the traffic volume survey[1]

2. Situation of response toward the solving of problems when facilitating the introduction of machine observation

Table 1 shows part of the results of questionnaire survey about the introduction of machine observation, etc. that was conducted with local governments after the results of survey in FY 2021 were published. Opinions have been expressed stating that although they feel that there are advantages in the introduction of machine observation such as reduction of personnel and improvements in measurement conditions, etc., there are problems such as shortage of information that is good for introduction and difficulties in machine procurement. Among them, as response to the point that detailed information about the implementation procedure for machine observation is unknown, it is considered to be effective to prepare a manual that has organized specific methods of implementation of machine observation and information, etc. required for survey preparation, and therefore we have just started to conduct a study of such manual.

Table 1: Advantages of the introduction of machine observation and problems

メリット	課題
• 人手不足の状況である中、現地調査員の確保が不要となり、調査に必要な人員が削減できる。 • 調査員が異なるために生じる計測データのばらつきがなくなり、同じ条件で計測できる。	• 機械観測の実施手順に関する詳細な情報が不明。 • 全国で同時期に調査するため、機械をレンタルするのに苦慮。 • 5年に1度の調査のみのために機械を購入するのは不経済。

As an example of the information that should be included in the manual, Table 2 shows the features of each technique of machine observation that was used in the FY 2021 survey, etc. Since multiple machine observation techniques are available, we would like to proceed with a study of such techniques, so that an optimum observation technique can be adopted based on the site conditions of the survey area and observation time range, etc. (Example: On a 2-lane road, optical observation near the ground can be employed.)

Table 2: Main techniques of machine observation and their features

	計測原理	設置箇所	計測可能な車線数	車種判別	天候・夜間の影響	歩行者・自転車の計測
画像処理式	ビデオカメラ等で車両を撮影して画像処理する	高所	4車線（4車線以上可能な場合がある）	2車種（4車種が可能なものがある）	影響を受けやすい	可能とされているものが多い
光学式	車両に赤外線等を発射し、遮断・反射を検出する	高所、地上付近	1～3車線（1センサーあたり）	2車種	影響を受けにくい	計測対象外
電波式	車両に電波（マイクロ波、ミリ波）を発射し、遮断・反射を検出する	高所	最大4車線（1センサーあたり）	2車種	影響を受けにくい	歩行者のみ可能なものがある

We would like to be engaged in the preparation of an effective manual, and the like, so that machine observation of the traffic volume will further be promoted in the next Road Traffic Census.

☞**For detailed information, refer to the following:**
1) FY 2021 Road Traffic Census, General Traffic Volume Survey, Summary Table, June 30, 2023
https://www.mlit.go.jp/road/census/r3/

Development of a processing system to enhance the utilization of ETC2.0 probe data

(Research period: FY 2021 - FY 2024)

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Key words: ETC2.0 probe data, system development, map matching

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism obtains ETC2.0 probe data by recording travel history and behavior history in an ETC2.0 onboard device mounted in a vehicle and by means of bidirectional communication between the device and roadside units installed all over Japan (Fig. 1). This enables the ETC2.0 onboard device to be used for toll collection as well as for providing the driver with information and for the utilization of the obtained data in various road-related measures.

The ETC2.0 probe data provides positional information at each point of time, and the data all over Japan is collectively accumulated and processed by means of a processing system. Regarding the utilization of the ETC2.0 probe data, the range of utilization is required to be enlarged in the future, and it is necessary to create data that can meet a variety of needs.

The NILIM is developing a new processing system in order to address system problems and to meet new needs, aiming to make the ETC2.0 probe data have higher usage value. Specifically, it is engaged in increasing the efficiency of internal processing and changing the method of data accumulation in order to increase the accuracy of map matching. This paper presents, among other things, how to increase the accuracy of map matching.

2. What is map matching?

Map matching is a technology that corrects positional information according to the location of a road on a map, so that the obtained positional information can be utilized for summarization and analysis (Fig. 2). The ETC2.0 probe data is map matched to the road information in the Digital Road Map Database provided by the Japan Digital Road Map Association [1].

