
Desirable Communities in a Few Decades

--- Consideration as an Engineer Facing a Period of Maturity ---

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1. How to draw a picture of community / land

After devoting several years to the cause, the National Institute for Land and Infrastructure Management (NILIM) established a firm research policy and, following an evaluation of institutions conducted last year, introduced a framework for performing R&D activities at home and abroad. In reference to the opinions received from the Evaluation Committee, we need to implement reviews and improvements constantly. Meanwhile, new viewpoints of R&D in the housing and social capital fields have been broadly discussed in the Round-Table Conference on Basic Policy ¹⁾ of the Social Capital Council, etc. Various new concepts and technologies have appeared, including smart city, MaaS, IoT, and AI. However, how do we draw a future picture of our land or community realized via the research, development and installation of these technologies? This subject is discussed in this paper in the background of recent socioeconomic development, which is said to have entered a stage of maturity.

Housing development and the provision of other social capital in postwar Japan has repeated a pattern of first securing a construction site and then starting construction on a vacant lot. In other words, this approach is similar to drawing a picture on a white canvas. The facility is designed and constructed in accordance with a certain concept / plan -- a picture to be drawn. This is considered reasonable for a growing society.

However, since Japan's socioeconomy is said to have entered a stage of maturity, various issues have arisen, including the deterioration of social capital, the revitalization of vacant housing and new community development. Hence, how to use and

change existing stock in a future society has been often discussed. That is, the issue is how to retouch an old picture so that it looks new. If the only concern is to maintain the functions of individual facilities, it suffices to explore technologies for each facility in light of advanced design standards, etc. However, to redraw the picture, engineers require a target, such as whether to repair or remove a bridge or what the streetscape should look like in relation to the entire community. Do we have the technology to redraw a community to a targeted future image? Discussions are often made about community development for regional vitalization, addressing for example a group of buildings in the historic district, streetscapes in the Taisho Roman style, and shopping arcades from the Showa era. In such streetscape development using existing stock, it is often easy to share a future picture of a community. However, the basis for this is due in part to a streetscape from early modern to modern times being left either intentionally or accidentally in a community. Historically, streetscapes in Japan have changed because of repeated destructive damage across a broad area due to war, natural disaster, etc. partly because buildings were mostly built of wood. Consequently, there are almost no old streetscapes that have survived over several centuries like in Europe and elsewhere. This is believed why it is difficult to draw a future picture of a community that everyone can agree to. Now that various streetscapes exist under a mature socioeconomy and the maintenance, renovation and reuse of individual facilities are being discussed and implemented, it would be greatly significant for engineers to consider an "ideal" picture of a good streetscape that would last long into the future. Isn't it

important, even in the meaning that engineers have a source of vitality for R&D, to consider a target picture of community where residents 100 years after would feel that they live in a good town?

The same also applies to the natural environment as the base of streetscape. The land of Japan is small and the plains where the present socioeconomic activities concentrate have been formed in only the two thousand years after the Jomon Era. Human activities have existed since the formation of the ecosystems in these plains. In addition, in the mountainous land of Japan, many human activities have been conducted and forests have been used since the Jomon Era. As a key word in nature conservation, *satochi-satoyama* (community-based forest areas and the surrounding countryside) appeared a long time ago, so the natural environment that fostered Japanese society has been groomed for the most part by human activities. At present, however, there are no longer human activities like before in the *satochi-satoyama* (including rivers) due mainly to the progress of urbanization, and it is changing into a new natural environment. Engineers in the housing / social capital field should scientifically discuss how Japan's plains and natural environment of peripheral mountainous land will change also in respect of sustainable management of future lands and communities. Particularly, since there is growing concern over climate change, it would also be a technical challenge to consider future communities and sustainability concerning management of social capital that is present with natural environment, based on discussion on what kind of natural environment can be established in the plains of Japan.

2. Local communities and their functions

While disasters occur frequently, there is a discussion about the fact that many residents do not evacuate even when an evacuation order is issued. In this discussion, focus is placed on the relationship between the function of local government, which issues evacuation orders (public help), and the function of individuals who evacuate (self-help). However, it seems that the function of the local community (mutual help) that lies

in-between local government and individuals has not been discussed in recent years.

Not only the viewpoint of bearing mutual help for encouraging evaluation of individual residents, but local community can have various functions for community development and maintenance / management of social capital such as setting of community development objectives suitable for the community or participation in sustainable maintenance of social capital. When aiming to form good streetscapes and living environments in Japan tens of years or a century from now, it is possible to consider a social system where the local community maintains the social capital including roads, rivers, and parks and revitalize existing streetscapes through frequent use of public space. It has been a long time since the collapse of the local community first attracted attention, but it would be necessary to establish a new relationship between government and the local community in order to build such a social system. So, what entity can be established as a new local community? As the *satochi-satoyama* was formed based on the relationship between nature and the local community, which existed as a socioeconomic system at that time, what will be a sustainable socioeconomic system where the local community is involved with new land or community management? This is an issue that should also be considered in regards to a local community that supports future community development, and maintains and manages social capital.

The discussed topic might be a little specific as an opening message of the NILIM Report, but the R&D challenges in the housing and social capital fields seem to be still full of possibilities, including new technologies.

☞ See the following for details.

1) Interim Report of the Round-Table Conference on Basic Policy for Land Transport Technical Administration: Panel on Infrastructure Development / Council of Transport Policy, Technical Subcommittee, Technology Group, Round-Table Conference on Basic Policy for Land Transport Technical Administration, Nov. 2018
<http://www.mlit.go.jp/common/001260362.pdf>

Countermeasures for Large-scale Sediment Disasters Caused by Successive Local Heavy Rains

Sabo Department

Increase in the frequency of sediment disaster by local heavy rain and damage intensification have been remarkable, such as the July 2017 Northern Kyushu Heavy Rain and the July 2018 Heavy Rain. Then, we study forecast techniques and countermeasure technologies for frequent large-scale sediment disasters.

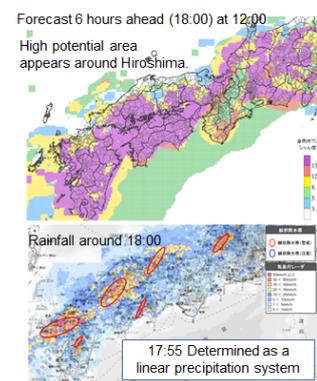
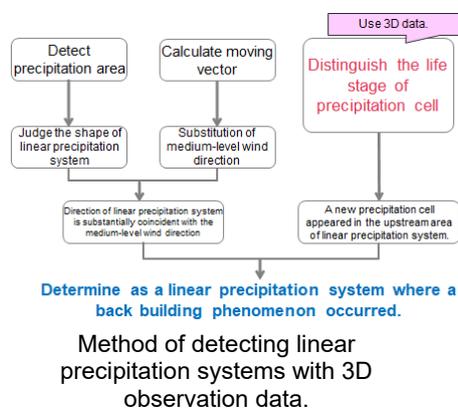
Social background and issues

- Frequent occurrence of large-scale sediment disaster from local heavy rain caused by linear precipitation system
- Damage of sediment disasters is intensifying, such as outflow / accumulation of sediment / driftwood in wide downstream area causing flood as well as damage from debris flow and collapse in upstream area.
- It is urgently required to establish a method of predicting linear precipitation systems, a method of predicting accurately sediment runoff according to the grain size of produced sediment and scope of water / sediment flood, and an effective and efficient sabo facility arrangement planning method based on the foregoing methods.

Study contents

Study on forecast of the linear precipitation systems that cause sediment disasters.

Development of a system for automatically detecting linear precipitation systems based on the indicators of atmospheric instability, amount of water vapor, possibility of causing an ascending current, etc. as well as 3D observation values of X-band MP radar, using numerical weather forecast of the Meteorological Agency. As a result of applying to the heavy rains that caused major sediment disasters in recent years, it was demonstrated that appearance of a linear precipitation system can be forecast about 2 to 6 hours before.



Example of detection from the July 2018 Heavy Rain

Study on forecast of sediment disaster damage and effective countermeasure facility planning.

Improve the river-bed variation calculation based on the behaviors of fine sediment that vary according to gradients, such as sediment being caught between the gravels of debris flow, forming bed / suspended load in low-gradient sections. Verify the reproducibility to previous disasters and confirm application to damage prediction for sediment floods that cause damage in wide downstream area. Further, points of attention in calculation and application to the sabo facility arrangement plan were summarized as Technical Note of NILIM.

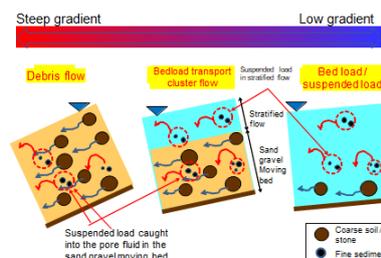
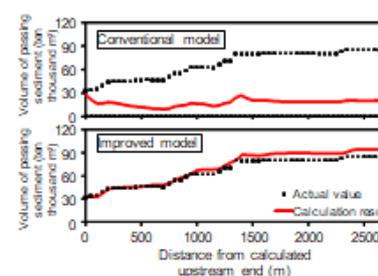


Image of modeling considering the variation of sediment movement patterns from debris flow to bed load / suspended load.



Numerical simulation of the sediment runoff in the July 2016 Northern Kyushu Heavy Rain (Left: Upstream, Right: Downstream)

Effective sabo facility arrangement plan is possible based on the method of predicting occurrence and damage of sediment disaster by local heavy rain and relevant numerical calculation.

Related articles.

- A Study on Automatic Detection of Linear Precipitation Systems etc. for Sediment Disaster Warning and Evacuation
- Issuance of the Guide (draft) to Study on Sabo (erosion control) Facility Arrangement as Countermeasure for Sediment Flooding / Inundation using River-bed Variation Calculation

Road traffic management using big data

Road Traffic Department

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

Social background and issues

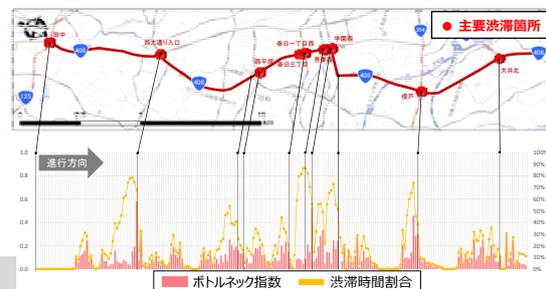
- Roads should continue to play their functions to improve the abundance and quality of public life as important social infrastructure that forms national land even in social environment faced with various issues including depopulation, arrival of a super-aging society, and need for revival of local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

Study contents

Study for improvement of the smooth performance and comfortableness in road traffic

Extract original-destination (OD) data, traveling history data, speed data, traffic volume data, etc. from video images in addition to probe data including ETC2.0 probe information. By merging these basic data and existing data for analysis, establish a technique for monitoring OD traffic volume, automobile route, use route change, and bottleneck points (Right Figure). Use also for impact analysis by application of road measures.

Bottleneck index indicates the "starting point of traffic congestion" and can identify bottleneck points more accurately than the congestion time ratio (yellow broken line).

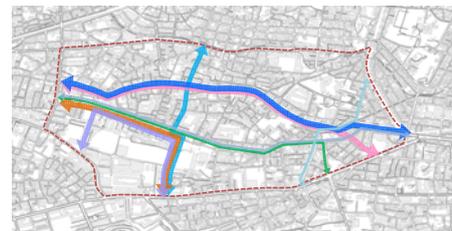


Study of bottleneck point identification method

Study for improvement of safety in road traffic

Extract traveling history data, behavior history data, hazardous event information, etc. from the drive recorder data in addition to ETC2.0 probe information. By merging these basic data and existing data for analysis, establish a technique for monitoring the site / area of hazardous event, route passing through the community road, hazardous event information in individual sites, etc. Use also for impact analysis by application of road measures.

Arrangement of "portable roadside unit" concerning ETC2.0 probe at the entrance of the community road area may enable more efficient / effective analysis of the route passing through the community road (image on Right Figure).



Analysis of the pass-through route in community road district (red broken line)

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

☞ Related articles.

- Collection and utilization of ETC2.0 probe information
- Trend survey of traffic volume measurement technology using AI
- Method of using ETC2.0 probe information for traffic safety measures

To the second stage of road structures maintenance

Road Structures Department

Since the statutory periodic inspection, which started in order to maintain a huge number of road structures properly, has entered the second round, we are working on technical development for inspection, diagnosis, repair, and reinforcement and studying criteria for social implementation thereof in order to realize a more safe and economical maintenance cycle.

Social background and issues

- Since completion of the first round of the road structures statutory inspection, introduced in 2014, there have been many reports on damaged structures for which measures should be taken as soon as possible or structures whose service has to be limited, such as traffic regulation.
- In order to realize economical preventive maintenance through accurate repair / reinforcement of existing structures under various conditions, it is essential to develop inspection / test techniques that enable accurate and timely diagnosis as well as design techniques that can control the behaviors of structures with high accuracy.
- In addition, in order to realize a resilient road network against frequent major disasters, introduction of design techniques and standards that can harmonize the performance of individual structures such as bridge, earthwork, and pavement with focus on road functions.

Study contents

Study on the maintenance technology of road structures

If load-bearing behavior after yield of bridge members can be controlled, economical and efficient repair / reinforcement can be realized while preventing critical situations such as bridge fall for existing and/or damaged bridges subject to the old standards. Conduct the experiments and analyses under various conditions to establish design techniques and review standards.

In addition, for introduction of various inspection supporting technologies, which are being developed intensively, it is essential to clarify characteristics, such as relationship between application conditions and reliability / accuracy of results to be obtained. Develop methods and evaluation criteria for evaluating the performance of various supporting technologies according to needs in the maintenance cycle.



Improve the toughness of steel beam by adding horizontal stiffener



Basic performance test

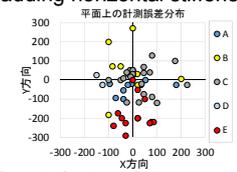
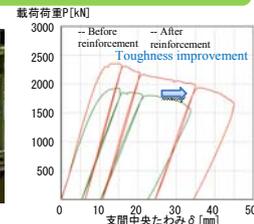


Application performance test



Performance test on the actual bridge level

Performance check by phased test



Example for the unified presentation method of technical evaluation

Study of a performance evaluation method for road structures with focus on road functions.

In periodic inspections, soundness, necessity for actions, etc. are judged based on short-range visual observation. In order to improve inspection quality while overcoming the limit of appearance visual inspection and reducing excessive dependence on engineers' knowledge, implement analysis of inspection results across the country.

Additionally, the design criteria of road structures were established as performance specification, but in order to properly realize performance consistent between structures from a viewpoint of network, it is essential to realize a permanent performance assessment method not dependent on types of structures, whether new or existing, and such a method should be developed through analysis and evaluation of inspection results and existing structures.



An example of road functions being affected by run-off of bridge superstructure or clogged road.

Realization of a society where roads are maintained properly at the minimum life cycle cost and safe and safe public life is secured.

Development of effective technologies for the use of currently

Urban Planning Department, Building

At the NILIM, in the General Technological Development Project* Development of Effective Technologies for the Use of Currently Available Buildings Through the Rationalization of Fire Safety and Evacuation Regulations (2016-2020), necessary technologies are being developed to rationalize and streamline the application of fire safety and evacuation regulations, as well as regulations on building uses under the Building Standards Act to respond to social needs. Some of the research outcomes were reflected on legislative revisions (the revision of the Building Standards Act in 2018).

Social background and challenges

- Local governments and private businesses are expecting to effectively use already available buildings, such as historical buildings that remain in their regions, for regional revitalization and tourism promotion.
- To enable smooth progress of such activities, necessary technologies need to be developed to rationalize and streamline fire safety and evacuation regulations and regulations on building usages.

Development of technologies to ensure fire safety in individual buildings and urban areas

Rationalization of fire safety and evacuation regulations for individual buildings

○To require fire resistant structures in buildings, prevent damage to the surroundings caused by the collapse of large wooden buildings, and secure the safety of people inside the building.

[General Technological Development Project] Implementation of investigations concerning search and rescue and fire extinguishing work and the development of technologies to evaluate the safety of buildings based on the outcomes of experiments

Realization of structures to prevent buildings from collapsing using the effect of fire extinguishing systems and the concept of structures that would keep buildings from collapsing until the completion of the evacuation and rescue of residents



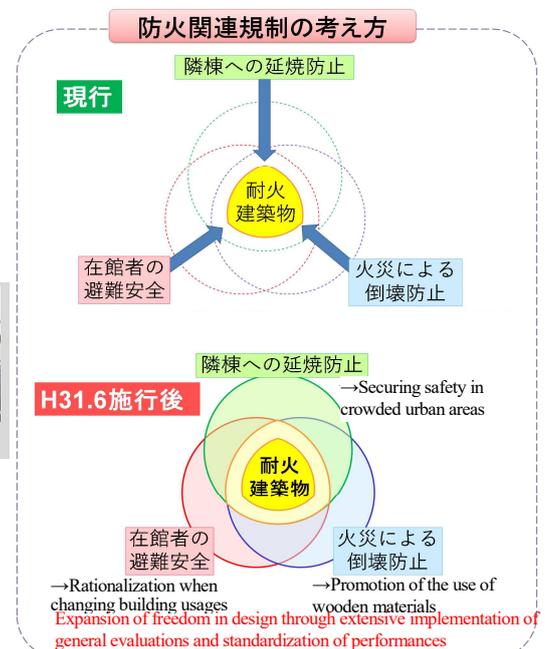
Status of investigation and experiments concerning rescue and fire extinguishing activities

Ensuring and rationalizing fire safety in urban areas

○Requirement of the same specifications based on sizes or other conditions for buildings in fire safety zones or semi-fire safety zones

[General Technological Development Project] Development of technologies to evaluate measures to enable effective of the spread of fire concerning performances require sections with the risk of the spread of fire as well as tl and outside of a building

Realization of the concept of structural methods equivalent of the current regulations on the prevention of the spread of fire



Requirement of the same fireproof performance on main structural parts (current regulation)

Intensive application of required performance on the exterior section, and the use of wooden materials inside building (a revised image)

The image of equivalence in the prevention of the spread of fire in building

⇒ Relevant articles

About the Law to Amend Part of the Building Standards Act (2018, Law #67)

http://www.mlit.go.jp/jutakukentiku/build/jutakukentiku_house_tk_000097.html

-Development of effective technologies for the use of currently available buildings through the rationalization of fire safety and evacuation regulations

-Various ideas to preserve and utilize historical streetscapes

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

Scheme for analyzing energy conservation performance of buildings using big data

Housing Department

A scheme was constructed to gather big data on the energy conservation performance of buildings and analyze them in the cloud system using a web program designed to judge conformance with energy conservation standards. This enables a detailed analysis of the relationship between design specifications and energy conservation performances, which used to be unclear with conventional investigation methods, as well as the efficient supply of useful data for proposing energy conservation measures.

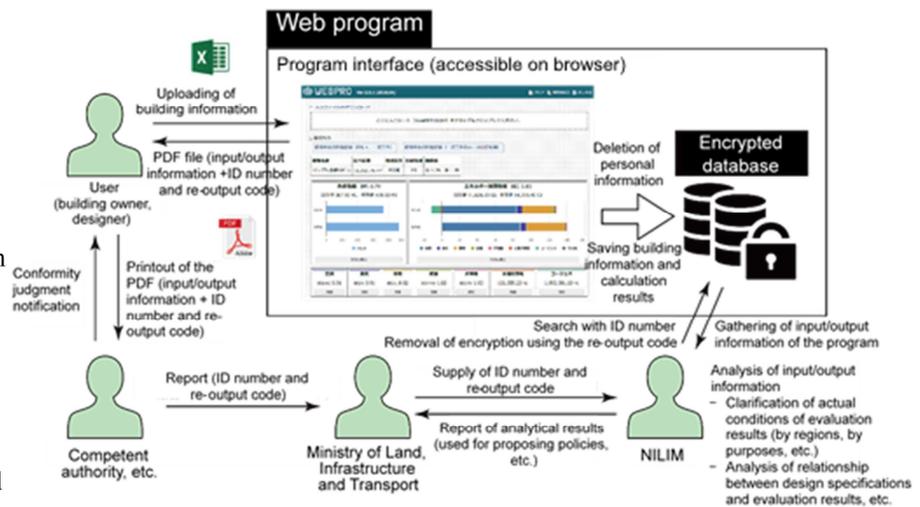
Social background and challenges

- ✓ Under the Global Warming Countermeasures Plan established based on the Paris Agreement and other measures, regulations are gradually being reinforced on large non-residential buildings, such as mandating the conformance with energy conservation standards under the Act on the Rational Use of Energy.
- ✓ It is important to properly identify actual energy conservation performances to efficiently promote energy conservation in the future.
- ✓ Currently, competent authorities are aggregating the results of evaluating energy conservation standards and reporting them to Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Yet, all these procedures are being done manually, and thus the burden is large. In addition, detailed analyses cannot be done because information to gather is restricted to avoid increasing the burden.
- ✓ It is an urgent task to develop a scheme to comprehensively identify and analyze energy conservation performances without increasing burden on authorities.

Contents of research

Development of a scheme to gather energy conservation performance data using a web program

- The energy conservation standards require the evaluation of energy consumption performance using energy conservation standards conformance judgment program (web-based program) for buildings 300 m² or larger. The functions of this program will be expanded to gather data in the cloud system.
- Targeting non-residential buildings, data from 18,000 buildings per year (design specifications and evaluation results) will be encrypted and stored every year.



Trial of data analysis

- As a trial, the ID numbers of about 6,000 buildings for which applications were received in FY 2018 were obtained from some of the competent authorities.
- The data were analyzed to assist the amendment of the Act on the Rational Use of Energy (Cabinet Decision in February 2019), and the results were reported to MLIT.

This trial supported the proposal of energy conservation measures for buildings based on actual performances by supplying timely and proper information while reducing the workload of the authorities.

Relevant articles (introduction of relevant articles of the research laboratory)

- Identification of the actual conditions of energy conservation designs in non-residential buildings

For comfortable movement in cities

Urban Planning Department

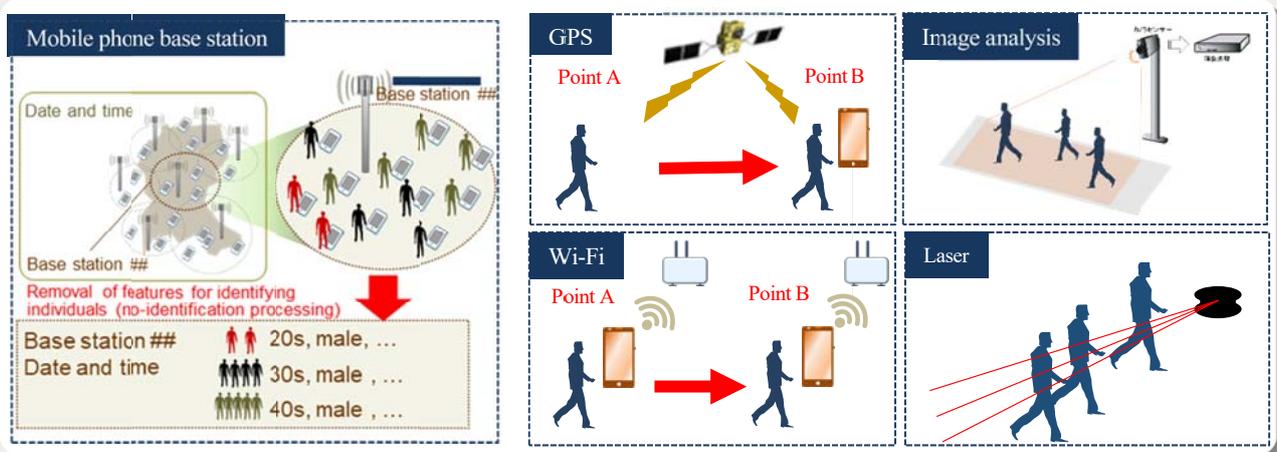
Research is being conducted to identify when, where, and how many pedestrians are present in cities and how they are behaving in order to create attractive and energetic urban spaces where people gather and walk around comfortably.

Social background and challenges

- Questionnaire-based surveys have conventionally been used to identify pedestrian flows. In recent years, however, the questionnaire response rate has been decreasing as people's awareness of privacy has changed. Although the cost has increased, statistical reliability of questionnaire-based surveys has been decreasing.
- In recent years, traffic-related big data, such as mobile phone base station operation data and GPS data, are being provided. Use of these big data has enabled the efficient identification of pedestrian flows.
- The conditions of pedestrian spaces are being reevaluated as pedestrian attributes have become diversified along with the aging of the society and the promotion of tourism.