In the map matching of the ETC2.0 probe data, the accuracy of positional information after correction and the processing speed are important. Since the position of a road that has been traveled is identified by the positional information obtained by GPS, if the interval of obtaining the positional information is short, correction can be made relatively accurately. However, the ETC2.0 probe data has specifications such that the

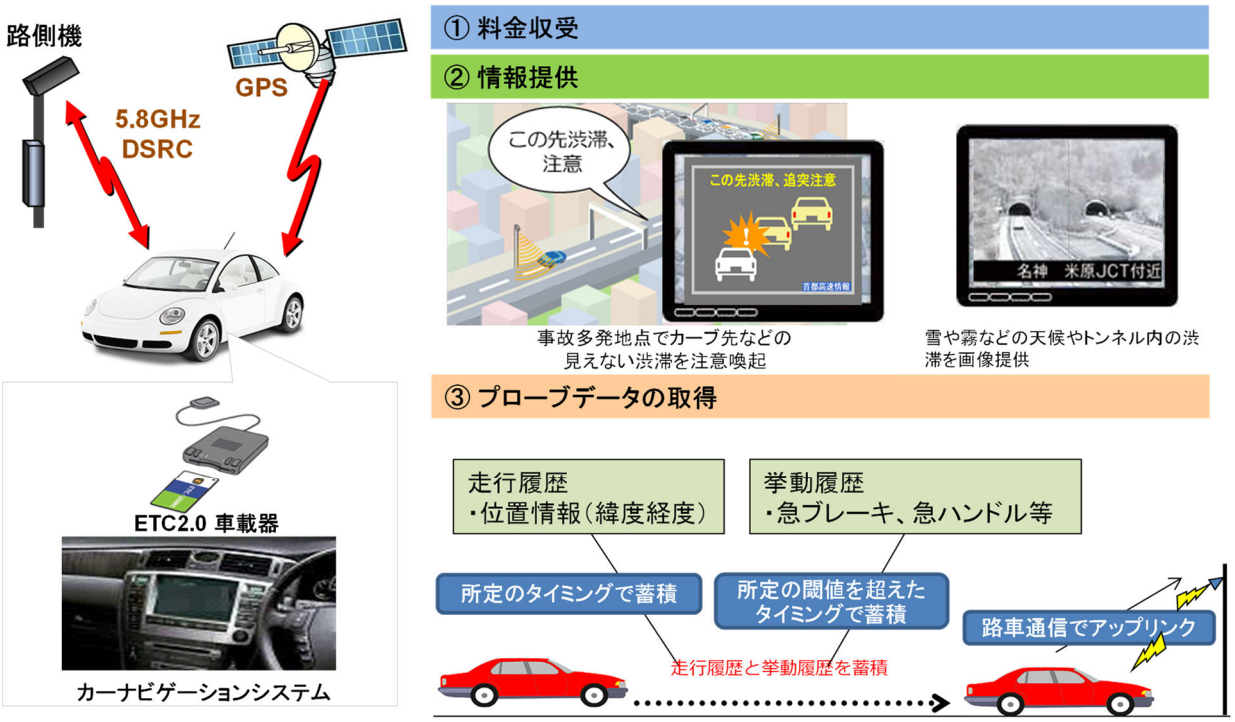

Fig. 1: Overview of ETC2.0

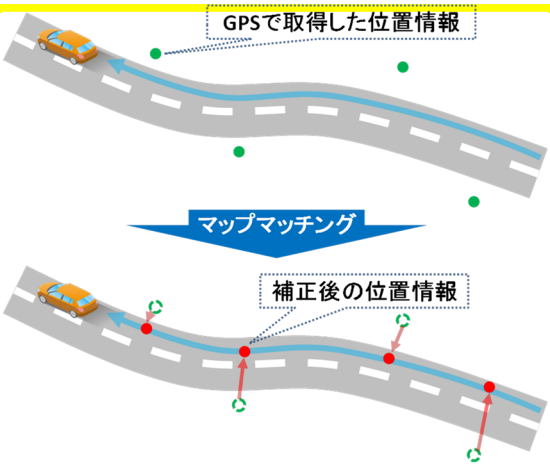

Fig. 2: Image of map matching

positional information recorded in an ETC2.0 onboard device is collected by a roadside unit, due to the constraints on capacity, the interval of obtaining positional information is set to about 200 m. Therefore, the accuracy of map matching greatly affects the accuracy of the time required for traveling the road, etc. In addition, since the information obtained from ETC2.0 onboard devices all over Japan (about 1 billion points/day: as of 2023) is processed collectively, high-speed processing is required to ensure immediacy of the data.

3. Map matching of detailed roads

When the current processing system was first developed, the system was intended to analyze roads considered in the Road Traffic Census, and so map matching is done by limiting the roads to the "basic roads" in the Digital Road Map Database [1]. Therefore, the travel data on roads not included in the "basic roads," map matching will be done to erroneous roads, or the data will be excluded from those to be analyzed. Also, where a high priority is placed on factors such as safety measures on residential roads, etc., an analysis of detailed roads is necessary. Taking that into consideration, the NILIM is developing map matching processing functions that are ready for use with roads including more detailed "small roads."

With a view to realizing map matching having high accuracy while securing the processing speed, we have developed a method for implementing the processing of highways and ordinary roads separately (Fig. 3). In the map matching processing, as the applicable road network becomes denser, more processing time is required and the accuracy decreases. Regarding the complexity of roads, the total length of ordinary roads is about 87 times that of highways. On the other hand, about half of the ETC2.0 probe data is the data of travel on highways. In addition, since the ETC2.0 probe data includes information on the roadside units that have obtained the data, it is possible to estimate whether the travel data came from a highway or an ordinary road. If the data being estimated is obtained by traveling on a highway, it can be expected that

Fig. 3: Classification of those subject to map matching

processing will be significantly reduced by limiting the roads to be map matched to highways. Concerning the challenges of processing of travel data when ordinary roads are included, further high-speed processing is being examined, utilizing the features of the ETC2.0 probe data and by dividing the processing at a position where the vehicle has turned to the right or left at an intersection, etc.

4. Conclusion

At present, we are building a test environment with the map matching technique that has been developed. In the future, we plan to collect data from all over Japan, and to verify the processing speed and accuracy. We will promote the development of an improved processing system, towards the broader utilization of the ETC2.0 probe data.

☞For detailed information, refer to the following:

1) Japan Digital Road Map Association: https://www.drm.jp/database/structure/

Analysis on the serviceability of pavement on national highways under the jurisdiction of the Ministry of Land, Infrastructure, Transport and Tourism

(Research period: FY 2022 -)

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Key words: road pavement, serviceability, inspection

1. Introduction

In the national government and local governments, etc. in charge of management of road structures, shortage of engineers and financial difficulties associated with depopulation as well as a declining birthrate and aging population have become more and more serious. Among them, since pavement has a short renewal period and requires a large amount of stock, it has become a pressing challenge to establish a maintenance cycle and reduce the life cycle cost (LCC) by increasing the lifespan of pavement. Due to these circumstances, "Pavement Inspection Procedures" were established in October 2016. According to the Procedures, the road administrator shall classify roads into 4 categories according to the traffic volume and the importance of the route, etc., thereby managing the roads with emphasis on key issues. In particular, regarding the national highways under the jurisdiction of the MLIT, according to the Pavement Inspection Procedures" of the MLIT jurisdiction edition [1)] March 2017, inspections shall be carried out once every 5 years, for all the national highways under their jurisdiction. The 1st round of inspections of all the national highways under the jurisdiction of the MLIT was completed during the period from FY 2017 to FY 2021.