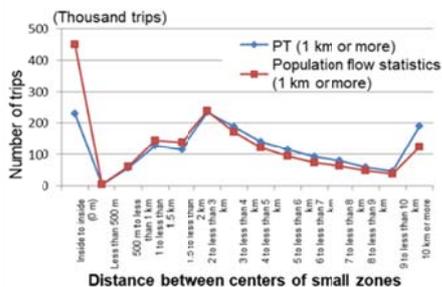
Contents of research

Method to observe pedestrian flows using new technologies

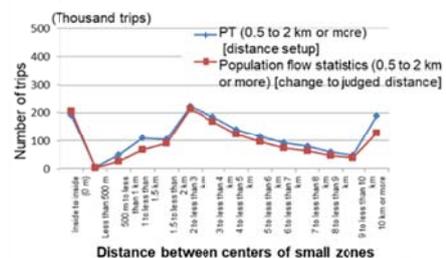


Study on the applicability of traffic-related big data on person trip survey

Movement Statistics Information generated from the operation data of mobile phone base station, which is one of traffic-related big data, consists of the number of data that is the same as the number of mobile phones operating under the carriers providing the data. This means that the advantage is that data concerning the movement of people can be obtained 24 hours, 365 days throughout Japan. Yet, the current data processing method generates errors in the number of trips and other aspects compared to the results of conventional person trip data. Therefore, research is being conducted on improvement methods, such as changing methods to judge "movement" and "staying." In addition, traffic-related big data have different characteristics depending on data types. Thus, researches are conducted to apply traffic-related big data on person trip survey such as making comparisons to clarify characteristics of different data.



Application of improvement measures



By identifying actual conditions of pedestrian movement and analyzing the conditions of their movement,

Relevant articles

- Research of the improvement of the efficiency and advancement of methods to investigate, analyze, and plan urban traffic using new technologies
- Pedestrian movement characteristics at tourist attractions

Considerations on Research Institution Evaluation

--- For better research management

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Keywords: research evaluation, Institution Evaluation, research policy, research management

1. Implementation of "Research Institution Evaluation" Every 5 Years

The National Institute for Land and Infrastructure Management (NILIM) conducted a "Research Institution Evaluation" ("Institution Evaluation") in fiscal 2018 by hearing opinions in the experts committee. Research activities and the performance of institution operations were evaluated for the five years from FY2013 to FY2017.

The Institution Evaluation does not evaluate individual research topics and is not regard individual researchers since it is conducted every five years, and the preparation of presentation materials or holding of a committee meeting is apt to be considered as the purpose. This paper intends to review the last evaluation conducted, reconsider its significance and organize ideas for improving future research management.

2. Meaning of Institution Evaluation for NILIM

1) Grounds for requiring Institution Evaluation

First of all, why is it required to conduct an Institution Evaluation? Under the Japan's National Guideline on the Method of Evaluation for Government R&D (decided by Prime Minister in December 2016), institutions conducting R&D activities with national funding are required to "conduct evaluations" at an interval of "3 to 7 years" in accordance with the "middle- (long-) term objectives, etc."

2) Institution Evaluation by NILIM, which is different from the National Research and Development Agency

"Middle- (long-) term objectives" used herein are mainly based on the National Research and Development Agency (NRDA). For NRDA, the Act on General Rules for Incorporated Administrative Agency provides that the competent minister shall provide "objectives". On the other hand, NILIM is excluded from the application of the same act and no medium-term objectives are provided because it needs to flexibly respond to administrative needs as an internal agency of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). NRDA is evaluated mainly based on the degree of achievement in light of the numerical indicators provided by the medium-term objectives, while an evaluation method needed to be established independently for NILIM since the same

evaluation method was not applicable. For this reason, we first set up an evaluation axis based on the following.

- Evaluate performance and work for improvement based on evaluation results.
- Show the intentions of activities and operations clearly and systematically.
- Value the presentation of quality, such as the depth of policy development of performance and thorough implementation of management measures, rather than the number of papers, etc.

3. Outline of Institution Evaluation

1) Evaluation axis

Figure 1 shows the contents of the material explained in the committee. The first half describes the performance of research activities and the last half represents the improvement in institution operation; all the contents, including details from (1) to (8), are in accordance with the research policy (revised in Nov. 2017). Revision of the research policy was not intended to respond particularly to the Institution Evaluation but served as a basis for systematically showing the intentions of NILIM.

2) Evaluation results

The committee summarized its evaluation of NILIM

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|--|
| I. Implementation / Promotion of R&D |
| (1) R&D to support planning, drafting, and dissemination of land, infrastructure, and transport policy |
| (2) Advanced technical support for response to disasters / accidents and upgrading of countermeasure technologies |
| (3) Support improvement of on-site technological capability of Regional Development Bureaus, etc. |
| (4) Collection, analysis, management, and social return of data serving as technical infrastructure of policy formation |
| II. Institution operation |
| (5) Establish a mechanism of management to support high quality research. |
| (6) Develop personnel who foresee policy development in terms of both research and administration / site based on technology. |
| (7) Maintain and strengthen the functions of test facilities, etc. that support technical research / development in the housing / social capital fields. |
| (8) Effective transmission of research findings and activities |

Fig 1: Contents of institution evaluation and presentation material

as follows: "Achieved outstanding performance", "Constructed a system that enables high-quality research", and "Sufficiently appropriate", while opinions for improvement were also provided (described below). The presentation material and deliberation on the day evaluated are separately summarized in the report ¹⁾.

4. Review of the Significance of the "Institution Evaluation"

Matters we noticed through this evaluation are roughly organized into the following three phases.

1) Constant awareness to improve research activities and institution operations

Since the "Institution Evaluation" is formally an "ex-post valuation" of five years, it is based on results and performance.

For the performance of research activities, however, simple aggregate or examples of performance required by the draft of evaluation criteria may be considered as activities with less uniformity because NILIM responds to various administration departments and needs. For this reason, we clarified what is "research that supports policies" and focused on what can be explained in common across the frames of administration and research fields.

This also applies to "institution operations", as merely listing various examples of improvement is hard to understand what the overall aim is. For specific activities, including cooperation with internal / external research management or outside parties, human resource development, and maintenance, management, etc. of facilities, we made it possible to provide the underlying concept of such activities and specifically explain the content of improvement in light of the concept.

However, the explanation itself is not a goal. What is important is the process of repeating discussions, sharing the concept as an organization, and using the concept for autonomous research activities and system improvement.

2) Recognition of the original significance triggered by "Institution Evaluation"

This Institution Evaluation also served as an opportunity to organize / recognize anew the meanings of terms in common use.

Taking the aforementioned "research that supports policies" as an example, it had been defined before as "drafting / implementation of technical standards, etc.", but it has been newly organized including the scope of "etc.", the meaning of "drafting" as research, and the roles played in "implementation."

There have also been increasing requests to NILIM in recent years for open data. In conducting this Institution Evaluation, we organize anew data held by NILIM at present, circumstances of acquisition / possession, original owner, characteristics of each data, etc. Various discussions would be required for open data and it seems that we have obtained a hint for a

future stance on data handling.

3) Assimilation of experts' opinions and merging of intentions

As the main opinion, further promotion was advocated with regard to the "Visualization of the use of findings to the public" and the "Promotion of international projects." It is also important to consider how to use opinions of experts for improvement. It is necessary to assimilate their opinions with proper intention, without sticking to only the indicated content.

For example, in the former opinion, attention should not be focused only on matters such as the improvement of publicity or the increase in press releases. These are just means and improving recognition of NILIM itself is not an ultimate purpose. It is necessary to have an idea of what the meaning of recognizing NILIM in policy realization / implementation is and how to position and conduct PR activities in the flow of research to that end.

For the latter opinion, quantitative indicators are important, but it would be more important to study from a viewpoint of what kind of international activities are required as an internal agency of the MLIT.

5. Conclusion

In the Institution Evaluation, what I felt in the series of actions from preparation to post-evaluation is described as follows.

As mentioned a little in the beginning, the Institution Evaluation is not a transient event but should be considered as an opportunity to review, from an external viewpoint as well, the continued effort to improve research activities and operations. In addition, since evaluation results are also deeply related to individual research operations by way of a specific policy / mechanism of an organization, not only management departments but individual researchers should consider the future vision of their research activities and have interest in the operations of the institution.

The content of this paper is mainly for the personnel of NILIM but is considered to have parts in common with research activities and management in general. We will be glad if this paper is used as reference.

☞ **See the following for details.**

1) Technical Note of NILIM, No.1057
<http://www.nilim.go.jp/lab/bcg/siryounn/tnn1057.htm> ¹

Research and Development of Sewerage Technologies

INOUE Shigeharu, Director, Water Quality Control Department

Keywords: road map, development field, technical needs, issue on introduction, promotion of introduction

1. Know the vision.

In order to advance research and development accurately while socioeconomic circumstances are changing, long-range outlook is indispensable. In the sewerage field, for achievement of the Sewerage Vision (formulated in July 2014), which is a policy vision, the Sewerage Engineering Vision ("Engineering Vision") was formulated in December 2015. In order to solve important issues in sewerage service, the Engineering Vision shows as a road map technical targets and technical development items required for achievement of targets on 11 technical development fields and specifies what should be addressed by stakeholders including the government, project owners, private sectors, and research institutions. Of the issues in the road map, those for which R&D is urgently required or those for which medium- to long-term solution is indispensable are studied every year in the Conference on Technical Development of Sewerage Systems (established in January 2016, for which NILIM serves as secretariat) ("Development Conference") considering the latest situation and are published as priority issues of the road map. Details of these issues are available in the Sewerage Technology Development Report.

2. Road map implementation

According to the literature search on sewerage-related papers (conducted by the Development Conference in 2018), in the technical development fields mentioned in the Engineering Vision, many researches and developments, etc. were implemented concerning "low carbon sewerage system" and "energy creation and renewable energy." Activities in these fields widely range from basic to demonstration stages and are implemented in a large number as well as in "Sustainable sewerage system (rehabilitation, response to deterioration, smart operation)", "Measures against earthquake / tsunami", and "Rainwater control (inundation measures)." Next come "Basin zone control" and "Risk management." For the former, many projects are implemented in the application / demonstration stage, while the latter, in the basic stage. The field of risk management has been becoming important in recent years, and development toward application etc. is expected in the future. Note that in each field, technical targets for the present (5 years) are generally addressed, compared with medium-term (10 years after) or future (about 20 years later) targets.

Particularly, there are many activities for priority issues of the road map on which support of the government is focused. On the other hand, there were not so many researches on ICT or robots found in the range of this literature search, but it is expected to work on these fields for response to changes in socioeconomic circumstances.

3. Where are needs of project owners

According to the country-wide questionnaire survey to sewerage service provider (in 2016 and 2017 by the Development Conference), the fields where the possibility of introducing / using new technologies is relatively high or at least fifty-fifty (medium degree) were "Earthquake / tsunami countermeasures", and "Sustainable sewerage system." Also in fiscal 2018, disasters by earthquake etc. occurred in many regions, and technical needs related to safety and security are always high regardless of the size of cities. For "Rainwater management", "Energy creation and renewable energy", and "Low carbon type sewerage system," needs are higher in large cities (administration population of 300,000 or more) than small and medium-sized cities (administration population of less than 300,000), and a certain trend is seen in the level of sewage maintenance. Particularly, in the cities with a size of core city that are eager about studying issues and could lead technical development / introduction, etc., according to the questionnaire and hearing survey (by the Development Conference in 2018) to such cities, many of them answered that they need technical development concerning "Pipeline rehabilitation", "Pipeline maintenance", and "Rainwater measures" such as measures for water from unknown source or infiltration water. Timewise, there are also immediate needs, such as "quickly" or "within one year." While there is a concern about rapid increase of old facilities, the issue of "pipeline management," for which data accumulation, etc. are highly required, is often discussed as a technical issue in major conferences on sewerage and attracting the interest of business operators.

4. What obstructs new technology introduction?

According to the above-mentioned country-wide questionnaire survey, as an issue on new technology introduction, many business operators are concerned about procurement of technologies, such as

"insufficient development of estimation standards, technical guidelines, etc." Particularly for bidding and contract procedures, many of them are concerned about limitation to a specific company although competitive bidding is basically required, such as "Competitiveness does not work for new technologies and bidding is limited to a specific company" or "Fairness / transparency is not assured." Many of them also answered that little progress in considering introduction is attributable to insufficient information, insufficient understanding of the technology, etc., including "Uncertain reliability of the performance of new technology" (business operators in large cities), and "Unknown whether there is any applicable new technology," "Difficult to choose optimum one among similar technologies / approaches" and "Unable to consider new technology introduction because of shortage of technical staff" (all in small and medium cities). In addition to the effort to introduce details, effects, etc. of new technologies in an easy-to-understand manner, promotion of development of new technologies applicable to small and medium-sized cities, where many businesses are operating, supporting system for introduction consideration, etc. are also important issues. Particularly in the cities with a size of core city, the following opinions were raised by business operators in the above-mentioned hearing survey: (i) For a certain period after new technology introduction, follow-up service by manufacturer is required for the purpose of know-how transfer, etc. for maintenance since even partial renewal may require adjustment of the operation control method of the whole system; (ii) Place a focus on life cycle cost but may hesitate to introduce new technology for financial reasons if initial cost is high; and (iii) Since it is difficult to implement an ordering system that determines the validity of technical proposal evaluation and price, such as comprehensive evaluation bidding system, due to shortage of technical staff, securing competitiveness or performance / stability of the technology to adopt is necessary.

5. For promotion of introduction

It is desirable to implement at an early stage new technologies that can respond to technical issues of business operators. As a measure of the government to support the promotion of new technology introduction, etc. in the sewerage field, Breakthrough by Dynamic Approach in Sewage High Technology ("B-DASH" Project) has been implemented since 2011, in which the government takes the initiative in verification of innovative technologies that can serve the solution of business issues and formulate guidelines for dissemination and development of new technologies across the country. A total of 41 technologies were so far demonstrated in real scale, covering all the fields of sewerage. We are going to continue research activities with focus on follow-up after preparation of guidelines. Further, for the issues of matching of seeds and needs, shortage of information, etc., we are considering systematic mapping of the content of the study implemented by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) in cooperation with the Environmental Engineering Committee of the Japan Society of Civil Engineers, as well as the use of GAM (Gesuido Academic Mapping), a project aiming to strengthen cooperation of industry, academia and government. Further, the Energy Subcommittee was installed in the Development Conference and is implementing institutional study considering various issues so far found in new technology introduction. Through the activities etc. introduced above, we intend to advance actively social implementation of R&D findings.

☞ See the following for details.

1) Technical Note of NILIM, No.1033, "2017 Sewerage Technology Development Report"
http://www.nilim.go.jp/lab/eag/gesuidougijyutsukaihat_sureport.html

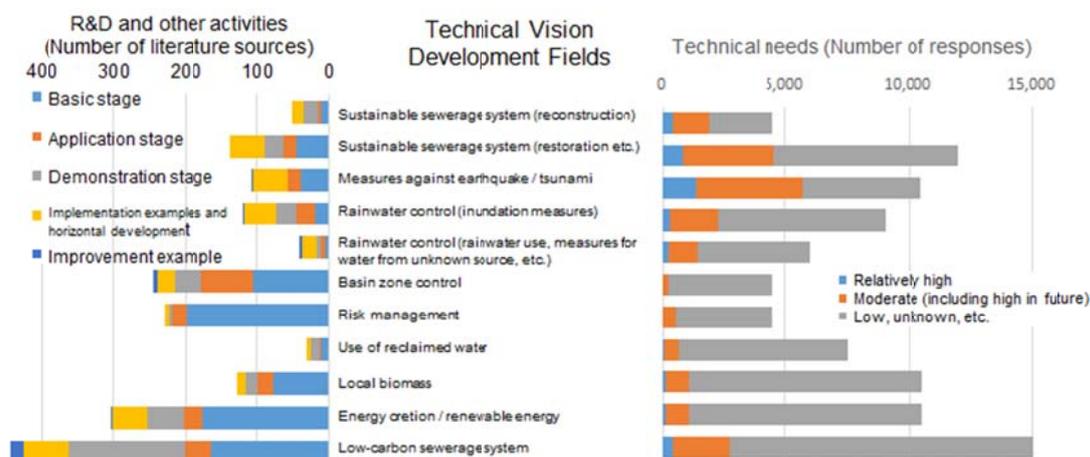


Fig. R&D activities, etc. and technical needs

New Flood Control Frame considering Future Climate Changes

AMANO Kunihiro (Ph. D.), Director, River Department

Keywords: climate changes, adaptation measures, flood control

1. Introduction

With regard to the July 2018 Heavy Rain, which caused a great flood disaster centering on the western part of Japan, the Meteorological Agency, based on the results of discussion in the August 2018 extraordinary meeting of the Abnormal Weather Study Workshop, operated by the same Agency, referred to "the long-term trend of increase in water vapor content in the air in accordance with the long-term upward trend of air temperature due to global warming" and to the well-known fact that "water vapor content will increase about 7% when air temperature rises by 1 °C." The Agency also announced for the first time the manifestation of climate change effect on heavy rain generated, stating, "Increase in water vapor content due to global warming is also considered to have contributed to this heavy rain."

In recent years, large-scale flood disasters have frequently occurred and there is a concern that flood disasters are expected to become more intensified and frequent if global warming proceeds without improvement. In addition, for the future of Japanese society, depopulation and declining birthrate and aging are forecasted and the capacity of investment in disaster prevention / mitigation and resistance to disasters may become weak. While scale of disasters is expected to increase, stability and sustainable development of society may be impaired if there is no improvement in disaster prevention / mitigation capacity. Hence, management of flood disasters by promoting disaster prevention / mitigation measures is increasingly important.

In response to the circumstances stated above, this paper details forecasted changes in heavy rain due to climate changes, consequential changes in river flow, and the new flood control frame proposed by the NILIM.

2. Future climate forecast

Future climate forecast is conducted basically with General Circulation Model (GCM), which conducts three-dimensional calculation for the whole earth and Regional Climate Model (RCM), which conducts high resolution calculation for some regions with the calculation result of GCM as the boundary condition. In the climate forecast for regions with complex topography as in Japan, RCM is useful since it is based on high resolution, and calculation has been

conducted with the horizontal resolutions of 20 km and 5 km, and calculation based on 2 km resolution is being conducted. Future climate forecast is conducted based on some scenarios. The 5th IPCC Assessment Report selected four scenarios, including Low Emission Scenario (RCP2.6), which controls air temperature rise to 2 °C after the Industrial Revolution, and High Emission Scenario (RCP8.5), which does not conduct mitigation measures considering air temperature rise to be 4 °C. With the resolution of 20 km prepared in the Climate Change Risk Information Creation Program by the Ministry of Education, Culture, Sports, Science and Technology, the NILIM collected data for each basin of the 109 first class river systems across the country using d4PDF, which is a database in which ensemble calculation is conducted on the data for the past 3,000 years and future 5,400 years. As a result of analyzing the data, rainfall from heavy rain is expected increase by approx. 1.3 times on a national average at the end of the 21st century under the RCP8.5 scenario. Based on this result, future rainfall is estimated to increase approx. 1.1 times under the RCP2.6 scenario. Further, as a result of conducting run-off calculation using the results above as rainfall conditions, the flow rate in the scale of flood control plan under the RCP8.5 and RCP2.6 scenarios showed approx. 1.4 times and approx. 1.2 times and the frequency of flood in the same scale increases about 4 times and 2 times, respectively.

Table 1: Forecast of future changes in heavy rain size, flood size, flood probability (national average)

Climate scenario	Heavy rain variation magnification	Plan size flow rate variation magnification	Flood probability variation magnification
RCP8.5 (4°C rise)	approx. 1.3 times	approx. 1.4 times	approx. 4 times
RCP2.6 (2°C rise)	approx. 1.1 times	approx. 1.2 times	approx. 2 times

From the forecast of the effect of climate changes, it was found that heavy rain size in the scale of the present flood control plan (occurrence probability) is forecasted to increase about 1.1 times on a national average under the low emission scenario with temperature rise of 2°C, while flood probability was forecasted to increase about 2 times. Thus, even if change in heavy rain seems not so great, it is likely to be a great change in terms of occurrence of flood / inundation (flood disaster). The meaning of increase

in flood discharge will be easier to understand when examined with a chart with horizontal axis of flood discharge and vertical axis of non-exceedance probability (probability of not exceeding a certain flow rate: When it is 99%, the probability of exceeding the flow rate (exceedance probability) is 1%). For example, when a flow rate of the flood control plan is set based on the current climate conditions (blue line) with non-exceedance probability of 99%, i.e., exceedance probability of 1%, the flood discharge at the position of blue circle will be the plan size flow rate. If the occurrence probability of flood discharge in future when flood discharge is forecasted to increase changes to the distribution as shown in brown lines, the flood discharge variation magnification (comparison with horizontal axis) corresponding to the exceedance probability in the present flood control plan will be different from the flood probability variation magnification (exceedance probability variation magnification of the present plan size flow rate (comparison with vertical axis). When a probability distribution changes as shown in Fig. 1, there is a risk of great increase in flood disaster occurrence probability (frequency) only with a little increase in heavy rain size.

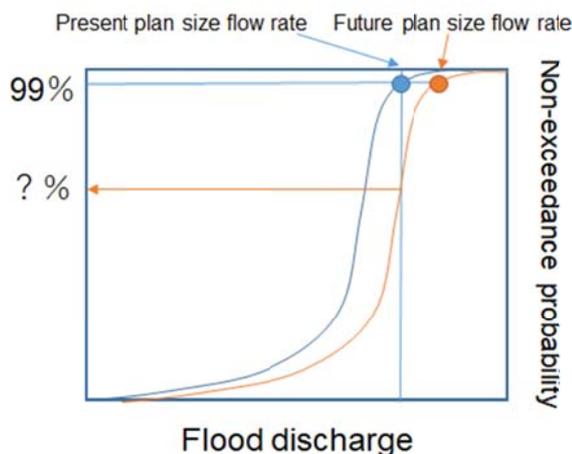


Fig. 1 Flood discharge probability distribution variation and flood disaster frequency variation

3. New flood control frame

Now that flood disaster probability has been forecasted to increase substantially due to climate changes, in order to prevent fall in safety level of flood control in river basin, it is also necessary to fully prepare a flood exceeding the plan size in addition to further promotion of river development. Fig. 1 suggests that residual risk may remain to be increased under the future flood discharge probability even if river development is conducted by raising exceedance probability to the current level.

Considering the effect of climate changes on the water policy as stated above, the NILIM proposes a new flood control frame as a flood disaster control policy that principally implements disaster prevention and

mitigation in combination of flood frequency reduction (disaster prevention by river development, etc.) and damage control after flood occurrence (disaster reduction or risk management). The estimation curve ("risk curve". Fig. 2) showing how flood disaster damage changes according to heavy rain sizes is drawn at lower right of the Figure and results of technical studies are organized about basic matters for implementation using all possible measures that should be implemented for control, scenario setting methods, concept of evaluation in damage control, method of studying measures, evaluation of climate change adaptability, etc. ¹⁾

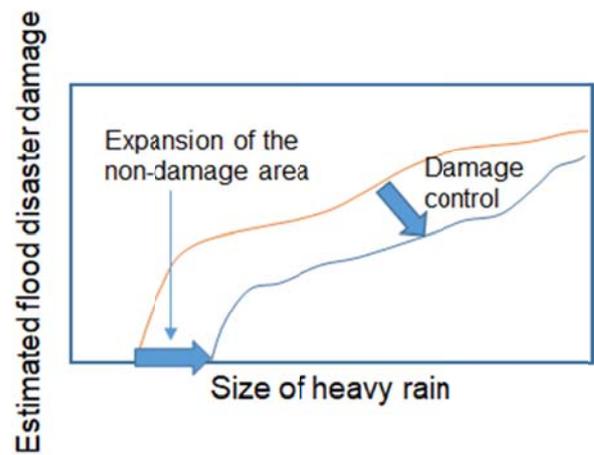


Fig. 2 Concept of flood disaster risk curve

In studying control measures, they were classified into (i) measures in the river, (ii) measures in basins (run-off area from rainfall to flood), and (iii) measures in flooded area, and an overall frame is formulated by incorporating measures available for damage reduction systematically and properly at each stage of mechanism in the range from occurrence of the source event (heavy rain) that causes a disaster to final flood disaster damage, such as control to prevent flood damage from expansion or control to facilitate recovery from damage in addition to the control of flood size in the process from heavy rain to flooding. For the new flood control frame, it is necessary to further advance technical study in actual application, including the effect of measures and quantitative evaluation method of uncertainty, which are an important future issue for the River Department.

 ☞ See the following for details.

1) NILIM Project Research Report No.56, Research on Climate Change Adaptation Measures in River and Coast Fields
<http://www.nilim.go.jp/lab/bcg/siryoku/kpr/prn0056.htm>

be provided to local governments, etc. in the event of a disaster.

- Lecture and seminar on the current technical development / research situation of emergency surveys, emergency measures, etc. by the NILIM and the Public Works Research Institute.

- Analysis and discussion on the issues and countermeasures in implementing emergency surveys and measures by each Regional Development Bureau, etc.

- Lecture and discussion on lessons and important points in future response considering actual emergency surveys and technical guidance.

- Implementation of waterway experiments on landslide dam erosion by overflow assuming the shapes of landslide dams and countermeasure works.

- Summarization of discussions and results concerning countermeasures for the issues arising in implementing emergency surveys and measures. The participants were classified into 4 teams to prepare reports for the following issues.

- (1) Points of attention in emergency inspection of the areas vulnerable to sediment disaster and standardization of evaluation results.

- (2) Preparations for welcoming the TEC-FORCE in the event of a large-scale sediment disaster.

- (3) New technology effective in the survey of unfamiliar areas.

- (4) Points of attention in helicopter surveys of sediment disasters, etc.

These four issues are based on what Regional Development Bureaus have noticed in responding to disasters. For example, for "Helicopter surveys when a landslide dam was formed," there was a proposal about preparation and survey method during flight through hearings from helicopter pilots because of insufficient experience in helicopter surveys, and for "New technology effective in the survey of unfamiliar areas," applications and devices were organized as a form of brochure so that they would be useful for localization in surveys of unfamiliar areas by the TEC-FORCE and Regional Development Bureaus. Thus, results very effective for practical operation were obtained.

In addition, results of the program have been shared systematically through presentation and discussion involving Sabo Control Department and leading members of Regional Development Bureaus in charge of erosion control in the human resource development program meeting held at the MLIT on February 5, 2019. Results of discussions are also posted on the NILIM intranet as "Answer book for large-scale sediment disaster response measures" so that they may be available to MLIT personnel.

Until now, a total of 48 persons completed the program and the personnel who concurrently served in the NILIM now serve as an instructor in emergency survey seminars and large-scale sediment disaster training held at each Regional Development Bureau,

work on the site of disaster surveys using the technologies learned, and report the status of use in the human resource development program meeting.



Photo 1. Training of laser distance measurement from the helicopter at the site of an actual landslide dam

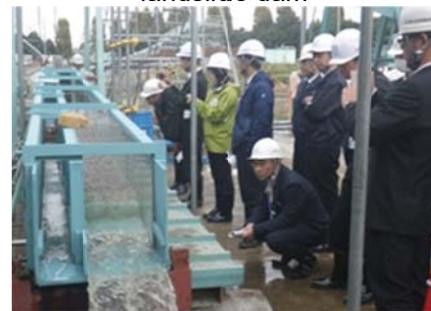


Photo 2. Experiment with a landslide dam overflow model

In addition, road management subsection managers from the Kinki, Shikoku, and Kyushu Regional Development Bureaus participated in the FY2018 program for the first time, and attended disaster survey training on Mt. Tsukuba, a lecture and seminar on landslide countermeasures, and a lecture on sediment disaster warning information. Some participants described their participation with comments like "The field training in disaster surveys was very helpful and would be useful for activities of the TEC-FORCE" and "It was a good opportunity to learn basic knowledge for carrying out inspections and other operations because there is almost no opportunity to learn about sediment disasters." NILIM has already been provided technical support to road departments of Regional Development Bureaus when disasters occurred. Henceforth, we intend to provide support for personnel of road departments to learn advanced sediment disaster response technologies, etc. so that they can contribute to the early recovery / restoration of disaster-stricken regions.

4. Conclusion

Since the risk of sediment disaster varies according to changes in climate, socioeconomic structure, etc., technical development for damage mitigation should be continued constantly. However, no matter what technology may be developed, its effect will be demonstrated only when there are human resources who can use it. We intend to continue our ongoing efforts for human resource development as well as technical development.

Efforts of the Road Traffic Department for Road and Traffic Innovations

FUKUSHIMA Shinji, Director, Road Traffic Department

Keywords: road traffic, ETC 2.0, traffic safety, vehicle operation management, autonomous driving, removal of utility poles

1. Introduction

Roads constructed across Japan have greatly contributed to the improvement and enrichment in the quality of life as infrastructure. Meanwhile, roads must continue to respond to rapidly progressing technological innovation, reconsiderations of the relationship between people and cars, and social needs for the pursuit of new cooperation / collaboration through road space. In such circumstances, the Road Subcommittee of the Social Infrastructure Improvement Council prepared a proposal titled "Road / Transportation Innovation" in August 2017 as a future vision of road policy, including the following three directions: "Road, transportation, and innovation --- Innovate social infrastructure beginning with roads", "Best mix of people and cars --- Realize advanced road transport," and "Make roads more open --- Pursue various forms of cooperation and collaboration".

This paper introduces part of the activities of the Road Traffic Department, NILIM, in relation to specific proposals for road policy based on the new directions of the above-mentioned proposal.

2. Ensuring smooth mobility

--- Strengthening transportation management with full utilization of ICT, etc. ---

(1) Road traffic management using big data

ETC 2.0 can collect travel and behavior histories of automobiles accumulated in ETC 2.0 on-vehicle units through the roadside units installed by the road administrator. ETC 2.0 on-vehicle units are widely installed, totaling about 3.12 million as of the end of September 2018, and it is possible to utilize these probe data as big data. Probe data on the speed, position, etc. of automobiles equipped with ETC 2.0 can be obtained in time and space sequence regardless of the type of road, etc.

NILIM is conducting R&D activities for traffic management by grasping the situation of road traffic in real-time using ETC 2.0, road monitoring cameras, etc. For example, traffic safety measures including speed control and through-traffic access control measures are implemented by identifying dangerous spots, such as where abrupt slowdowns occur, with utilization of analysis results of ETC 2.0 data, etc. Further, in order to utilize ETC 2.0 data as well to analyze the effect of measures, R&D for upgrading the analytical method, etc. and technical support for road administrators are conducted.

(2) Next-generation cooperative ITS

Autonomous vehicle technologies that supports safe driving, such as an automatic braking system, which is one of many automatic driving technologies, have been developed as cooperative / collaborative efforts of automobile manufacturers, IT companies, etc. and have already been installed in commercial cars. Since information on roads, such as the traffic situation of the trunk road at the junction with an expressway or regulated traffic areas on the road ahead, is also needed for the realization of fully autonomous driving (as information only from autonomous vehicle technology is insufficient), collaborative activities for the next-generation cooperative ITS are going on between government and industry.

In fiscal 2017, the NILIM started government-industry joint research into services for providing information at expressway junctions on traffic accidents and other matters on the road ahead, and conducting technical studies to achieve the government target of realizing autonomous driving on expressways by 2020.

(3) Making ETC 2.0 probe data open

In order to promote open innovation with big data utilization, it is necessary to establish an appropriate mechanism for making data open, including secondary use, considering the viewpoint of personal information protection. With the aim to promote the utilization of ETC 2.0 data, NILIM has been conducting joint research since October 2018 in cooperation with industry in order to open access to ETC2.0 data collected by the government.

3. Promotion of strategic flow of people and goods

(1) Upgrading of road management with on-vehicle sensing technology

For the purpose of upgrading and reducing the labor of road management, Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has been studying the utilization of sensing technology, including camera image analysis and laser measurement, which has progressed remarkably in recent years. In 2017, NILIM sought practical applications of on-vehicle sensing technology from the public. As a result, 9 teams from survey and map companies joined an experiment to compare and verify the accuracy, cost, etc. of the prepared map data. We continue to prepare technical data concerning the performance of sensing technology required for road management and to study ways to upgrade the examination of specially

permitted commercial vehicles.

(2) Vehicle operation control support services for logistics business operators

MLIT is promoting the introduction of a service that enables logistics and other business operators to use ETC 2.0 for operation management through real-time acquisition of information on the position of their trucks, use of brake, etc., and, thereby, improve the efficiency of operation management, such as by reducing the time for waiting for cargo, and ensure the safety of drivers.

Aiming to realize this vehicle operation support service, NILIM conducted a social experiment from 2015 to 2017 in cooperation with logistics and other business operators for the purpose of analyzing and evaluating the effectiveness, feasibility, and social effect of the service and developing measures. Since this service went into full-scale operation in October 2018, NILIM has been working to improve the convenience of this service by analyzing operation results, etc.

(3) Autonomous driving demonstration experiment based on Michi-no-Eki (roadside rest area), etc.

MLIT has been conducting a demonstration test of an autonomous driving service based on Michi-no-Eki and other sites, with the aim of social implementation by 2020. The purpose here is to promote the flow of people and logistics in the interest of rural area revitalization by utilizing autonomous driving vehicles in hilly and mountainous areas, where the population is aging.

In fiscal 2017, a demonstration test was conducted in 13 areas across the country for a period of about one week. The Regional Development Bureau formed a regional council of experts, local governments, vehicle providers, etc. and NILIM provided technical support. As a result, many issues that weigh on the realization of an autonomous driving service were found, including defect events that arise under various road structures or traffic environments. Since fiscal 2018, we have been conducting a more practical long-term demonstration test of one to two months, in order to develop standards for road space adapted to autonomous driving and establish operation management systems and business models according to the circumstances of area.

4. For disaster resilient roads of high safety and reliability

(1) Promotion of no utility poles

MLIT has been systematically working to remove utility poles from the viewpoints of improving the disaster prevention capacity of roads, securing safe and comfortable traveling space, beautifying landscapes, and promoting tourism. However, progress is far behind major European and American cities and one of the factors for the delay is the high cost. MLIT also intends to promote the removal of utility poles because many poles were damaged and

fallen by strong winds caused by typhoons last year. NILIM is studying technical issues for introducing a method of implementing the no utility pole project at low cost and smooth consensus-building with relevant organizations, etc.

(2) Strengthening heavy snow countermeasures

In recent years, heavy snow has stranded vehicles on a large scale and suspended traffic for long periods of time. Moreover, traffic hazards due to heavy snow often occurred in areas other than snowy areas. Given the circumstances, NILIM has been studying measures to solve issues, including road structures unlikely to cause traffic standstills such as wide shoulders required from a viewpoint of winter road management and uphill lanes, by grasping characteristics through analysis of data on cars in stuck and on-site hearings and organizing causes, issues, etc.

5. Conclusion

This paper introduced some of the activities for road and traffic innovation, but the relationships between people, cars, society, and road technology are changing at an unexpected speed, as evidenced by the advent of a super-aging society, changes in fuel and type of ownership, micro mobility, and autonomous driving technologies. In response to such changes, NILIM intends to work for the realization of safe and smooth road traffic quickly and flexibly based on a medium to long-term viewpoint.

For Strong and Resilient Roads

KIMURA Yoshitomi Director, Road Structures Department

Keywords: road structures, disaster prevention / mitigation, maintenance, design / construction

1. Introduction

Road structures such as bridges, tunnels, earthworks, and pavements support a safe, secure, and highly productive society by providing road functions. In order to support proper maintenance and efficient renewal of these road structures, the Road Structures Department drafts technical standards and conducts research necessary for that, provides technical consultation about on-site issues, and implements technology transfers.

In fiscal 2018, various disasters and accidents occurred and the Road Structures Department accordingly advanced its policies greatly, which included making modifications to the National Resilience Plan and revisions to periodic inspection procedures. This paper introduces the status of road structures, NILIM's activities, and future vision from the three standpoints of disaster prevention / mitigation and crisis management, infrastructure maintenance, and efficient development of road assets.

2. Disaster prevention / mitigation and crisis management

Table 1 lists the disasters that occurred in fiscal 2018. This table summarizes the data published in the website of the Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") concerning disaster information. As "disaster" was chosen as the kanji (Chinese character) representing the year of 2018, many disasters occurred in 2018.

In the same year, NILIM also took an emergency posture more than 10 times and conducted field surveys and technical support as described herein.

Disasters suffered in the year include liquefaction in filled wetlands, sediment disasters that seriously impacted transportation

systems, and earthwork deformation. To establish a risk management method for such natural disasters, NILIM focuses on the improvement in disaster prevention performance by upgrading technical standards for new infrastructure, preventive measures for potential risk mitigation and disaster reduction for existing facilities, identifying disaster scale for securing the emergency system, and technologies for elimination of road obstacles, emergency restoration, and disaster recurrence prevention, and aims to reflect research findings successively in practice.

Particularly for liquefaction, we study risk assessment methods for box culverts, embankments, etc. and provide information on strong motion observations to facility administrators through joint research with the Public Works Research Institute, etc. We also develop facilities required for studying impact mitigation technology concerning subsidence of road structures caused by earthquakes.

3. Maintenance of infrastructure

As international standards for asset management, the ISO 55000 series requires the establishment of a hierarchical management cycle as shown in Fig.1, as well as a system to evaluate and improve implementation of the cycle.¹⁾ NILIM conducts R&D of various technologies that constitute the management cycle and is responsible for proposing necessary measures through analysis of inspection

Table 1: Disasters in fiscal 2018

Date	Type	Disaster	NILIM's response
Apr. 9	Earthquake	Earthquake centered in the western part of Shimane-ken	Watch
Apr. 11	Other	Sediment disaster in Nakatsu-shi, Oita	Watch
Apr. 14	Earthquake	Earthquake centered in the ocean off the south-eastern coast of the Nemuro Peninsula	Watch
Apr. 19	Volcano	Eruption of Mt. Kirishima (around the Ebino Highland)	Caution
May 12	Earthquake	Earthquake centered in the northern part of Nagano-ken	Watch
May 18	Storm / flood	Heavy rain from May 18	Watch
May 25	Earthquake	Earthquake centered in the northern part of Nagano-ken	Watch
June 17	Earthquake	Earthquake centered in the southern part of Gunma-ken	Watch
June 18	Earthquake	Earthquake centered in the northern part of Osaka-fu	Emergency
July 3	Storm / flood	July 2018 Heavy Rain (by Typhoon No. 7 and rain front)	Emergency
July 7	Earthquake	Earthquake centered in the ocean off the eastern coast of Chiba-ken	Watch
July 30	Storm / flood	Typhoon No. 12	Emergency
Aug. 5	Storm / flood	Heavy rain from Aug. 5	Emergency
Aug. 8	Storm / flood	Typhoon No. 13	Emergency
Aug. 15	Volcano	Volcanic activity on Kuchinoerabu Island	Watch
Aug. 22	Storm / flood	Typhoon Nos. 19 and 20	Emergency
Sep. 4	Storm / flood	Typhoon No. 21	Emergency
Sep. 6	Earthquake	2018 Hokkaido Eastern Ibari Earthquake	Emergency
Oct. 1	Storm / flood	Typhoon No. 24	Emergency
Oct. 9	Storm / flood	Typhoon No. 25	Emergency
Jan. 3	Earthquake	Earthquake centered in the Kumamoto Region of Kumamoto-ken	Emergency
Jan. 26	Earthquake	Earthquake centered in the Kumamoto Region of Kumamoto-ken	
Feb. 21	Earthquake	Earthquake centered in the middle-eastern part of Ibari Region, Hokkaido	Emergency

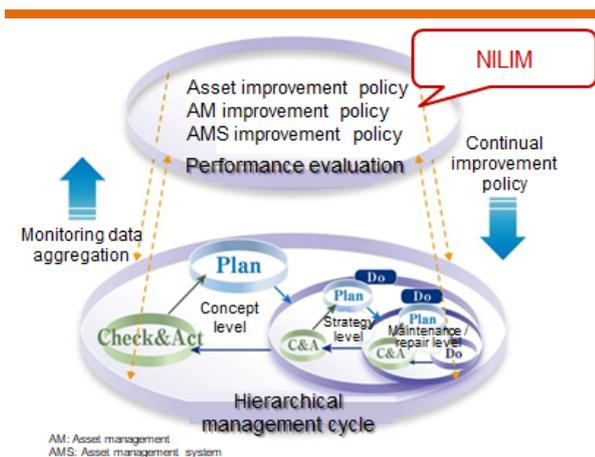


Fig. 1: Maintenance cycle

results and collection of defect information. For road structures including tunnels and bridges, visual proximity inspections are to be conducted under the act every five years as of fiscal 2014. For the second round of inspections under the act, which starts in fiscal 2019, NILIM has proposed revising the inspection procedure based on the analysis of the periodic inspection results and serious damage / accident cases. In the proposal, while specifying the spots to check according to structures to reduce hammering test / inspection by touching, spots to check and points of attention for characteristic deformation are increased. NILIM is also organizing the environment for cycle establishment, including guidelines for the utilization of inspection supporting technologies, which are being developed in each field, performance catalogs, etc. We want to improve the reliability and efficiency of inspections by continuing to use inspection results.

As inspections proceed, structures requiring repair / reinforcement are also becoming apparent. In order to streamline operations, we continue to push the introduction of the partial factor design method into repair / reinforcement design of road bridges, as well as the survey / design method for improving early deteriorated pavement sections.

We also promote the study of management methods commonly available for road structures so that efforts in asset management, which is spreading across the country, are more streamlined and effective.

4. Efficient development of road assets

For road bridges, the design technology standard was revised in July 2017 from the allowable stress design system to the partial factor design system, and the condition that "Design is possible that realizes various performances including safety reasonably and meticulously considering reliability" for various conditions of new equipment design was established. Applying this condition, we study ways to rationalize measures by utilizing new technologies such as high

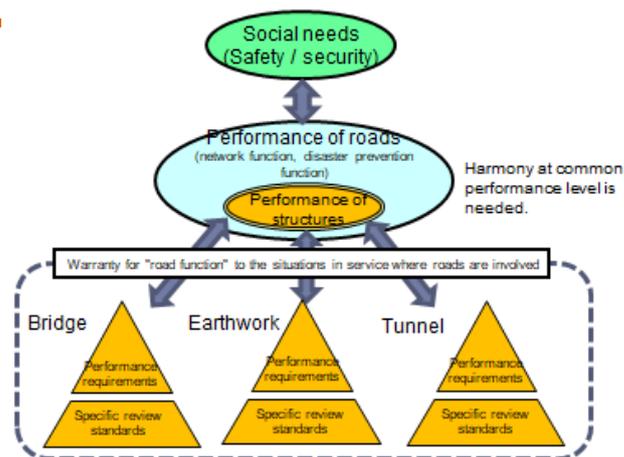


Fig. 2: Road performance and structures

strength materials and an effective and reasonable repair / reinforcement methods for existing structures. Furthermore, as shown in Fig. 2, in order to harmonize the performances of all road structures from the viewpoint of road functions, which is the ultimate purpose of road structures, we organize performance requirements systematically by design technology standards for tunnels, earthwork structures, pavement, etc. and study regulation measures that enable more specific performance design.

Furthermore, in consideration of the development of ICT technology, we also study an efficient management method using ICT technology for the process from design to maintenance of road structures.

Through the activities described above, the Road Structures Department intends to contribute to the development of strong and resilient roads and robust land.

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Response to various uncertainties in the processes of planning and establishing technical standards

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

Keywords: Technical standards, social needs, uncertainties, allowance, safety and sense of security, revitalization of rural regions

1. Introduction

The mission of Building Department is to respond to various needs of citizens and society that keep changing with movements around the world and realize the safe, secure, and comfortable building environment. Therefore, the Building Department is providing administrative support based on scientific and technical knowledge upon planning, drafting, establishment, and revision of various technical standards, including the Building Standards Act. Other activities of the Building Department include on-site investigations at the scene of natural disasters, examination of measures to implement in the future, application and promulgation of investigations and research findings to the society, and the supply of technical support to organizations inside and outside of Japan.

2. Response to various uncertainties in the processes of planning and establishment of technical standards

This article introduces how the Building Department has perceived and responded to various uncertainties that we face while drafting technical standards using the Measure to Respond to Long-period Ground Motion caused by Massive Earthquake along the Nankai Trough¹ that entered into force in April 2017.

1) Basic concept

Engineering is a field where manufacturing is required even when there are unknowns, and experiences are lacking. Such uncertainties have long been handled to a certain extent by providing a proper allowance. Therefore, the position of seismic motions to enter for designs is first organized as shown in Figure 1.

Some of the past earthquakes have recorded seismic motion that exceeded standard seismic motion to be entered for designs and seismic motion of which properties, such as frequency characteristics, greatly differed from standard motion. This means we cannot deny the possibility that seismic motion that differs from or is much greater than ones entered for designs would affect a building. In addition, in the 2016 Kumamoto Earthquakes, level-7 seismic motion on the Japan Meteorological Agency's seismic intensity scale occurred twice. This series of earthquakes made some scientists

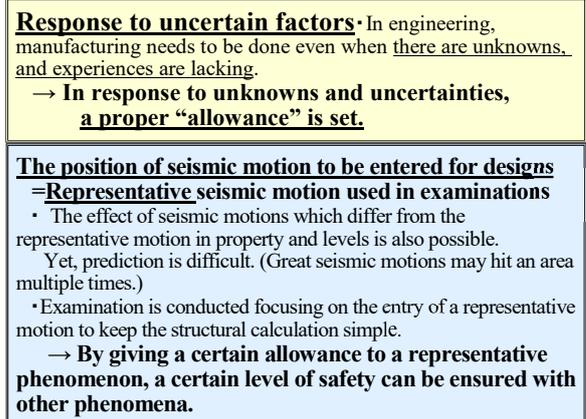


Figure 1 Position of seismic motion to input for designs

think that building designs would need to be adjusted accordingly. In reality, however, it is difficult to forecast the types of earthquakes to occur and how many times. Even when such predictions can be made, structural calculations would be extremely complicated. Based on the above observations combined, a reasonable way to handle seismic motion to be entered for designs is to position the motion as representative seismic motion used in examinations and to ensure a certain level of safety for other phenomena by adding a certain allowance to the designs.

2) Ways to provide engineering allowances

Figure 2 shows an example of how to provide the allowance in designs based on the above observations. The figure exhibits the relationship between the horizontal force on a building during an earthquake and deformation. The safety limit indicates the upper limit up to which structural safety is ensured. If the response to a large earthquake remains around the response range (ensuring safety) in front of the safety limit, it means that a collapse that would lower durability would not occur to a building, and structural safety can be ensured. If seismic motion is greater than expected, however, it may exceed the safety limit, and a certain variation will be seen in the evaluation of the response. Therefore, it is important that a building can change its shape without causing damage or collapse to an extent at which the building can absorb earthquake energy, which is somewhat greater than the safety limit.

In regard to providing such allowance in the design, the New RC Structure Design Guideline² for example,

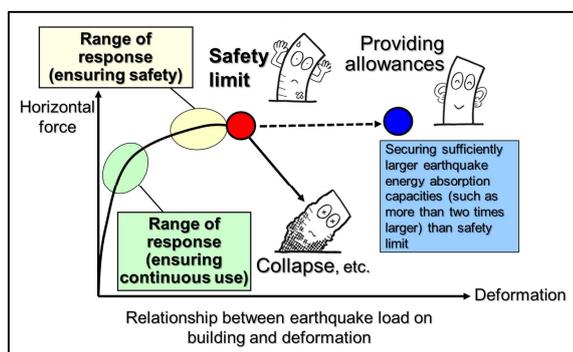


Figure 2 Idea of responses to uncertain factors

requires having more than double the energy amount compared to when responding to a large earthquake. Based on this guideline, the appropriateness of individual performance is being assessed in the scene of the performance evaluation.

Meanwhile, since many people use super high-rise buildings, earthquake-caused damage that would make such buildings unusable should be avoided as much as possible since its effects are extremely extensive. Thus, it is recommended that the response to a large earthquake should be kept approximately within the response range (ensuring continuous uses) to keep a building usable after an earthquake without any repair or with quick repairs. By doing so, a sense of security can be added that even in the case of an unexpected phenomenon, the building can withstand it thanks to the allowance up to the safety limit. A design policy like this is one of the ways to respond to social demand on super high-rise buildings.

3. Main research themes that are now in progress

The section below introduces main research themes that are now in progress. All of these research projects are aiming to realize a safe and secure society and to create and revitalize attractive rural areas, which is one of the recent needs as General Technology Development Projects.

1) Technological development to support the use of already available buildings through the rationalization of fire safety and evacuation regulations (2016-2020)

The government of Japan set 2015 as the first year of rural revitalization and is conducting activities to ensure safe, secure, and delightful lives for the future by solving various challenges associated with regional characteristics in order to overcome depopulation and the shrinkage of rural economies. In relation to the above, local governments and private businesses engaging in town development are expected to utilize currently available buildings, such as historical architectures, which

are useful regional assets, as lodging facilities or restaurants for tourism promotion and invigoration of their regions. The environment thus needs to be developed to smoothly enable such activities. Therefore, the objective of this research theme is to develop technologies to ensure rationalization and smooth operation of fire safety and evacuation regulations and regulations on the purposes, thereby realizing smooth utilization of currently available buildings.