This paper reports the summarized results of the 1st round of periodical inspections of the national highways under the jurisdiction of the MLIT, with the goal of further economizing the management of pavements. Also, with a view to grasping the relations between pavement performance and external factors, and reviewing the design methods, it reports the summarized results of the road property survey that grasp the serviceability quantitatively in 12 places of the national highways under the jurisdiction of the MLIT.

2. About the results of inspection in the first round

Regarding the results of pavement inspection carried out during the 5 years from FY 2017 to FY 2021, the inspection data has been summarized. Regarding these data, the target number of years of use and the number of years of service of the surface layer and the results of integrity diagnosis, etc. have been summarized.

(1) Target number of years of use

The target number of years of use is to be set by the road administrator, taking into account the asphalt pavement with wide variations in the speed of degradation, as the surface layer is continued to be used during the target period. This is to inhibit early degradation of sections of the surface layer. The situation of resurfacing the asphalt pavement of the national highways under the jurisdiction of the MLIT (excluding those under the new jurisdiction method) is shown in Fig. 1. The highest ratio of the target number of years of use, in about 45% of the cases is "13 years". This may have been affected by the fact that, during the introduction of the long-term guarantee system for asphalt pavement, a performance guarantee after a period of 13 years was taken into account. In the 2nd round and thereafter, it is required that the target number of years of use be reviewed whenever necessary with the goal of reducing LCC through exclusion of the early degradation section.

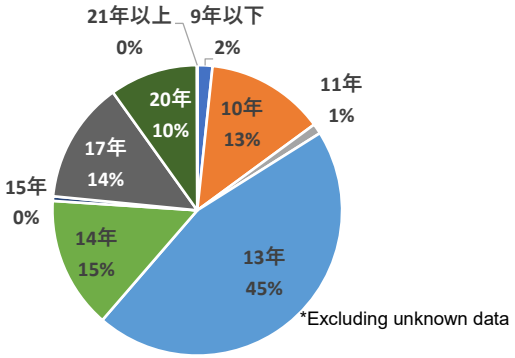

Fig. 1: Setting the target number of years of use (ratio of the total length of the lanes with asphalt pavement)

(2) Integrity

The results of integrity diagnosis according to the number of years of service of the surface layer is shown in Fig. 2 and Fig. 3. In the range of around 0 to 20 years in the number of years elapsed, there is a tendency for both asphalt pavement and concrete pavement to deteriorate , as the number of years elapsed increases. However, it can be seen that, with concrete pavement, the ratios of the total length with integrity "II" and "III" are relatively low, and the ratio

of maintaining the state of integrity "I" is high. Although it has long been said that concrete pavement has durability that is superior to asphalt pavement, this has been proven by the results of inspection of the national highways under the jurisdiction of the MLIT in practical work as well.

(3) Causes of damage

Of the areas inspected in which the integrity of the surface layer of asphalt pavement and concrete pavement is "III", the results of summary of the ratio of damage that has been a major consideration when making judgments is shown in Fig. 4. In asphalt pavement, the ratios related to "cracking" and "IRI[1])" that is an index associated with the ride comfort of the driver are high, were about 47% and 32% respectively. However, the ratio related to "rutting" is low, being about 15%. It is conjectured that this is due to the improvement of the fluidity resistance of pavement by the use of modified asphalt. On the other hand, in concrete asphalt, the ratio related to "IRI" is high, at about 57%. One of the possible reasons is that, in joint portions that are the structurally weak points of ordinary concrete pavement, rainwater infiltrates due to the scattering of joint materials, and level differences occur causing the ride comfort to decrease. Therefore, as shown in the Inspection Procedures, appropriate maintenance and management such as refilling of the joint materials is important.

3. The survey results for long-term serviceability

Periodical inspection of pavement is qualitative evaluation, and quantitative monitoring is necessary to discover degradation trends and make structure evaluation. Therefore, a follow-up survey of the road surface properties such as rutting is implemented in the survey sections of the national highways under the jurisdiction of the MLIT. Road surface property surveys have been implemented in 12 existing locations among the sections of ongoing surveys since around 1989. The tendency of decease in long-term serviceability is being grasped as shown in the typical example in Fig. 5. We plan to continue to accumulate long-term serviceability data and to analyze correlations between the performance of pavement and the external factors such as traffic volume. Our hope is that the work will lead to further streamlining of management by considering the period in which the retention of each performance is assumed and the state during the next time inspection.

4. Outlook for the future

Aiming at the reduction of LCC by increasing the lifespan of pavement, we plan to continue the survey and summarization of inspection and serviceability survey in future as well, in order to further rationalize pavement management, and to use the results of such survey and summarization as the basic material of the revision of inspection procedures and technical standards, and the findings thus obtained will be reflected in the technical standards, etc.

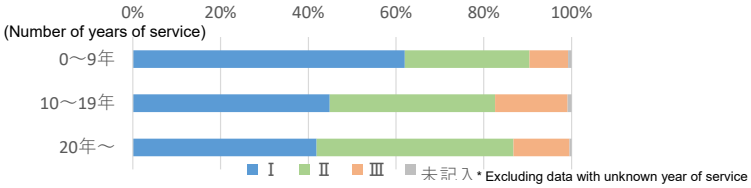

Fig. 2: Integrity according to the number of years of service (ratio of the total length of the lanes with asphalt pavement)

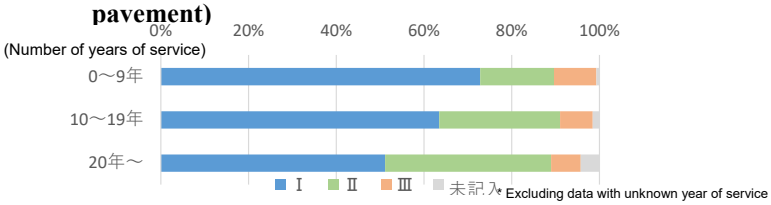

Fig. 3: Integrity according to the number of years of service (ratio of the total length of the lanes with concrete pavement)

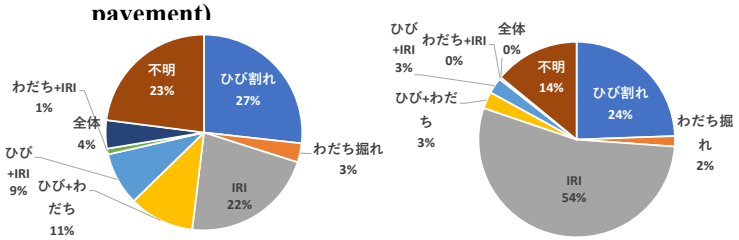

Fig. 4: Major factors of integrity III (ratio of the total length of the lanes)

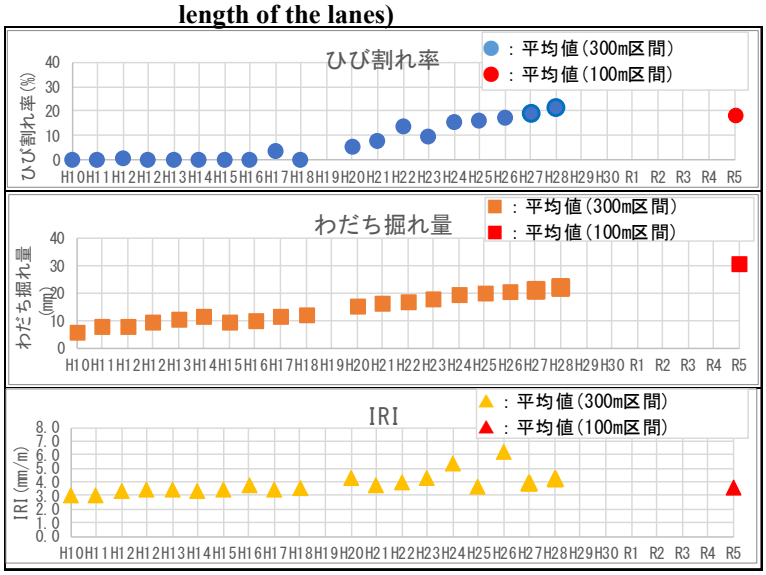

Fig. 5: An example of the results of survey of serviceability (large vehicle traffic volume: 11,148 vehicles/day (FY 2015), Civil Engineering, DID)