In June 2018, the Enforcement Ordinance for the Building Standards Act was revised using outcomes of this research theme among other aspects. Currently, notices and description of technical standards are being prepared.

2) Development of design and construction technologies of mixed-structure buildings using new types of wooden materials (2017-2021)

A statement, “the development and promulgation of CLT and the promotion of the use of wood materials in public buildings will further be strengthened in order to accelerate the use of wooden structures and materials in buildings” was included in the Basic Policy of the Regional Empowerment for Japan’s Growth, which determined in the Cabinet in 2015 in order to respond to issues of the vitalization of rural areas and environmental problems and to create spaces where wood is used. The purpose of this research is to conduct technological development of structures, fire safety, and durability to advance design and construction technologies for mixed-structure midrise buildings constructed by combining wooden structure using large wooden panels, such as CLT with an RC structure or steel structure in order to satisfy various needs, such as the use of wood materials, the increase of variability, reduction of construction periods, and response to user needs to use wood materials on the surface.

Under this research theme, researchers are going to organize examples of designs related to multiple prototype buildings, their characteristics, and precautions using outcomes of various tests and experiments and accelerate the spread of relevant technologies.

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Society 5.0 Housing and Building

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Keywords: Society 5.0, IoT, AI, big data

1. Introduction

The term “Society 5.0” is starting to attract the attention of society.

Society 5.0 is the first concept advocated as the ideal future condition of the society of Japan in the fifth Science and Technology Basic Plan. It refers to the following ideas:

- Human-centered society where systems based on advanced integration of cyberspace (virtual space) and physical space (actual space) will realize economic development and solution to social problems
- A new society that comes after the hunter-gatherer society (Society 1.0), farming society (Society 2.0), industrial society (Society 3.0), and information-based society (Society 4.0)

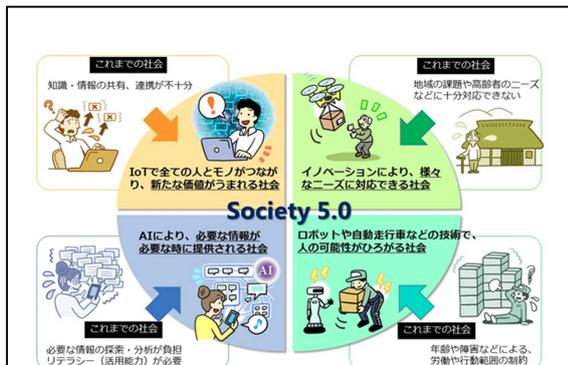


Figure 1 A society realized as Society 5.0¹

In the information-based society so far (Society 4.0), the sharing of knowledge and information and the cooperation beyond the boundaries of individual fields are said to be the challenge for reasons, such as the difficulty in finding necessary information among overwhelming amounts of information due to the limitation in human ability and the difficulty in properly processing discovered information.

Another challenge was the use of information in actual spaces. A major issue was to reduce the workload of humans due to the social background with declining birthrate and aging population, depopulation in rural areas, and economic disparity.

In Society 5.0, the following aspects are going to be

realized:

- Connecting all humans and things through the Internet of Things (IoT) to share various knowledge and information
- Supplying and processing necessary information when necessary using artificial intelligence (AI)
- Using information in actual spaces using technologies such as robots and self-driving vehicles

By realizing the above, the goal is to overcome challenges of a declining birthrate and aging population, depopulation in rural areas, and economic disparity and to realize a society where people can respect each other beyond the boundary of age groups and generations and individual people can live comfortably and actively.

This article discusses challenges in realizing Society 5.0 in housing and building field based on the current state of IoT and AI technologies used in housing and building.

2. Current state and challenges of IoT and AI technologies used in housing and building

(1) Investigation to identify current conditions

The authors studied cases of the use of IoT, ICT, and AI technologies in housing and building published on the web to identify current usages.²

This study found that most frequently used technologies were ones related to building operations used after the use of a building had started. Specifically, diversified technologies were introduced on the web, such as the operation management of buildings and building facilities (BEMS [Building and Energy Management System] and HEMS [Home Energy Management System]) based on IoT, AI, and other technologies designed to improve energy efficiency, comfort, health, and convenience, systems to accumulate the information of building, and the demand-response of power load.¹

Based on this finding, the authors selected targets of the study mainly focusing on technologies related to the operation of buildings after the start of the use of the building. The authors then conducted hearing investigation targeting academics, experts, general

contractors, building facility subcontractors, and manufacturers. The hearing investigation asked them of the advantages and technical and social challenges in system development, installation, and operation from the eyes of developers.²

2) Challenges

Based on the findings of the above investigation, the authors found following challenges for the use of IoT and AI technologies in buildings to generate great social benefits as follows:

- ① Housing and building dependent on IoT technologies are vulnerable to the disruption of power supply. To ensure resistance of cities and buildings against natural disasters, ensuring continuity even with the disruption of power supply will become a major challenge.
- ② The hurdle for installing IoT-related devices in housing and building has become drastically low as their prices have lowered. Yet, while the prices of IoT devices have lowered, the ratio of the cost of cabling for IoT devices (for power supply and communication) and associated construction costs have kept rising. Therefore, the commercialization of cable-less IoT^{*2} will become a major key in promoting the use of IoT devices especially in already available buildings. (This is also effective as a solution to ① above.)
- ③ In the current IoT-based systems that are now becoming commercialized, no coordination is available among groups constituting and supplying systems; they are becoming similar to individual silos without mutual compatibility and connectivity among individual systems. The task is to develop technologies and social systems by evolving from the silo-like technologies and realizing technologies that are mutually connectable and operable.
- ④ In comparison to the life cycle of IoT-based systems, the service life of housing and building will be much longer. Thus, another task is to realize systems of which parts and components with different service lives are replaceable (the issue of generation management in systems).
- ⑤ In relation to ④ above, another task is to clarify responsibilities over overall systems when system components and parts are replaced and to establish rules concerning the boundary of the responsibilities.
- ⑥ With regard to AI, deep learning technology and

image recognition based on deep learning are progressing at a significant pace. Some researchers and scholars consider the appearance of so-called machines with eyes as a great innovation comparable to the Cambrian explosion, in which the first appearance of an organism with complex eyes explosively accelerated the evolution of organisms.³ No method to evaluate the effectiveness of AI has been established at this point; however, the challenge is to develop technological and social framework to evaluate the effectiveness.

3. Summary

There is a need to overcome various challenges and difficulties listed in 2 above and to make these new technologies truly beneficial to society.

The NIMLM also needs to actively examine the following aspects.

- Establishment of technological and social framework to mutually connect silo-like systems
- Establishment of social rules concerning the problem of generation replacement and boundary of responsibilities
- Elimination of regulations that inhibit the introduction of new technologies
- Establishment of social rules to ensure safety and the development of beneficial new technologies such as cable-less IoT

*1: Demand-response: To enable the stable supply of electricity by controlling electricity on the consumer side by responding to the request from power companies to conserve electricity (with economic benefits as compensation)

*2: Cable-less IoT: System that enables wireless communication without external supply or electricity Installed using environmental power generation technology (energy harvesting) + energy efficient wireless communication technology such as LPWA

☞ For more information:

- 1) Website of the Cabinet Office
https://www8.cao.go.jp/cstp/society5_0/index.html
- 2) “Application of ICT, IoT, and AI technologies for disaster prevention and disaster risk reduction for housing and buildings”, NILIM document No. 1055, January 2018
- 3) “Can AI exceed humans? - What awaits ahead of deep learning -” Yutaka Matsuo (The University of Tokyo), memorial lecture at the 100th Anniversary Ceremony of the Society of Heating, Air-Conditioning and Sanitary Engineers of Japan, December 1, 2017

Future urban research projects examined based on the evaluation of research and development

SATO Kenichi, Director of Urban Planning Department

Keywords: Open innovation, revitalization of rural areas, super smart society, human resources, workstyle

1. Evaluation of research and development

FY 2018 was the year of the NILIM institution evaluation, which is conducted once every five years. An institution evaluation is one of the research and development evaluations of the NILIM. It is a voluntary evaluation of all the research and development projects conducted at the NILIM during the past five years and the administration of the institution based on external opinions. The results are utilized for future activities after making decisions on improvements, enhancement of quality, and distribution of resources conducted following the evaluation.

This article focuses on the institution evaluation from the perspective of the evaluation of research and development and the reflection of findings on future activities. Findings in this article will be reviewed and used as the reference for future urban planning researches.

2. Results of the institution evaluation

Upon the institution evaluation, eight evaluation criteria, such as ① Research and development to support the planning, proposal, and promulgation of land and transport policies, and ② Technical support for responses to natural disasters and accidents and the advancement of responding technologies, were set based on the NILIM Research Policy that was entirely revised in November 2017. General opinions and opinions on individual evaluation criteria were then received from the evaluation committee (chairperson: Toshio Koike (National Institute for Educational Policy Research), the Public Works

Research Institute, Risk management International Center). The following includes the opinions received. For opinions on the evaluation criteria, the main issues mentioned in the committee are selected for this article.

General opinion

In regard to the implementation and promotion of research and development, cross-sectional activities should further be conducted. In regard to the institution administration, the development of productive research environment for individual faculties should be conducted. For both of these aspects, how people who receive the research outcomes from the NILIM use them should be made visible, and international activities should be promoted.

① Research and development to support the planning, proposal, and promulgation of land and transport policies

Besides short-term research themes that respond to needs, it seems as if no long-term research theme is set and implemented.

② Technical support for responses to natural disasters and accidents and the advancement of responding technologies

It is not easy to see that NILIM activities and research have resulted in the acceleration of disaster restoration and damage reduction.

③ Support for the improvement of on-site technical capacity at Regional Development Bureaus and other facilities

Mid-to-long-term measures (plans) to ensure the improvement of the quality of on-site technical capacity are unclear.

④ Data gathering, analysis, and management to develop technical foundation for formulating policies and utilization of the information for the society

A concern is whether the information is organized in a way that is readily usable as open data by government organizations and the private sector.

⑤ Development of management system to support high-quality researches

A concern is that the number of joint research projects and the number of cooperating facilities are decreasing.

⑥ Nurturing of human resources who have technological backgrounds and have the ability to observe policy development from the perspectives of both researchers and administrator/on-site workers

It is necessary to check whether requested human resources have the ability to observe policy development from the perspectives of both researchers and administrators/on-site workers.

⑦ Ownership and the reinforcement of the function of experimental facilities to support technological research and development in the field of housing and social capital

It is necessary to identify whether experimental facilities are in the condition that will allow effective uses. It is also necessary to properly analyze the maintenance of experimental facilities and clarify issues and problems. Facilities should be updated based on plans.

⑧ Effective public relations of research outcomes and research activities

Clear strategies need to be established to engage in effective public relations activities. More efforts are also needed to establish the NILIM as a world-class brand.

3. Handling of research outcomes -For the future urban planning research-

The NILIM is organizing and releasing the handling of research outcomes. Thus, this article provides some additional information concerning past activities and future plans from the standpoint of urban planning research.

The first is the promotion of cross-boundary activities as mentioned in the general opinion and ④ and ⑤.

The same issue has been raised in the past two times in

the institution evaluations in FY 2008 and FY 2013. This is a life-long issue for the NILIM as it is the general research facility of land and transport technology policy. Meanwhile, a difference from up to the last evaluations is the expectation for open innovation to actively incorporate knowledge and technologies from outside of the NILIM under the intensifying global competition over innovation in recent years and for the generation of knowledge and values beyond the conventional framework. Actually, the number of research and development programs conducted through the cooperation of different fields and industry, academia, and government has been increasing as a means to realize above.

It is possible for Urban Planning Department to nurture and secure human resources and function as a control tower by effectively using its nature as the organization engaging in general research. It is also important to conduct research and development to support the activities of various cities facing the problems of depopulation and an aging population to establish independent innovation, create new businesses and economic activities, revitalize regional economies, and consequently result in reinvigoration of rural areas, for example.

The second point is the implementation of long-term activities as mentioned in ① and ③. This point has also been mentioned in the past.

The NILIM has set individual research and development themes based on the various factors of socioeconomic challenges and trends, national plans and future outlook of the private sector, and unexpected phenomenon, such as natural disasters and accidents. In this process, short-term themes that respond to needs are readily understood and prioritized. Meanwhile, long-term problems where the outcomes are difficult to recognize and unique themes based on the motivation of researchers are often put off. Actually, the budget for fundamental research has been significantly decreasing in recent years.

Research, development, and especially innovation are associated with uncertainties, the requirement of the long term before producing outcomes, and impossibility to forecast outcomes. Given the above, it is necessary to ensure that fundamental research that requires long-term commitments based on political strategies and demands, as well as academic research based on free ideas that may become the source of future innovation, can receive stable funding under proper evaluations.

To realize Super Smart Society (Society 5.0) in the future, the Urban Planning Department is going to engage in the following activities under a long-term perspective while cooperating with relevant parties: research to deepen the observation of how technological development will affect cities and the state of humans and cities, development of technologies to organize and utilize data about urban information owned by various entities through sharing and coordination, and activities that would improve the status of the NILIM in domestic and international research network.

The third point is about the development of the productive research environment for individual research and the nurturing of human resources as mentioned in the general opinion and ⑥.

The NILIM is accepting summer college interns every year and offers them the experience of working in research facilities. The Urban Planning Department is one of the most popular fields among students and receives many applications from students every year. In addition, some research processes are outsourced to urban planning consultants when conducting individual research. Young engineers are actively working in such processes. (A notable characteristic is that many female engineers are working in this field.) On the other hand, people-based connections with local governments and foreign countries have been weak.

There are various reasons for such a state, but urban planning research so far did not have enough diversity or fluidity in human resources, and the accumulation of

human resources has also been insufficient. The research environment seems as if it has not changed much from 40 years ago. Human resources support research and development, and the environment plays a major role in accumulating the human resources. It is necessary to consider improving workstyles to realize flexible research environments where diversified human resources can work successfully.

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- 2) Integrated Innovation Strategy, June 15, 2018, Cabinet Decision
- 3) "Mid-term Summary of Basic Policy Conference on National Land and Technology Policy" November 2018, Social Capital Development Council, Council for Transport Policy, Technical Subdivision, Technical Group, and Basic Policy Conference for National Land and Transport Technology Policy

Research Center for Infrastructure Management Activities for the Third Year and Future Prospects

SHIMIZU Akira, Director, Research Center for Infrastructure Management

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

1. Introduction

Researches in Research Center for Infrastructure Management (the "Center") cover a wide range of fields, including estimation, public bidding / contracting methods, project evaluation, analysis of economic effect, construction work using ICT, utilization of the three-dimensional data from research to maintenance, urban greening, ecosystem conservation, landscape / historical community development, and support of recovery from the Kumamoto Earthquake disaster. The following introduces main activities of the Center, which is now in the third year from installation, including future prospects.

2. Efforts for productivity improvement

The MLIT is making all-out effort for productivity enhancement by designating the year of 2016 as the "year to start productivity innovation" and the year 2019 as the "year to achieve productivity innovation." For productivity improvement in construction sites, the MLIT is also working for "i-Construction" as one of the important measures, which utilizes three-dimensional data, ICT, etc. in each stage of construction process, including research, design, construction, test, maintenance, and renewal. From this year, Public/Private R&D Investment Strategic Expansion Program (PRISM) is also promoting i-Construction, and the Center is also working for research based on PRISM.

(1) Works using ICT

Technologies to obtain position data using satellite positioning and three-dimensional data using laser scanner, etc. are progressing, and works using ICT that utilizes such technologies to conduct engineering survey, automatic control of construction machines, work progress control, etc. have been implemented in earthwork, pavement works, and dredging works. The Center has been studying formulation of standards for promoting the introduction of the above-mentioned devices into construction sites. In fiscal 2017, such

standards were just revised to allow for survey with an echo sounder and work progress control using the history of construction machines. We continue to study on the expansion of types of works and utilization of new technologies.

(2) Introduction / dissemination of CIM

The MLIT has been using CIM models since fiscal 2012 as one of the activities for utilization of three-dimensional data.

CIM (Construction Information Modeling/Management) aims to facilitate information sharing among the persons concerned with the project and thereby achieve efficiency improvement / upgrading of the construction production system by introducing 3D models from the stages of planning, research, and design to the stages of construction and maintenance. The Center is also studying procedures and standards for the introduction and dissemination of CIM. The Center will also study three-dimensional models available for calculating the quantity of civil engineering works, simple 3D models of existing structures, etc. for further utilization of CIM models. The Center also intends to study CIM introduction for machines and equipment.

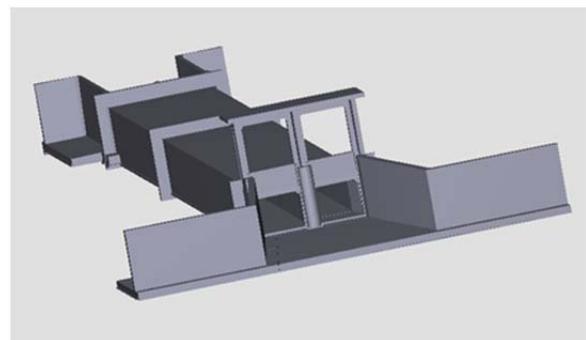


Fig. Expansion of the applicable types of works for "3D Annotation Standards (Draft)"
(Figure is an example of sluice)

(3) New technologies including IoT and AI

The Center is also working for introduction of new technologies including IoT and AI by studying

measures for preventing construction work accidents using AI, data creation for time series changes in construction sites in view of automatic construction / process control, etc. We intend to aim at productivity improvement by taking in new technologies actively.

3. Improvement of public bidding / contracting methods

Public bidding / contracting methods have been continuously improved according to the demand of the times and changes in social situations. As a result of the 2014 revision of the Act on Promoting Quality Assurance in Public Works ("Quality Assurance Act"), quality assurance for the present and future public-works and development / securing of human resources on a mid- and long-term basis were added to the purpose of the Act, and introduction / utilization of various bidding / contracting systems were included. Such systems include the technical proposal / negotiation method, which requests the builder's technical cooperation from the design stage, and is also consistent with the concept of front-loading / concurrent engineering (parallel / joint work), which aims at total optimization of the construction production process.

For this technical proposal / negotiation method, operation of the guideline started in 2015, and projects using this method began to appear in 2016. However, such projects are still few in the country and we are organizing effects of application, issues, and improvement matters considering the status of implementation in construction stage, technical proposal / negotiation method is applied to construction works in which the owner cannot determine optimal specifications or conditions requisite for specifications. We intend to continue the study to facilitate the progress of such works.

4. Traditional construction method supporting community-specific historic scenery

Since the establishment of the Act Concerning the Maintenance and Improvement of Historic Scenery in 2008, the movement of "Historical community development" is becoming active as seen from the fact that 70 municipalities were certified for their historic scenery maintenance and improvement plans (as of the end of Dec. 2018).

In such circumstances, repairing / maintenance sites of buildings that constitute historic scenery of the community are faced with the issue of how to secure

human resources, materials, funds, etc. concerning the traditional construction method specific to the community. The Center is therefore working for sharing the basic concept, specific ideas, and know-how in implementing sustainable community development through maintenance / utilization of traditional construction methods by conducting hearings from experts concerned, research of similar activities in the country, etc. We intend to continue researches for development of unique and good communities.

5. Support of restoration from the Kumamoto Earthquake disaster

In the works for restoration from the Kumamoto Earthquake disaster, which occurred in April 2016, advanced technical knowledge about bridges etc. has been required and a division was installed in April 2017 by stationing research personnel on the site to accelerate the project. This division is providing prompt and elaborate technical support on the site and contributing to early restoration for projects led by Regional Development Bureaus and local governments.

In July last year, restoration of the Kuwazuru Bridge by exchanging the hanging cable of the cable-stayed bridge was finished and shared. The division also gives advice on future management in addition to guidance for restoration. While providing technical support for early recovery, we intend to reflect the knowledge obtained in technical standards and study aseismic structure etc. enabling easy functional recovery based on the same knowledge.



Photo: Kuwazuru Bridge after restoration

6. Conclusion

As new technologies including IoT and AI are remarkably progressing, we intend to improve on-site productivity and study social capital management according to site needs using these new technologies.

Utilization of In-pipeline Water Level Information for Inland Flood Control Measures

(Research period: FY2017 to FY2018)

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Keywords: inland flood, inundation control measures, water level information, pump operation control

1. Introduction

In recent years, the risk of inland flood damage caused by rainwater overflowing on the ground from the sewerage system in excess of its capacity has been increasing in accordance with the increase in local heavy rain. Since development of inundation control facilities, including storage facility, takes a lot of cost and time, inundation control methods using the capacity of existing stock to the utmost is required for early damage mitigation.

In general rainwater pump stations, operation is based on the water level of the pump well. Since it takes a certain time to start up the pump, it may be difficult to respond to a sudden increase in inflow resulting from uneven distribution of rainfall or sudden heavy rain. We therefore studied on selection of water level measuring points and utilization of water level information in order to raise the efficiency of rainwater pump operation in the event of heavy rain by using the in-pipeline water gauge, which is relatively easy to maintain.

2. Study method

Using a pumping drainage area, 329 ha in area and about 3.8 km in trunk pipeline length, as a model drainage area, we examined proper water level observation points and pump operation control method through analysis of variation of in-pipeline water levels at the time of rainfall and analysis of inundation situation (flood analysis). In examination, movement of rainfall was indicated by using the centralized rainfall pattern as shown in Fig. 1, which exceeds the facility's capacity, and changing rainfall start time and order of start with the drainage area separated into three areas (upstream, midstream, downstream).

3. Study results

It was confirmed from the results of analyses that timing of water level rise varies according to

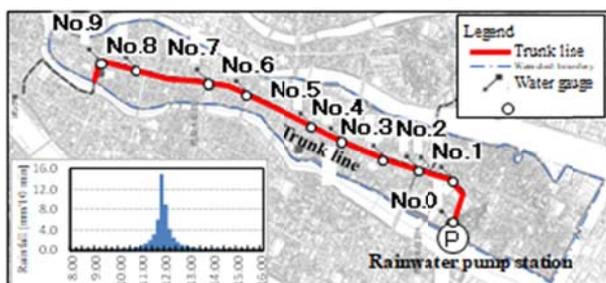


Fig. 1: Model drainage area plan view and rainfall studied

observation points and moving patterns of rainfall and that there is a case where increase in inflow by heavy rain can be detected earlier than measurement at the pump well by using observation values at the points where water level rise is earlier than a pump well (Table 1). It was also found from results of the flood analysis that inundation area will be reduced by making the pump start-up timing earlier in the event of heavy rain using the detection information at the water level observation points shown in Table 2, which is particularly effective for rain that first falls in the upstream area.

Note that in some rains, the pump started before increase in inflow and the control system caused problems in operation, including pump stop due to sudden water level decline and sequential occurrence of start-stop. Accordingly, it is also necessary to take measures considering inflow, not only to simply accelerate the timing of start-up.

4. Conclusion

We have confirmed the possibility of reducing inundation area with utilization of in-pipeline water level information. We are now studying reflection of operation control conditions according to pump facility types and proper operation method. In the future, we are going to collect findings from these studies and organize the procedures for introducing operation with utilization of in-pipeline water level information into pump stations.

Table 1: Difference between the time to reach five-divided water in the pipeline and pump starting time (minutes)

Rainfall moving patterns	No.1	No.2	No.3	No.4	No.5	No.6
Uniform rainfall	-5	8	20	15	10	6
Downstream → midstream → upstream 15-min. interval	-9	-2	7	1	-5	-13
Downstream → midstream → upstream 30-min. interval	-11	-9	-6	-13	-20	-29
Upstream → midstream → downstream 15-minute interval	2	16	29	25	22	22
Upstream → midstream → downstream 30-minute interval	8	22	35	33	31	34
Center → upstream-downstream both ends style both ends 15-min. interval	0	13	25	20	14	6
Center → upstream-downstream both ends style both ends 30-min. interval	4	16	28	23	17	6

* Note: Depth of color represents extent of time allowance (blue) or extent of delay (red)

Table 2: Water level observation points and reduction of inundation area (ha) by control operation

		Present operation	No.1 point	No.3 point	No.5 point
Uniform rainfall	Inundation area	62.01	62.00	61.79	61.80
	Reduction area	-	0.01	0.22 (maximum effect)	0.21
Downstream → Midstream → Upstream 15-min. interval	Inundation area	60.04	60.01	59.95	60.04
	Reduction area	-	0.03	0.09 (maximum effect)	0
Upstream → Midstream → Downstream 15-min. interval	Inundation area	59.63	59.63	59.01	59.02
	Reduction area	-	0	0.62 (maximum effect)	0.61

A Study on Post-disaster Timeline Introduction in the Sewerage Field

(Research period: FY2017 to FY2019)

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Keywords: sewerage, pipeline, an earthquake, timeline

1. Introduction

When sewerage facility suffers damage from an earthquake, traffic disturbance and hygiene issues may occur, such as sewage runoff, floating of manhole covers, and subsidence of road (See Photo). In the event of serious disaster, it may be required to regulate road traffic or develop sanitary facilities such as temporary toilet due to temporary restriction on use of sewerage. Hence, in order to recover the sewerage facilities, cooperation of many persons and entities concerned is essential, such as road, water works, health, and river management departments, shelters, and local residents.