☞For detailed information, refer to the following:

1) Pavement Inspection Procedures, Ministry of Land, Infrastructure, Transport and Tourism, March 2017 https://www.mlit.go.jp/road/sisaku/yobohozen/tenken/yobo3_1_10.pdf

2) Features of the results of the 1st round inspection of the pavement in the national highways under the jurisdiction of the MLIT, Satoshi Horiuchi, Yuya Wakabayashi, Kazuhiro Watanabe, Japan Society of Civil Engineers 78th Annual Academic Lecture Meeting, V-151, 2023

Research for promoting DX in the infrastructure sector

(Research period: FY 2021 -)
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Key words: DX (digital transformation), BIM/CIM, productivity improvement

1. Introduction

Currently, digital technologies are progressing rapidly, such as the evolution and networking of ICT, and in the "Fundamental Plan for National Resilience" of which cabinet decision was made in July 2023 as well, the "advancement of national resilience measures by the utilization of new technologies such as digital technologies" is given the status of one of the fundamental policies.
The Ministry for Land, Infrastructure, Transport and Tourism is promoting efforts based on the "DX Action Plan in the Infrastructure Sector," and the NILIM also pursues the promotion of research and development by establishing the "Digital Transformation of Infrastructure Systems Research Committee." This paper presents the major efforts related to DX that are promoted by the NILIM.

2. Construction and operation of the DX Data Center

The DX Data Center is to store three-dimensional data such as BIM/CIM models and point group data for searching, displaying, and providing such data. From January 2023, it is available not only for MLIT employees, but also over the Internet for private businesses that have been awarded contracts for MLIT operations and works (Fig. 1).

We consider that this enables the promotion of utilization of the BIM/CIM models to be created at each of the stages of surveying, investigation, design, and construction in other works and operations as well as in maintenance and management.

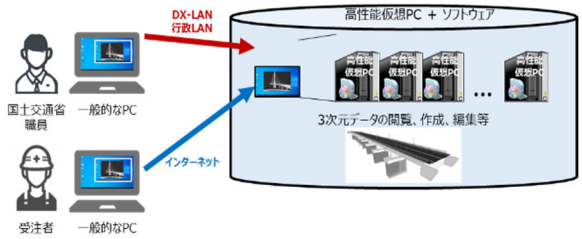

Fig. 1: Overview of the systems of the DX Data Center

3. Commercialization of the finished form measurement technologies in seaport works by utilizing ICT

In order to increase the efficiency and improve the safety in finished form management and supervision/inspection, we proceed with the development of technologies for finished form measurement utilizing ICT technologies.
For example, regarding the foundation works for seaport works, on-site testing is carried out for technologies to measure the finished form of the top end face of rubble rock that has been made flat by using multibeam echo sounding (Fig. 2). In addition, we also carry out on-site testing for technologies that utilize the construction history data of the foundation works flattening machine and of the grab dredger for bed digging works in the finished form measurement, thereby carrying out a study for commercialization.

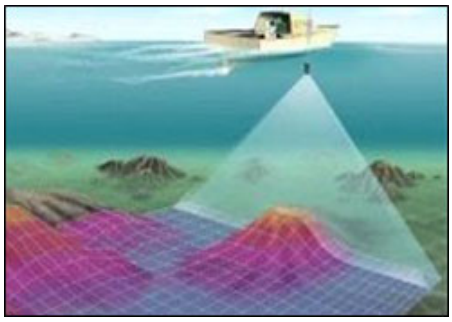

Fig. 2: Finished form measurement of foundation works by means of multibeam echo sounding

4. Conclusion

The MLIT has given the status of the "year of deployment" of infrastructure DX to 2024, and the NILIM also wishes to further proceed with the research and development related to infrastructure DX, at the same time making efforts to transmit information so that it will lead to the dissemination of the contents of such efforts in future as well.