In this regard, "timeline," which has listed and organized relevant organizations with information of "when and what they are supposed to do," is an excellent method in cross-sectional co-ordination of organizations, i.e. it is effective in strengthening cooperation system through clarification of responsibility sharing in coordination with related organizations. Accordingly, timeline is effective as a method of conducting organizational co-ordination under BCP smoothly. For the reasons stated above, we study on introduction of the viewpoint of timeline into the sewerage field

2. Outline of the study

Local governments manage their sewerage facilities and, as countermeasures for earthquakes, are formulating Sewerage BCP and making preparation based on the plan in reference to Sewerage BCP Manual etc. For this reason, aiming to promote introduction of the viewpoint of timeline into local governments, this study organizes "concepts" concerning introduction and is going to examine following three items.

- (i) Preparation of a basic and simple post-disaster timeline based on collection / organization of existing literature.
- (ii) Preparation of a post-disaster timeline in a model city and organization of issues in preparation.
- (iii) Preparation of the concept of introducing the viewpoint of timeline in local governments based on the results of (i) and (ii) above.



Photo: Example of sewerage facility at the time of disaster

3. Content of study

First, collecting and organizing 67 pieces of existing literature, we prepared a basic and simple post-disaster timeline. Preparation is based on the "2017 Sewerage BCP Formulation Manual (Earthquake / Tsunami Part)." In addition, we used the "Rules for Supporting Sewerage in Disaster," which provides rules for supporting by relevant organization in the event of disaster, from the viewpoint of cross-sectional organizational co-ordination.

Next, based on results of the above, we prepared a post-disaster timeline with cooperation of two local governments. In preparation, we worked based on information obtained from hearings as well as materials including the disaster prevention plan and sewerage BCP owned by the local government, and consequently organized the issues including necessity to clarify "Time required of individual operations" and "Prioritization of operations."

As a result, we prepared a post-disaster timeline for the model local government and identified issues in preparation. We are going to organize the easy-to-understand concept of introducing the viewpoint of timeline for various local governments.

Analysis of the Effect of Accumulated Fallen Leaves on Drainage at Catch Basin Cover (Research period: FY2015 to FY2018)

NAKAMURA Hiromi, Research Engineer, KONDO Hiroki, Guest Research Engineer, MATSUURA Tatsuro, Senior Researcher, IWASAKI Hirokazu, Head, Wastewater System Division, Water Quality Control Department

Keywords: catch basin cover, fallen leaves, drain capacity, road inundation

1. Introduction

As one of the causes of road flooding, cases where accumulation of fallen leaves around the cover of or inside catch basin prevents rainwater from flowing into sewer pipes were reported. Since the possibility of the accumulation of fallen leaves on and around basin cover greatly affecting drain capacity was indicated based on the accumulation of fallen leaves inside the basin according to past studies ¹⁾, it is important to grasp the effect of fallen leaves on catch basin cover and drain capacity in the basin in studying measures for reducing the frequency of road flooding. We therefore conducted an experiment to confirm the effect of accumulation of fallen leaves around the basin cover on the drain capacity of basin cover.

2. Outline of the experiment

The experiment was conducted on a total of 253 cases of basin cover drainage using a real-size road model (Fig. 1) in combination of 3 types of fallen leaves including zelkova, no fallen leaves, 3 types of the accumulation of fallen leaves (1 / 3 / 5 kg), 3 types of basin covers (Fig. 2), 3 conditions of water supply (1.3 / 2.6 / 4.3 L/s) corresponding to rainfall of 30 / 60 / 100 mm/h, and 3 types of road longitudinal slopes (0.5 / 2.0 / 6.0%). As means for accumulating fallen leaves, assuming fallen leaves flowing from upstream during rainfall, we spread evenly a half of the accumulation of fallen leaves on road gutters in advance, about 4.5 m upstream from the catch basin cover, and additionally input the other half in divided amounts after elapse of one minute from the start of water supply.

Drainage from the basin cover was measured in the triangular weir by evaluating the value ("drainage rate")

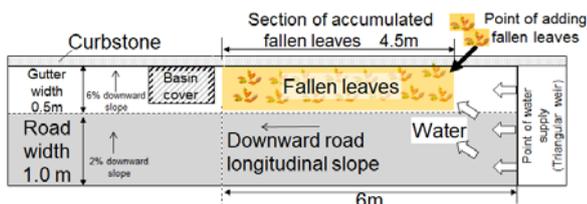


Fig. 1. Model plan view

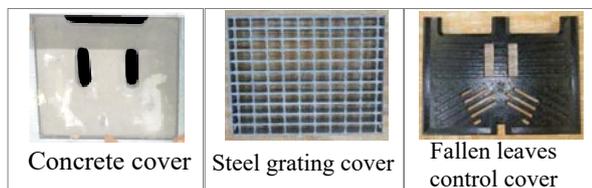


Fig. 2. Basin cover type

obtained by dividing drainage (L/s) by water supply (L/s) as drainage capacity of the basin cover.

3. Experiment results

Table 1 shows the results of drainage experiment on the steel grating cover by changing road longitudinal slope, water supply, and accumulation of zelkova fallen leaves ("Amount of accumulation"). In order to check the difference of drainage rate according to whether fallen leaves are present or not, the drainage rate when there are no fallen leaves and 3 drainage rates of the three types of accumulation of fallen leaves of zelkova were compared under the same conditions of road longitudinal slope and water supply. In all the 27 cases, the drainage rate when zelkova fallen leaves were accumulated was smaller than the drainage rate of no fallen leaves. Further, drainage rates for each amount of accumulated fallen leaves under the same conditions of road longitudinal slope and water supply were compared in order to confirm the difference of drainage rate according to the difference of accumulated amount of zelkova leaves. In 5 out of 9 cases, maximum value was observed when the amount of fallen leaves was 1 kg, intermediate value, when 3 kg, and minimum value, when 5 kg. In the other 4 cases (Table 1, yellow hatches), when the accumulated amount was the maximum (5 kg), the drainage rate was not the minimum value and we continue to analyze the experiment results.

Table 1 Experimental results

Road longitudinal slope (%)	Water supply (L/s)	Drainage rate (%)			
		No fallen leaves	Amount of zelkova fallen leaves		
		0kg	1kg	3kg	5kg
0.5	1.3	100.0	100.0	59.8	75.9
0.5	2.6	100.0	58.5	41.3	41.3
0.5	4.3	100.0	54.7	35.0	33.1
2.0	1.3	100.0	71.0	59.8	71.0
2.0	2.6	100.0	75.7	45.2	38.7
2.0	4.3	100.0	72.4	38.9	27.1
6.0	1.3	100.0	57.7	57.7	68.7
6.0	2.6	97.8	75.7	63.4	61.7
6.0	4.3	98.2	56.0	54.7	48.7

Maximum value. Minimum value Intermediate value

1) 2018 NILIM Report, p.49

<http://www.nilim.go.jp/lab/bcg/siryou/2018report/ar2018hp019.pdf>

A Study on Channel Design Method Considering Disaster Mitigation

(Research period: from FY2019)

FUKUSHIMA Masaki (Ph. D.), Head, YAMAMOTO Yoko, Senior Researcher, SUZUKI Atsushi, Researcher, River Division, River Department

Keywords: climate change, evacuation, lead time, flow rate reduction

1. Direction of river maintenance under the conditions of climate changes

Since climate changes are expected to increase flood frequency and water flow in future, it is required to take disaster mitigation measures that reduce damage as much as possible even in the event of a flood exceeding the capacity of countermeasure facilities or the planned scale. For disaster mitigation measures, focus is usually placed on what is called "non-structural measures," such as prior communication of the risk of flood disaster or proper provision of disaster prevention information at a disaster, but this study focuses on the following structural measures and verifies their effects. Then we intend to verify practical effectiveness of the measures and reflect them in channel and levee design.

- Measure I: River maintenance to secure lead time for evacuation, such as reducing flood flow in the event of levee failure or delaying the timing of levee failure
- Measure II: River maintenance to reduce peak discharge

Examples and concepts are provided for Measures I and II, respectively, to introduce the contents of the study.

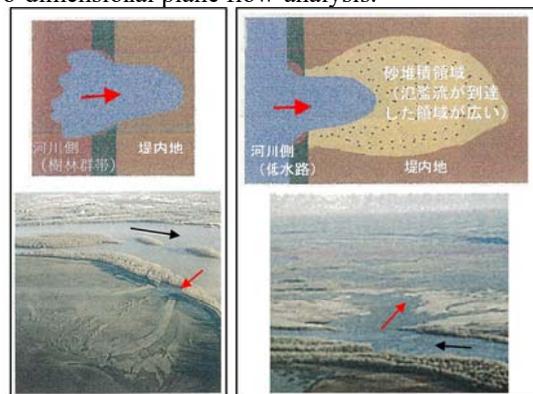
2. River maintenance to secure lead time for evacuation

Literature 1 shows that the degree of burst (amount of flood, extent of flood flow, etc.) is mitigated by the forest community zones along the levees as a result of studying burst cases at 67 spots in the US Mississippi River (Fig. 1). Literature 2 proposes what is called "crisis management type structural measures," such as protection of levee crest, etc. with asphalt and reinforcement of levee slope toe, etc. with blocks, as measures to prolong the time until burst as much as possible. This study is going to collect data on levee damage cases including not only cases resulting in burst but Hiyari-Hatto (near miss) incidents such as partial loss of levee, examine factors that affected the extent of damage as well as magnitude of the effect, and embody the river maintenance method for securing lead time for evacuation based on the detected factors.

3. River maintenance to reduce peak discharge

Flood control dams have holes in the body and reduce

peak discharge in downstream channel by storing flood flow temporarily when flood flows in at a rate greater than the capacity of the holes. There is also topography having similar function in the river, e.g., narrow area, wide high-water channel, meandering, curve, and riverbed gradient changing points. However, it is not clear to what extent they are effective in reducing flow or what kind of flood flow they are effective. This study is going to clarify river topography that should remain in river maintenance by setting a lot of channels in different conditions including whether there is a narrow part, width and height of high-water channels, and curve shapes, operating a number of flood waves with different rising speed of flood, flood continuation duration, etc. and examining the effect of reduction in peak discharge in downstream channels by the two-dimensional plane flow analysis.



樹林群帯により高水敷の侵食が抑制されたケース 高水敷が侵食され、氾濫流によって砂が広範囲に堆積したケース

Relationship between channel conditions and burst situation (Addition to 1)

(Black arrow: Flow of the river, Red arrow: Flow of the flood)

☞ See the following for details.

- 1) Ministry of Construction, Public Works Research Institute, River Department, River Division "Actual Status of Topographic Changes by Large-scale Levee Collapse," PWRI material, No. 3526, Oct. 1998
- 2) River Division "A Study for Devising the Structures of River Levee Crests / Slope Toes to Prolong the Time until Burst by Overtopping Even a Little," Technical Note of NILIM, No. 911, May 2016

A Study on Maintenance Standards to Avoid Progress of Chain Destruction in River Crossing Structures

(Research period: FY2017 to FY2019)

FUKUSHIMA Masaki (Ph. D.), Head, YAMAMOTO Yoko, Senior Researcher, NAKAMURA Ryoji, Researcher, River Division, River Department

Keywords: river-bed degradation, river crossing structures, design, maintenance

1. Damage to river crossing structures due to river-bed degradation

There are cases where the foundation of revetment, etc. is exposed due to the progress of river-bed degradation and suffers damage in the event of flooding. In addition, in the downstream of river crossing structures, such as ground sills, the effect of river-bed degradation may appear more remarkably and deformation, such as subsidence of bed protective works, may arise. In such an event, some cases are reported where bed protective works were swept away in a chain and the main body of river crossing structures, such as ground sills, suffered damage. Specifically, when part of the main body of river crossing structures is swept away, levee slope may be eroded by the drift generated by the flow concentrated on the site where the body was swept away. In addition, if the entire main body is swept away, the effect of river-bed degradation may extend to an upstream section and cause damage to a bridge etc. located at the upstream. Accordingly, it is important from a viewpoint of the maintenance of river crossing structures to grasp the conditions that decide the chain destruction of bed protective works and the phenomena that arise in case of destruction.

2. Development of numerical analysis models for reproducing chain destruction

Accordingly, NILIM has been implementing "Development of technologies for forecasting deterioration / damage / destruction of river-crossing structures in river bed degradation" together with two research groups, Gunma University (Representative: Professor Yoshihiko Simizu) and Nagaoka University of Technology (Representative: Professor Satoru Otsuka), using the River Erosion Control Technical Research Development System. Gunma University develops a numerical calculation model to evaluate the fluid force that acts on bed protective works, focused on variation of flow regime due to expansion of the scouring hole in the downstream of bed protective works. Nagaoka University of Technology develops a numerical calculation model to evaluate the fluid force that acts on bed protective works, focused on seepage flow under the main body, such as ground sills. NILIM directly measures and grasps, through a large hydraulic model experiment, the effect of scouring condition in the downstream of bed protective works and difference in seepage characteristics under bed

protective works on the fluid force that acts on bed protective works. Through these studies, it was found that, as a phenomenon that defines the chain destruction of bed protective works, the position of hydraulic jump greatly changes the fluid force that acts on bed protective works. As the Figure shows, the position of hydraulic jump changed in connection with the river-bed degradation in the downstream channel and the fluid force that acts on the gabion of bed protective works at downstream end increased in the case where deformation proceeds. On the other hand, in the case where no deformation proceeds, the fluid force acted so that the gabion at downstream end is stabilized by reverse whirlpool flow.

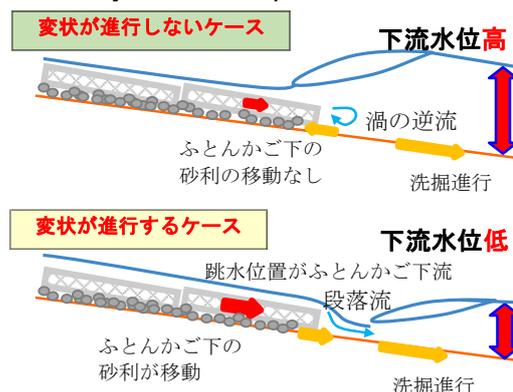


Fig.: Phenomenon that defines the chain destruction of bed protective works

3. Design considering maintenance

NILIM is going to propose specification of maintenance standards in the design phase of ground sills, etc. using the findings of these studies. Maintenance standards are intended to set forth a state in the design phase where the chain destruction of bed protective works may proceed and maintenance and repair based on inspection results are implemented by using the numerical calculation models created by these studies in the design phase.

☞ See the following for details.

1) River Erosion Control Technical Research Development System

<http://www.mlit.go.jp/river/gijutsu/kenkyu.html>

2) Yamamoto et al.: "Study issues organized from the deformation hydraulic experiment on armor block type ground sills," Collection of Papers on River Engineering, Vol. 24, June 2018.

Development of Channel Design Techniques for Small and Medium-sized Rivers where a Large Amount of Sediment Flows in from the Upstream

(Research period: from FY2018)

FUKUSHIMA Masaki (Ph. D.), Head, SEZAKI Tomoyuki, Senior Researcher,
NISHIMAE Shuntaro, Researcher, River Division, River Department

Keywords: sediment and flood inundation, sediment production, channel planning

1. Introduction

In recent heavy rains, much damage has also been caused by what is called a "sediment and flood inundation," which refers to the inundation of sediment and flood in the downstream due to the inflow of sediment caused by a sediment disaster in the upstream into the river channel (e.g., Photo 1). This study strives to grasp phenomena through waterways experiment to examine channel design techniques for damage mitigation.

2. Grasp of phenomena by waterways experiment

In order to grasp the basic phenomena of sediment and flood inundation, we conducted a waterways experiment simulating a section from a place between mountain torrent part to a valley plain part. In the waterway upstream section corresponding to the mountain torrent, a large amount of sand is supplied to the extent possible. The waterway downstream into which the sand flows and which corresponds to the valley plain consists of (i) a channel with the same river width as the upstream section and small channel bed gradient and (ii) the flood plain where width expands as water flows down.

In the experiment case 1 where very coarse sand (mean diameter of 1.5 mm) corresponding to boulders in local scale conversion, deposition onto the channel bottom started when water flowed into the valley plain and when water flow was continued, the channel was clogged at spots where deposition proceeded and the deposition area rapidly expanded to the valley plain (Photo 2). This would be attributable to tractive force being reduced by thin flow expanding to the flood plain due to the clogged channel.

On the other hand, in the sediment and flood inundation that occurred in the Akatani River at the time of the 2017 Northern Kyushu Heavy Rain, the channel was clogged by the sediment mainly consisting of sand and small gravels carried in a floating form, considering the hydraulic quantity at flooding. In order to reproduce this phenomenon, we conducted experiment case 2 in which fine sand (mean diameter of 0.2 mm) whose grain size is smaller by 1 order than the case 1 was supplied. As a result, although there was some deposition of sediment on the channel or flood plain, clogging of the channel did not occur in the duration (about 40 seconds) in which



Photo 1: Sediment and flood inundation in the July 2018 Heavy Rain



Photo 2: State after water flow in the experiment case 1 (grain size of 1.5 mm)



Photo 3: State after water flow in the experiment case 2 (grain size of 0.2 mm)

water flow is possible with the relevant equipment (Photo 3).

3. Future activity

At present, sand supply equipment that can continue supply stably a plenty of fine grain sediment for a long time is being manufactured and we continue to grasp the process of sediment and flood inundation.

In the recent events of sediment and flood inundation, there were sections of weathered granite and unconsolidated volcanic ash geology in the upstream, and some cases where a large amount of fine grain sediment was supplied were reported in recent years. We intend to study through experiments how to establish a channel design method where a large amount of fine grain sediment is supplied in rapid rivers where river bed consists of boulders etc.

Study on the Simple Evaluation Method of Piping Progress in River Levee

(Research period: FY2017 to FY2018)

FUKUSHIMA Masaki (Ph. D.), Head, SEZAKI Tomoyuki, Senior researcher, SASAOKA Shingo, Researcher, TANAKA Hidetake, Guest Research Engineer, River Division, River Department

Keywords: piping, progressiveness, multi-layered structure

1. Background of study

When deformation, such as water leakage or sand boil, is found in the river levee, measures against penetration, such as drain works or sheet piles, are usually taken. On the other hand, in the studies for the last several years, cases were reported where piping stopped after proceeding to some extent, although water leakage or sand boil occurred. If it is possible to evaluate whether there is progressiveness of piping, detection of the section where measures should be preferentially implemented can be identified from the sections where piping countermeasures are required.

2. Simple evaluation method to evaluate the progressiveness of piping

In evaluation of the progressiveness of piping, it is difficult even in these days when analysis technique has advanced to reproduce the process, with numerical analysis, in which piping is formed due to water leakage or sand boil and proceeds. Then, piping was simulated by setting the spots for which the coefficient of permeability was enlarged, and groundwater analysis was conducted after changing the length (Fig. 1). Note that the thickness of piping was fixed to 10 cm. As Fig. 2 shows, a case of decrease in local hydraulic gradient (i_h , i_v) when piping proceeds was confirmed. Decrease in local hydraulic gradient suggests a possibility that piping ends without proceeding to the river side. In order to verify the validity of the foregoing analysis, we conducted reproduction analysis of the levee model experiment ¹⁾. As shown in Fig. 3, the local hydraulic gradient decreases rapidly according to the progress of piping, but increases gradually when the length of piping reaches approx. 2m, which predicts the proceeding of piping. Since the situation where progress of piping once becomes slow was also confirmed in the experiment, the result of analysis generally reproduced the result of experiment.

3. Future study

We intend to apply the simple evaluation method proposed and discussed herein for the progressiveness of piping to various soil conditions to check the accuracy of prediction and improve it for securing required accuracy so that the method can be used in practice.

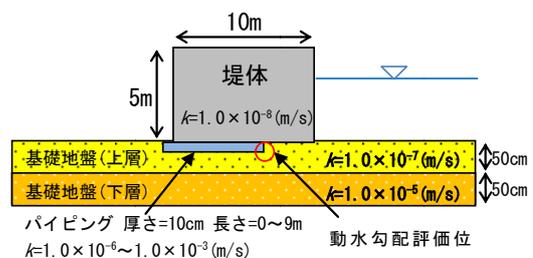


Fig. 1: Analytic model figure

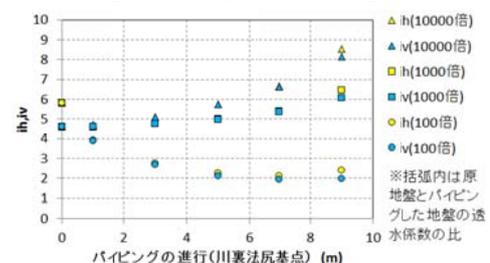


Fig. 2: Progress of piping and local hydraulic gradient

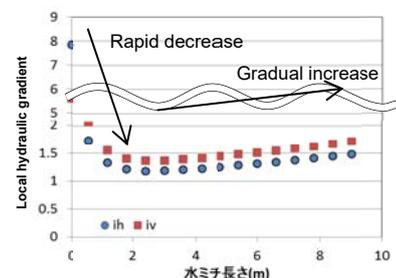


Fig. 3: Changes in local hydraulic gradient in reproduction analysis

See the following for details.

1) Tanaka et al., "Study on the evaluation of piping progress in river levee foundation ground," The 6th River Levee Technical Symposium, pp. 29-32, Dec. 2018

An Experiment on Structure of Resilient Coastal Levees against Scouring by High Waves on the Sea Side

(Research period: FY2017 to FY2018)

TAKESHITA Tetsuya (Ph. D.), Senior Researcher, FUKUHARA Naoki (Ph. D.), Researcher,

KATO Fuminori (Ph. D.), Head, Coast Division, River Department

Keywords: coastal levee, waves, scouring, resilient structure

1. Introduction

The Seacoast Act, revised in 2014, requires coastal levees to have a structure able to reduce damages from tsunami, storm surge, and high waves that exceed the design scale, in consideration of the situation of hinterland, etc. For the land side of levee, resilient levee structure against the overflow of tsunami has been used in practice, and the same structure also serves as reference for the overflow of storm surge. Further, for waves exceeding design scale ("high waves"), it was confirmed from the NILIM's past researches that securing of embedment depth with sheet piling, etc. on the levee side is effective for resilient structure.

On the sea side of levee, however, measures for scouring using sheet piling or foot protection works have been conventionally adopted but levees may be destroyed by high waves because their design conditions were set experientially based on past disasters. It is also possible to construct foot protection works larger than those designed, but large-scale foot protection works etc. will be required as expected scouring depth becomes larger and design may be excessive against the event of high waves with low frequency of occurrence. For these reasons, this study examined the structure of resilient coastal levees that are designed not excessively against scouring caused by high waves on the sea side and can demonstrate the effect sufficiently.

2. Experiment outline and main results

In the experiment, a levee model, 1/30 scale, 0.20 m high, 0.10 m in crown width in the wave experiment channel, 127.5 m long, 0.6 m wide, 1.5 m deep, (actual size conversion: height: 6 m, crown width: 3 m), outer slope-back slope ratio; 1:2, was installed and the experiment was conducted under 6 cases of conditions for outer slope toe as shown in Fig. As a wave generation condition, irregular waves with peak overtopping flow rate of $0.1 \text{ m}^3/\text{s}/\text{m}$ (actual size conversion), which is larger than the design condition of general coastal levees, were used.

In case 1.1 (only foundation work), foundation works and figure experiment case (near the levee outer slope toe, model dimensions) outer slope armor moved by scouring but hardly moved in other 5 cases.

Since embedment depth was deeper than scouring depth, no destruction occurred in case 1.2 (sheet piling) and case 1.3 (soil improvement works). In case

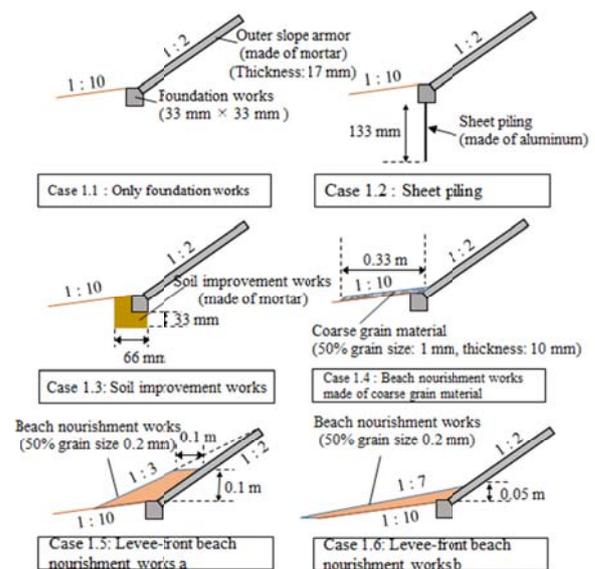


Fig. Experiment case (near the levee outer slope toe, model dimensions)

1.4 (Beach nourishment works with coarse materials) and cases 1.5 and 1.6 (Levee-front beach nourishment works a, b), scouring depth was less than the thickness of foundation works and the effect of reducing scouring by beach nourishment was confirmed. It was also suggested from the experiments in cases 1.2 to 1.6 that scouring depth becomes large and effect of scouring reduction is limited when exposed to the effect of waves longer than the time set in the experiment or when the size of beach nourishment materials is smaller.

3. Future schedule

We are going to conduct an experiment with a model in a scale of 1/8, closer to actual dimension, and prepare technical material for practical use after examining the effect on scouring due to difference in the size of sands constituting coastal landform.

☞ See the following for details.

1) TAKESHITA Tetsuya, FUKUHARA Naoki, KATO Fuminori, KOIZUMI Tomoyoshi, SHIGEHARA Toshihiro, IGARAAHI Tatsuyuki: Experimental Study on Structure of Resilient Coastal Levees against Scouring by High Waves on the Sea Side, Journal of Japan Society of Civil Engineers, B2 (Ocean Engineering), Vol. 74, No. 2, I_1087-I_1092, 2018.

Visualization of Flood Risk with Flood Risk Line

(Research period: FY2015 to FY2018)

TSUCHIYA Shuichi (Ph. D.), Senior Researcher, KAWASAKI Masaki, Head,
MAKUUCHI Kanako, Researcher, Water Cycle Division, River Department

Keywords: flood risk visualization, flood risk line

1. Introduction

Launching the "Flood Risk Visualization Project," the NILIM has been developing a method of visualizing flood risk for transmitting the risk and urgency of flood in real time and a technology for grasping / forecasting the profile water level as a technology for realizing such a method.¹⁾ We have recently developed a system called "Flood Risk Line," which indicates (visualizes), as information of the "lines" along rivers, when and where a flood can occur (flood risk) through relationships etc. of river profile water levels and the dangerous water levels set for each profile, etc. In addition, the Flood Risk Line was introduced during the flood season of this year in the Arakawa (Ara River, Tokyo etc.), Yamakuni River (Oita-ken etc.), and Sendai River (Kagoshima-ken etc.) to provide the information of Flood Risk Line to the municipalities etc. concerned on a trial basis.

2. Flood Risk Line

"Flood Risk Line" system consists of the river level forecast system and the flood risk indication system. The river level forecast system computes the present status of each river profile (at the interval of 200-400 m) and water level forecast using run-off model, channel model, and the river level forecast model consisting of the multipoint water level data assimilation technology. The flood risk indication system evaluates as risk the relationship between the water level of each profile and the dangerous water level set for the relevant profile and indicates the danger levels of each profile as Flood Risk Line by color-coding them along the river. The Figure is an example of Flood Risk Line indicated by recognizing the difference between the dangerous water level and the present river level as risk. Two lines in the Figure show Flood Risk Lines, which indicate risks according to the right and left sides of the river through evaluation. The risks indicated are color-coded, such as red when the river level is higher than the dangerous water level or orange when the water level is 0 to 1 m below the dangerous water level. Further, risk assessment using forecast water level instead of present water level enables indication of changes in Flood Risk Line for 6 hours in advance.



Fig. Display example of "Flood Risk Line"

3. Trial of Flood Risk Line and future

For this year's flood season, in the three rivers where the Flood Risk Line system was introduced on a trial basis, there was no flood that reached the flood danger level since the introduction (late July 2018) and Flood Risk Line was therefore not colored drastically. However, high interest in the Flood Risk Line system is recognized from the access of multiple municipalities etc. to the system when flood is expected due to approach of a typhoon etc. In the future, utilization of the Flood Risk Line is expected for more efficient evacuation actions and crisis management. Based on the results of trial introduction, the NILIM is also working for addition of the function to indicate average rainfall in basins, study of the method of longitudinal correction of river levels, etc. We plan to expand the introduction of Flood Risk Line in all the first-class river systems, and each Regional Development Bureau is constructing the system etc. NILIM is going to provide technical support to Regional Development Bureaus and conduct various studies.

☞ See the following for details.

- 1) 2018 NILIM Report, p. 60
- 2) Press release of the MLIT http://www.mlit.go.jp/report/press/mizukokudo03_hh_000954.html

Utilization of Ensemble Forecast Precipitation in Preliminary Release Operation in Dams

(Research period: FY2016 to FY2018)

KUDO Shun (Ph. D.), Researcher, KAWASAKI Masaki, Head, Water Cycle Division, River Department

keywords: preliminary release operation, ensemble forecast precipitation

1. Introduction

A possibility of increase in the scale of heavy rain is indicated as a result of climate changes, and importance of demonstrating the ability of existing disaster prevention facilities more efficiently is suggested as a countermeasure. As one of the measures for existing dams, flexible dam operation is expected, which aims to reduce damage in the downstream as much as possible through more effective use of the dam capacity based on the rainfall forecast information, which is remarkably progressing in technology.

Here, since forecast precipitation always accompanies an error, small or large, it is important to consider the width of forecast in order to use of forecast rainfall for dam operation. As means to express the width of forecast, NILIM has focused on "ensemble forecast precipitation" (multiple forecast precipitations outputted from forecast calculation under multiple initial / boundary conditions) and studied prior discharge operation and special operation for disaster prevention as advanced operation using "ensemble forecast precipitation." This paper introduces a method of using ensemble forecast precipitation with focus on preliminary release operation.

2. Decision making method for preliminary release operation using ensemble forecast precipitation

Preliminary release refers to an operation to reduce the reservoir level of a dam to a preliminary release level to secure the flood control capacity when a flood is expected. Since the capacity to be secured by preliminary release is also the flood control capacity in dam design, the reservoir level needs to be reduced to the preliminary release level before the dam starts a flood control, i.e., before inflow reaches the flood volume. Accordingly, it would be necessary for dams that adopted the preliminary release method to make decisions on whether preliminary release is necessary before flood or the volume of release for completing preliminary release.

As material for such decision making, this study devised two indicators, i.e. "whether inflow is expected to exceed flood volume" and "whether water level can be reduced to the preliminary release level with the set discharge." These indicators can be expressed as a ratio using ensemble forecast rainfall, which are organized as shown in Fig. 1. "The ratio of

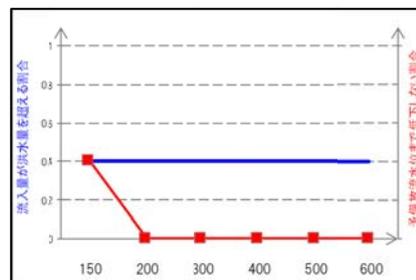


Fig. 1: Example for indicators of preliminary release operation

inflow exceeding flood volume" on the left vertical axis indicates the ratio of ensemble members that result in the forecast of inflow exceeding flood volume, and shows the necessity for preliminary release operation. "The ratio of not falling to the preliminary release level" on the right vertical axis indicates the ratio of ensemble members that result in the forecast of the reservoir level not falling to the preliminary release level against each of the release volume set on the horizontal axis, and serves as material for judging release volume for completing preliminary release. In Fig. 1, for example, since there is a ratio of inflow exceeding flood volume at this point, preliminary release operation is started or continued. For discharge in this case, other outlet structure is co-used since outflow may not reduce to the preliminary release level if it is 150 M³/s, which is maximum water use discharge, and selection of appropriate discharge is considered so that the ratio of not falling to the preliminary release level is zero.

Thus, expression of indicators as a ratio that serve as material for deciding preliminary release operation through conversion from ensemble forecast rainfall is expected to reduce the burden of decision making by dam administrator and support effective / efficient operation. We intend to verify applicability as a system supporting decision-making for a series of dam operations in close cooperation with the site, based on the study of preliminary release operation, prior discharge, and special disaster prevention operation.

Promotion of Emergency Use of Groundwater at Disaster

--- Evaluation of the available volume of groundwater with hydrological cycle analysis ---

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Keywords: groundwater, groundwater management, hydrological cycle analysis, disaster cooperation well system

1. Introduction

Groundwater is one of the important factors that constitute the hydrological cycle system and has been one of the important water resources in Japan's history since good groundwater can often be obtained close to home.

However, excessive intake of groundwater in the rapid economic growth etc. had caused various groundwater problems, including fall of ground water level, intake trouble, ground subsidence, and saltwater intrusion into groundwater in seaside area. Accordingly, intake of groundwater had been regulated and conversion of water source from groundwater to surface water had been conducted centering on the areas where groundwater problems occurred. As a result, the tendency of recovery in groundwater level has been confirmed and groundwater is used effectively in some communities, but it is necessary to use groundwater carefully in order not to repeat the past failures.

On the other hand, the environment surrounding "water" has also been changing in Japan. For example, there is reportedly no room to suspect global warming, rainfall is becoming extreme, and increase in the risk of flood / drought is concerned. There is also a concern about water failure when the water supply system is hit by earthquake since occurrence of a large-scale earthquake, such as Nankai Trough Earthquake, is forecast at a high probability. It is also still fresh in our memory that water supply system was cut off and water supply activities were conducted in wide area in the July 2018 Heavy Rain and the 2018 Hokkaido Eastern Iburu Earthquake.

2. Evaluation of the available volume of groundwater with hydrological cycle analysis

Use of groundwater in the event of a disaster instead of surface water is expected to strengthen the resistance against disasters. To this end, available volume of groundwater needs to be evaluated in advance, and a case study was conducted in this study for the basin of Sendai River in Tottori Prefecture. Specifically, a hydrological cycle analysis model was built at the same basin to analyze a case of water source change to groundwater (diluvium) by 20% of the intake of surface water in terms of the drought event (shrinkage of the rainfall from April to August

in the 1994 rainfall waves to 1/100 of the year probability). In this analysis, comparison of analysis values was made with the minimum groundwater levels in the past and the groundwater level when ground subsidence became moderate and the possibility of emergency use of groundwater at a drought was found.

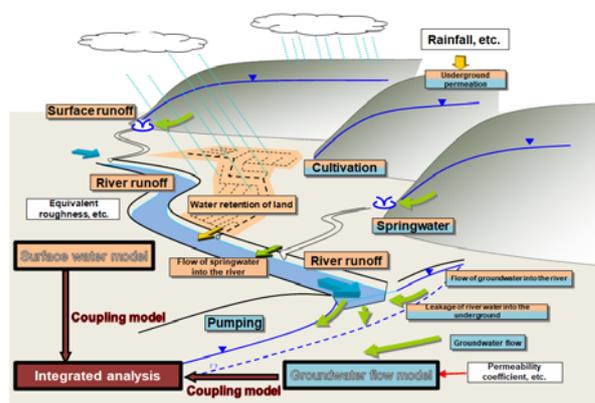


Fig.: Conceptual diagram of hydrological cycle analysis model

3. Cooperation well system at a disaster

The 1995 Hanshin / Awaji Great Earthquake caused damage to waterworks facilities and "water" ran short in many scenes, including firewater, drinking water for evacuees, and domestic water, and attention was paid to use of groundwater. In the 2007 Niigataken Chuetsu-oki Earthquake, water failure continued for about three weeks but serious water shortage did not occur because groundwater from wells normally used as a snow melting well was used.

In consideration of such examples, some local governments established "Disaster Cooperation Well" System, in which wells owned by citizens etc. are registered as "disaster cooperation well" so that groundwater is provided to local communities at disasters from a great earthquake etc.

Since evaluation of the available volume of groundwater with hydrological cycle analysis supports this system, we intend to continue the study including alternative use at disasters.

[Reference]

☞ See the following for details.

1) Technical Note of NILIM, No.883 (March 2016)
<http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0883.htm>

Main Points of Technological Study Required for Redevelopment of Existing Dams

- Analysis by reviewing previous cases -

(Research period: FY2017 to FY2018)

SATO Hiroyuki, Senior Researcher, ISHIKAWA Ryotaro, Researcher, KONDO Masafumi (Ph. D.), Head, Large-scale Hydraulic Structure Division, River Department

Keywords: dam upgrade, dam redevelopment, effective use of existing dams

1. Introduction

While changes in rainfall characteristics, etc. resulting from climate changes have been indicated, needs are expected to further increase for dam redevelopment projects, which utilize existing dams and aim to improve their functions by heightening, reinforcement of outlet structure, etc. Under such circumstances, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) formulated "Dam Upgrade Vision" (June 2017), providing the measures for advancing effective use of existing dams and "Dam Upgrade Guidelines" (March 2018), which organized basic matters for promoting dam redevelopment smoothly. This study, with focus on dam upgrade projects that require large-scale alteration of facilities, such as heightening of the existing dam body or body drilling / cutting for extension of outlet structure, out of the dam upgrade methods provided in the Guidelines above, organized practical research / study matters related to engineering and their points based on case study, which are required in each phase of a project for contribution to efficient implement of the project.

2. Outline of the research and analysis

First, we extracted the items of various engineering researches and studies actually conducted in each phase of the dam upgrade projects in Japan (planning, design, construction, first filling of water). Then, we organized the purposes, information used, concepts and points of attention in making technical decisions, etc. in each research and study, together with the flow of technical study, which is required in implementing an upgrade project (Fig. 1).

Note that major characteristics of dam upgrade projects include that it is required to implement construction work while maintaining the functions of existing dams including flood control and that feasibility of construction work needs to be studied early in the design phase since it may determine the method of alteration. In this organization, considering these characteristics as well, we aimed to list as widely as possible research and study items in each phase of upgrade projects, including research of the state of dam body in the filled state and soil conditions of foundation and the analysis method on the structural design according to alteration methods,

and strived to specify the points of each item.

3. Future vision

Planning and design of dam redevelopment projects are more subject to the conditions specific to the dam than new dam construction, and sharing / succession of experiences in previous projects was not easy in some aspects. We are going to organize the results of this study in the future as engineering data and hope that it would be helpful in implementing future dam redevelopment projects more efficiently.

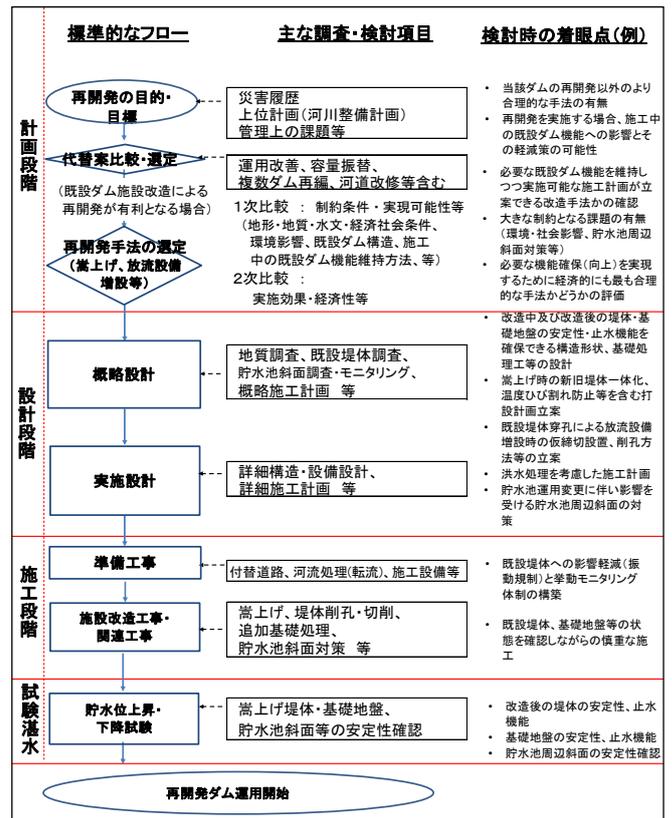


Fig. 1: Flow, items, etc. to be studied in dam redevelopment

Study on Urban Inundation Damage Control Measures Using Inundation Forecast Information

(Research period: FY2014 to FY2018)

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Keywords: guerrilla rainstorm, urban inundation damage, inundation forecast, social experiment

1. Introduction

Flood disasters have been frequently caused by record-breaking heavy rain etc. Particularly in urban areas, where concentration of population and assets, intensive use of underground space, etc. are proceeding, maintenance of sewerage and rivers is important since enormous damage is expected from incubation, and it is desirable to strengthen measures for reducing damage in the event of inundation since heavy rain exceeding the capacity of flood control facility is now frequent.

The inundation forecast system, which has been developed by Flood Disaster Prevention Division since 2014 under the SIP (Strategic Innovation Program (by Cabinet Office), receives measurement / forecast rainfall and river level data every 10 minutes, computes the flow of river, sewerage, and ground surface in an integrated manner, and distributes the forecast inundation depth, etc. one hour ahead within 10 minutes after receiving data.

2. Inundation forecast example and verification

Inundation depth was calculated based on the result and forecast rainfall data in the western Tokyo heavy rain on Aug. 13, 2018 and compared with the inundation depth obtained from the image of inundation on the website. The result showed 15 cm as estimated inundation depth in actual rainfall, 12 cm as estimated inundation depth in forecast rainfall, and about 20 cm as inundation depth read from the picture when actual inundation occurred. Thus, a certain level of accuracy was confirmed. We also recognized the

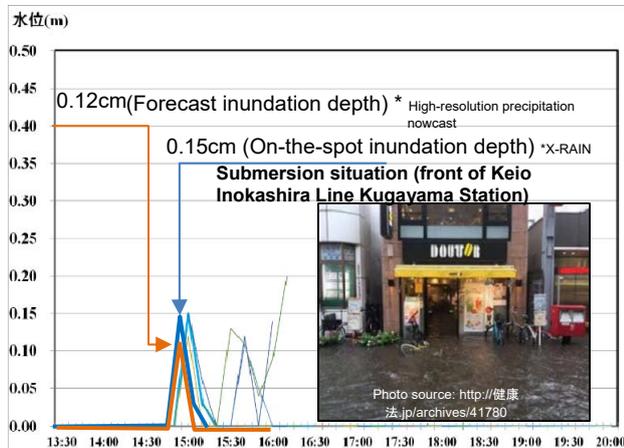


Fig. 1: Results of actual / forecast inundation depth calculation and image of inundation

importance of improving the accuracy of rainfall forecast since heavy rain was forecast immediate before the occurrence of inundation.

3. Social experiment

We continually conducted a social experiment involving about 50 people from local governments and local disaster prevention associations including those from the area prone to inundation in the basin of the Kanda River.

We confirmed that many of the participants use the inundation forecast information as a "trigger" for obtaining other information (TV etc.).

We also started a joint study with academic experts in order to expand the system to the eastern part of Tokyo for use of the inundation forecast system in local heavy rain to prepare for the 2020 Tokyo Olympic Games / Paralympics and to cover the entire area of Tokyo 23 Wards.

Fig. 2 shows the area of system expansion to the eastern Tokyo.



Fig. 2: Area of system expansion to the eastern Tokyo

4. Future vision

We intend to improve the accuracy of inundation forecast through the use of new rainfall observation / forecast technologies including new model weather radar and continue to study inundation damage prevention / mitigation measures using inundation forecast information.

See the following for details.

1) Flood Disaster Prevention Division, River Department, NILIM

<http://www.nilim.go.jp/lab/rcg/newhp/index.htm>

Proposal for Simple Creation Method of Flood Risk Information in Small and Medium-sized Rivers

(Research period: FY2018)

OYAMA Riku, Researcher, ITAGAKI Osamu, Head,
Flood Disaster Prevention Division, River Department

Keywords: flood risk, LP data, pond model, crisis management plan

1. Importance of sharing of flood risk information in society

Intensification and frequency of heavy rains due to climate changes are increasing in recent years and many places in Japan have been seriously damaged by river flood, etc. including the July 2018 Heavy Rain. In order to prevent destructive damage to community, it is important to formulate a crisis management plan, etc. so that flood damage may be minimized even in the event of a flood that cannot be prevented by the facilities.

When considering evacuation routes and emergency vehicle traffic routes in formulating such a plan, it would be important to avoid the use of roads with high risk of inundation to the extent possible. In consideration of the routes above, it is possible to use the flood-prone area and inundation records officially published for large rivers, while it is not easy for the inundation risk of small and medium-sized rivers to obtain necessary inundation risk information about many rivers. We have therefore developed in the past year a simple method of creating inundation risk information in small and medium-sized rivers flowing through valley plains and published it as a guide ¹⁾ in December 2018. In addition to this, we are advancing R&D for a simple method of creating inundation risk information in small and medium-sized rivers flowing through level terrain, which is introduced as follows.

2. Provisional calculation of simple inundation risk information based on LP data in level terrain

Issues in creation of inundation risk information for small and medium-sized rivers include limited existing data on cross section profile of river channel and limited budget and personnel for conducting flood simulations. In this study, risk information was provisionally calculated (Fig. blow) through (i) simplification using LP data in grasping cross-section profile of river channel and inland topography (elevation data including topography obtained by irradiating laser beams from an airplane), (ii) simplification using rational formula in run-off calculation and labor saving by using the evaluation system for the safety level of flood control in small and medium-sized rivers, and (iii) simplification using the pond model (i.e., method of calculating the inundation area and depth for the designated flood

volume by organizing the relationships between volume, inundation depth, and inundation advance) for flood simulations. Note that areas that partially have a runoff type flood which expected inundation area cannot be modeled by the pond model, outline drawing of the inundation area on the road crossing the water fall line was drawn by drawing water fall lines from the expected inundation area.

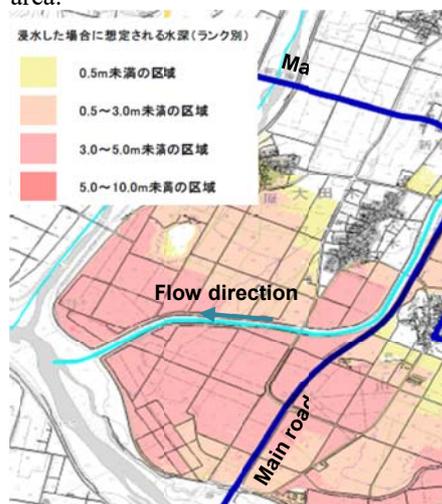


Fig.: Example for trial production of flood risk information in level terrain

3. For future use of the simple information

Based on the results of trial calculation, we are studying on the use of the risk information for the formulation of a crisis management plan. We intend to continue study on how to use the risk information in urban planning.

☞ See the following for details.

1) Guide to Creation of Simple Flood Risk Information in Small and Medium-sized Rivers (2018)

http://www.mlit.go.jp/river/shishin_guide_hou_kaninarisuku_tebiki.pdf

Development of Flood Control Activity Supporting Technology Based on Actual Status

(Research period: FY2017 to FY2019)

TAKEUCHI Yoshinori, Senior Researcher, ITAGAKI Osamu, Head
Flood Disaster Prevention Division, River Department

keywords: flood control activity, flood-fighting team, flood risk, supporting technology

1. Importance of supporting technology for flood control activities serving a very important role in local disaster prevention / mitigation

In recent years, floods exceeding the ability of levees or other disaster prevention facilities frequency occurred due to intensified rainfall. To prepare against such floods, it is important to root an effective and sustainable system of flood control in society as well as to promote steady development of disaster prevention. Accordingly, with focus on "systematic flood control activity for self-defense," which has been considered important since the old times in Japan, NILIM has been studying to clarify what technical support river administrators should implement in order to further improve the disaster reduction effect by flood control activity.