☞For detailed information, refer to the following:

1) Technical Note of NILIM No. 1250 p. 26
https://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1250.htm

International Research Activities

1. International Research Activities in NILIM

The National Institute for Land and Infrastructure Management (NILIM) promotes international research activities based on the following three perspectives.

(1) Contribution to domestic policy from the technical side

While utilizing bilateral agreements concluded mainly with NILIM and other agreements, etc. concluded by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) itself, NILIM builds networks with overseas government agencies and others, gathers information on advanced cases, etc., and reflects that information in domestic policy proposals and technical standards, etc.

(2) Contribution to technical cooperation with developing nations, etc.

Utilizing the knowledge and lessons learned in operation and maintenance (O&M) of public facilities in Japan, disaster response, etc. and the results of research on advanced disaster prevention and disaster mitigation measures reflecting those resources, NILIM provides support for the establishment of countermeasures and technical standards for the advanced technological challenges faced by local governments in the developing nations and improvement of the capabilities of government staff in technology-related positions.

(3) Contribution to overseas development of Japan's strong technologies

Using knowledge for the establishment of technical standards that support policy development in Japan, NILIM participates in international standardization activities such as those of the International Organization for Standardization (ISO), contributes to international standardization of technologies in which Japan is particularly strong, and also shares information on NILIM's research achievements at international conferences, the institute's English-language website, etc.

2. Main International Research Activities in 2023

Although NILIM's international research activities were unavoidably interrupted or delayed during the COVID pandemic, those activities were successively resumed in 2023, and have now returned to approximately the same level as before the pandemic.

Here, the following introduces the main international research activities of NILIM in 2023.

(1) Contribution to domestic policy from the technical side

① Research cooperation with the Directorate of Road and Bridge Development Engineering (DRBE), Ministry of Public Works and Housing of Indonesia

In 2009, NILIM and Japan's Public Works Research Institute (PWRI) respectively exchanged Memorandums of Understanding (MOUs) on research cooperation with DRBE (at the time, Institute of Road Engineering (IRE), the predecessor of the DRBE) and carried out research cooperation in the five fields of traffic technology, pavement, tunnels, earthworks and soft ground.

On November 23, 2023, the Director of DRBE and other officials from that organization paid courtesy visits on NILIM and PWRI, during which the two sides exchanged views on the current condition and challenges for bridges and tunnels in Indonesia, future research cooperation and other issues, and the visiting delegation observed the experimental facilities at NILIM and PWRI.

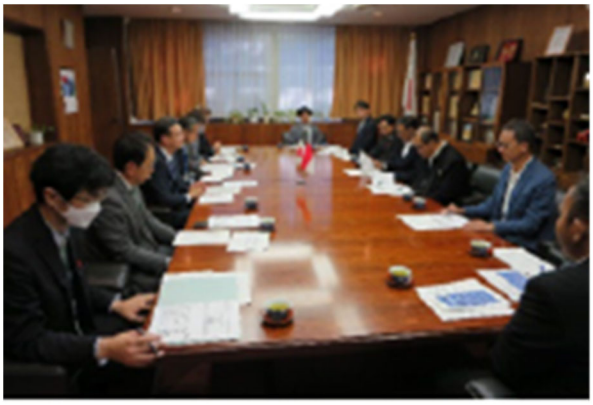

Photo-1 Courtesy visit by mission headed by the Director of DRBE

② Meeting of the Directorate for Roads in Vietnam (DRVN) and NILIM on highway bridges

NILIM has been engaged in research cooperation with the Directorate for Roads in Vietnam (DRVN), which is an agency of Vietnam's Ministry of Transport (MOT), based on a MOU between Vietnam's MOT and MLIT's Road Bureau concluded in 2012. NILIM also deepened its research cooperation by concluding a separate MOU on O&M of highway bridges in 2020.