2. Preparation of a risk information map that supports "Evacuation guidance by door-to-door visit"

The following were found from the detailed hearings from the flood-fighting teams (concurrent service by local fire brigade) in 5 municipalities in local area where flood control activity was actually conducted in recent years about the process of actual flood control activities. 1) In a series of heavy rains and floods, activities are conducted in very many cases to prevent branch river / inland flood before flood control activity at the main river levees. 2) Since these activities are various and require a large amount, activity for the main river is likely to become difficult. Then, NILIM has prepared "Possible Human Damage Map" (tentative title) on a trial basis in order to support "Evacuation guidance by door-to-door visit" from the activities in 1) above since it could take much time and affect other activities although it is highly effective in damage prevention / mitigation. In preparation, considering rainfall, run-off from the mountainous land in the back, and microtopography, the inundation depth distribution attributable to branch / inland floods was obtained from the two-dimensional unsteady flow calculation and overlapped with the inundation depth distribution by flooding of the main river. This is a risk information map showing difficulty in evacuation due to branch river flood / inland inundation, which could occur before issuance of evacuation information based on the main river water level, and relative possibility of human damage based on the maximum inundation depth at a flood of the main river. This map is intended to promote the

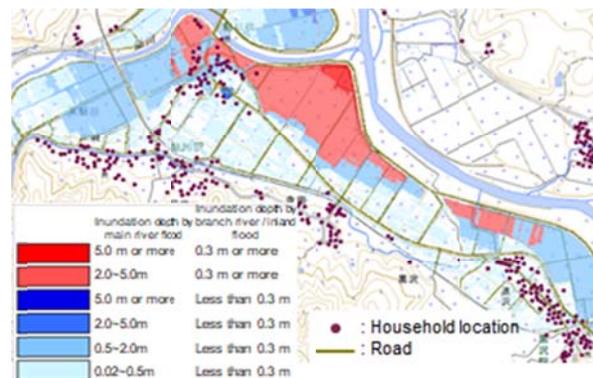


Fig.: Priority implementation of evacuation guidance in a high risk area.

preferential and early evacuation guidance for the high risk areas that were narrowed down based on various inundation events that can occur in connection with heavy rain events. Consequently, the result of trial calculation showed that not only the evacuation guidance time in high risk area but the evacuation guidance time in the whole inundation area can be reduced.

3. Actual flood control activities in metropolitan area and flood control activity supporting technology

The following characteristics, which are different from the characteristics in local area as stated in 2) above, were recognized from the hearing survey conducted to disaster prevention departments and flood-fighting teams (concurrent service by fire brigade) in some cities located in the low-lying area of metropolitan area. 1) In addition to the flood-fighting team, employees of the city also independently engage in on-site flood control activities. 2) Since there has been little experience in flood control activity that accompanies a large amount of activity in recent years, it could be difficult to have sufficient estimation about progress in the time series of damage from flood of inner / outer water.

Considering the actual status stated above, it would be effective to provide "information on forecast of inundation events likely to occur next" with the inundation forecast system, etc. developed by NILIM as technology to support flood control activity. We intend to study quantitative evaluation methods for the effect of these forecast technologies on flood control activity and the effect of damage reduction as a result of the former effect.

Consideration of Flood Evacuation Measures with a Case in the US

(Research period: FY2018)

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Flood Disaster Prevention Division, River Department

Keywords: U.S.A., flood disaster, evacuation

1. Introduction

Since the flood damage caused by Hurricane Harvey, which hit the City of Houston in August 2017, which has the fourth largest population of 2.3 million (estimation as of July 2017) in the United States. is an important case for study of flood damage reduction measures in big cities, NILIM conducted a hearing survey in March and May 2018 from employees, etc. of the Federal and local governments (jointly with Water and Disaster Management Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Cabinet Office personnel in charge of disaster prevention, etc.).

2. Scale of the flood damage

In the Harris County (population of 4.7 million), where Houston is located, about 125,000 houses, about 10% of the total number of houses, were inundated, about 300,000 cars were inundated, 36 persons were killed, more than 60,000 people were rescued, and a total of about 4.7 billion dollars (equivalent to about 520 billion yen (110 yen / dollar) were paid for a total of about 46,000 flood insurance claims. (May 2018 Harris County Flood Control District)

3. Case that should be referred in Japan

In the local hurricane evacuation map (Fig. 1), postal code areas are grouped and color-coded as purple, yellow, green, and orange according to storm surge disaster risks. Residents in the area of target group of evacuation order are supposed to evacuate, while residents of the area not color-coded are supposed to give way to evacuees from other areas without conducting horizontal evacuation. This is based on the concern that unnecessary horizontal evacuation of residents in low risk areas may cause road traffic congestion, etc. and prevent evacuation of residents in high-risk areas.

4. Issues to consider in studying flood evacuation measures in Japan

Of the calamity of the Hurricane, many were killed when moving in cars and many people were rescued from cars stuck on the road (the same County's crisis management center in March 2018), so that it was reconfirmed that horizontal evacuation also carries a risk. It is important for society to share the awareness that human damage / social cost may be increased when expanding the coverage area of evacuation order etc. for safety (Fig. 2).

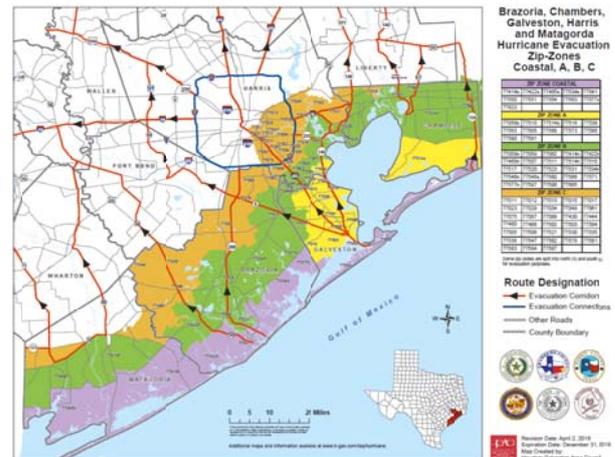


Fig. 1: Hurricane evacuation map (Houston-Galveston Area Council 2018)

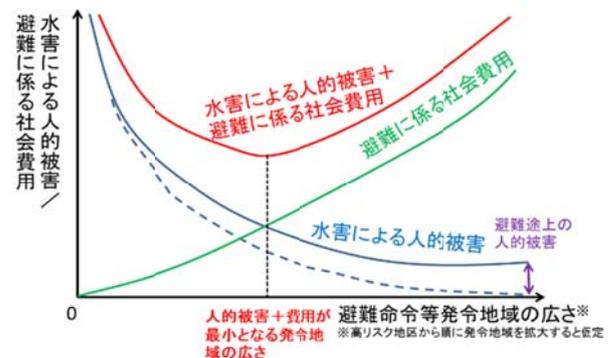


Fig. 2: Relationship between the coverage area of evacuation order and damage

5. Conclusion

It was found in the U.S. hurricane disaster above that limitation of target flood evacuees could lead to reduction of flood damage. We intend to study effective flood evacuation measures in Japan, where social characteristics, etc., are different.

See the following for details.

Research team report is to be published from the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), etc.

Proposal for Method of Forecasting Sediment Disasters by Long-period Continuous Rainfall using Sediment Transport Hydrological Observation

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KOMATSU Mio, Guest Research Engineer, Sabo Planning Division, Sabo Department

SAKURAI Wataru (Ph. D.), Research Coordinator for Sediment Disaster Prevention, Sabo Department

Keywords: sediment transport hydrological observation, basin sediment dynamics, sediment disaster countermeasures

1. Background and purpose

Warning and evacuation information concerning sediment disasters is prepared and issued based on rainfall but is hard to transmit urgency and does not necessarily lead to evacuation. Further, in the 2011 Kii Peninsula Flood Disaster, etc., it was observed that an abnormal sediment run-off that is not usually observed around the stricken area occurred before the occurrence of sediment disaster. Accordingly, we have conducted this study considering that if such abnormal sediment run-off can be observed, it would be possible to detect rise in the risk of sediment disaster and to issue information that communicates the urgency of sediment disaster more clearly. Specifically, we checked to what extent the event of abnormal sediment run-off was perceived in the recent disasters and confirmed whether such abnormal sediment run-off can be detected by the real-time sediment transport hydrological observation of mountain rivers, which has been conducted by river basin sabo offices in the country.

3. Study outline and results

For ten recent disasters caused by heavy rainfall, we organized data on the number of events of abnormal sediment run-off perceived, such as water turbidity and sound of sediment transport before the disaster, as well as time lag until occurrence of the disaster (Figs. 1)²⁾. In organization of data, disasters were classified into those caused by intensive rainfall in a short period (Nagiso Disaster etc.) and those caused by continuous rainfall in a long period (Kii Peninsula Flood Disaster, 2012 Aso Disaster, etc.). First, the event of abnormal sediment run-off was perceived before occurrence of the disaster in 8 out of 10 disasters. In the long-period continuous rainfall, the number of events of sediment run-off perceived and time lag until occurrence of the disaster were both greater than those in the short-period intensive rainfall. This shows that abnormal sediment run-off is often seen before occurrence of the disaster in disasters caused by long-period continuous rainfall.

We also organized the relationship between sediment discharge and water depth in a flood where debris flow occurred in the upstream and a flood where no debris flow occurred using the data obtained from observation of the Yotagiri River in the Tenryu River

system (Fig. 2).²⁾ The envelope was experientially determined based on the observation results of past floods where debris flow did not occur. It shows that plots are located in the upper left of the envelope when debris flow occurred. Accordingly, it was found that the possibility of detecting occurrence of abnormal sediment run-off due to occurrence of debris flow etc. in the upstream is high when focusing on the magnitude relationship of observation data and envelope.

3. Future perspective

In the future, we continue the verification of flexibility of the method above and study a method applicable even to basins on which data accumulation is insufficient.

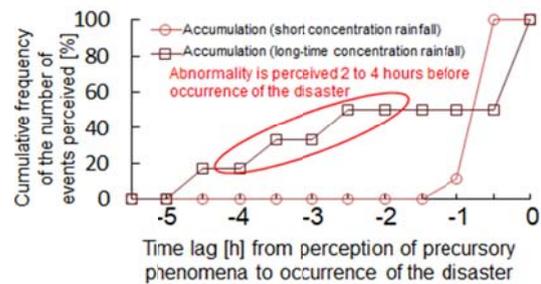


Fig. 1. Time of occurrence of precursory phenomena related to sediment run-off

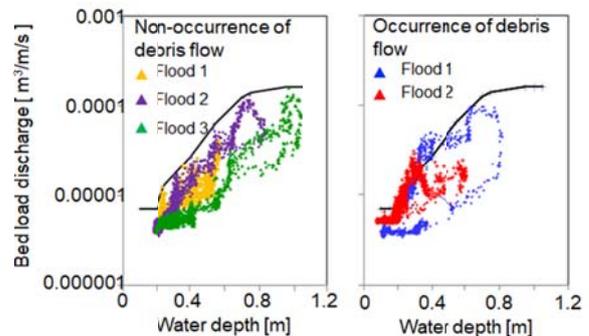


Fig. 2. Relationship between sediment discharge and water depth (Yotagiri River)

See the following for details.

1) Collection of Summaries on the 2018 Japan Society of Erosion Control Engineering Research Presentation Meeting, pp. 679-680

2) Geomorphology, Vol.306, pp.198-209

Study for Preparation of a Hazard Map of Sediment Disaster with the National Building Research Organization of Sri Lanka (Research period: from FY2017)

MATSUMOTO Naoki (Ph. D.), Senior Researcher, UCHIDA Taro(Ph.D.), Head, SUZUKI Kiyotaka. Guest Research Engineer, Sabo Planning Division, Sabo Department

Keywords: Sri Lanka, sediment disaster countermeasures, research partnership, hazard map

1. Introduction

In January 2018, the NILIM entered into a memorandum of cooperation for research on sediment disaster countermeasures with the National Building Research Organization ("NBRO") of Sri Lanka.¹⁾ Accordingly, a joint research was conducted on applicability of the numerical simulation developed in Japan in order to prepare a hazard map of sediment disasters in Sri Lanka as early as possible. This paper reports results of this joint research.

2. Contents and results of discussion

Sri Lanka prepared "Landslide Hazard Zonation Map" by assessing the risk of slope failure and published it. This Map, however, does not show areas where sediment generated by slope failure is expected to reach. In addition, since many houses stand on slopes in Sri Lanka, it is very important in disaster prevention to forecast area where sediments are expected to run off. We therefore studied the applicability in Sri Lanka using the two-dimensional debris flow simulation "Hyper KANAKO"²⁾ which can forecast the area of runoff / deposition of sediments generated by slope failure. First, we conducted the numerical simulation of slope failures that occurred in Koslanda, Sri Lanka, after advancing the study on configuration methods, etc. actually practicable in Sri Lanka for topographic maps and parameters. Fig. 1 shows an aerial photograph immediately after disaster and calculation results. According to the calculation results, deposition of sediments is much more than actual deposition in the collapsed area but a lot of sediments are deposited in the (red frame) area where a lot of sediments were actually deposited. In addition, the area of deposition calculated was larger than actual but the reaching distance was almost the same. The accuracy of calculation results is considered to have been affected by the slightly coarse topographic map of Sri Lanka (1/10,000). Further, in order to confirm how difference in input conditions affects calculation results, we conducted trial calculations, assuming future forecast calculations, by changing the ratio of fine-grained sediments, sediment volume, hydrograph, and grain-size distribution under the condition where no input conditions other than location and scale of collapse and topographic data are unknown. The result showed that the ratio of fine-grained sediments has a large effect on the reaching range. Consequently, it was confirmed that even with topographic data of coarse accuracy, forecast of reaching range, etc. is

possible.

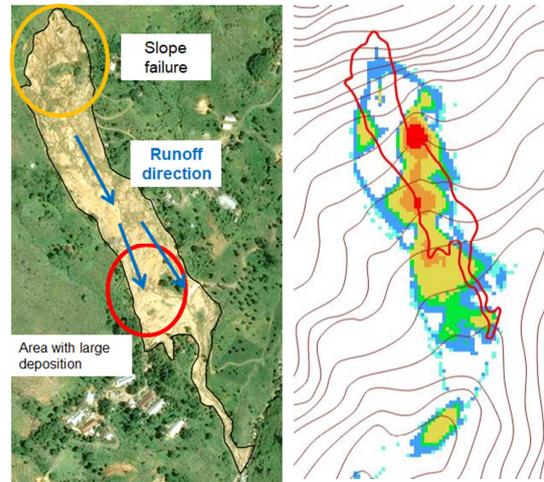


Fig.1 Results of numerical simulation (Slope failure in Koslanda)

3. Conclusion

In addition to technical study, this joint research also intends to transfer techniques for preparing a hazard map for sediment disasters by inviting three young researchers from the NBRO. In the future, while using Landslide Hazard Zonation Map as well, we are going to visit Sri Lanka to exchange opinions and continue discussion for early preparation of a hazard map through participation in workshops, field survey, etc.

Note that for inviting researchers from the NBRO, we received a subsidy from the Civil Engineering International Research Exchange Support Plan of the Public Works Research Center.

☞ See the following for details.

1) Civil Engineering Journal, vol. 60, No.5 p. 41

2) Hyper KANAKO Workshop website:

<http://www.hyper-kanako.com/>

Issuance of the Guide (draft) to Study on Sabo (erosion control) Facility Arrangement as Countermeasure for Sediment Flooding / Inundation using River-bed Variation Calculation

(Research period: FY2016 to FY2017)

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KOMATSU Mio, Guest Research Engineer, Sabo Planning Division, Sabo Department

Keywords: sediment flooding / inundation, sabp facility arrangement planning, sediment dynamics analysis method, mountain river

1. Purpose of issuance

To prevent disasters caused by sediment movement, it is important to evaluate the effect of control facilities properly and plan countermeasures while forecasting sediment movement phenomena that may occur in the future. However, mountain rivers targeted by sabo projects have complicated characteristics, i.e., a large amount of sediments caused by slope failure, debris flow, etc. are supplied in heavy rain and flow in different sediment dynamics, such as debris flow, bedload transport cluster flow (intermediate flow of debris flow and bed load), bed load, or suspended load. In order to evaluate such sediment dynamics of mountain rivers in heavy rain, it is required to use an analysis method according to the sediment dynamics of mountain rivers in heavy rain and set calculation conditions properly. Accordingly, the Guide (draft) described the method of estimating sediment / flood damage using river-bed variation calculation and the method of evaluating the effect of control facilities for more effective / efficient facility arrangement based on the results of recent research and technological development in the relevant field.

2. Main characteristics of the Guide (draft)

Of the target phenomena covered by the Sabo Basic Plan shown in Fig. 1, the Guide (draft) mainly covers "sediment flooding / inundation caused by river bed rise, etc. resulting from runoff sediment from the upstream" ("sediment flooding / inundation")
Damage patterns of sediment flooding / inundation and scenarios covered by the plan differ according to the locations of targets of maintenance. Accordingly, the Guide (draft) describes the method of setting proper rainfall conditions from a viewpoint of the location of maintenance target with regard to design rainfall as a countermeasure for sediment flooding / inundation. The Guide (draft) also describes the methods of watershed subdivision and water / sediment supply in river-bed variation calculation, method of setting channel shape and river bed conditions, method of verifying calculation results by numerical simulation, and concept of effective facility arrangement planning using river-bed variation calculation.

On the other hand, even when conditions are properly set by numerical simulation and calculation results are fully

verified, phenomena of sediment dynamics are complicated and even a little difference in input conditions may greatly affect analysis results. Further, considering a future scenario of increase in rainfall by climate change, etc., the Guide (draft) expects evaluation of uncertainty to be implemented including examination of multiple scenarios.

- | | |
|-----|--|
| A. | Short-term measures for sediment run-off (during a series of rainfall duration) |
| A-1 | Debris flow / driftwood measures |
| A-2 | Measures for sediment flooding / inundation (caused by upstream sediment movement) |
| A-3 | Measures for sediment flooding / inundation caused by driftwood |
| B. | Medium- to long-term measures for sediment run-off (active period of sediment run-off) |
| B-1 | Measures for particularly active sediment run-off |
| B-2 | Measures for continually active sediment run-off |
| C | Volcanic sediment and erosion control |
| D | Measures for abnormal sediment-related disasters |
| D-1 | Measures for debris flow caused by deep-seated landslide |
| D-2 | Measures for sediment flooding / inundation caused by landslide dam |

Fig. 1 Classification of phenomena to be covered by Sabo Basic Plan

3. Conclusion

Many events of sediment flooding / inundation occurred in the Northern Kyushu Heavy Rain in July 2017 and the Western Japan Heavy Rain in July 2018.

Countermeasures for sediment flooding / inundation are urgently required in order to address the localization and frequent occurrence of heavy rain. We hope that the Guide (draft) will be utilized in considering sabo (erosion control) facility arrangement planning as a countermeasure for sediment flooding / inundation and contribute to damage prevention / mitigation.

☞ See the following for details.

1) Technical Note of NILIM, No. 1048, Nov. 2018

A Study on Automatic Identification of Linear Precipitation System etc. for Sediment Disaster Warning and Evacuation

(Research period: FY2015 to FY2018)

NOMURA Yasuhiro, Senior Researcher, NORO Tomoyuki, Head,

TODATE Hikaru, Guest Research Engineer, Sabo Risk Management Division, Sabo Department

Keywords: sediment disaster, linear precipitation system, warning and evacuation

1. Introduction

In the recent years, sediment disasters caused by torrential rain due to linear precipitation system, etc. have frequently occurred in Japan, including the 2017 Northern Kyushu Heavy Rain and the 2014 Hiroshima Heavy Rain. Once a back building type of linear precipitation system, etc. is formed, cumulonimbus clouds generated at the windward successively flow in and heavy rain area remains over several hours, which often causes enormous damage. In addition, it is difficult at present to predict accurately the amount, location, and time of such heavy rains based on numerical weather prediction unlike rainfalls by typhoon, etc.

Then, in order to provide information quickly to the personnel in charge of disaster prevention, we studied the method of identifying linear precipitation system, etc. and developed a system that enables automatic identification on real time. This paper introduces the outline of this activity.

2. Content of study

Using the Meteorological Agency's two-dimensional analyzed precipitation data, we studied the algorithm and built a prototype system for identifying linear precipitation system from weather indicators (occurrence potential of local heavy rain) representing rainfall intensity, shape of heavy rain area, wind direction, and atmospheric instability, etc. We applied this system to the 2014 Hiroshima Heavy Rain, 2017 Northern Kyushu Heavy Rain, and 2018 Western Japan Heavy Rain and it was mostly possible to detect generation of linear precipitation system before occurrence of a large-scale sediment disaster.

Additionally, as the result of analyzing continuity of linear precipitation system in the 2016 Hiroshima Heavy Rain by identifying the developmental stage of cumulonimbus clouds particularly at the windward from those constituting linear precipitation system, using three-dimensional observation data based on the MLIT's X band MP radar, it was found that a more hazardous stagnant linear precipitation system can be identified (See Fig.).

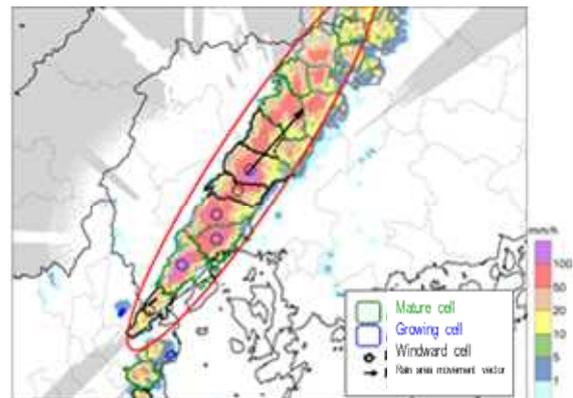
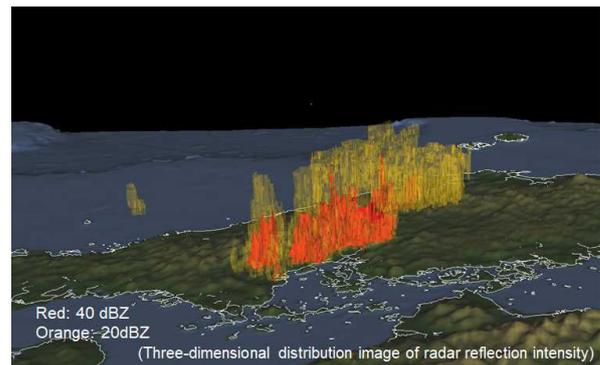


Fig. Identification of linear precipitation system using three-dimensional data (X-MP)

3. Future schedule

Demonstration experiment of this system is being conducted by Regional Development Bureaus across the country and sediment disaster departments of prefectures etc. from a viewpoint of sediment disaster risk assessment and the system is going to be improved for easier use by disaster prevention personnel. For upgrading of the linear precipitation system identification method using three-dimensional radar observation data, we intend to consider utilization of higher precise phased array radar (MP-PAWR), etc.

Basic Trend of Stuck Traffic in Winter Season

(Research period: FY2017 to FY2019)

IKEHARA Keiichi, Senior Researcher, KAWASE Haruka, Research Engineer, TKAHASHI Ayumu, Guest Research Engineer, KOBAYASHI Hiroshi (Ph.D.), Head,
Road Safety Division, Road Traffic Department

Keywords: winter road management, unclimbable, stuck, winter tire, chain

1. Introduction

In recent years, heavy snow has been causing large-scale stuck traffic and long-time suspension of traffic, and such traffic hazards due to local heavy snow often occurred in areas other than snowy areas. A case where a car got stuck ("stuck car") on a national management road occurred at 4,578 spots across the country for the period from FY2011 to FY2016 (including minor incidents), which are broken into (i) 34% for the region of Tohoku Regional Development Bureau, (ii) 18% for Hokuriku Regional Development Bureau, (iii) 14% for Hokkaido Development Bureau, (iv) 13% for Kanto Regional Development Bureau, (v) 11% for Chugoku Regional Development Bureau, and others. However, occurrence greatly varied according to fiscal years and was greatly affected by local heavy snow in the regions other than the top three.¹⁾ Considering these situations, NILIM has been grasping characteristics based on data analysis and on-site hearings concerning the occurrence of stuck traffic and organizing causes, issues, etc. as useful information for other regions. Based on results of this organization, NILIM has been studying the direction leading to solution by adopting a road structure resilient to stuck cars, etc. such as wide shoulder and climbing lane from the viewpoint of winter road management.

2. Trend of occurrence and countermeasures in Tohoku, Hokuriku, and Hokkaido

In the jurisdictions of Tohoku and Hokuriku Regional Development Bureaus and Hokkaido Development Bureau ("Tohoku, Hokuriku and Hokkaido") where stuck traffic occurs every year, we conducted questionnaire and hearing surveys in fiscal 2018 by extracting spots where stuck traffic frequently occurs in order to grasp the trend of occurrence and content of countermeasures.