Photo-2 Scene from the meeting with DRVN

In 2023, NILIM held an exchange of views with DRVN and Vietnam's University of Transport and Communications (UTC), which is affiliated with DRVN, on conducting monitoring to gather information and elucidate the causes of cases of cable damper damage in Vietnam. In line with those activities, NILIM also coordinated plans to hold a workshop for an exchange of opinions on trends in research and development for preparation of standards for the design and O&M of long-span bridges and issues related to the practical work.

③ Research cooperation with the Korea Research Institute for Human Settlements (KRIHS) in the urban policy field

NILIM is conducting ongoing research exchanges with KRIHS based on a MOU on research cooperation signed in 2012.

In March 2023, a NILIM mission visited Korea for a joint survey of the current condition of smart cities, and also carried out surveys and an exchange of opinions on the condition of suburban new towns in Korea and the condition of use of vacant houses.

Photo-3 Courtesy visit to KRIHS

(2) Technical cooperation with developing nations, etc.

① Acceptance of trainees from the World Bank, JICA, etc.

With the exception of lectures via the internet, acceptance of trainees was interrupted during the COVID pandemic, but in 2023, full-scale acceptance of trainees from overseas was resumed by the Japan International Cooperation Agency (JICA, an Independent Administrative Institution) and others.

As training for staff members of Cambodia's Ministry of Rural Development (MRD), in September, NILIM cooperated in providing training in various fields through lectures on the pavement field, public works procurement, etc. at the request of the World Bank Tokyo Disaster Risk Management (DRM) Hub.

② Support for technical cooperation projects

In response to a request by JICA, in 2023, NILIM dispatched its researchers for preliminary surveys for a flooding countermeasures project in Indonesia and a bridge construction project in the Philippines.

③ Dispatch of experts to the Japan Disaster Relief (JDR) Team

NILIM dispatched three of its researchers to an expert team of JICA's Japan Disaster Relief Team in response to damage caused by a major earthquake that occurred in February 2023 with its epicenter in southeast Turkey. (For details, see p. 100.)

④ Cooperation on establishment of technical standards for ports and harbors

In March 2024, the NILIM invited staff members of Vietnam's Institute of Transport Science and Technology (ITST) to the institute. The two research institutes exchanged views on climate change and decarbonization of ports and harbors, and plan to hold ongoing discussions on methods for reflecting the content of those studies in technical standards for ports and harbors.

⑤ Technical cooperation on revision of technical standards related to airport pavement

The Civil Aviation Authority of Vietnam (CAAV) plans to revise its technical standards for airport pavement, and the policy of Japan's Civil Aviation Bureau is to provide technical cooperation for the revision of those standards. The first meeting of working-level persons from the two countries was held in February, and NILIM explained Japan's technical standards for airport pavement.

(3) Contribution to overseas development of Japan's strong technologies

① ISO

During 2023, NILIM researchers participated in the following ISO Technical Committees (TC):

- TC224 (Drinking water, wastewater and stormwater systems and services)
- TC92/SC3 (Fire threat to people and environment)
- TC205 (Building environment design)

② Participation in ICOLD

NILIM participated in the Annual Meeting of the International Commission on Large Dams (ICOLD), which was held in Gothenburg, Sweden in June 2023, and discussed a proposed report on "Interpretation of seismic data obtained from dams" as the Japanese elected member of Technical Committee B, "Seismic Aspects of Dam Design."

Photo-4 Scene from the 2023 Annual Meeting of ICOLD

☞For more information:

1) NILIM website (International Activities)
https://www.nilim.go.jp/lab/beg/foreign/kokusai/kokusaitekikatudou.htm

2) NILIM website (International Coordination Division)
https://www.ysk.nilim.go.jp/kakubu/kanri/kokusai/