Fig. 1 organized the weather conditions of the spots where we conducted the questionnaire survey, and Fig. 2 organized the main generating factors. The weather conditions of the spots are characteristic in the air temperature of winter and distribution of precipitation, and generating factors have a trend according to the characteristics of weather conditions. When seen in the ascending order of average air temperature, stuck traffic often occurs in Hokkaido due to obstruction to vision or snowdrift, which would be greatly affected by low temperature or wind as well

as snow on roads. Stuck traffic often occurs due to snowfall and road surface freezing in Tohoku, and due to snowfall in Hokuriku. As characteristic measures, delineators are introduced at a high ratio in Hokkaido, automatic spraying equipment has been partially introduced in Tohoku, and snow-melting pipes has been introduced in part in Hokuriku. In all of three regions, the introduction rate of chain attachment/detachment area is high but there is a problem of stuck traffic due to no chain attachment. As an effective measure, climbing lanes are highly evaluated in all the three regions, which is probably because slow expansion of damage even in case of stuck traffic is evaluated.

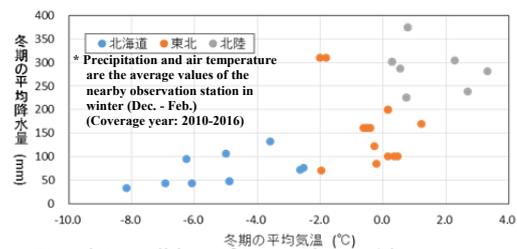


Fig. 1: Weather conditions of surveyed spots (air temperature and precipitation in winter)



Fig. 2: Main generating factors of stuck traffic (Hokkaido, Tohoku, Hokuriku)

3. Future summarization policy

We reported the outline of the occurrence trend and countermeasures in Tohoku, Hokuriku, and Hokkaido. We continue to organize the conditions and effects of application focused on measures based on road structure etc. and summarize results as information useful for introduction in other regions. In addition, for prevention of damage expansion, introduction of wide shoulders, as well as climbing lanes, would be effective in realizing snow-resistant road structure. We also intend to study measures for introducing these measures from a preventive viewpoint.

References: 1) IKEHARA Keiichi, KAWASE Haruka, KOBAYASHI Hiroshi, "Occurrence Trend of Stuck Traffic in Winter Roads", Civil Engineering Journal, April 2019 (under contribution)

Study on Accuracy of Slope Measurement using UAV

(Research period: FY2018 to FY2020)

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Earthquake Disaster Management Division, Road Structures Department

Keywords: elimination of road obstacles, unmanned aerial vehicle (UAV), slope failure, secondary damage

1. Introduction

In order to grasp the situation of disasters caused by earthquake, heavy rain, etc. as quickly as possible and support prompt elimination of road obstacles, the NILIM has been studying utilization of technologies for early grasp of disasters including an airplane for the purpose of surveying damaged areas before starting activities for elimination of road obstacles and grasping the risk of failure or re-failure of slopes when working for elimination of road obstacles.

This paper introduces the results of study on the possible accuracy of measurement of slope conditions, including level difference and subsidence with focus on unmanned aerial vehicle (UAV) in order to avoid secondary disasters from failure or re-failure of slopes when surveying damaged areas or working for elimination of road obstacles. Measurement was conducted using a part of the drone airfield as test field (Fig. 1).

2. Examination of the conditions affecting measurement accuracy

Measurement accuracy is affected by slope conditions (slope angle, vegetation density, etc.) or measurement conditions (reference point arrangement, flight altitude, etc.). Then, we studied the effect of each condition on measurement accuracy using the UAV-loading type laser scanner expected to be used for grasping the situation of ground surface under vegetation. This paper introduces the effects of terrain clearance and vegetation density.

For examination, the measurement cross section of Fig. 1 (red line) was used from the results of measurement at the terrain clearance of 80 m and 140 m. Fig. 2 and Fig. 3 show the results of measuring the measurement cross section. Although topography is grasped even under vegetation regardless of terrain clearance, Fig. 2, in which terrain clearance is smaller, shows measurement of topography with better accuracy. Note that the number of points per unit area of the ground surface where laser beam reached was 1.7 to 2.5 times at the terrain clearance of 80 m as compared with the terrain clearance of 140 m. In addition, the rate of laser beam reaching the ground (points of reaching ground / all the points) is different according to vegetation and was 26% for slender bamboos (*Sasamorpha*), 18% for broad-leaved forest, and 9% for coniferous forest at the terrain clearance of 80 m. This is attributable to changes in vegetation

density. Note that similar trend was observed in changes in the rate of reaching ground according to vegetation density at the terrain clearance of both 80 m and 140 m.

3. Conclusion

We are going to study measurement conditions on which the risk of failure / re-failure of slopes can be determined through acquisition of topographic data using UAV images and laser on actual disaster sites, etc. and examine how UAV can be utilized before and after activity to eliminate road obstacles.



Fig. 1: Test field

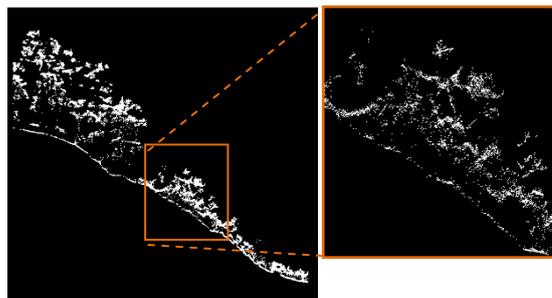


Fig.2 Measurement results (terrain clearance of 80 m)

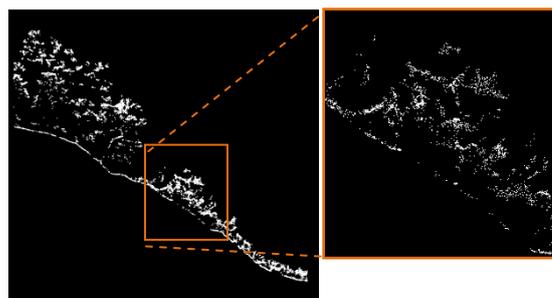


Fig.3 Measurement results (terrain clearance of 140 m)

Establishment of Seismic Behavior Observation System for the Entire System of Civil Engineering Structures

(Research period: FY2017 to FY2018)

ISHII Yosuke, Research Engineer, KATAOKA Shojiro (Ph. D.), Head

Earthquake Disaster Management Division, Road Structures Department

Keywords: seismic design standards, seismic behavior observation system, wireless communication

1. Introduction

NILIM has been observing seismic behaviors since 1958 with the aim to rationalize / upgrade the seismic design standards for civil engineering structures and clarify their seismic behaviors.

In recent years, structures having complicated seismic behaviors in the entire system are increasing. To improve the earthquake countermeasure technology for such structures, proper evaluation of behaviors in the event of earthquake is required. Accordingly, the NILIM has been working for establishment of a system that can observe behaviors of the entire system of structures (the "observation system") by conducting simultaneous seismological observations at many points in structures.

2. Experiment for sending / receiving observation records using wireless communication

As means of communicating records from multiple sensors that constitute to the observation system, wireless communication was used for convenience. Wireless communication technology has been applied to seismic observation inside buildings, etc. but has never been applied to outdoor observation such as for civil engineering structures. Therefore, observation records were sent and received in wireless transmission on the NILIM's test course, over 1 km in a linear distance, to check transmission distance and communication intensity (Fig. 1). The result of the experiment showed that observation records can be satisfactorily transmitted and received in wireless communication even in outdoor environment.

3. Construction and observation system

In order to detect issues in establishment of observation system using wireless communication, a system was temporarily installed on the elevated bridge. This observation system consists of sensors for observing seismic behaviors of the structure, an antenna for receiving observation records sent from the sensor in wireless communication, and a logger for recording / processing observation records. A total of about 50 sensors were installed on the bridge, 575 m in length, in order to observe the behaviors in the entire system of the structure (Fig. 2). We intend to continue observation to check communication intensity and recording accuracy.

4. Conclusion

In order to establish a technology using results of this study as a model case and obtain seismic records that contribute to further rationalize / upgrade the seismic design standards for civil engineering structures, we intend to improve seismic behavior observation in the NILIM.

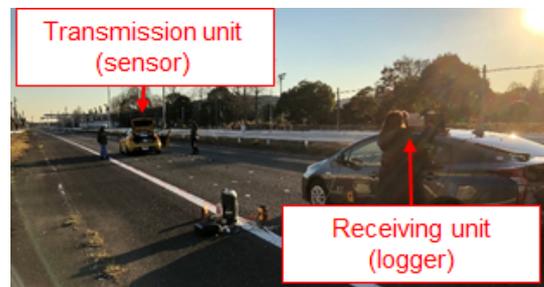


Fig. 1: Experiment using wireless communication

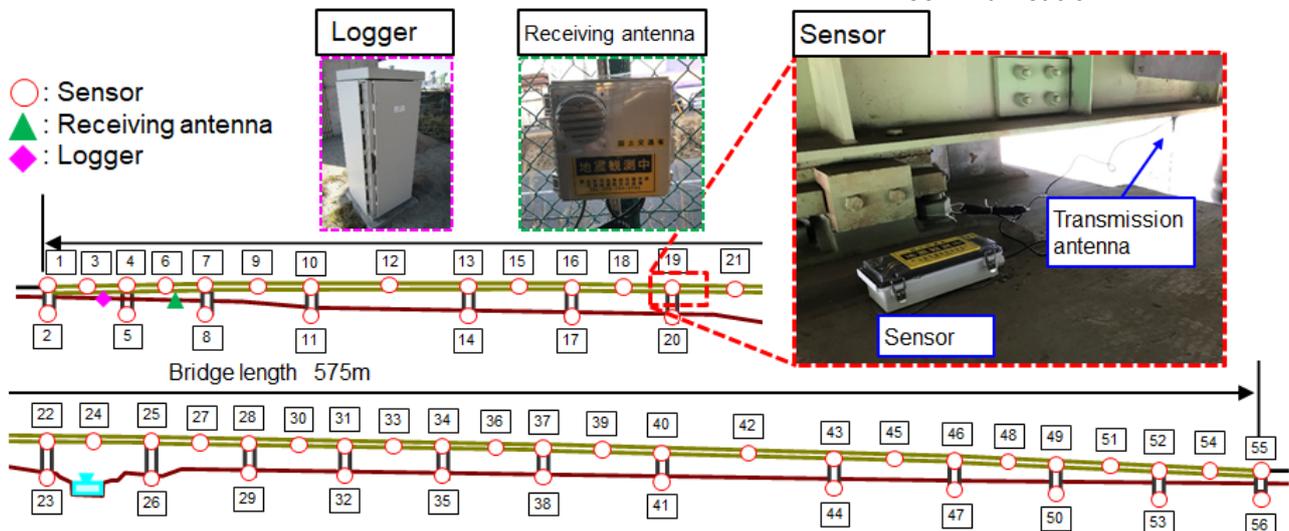


Fig. 2: Provisional installation on the elevated bridge

Consideration of Technological Requirements and Evaluation of Disaster Detection Technologies in the Road Field

SHIRAISHI Moemi, Researcher KATAOKA Shojiro, Head
 Earthquake Disaster Management Division, Road Structures Department

(key words) technological requirements, road damage, disaster prevention, initial response

1. Introduction

Plans are to proactively introduce both new technologies and technologies from other fields in order to collect damage information promptly. To develop and introduce technologies appropriately, it is important to clarify technological requirements. However, technological requirements in the disaster prevention field are unclear because of the variety and complexity of disaster scenarios.

NILIM has been making efforts to clarify the technological requirements of disaster prevention based on the systematized information needs of road managers since 2016, in order to develop and introduce technologies appropriately based on the arranged information needs of disaster response sites.

2. Presentation of technological requirements

In order to evaluate the level of information needed by road managers in disaster response and the level of information grasped by various technologies in terms of “promptness”, “coverage” and “reliability”, the level of information necessary for making decisions in disaster response has been set to five levels, from S to D. Figure 1 shows an example of the technological requirements for “Reliability”. These technological requirements have been improved by conducting a survey of road managers. Figures 2 and 3 show examples of the level of information needed by road managers in disaster response and the level of information grasped by various technologies in experimental trials. These evaluations help clarify which technologies to use and the technological goals to achieve. For example, in the case of disconnection optical fibers, the Reliability evaluation as a disaster prevention technology is “D”, which means it is difficult to utilize for making decisions as more detailed information is needed, but useful for initial response and wide area cooperation disaster response.

3. Future efforts and issues

In this research, we organized the technological requirements for disaster response in the road field, and constructed a framework for evaluating the suitability of information needed in disaster response and obtainable by various technologies. In the future, we will explore effective combinations of technologies and their utilization in other fields.

Fig-1 Example of technological requirements

Technological requirements (Reliability)	
S	Information confirmed by visual inspection in the field or information equal to it
A	Image information taken by cameras in the field or information equal to it
B	Information that makes it possible to roughly estimate the location and scale of damage
C	Information that makes it possible to roughly estimate the location and scale of damage
D	Information that makes it possible to identify that something unusual has happened

Fig-2 Evaluation of information level needed for decision-making in disaster response

Decision-making situation	Promptness	Coverage	Reliability
Estimate the scale of damage immediately after disaster occurrence and decide whether or not to establish an initial system and request wide regional cooperation.	S	S	D
Based on the damage information of all national roads, decide whether or not to close traffic in damaged areas and areas where secondary damage is possible.	B	A	S
Estimate the amount of work to restore areas where secondary damage is possible and determine the priority of road clearance.	D	D	S

Fig-3 Information level that can be grasped by various technologies

Technology	Features and characteristics	Promptness	Coverage	Reliability
UAV	Provides relatively high mobility compared to satellites and airplanes. Enables research from various angles and heights.	B	C	S
SAR imagery (Satellite)	Capable of wide area observations at night and in bad weather. Observation timing and area depends on satellite's orbit.	C	S	C
CCTV camera	Used for monitoring infrastructures in normal times and for detecting damage at the time of a disaster.	S	B	A
Disconnection of optical fiber	Immediately after the disaster, about few hundred meters discrepancy level 38000km in nationwide.	S	S	D

more information

1) 道路地震防災研究室HP

<http://www.nilim.go.jp/lab/rdg/>

Development of technologies to renovate facilities to ensure the health and safety of evacuees at evacuation shelters

(Research period: FY 2017-2019)

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Keywords: Evacuation shelter, health, safety, building facility

1. Introduction

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

The NILIM has been conducting research and development to respond to such issues since FY 2017. This article introduces the outline of the study, results of investigating actual situations at evacuation shelters under actual earthquake damage, and results of literature searches concerning problems.

2. Outline of the study

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

This fiscal year, three levels of target standards for the living environment, the level that is close to daily lives, the level that is about the same as past evacuation shelters, and the minimum level where serious health damage would not occur were organized using information collected concerning technologies of building facilities to respond to natural disasters by taking into consideration the promulgation status of facilities at schools that are

often used as evacuation shelters, as well as advantages and disadvantages of individual facilities. Figure 1 shows the image of target standard (draft).

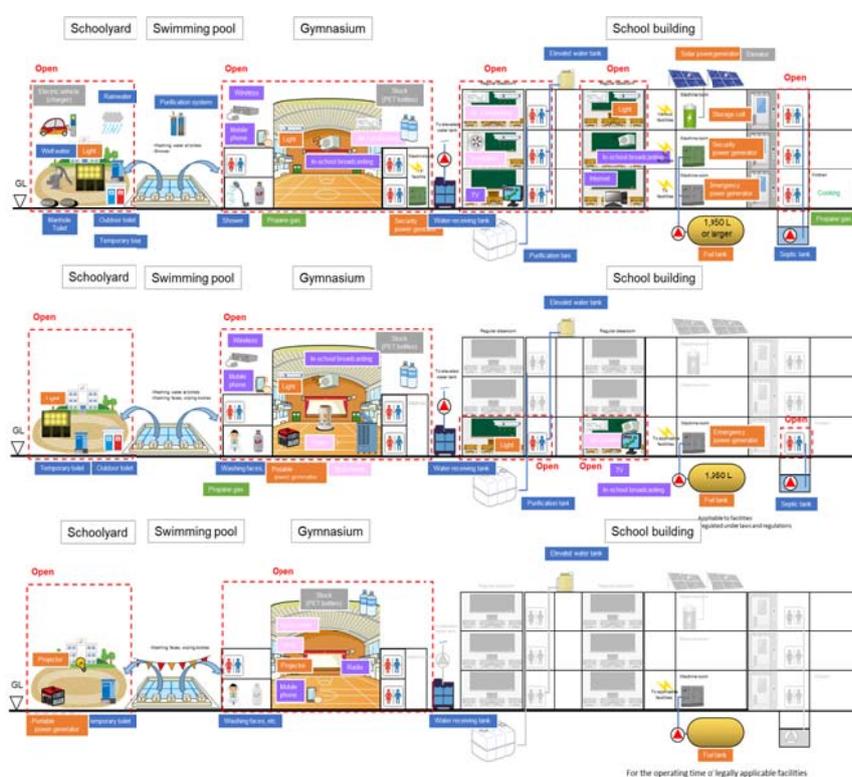


Figure 1 Image of the standard goal of the living environment at evacuation shelters (Top: the level that is close to daily lives, Middle: the level that is about the same as past cases, Bottom: the minimum level)

3. Future prospects

The NILIM is going to conduct hearings with officials of local governments concerning the adequacy of target standards and draft a manual concerning health measures for evacuation shelters. By taking into account the situations of individual local governments and expected natural disasters and reflecting the findings on natural disaster response manuals, it is possible to reduce health and mental damage during days spent in evacuation shelters.

Torsional response of ceilings during earthquake

(Research period: FY 2018-2019)

ISHIHARA Tadashi (Ph. D.) Head, Evaluation System Division, Building Department

Keywords: Rotation, diagram

1. Introduction

The ceiling standards under the Building Standards Act requires the arrangement of diagonal members in good balance to reduce the torsional response of the ceiling during earthquakes. Yet, the standards do not necessarily clarify the satisfactory levels and conditions of the balance, such as cases when the arrangement becomes unbalanced because of the relationship with facilities and devices like the case shown in Figure 1.

This study examines the torsional response of the ceiling during earthquake to clarify the condition of a well-balanced arrangement.

2. Outline of examinations conducted in FY 2018

First, diagram-based earthquake response evaluations and display methods were examined because torsional response is affected by multiple parameters and tends to become complicated. The diagram made it easier to estimate torsional response and interpret the results.

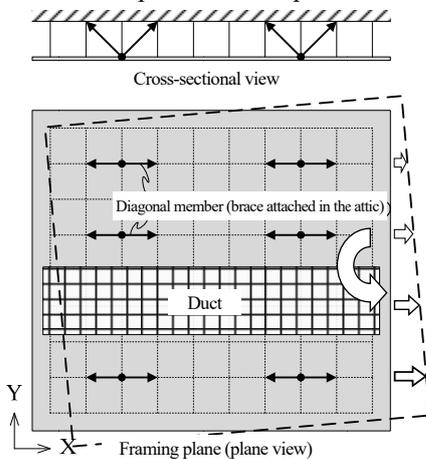


Figure 1 Torsional response of ceiling during earthquake (Top: Sectional view, Bottom: Framing plan)

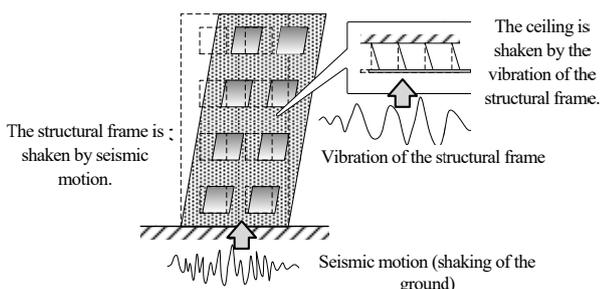
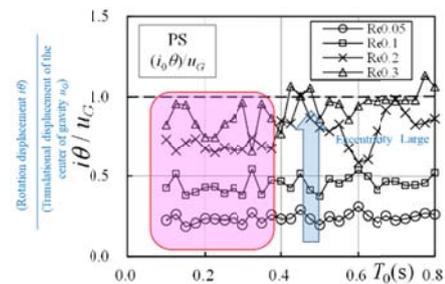


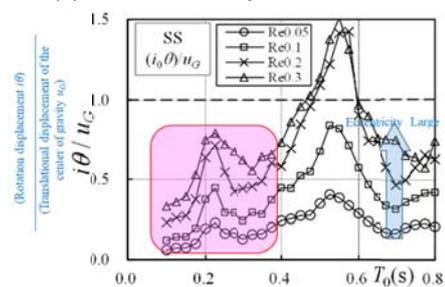
Figure 2 How the ceiling is shaken

Since the ceiling is attached to the structural frame, it is not shaken by seismic motion during an earthquake; rather, it is shaken by the vibration of the structural frame (Figure 2). To check these differences in the ways of being shaken, examinations were conducted while comparing vibrations caused by seismic motion and the vibrations caused by structural frames. As a result, the study found that the ratio between the torsional (rotational) displacement to the translational displacement of the center of gravity was smaller in the latter under a certain condition (Figure 3). This means that the torsional response hardly occurs in the ceiling.

Conditions of a well-balanced arrangement are going to be continuously clarified in the next fiscal year by repeating examinations.



(a) When shaken by seismic motion



(b) When shaken by the vibration of structural frame

Figure 3 Ratio of torsion (rotation) displacement

[symbol] i : rotation radius, θ : rotation angle, u_G : translational displacement of the center of gravity, T_0 : natural period without eccentricity, Re: eccentricity ratio

For more information:

1) Tadashi Ishihara: An observation concerning the torsional response during earthquake in secondary system: The 15th Japan Earthquake Engineering Symposium. December 2018

Survey of Houses Damaged by Quake, Sept. 28, 2018 Sulawesi-Indonesia

(Term: November 2018)

KOBAYASHI Hideyuki(Ph. D.), Researcher
Housing Planning Division, Housing Department

(Keywords) *MSRB, Precast, Bad job, Reinforcement*

1. Introduction

An M7.4 quake struck Central Sulawesi Province, Indonesia on September 28, 2018. The capital, Palu City, located on the moving fault sustained severe damage.

A tsunami destroyed the coastal zone, and liquefaction caused landslides damaging housing complexes. Most high-rise buildings collapsed.

NILIM surveyed the damaged houses and buildings between November 2-4 in order to support reconstruction.

2. Damaged buildings

Most detached low-rise houses survived within the city, even nearby the fault. Conversely, most high-rise hotels, hospitals, and shopping malls, which were constructed after 2006, collapsed.

As for damaged publicly operated rental houses, drawings were provided by the city, and we precisely checked the damage on-site (Figs. 1, 2).

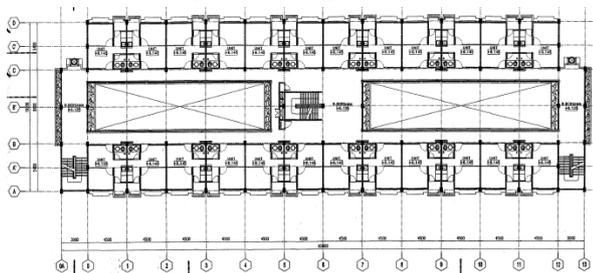


Fig. 1 Standard floor plan for MSRB of Palu

3. Review of past technical cooperation on the MSRB

The Building Research Institute under the Ministry of Construction provided technical cooperation to the Indonesian Research Institute for Human Settlement in the fields of quakeproof buildings and housing since the 1980s, including a project for developing Appropriate Technologies on MSRB (1993-98), which resulted in a proto-type design for the five-storied MSRB.

The damaged houses were based on the prototype through several outreach efforts for improvements by the Indonesian side, which included prefabrication. The houses were constructed through a national budget based on the technical standards provided by the Ministry of Public Works using stable pile foundations and precast columns, beams, and floor panels. The reinforcement bar was provided as part of the design, while construction



skills were seemingly poor (photo), especially the setting of the hoop bars, which caused displacement of the vertical bars (photo, Fig. 2).

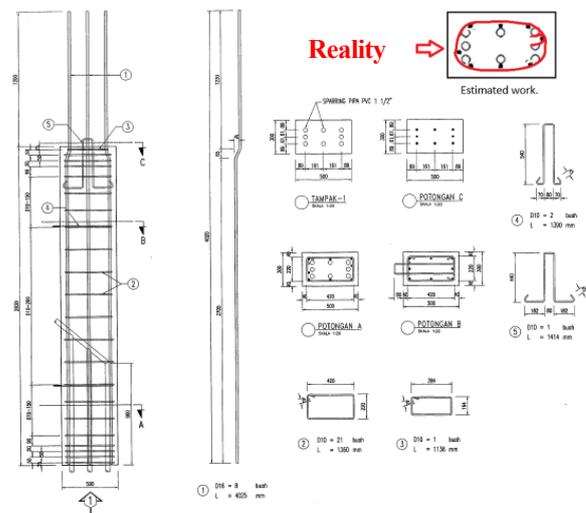


Fig. 2: Reinforcement of broken column

We sent the reports in English to the city and the Ministry of Public Works on Nov. 12. The next week, reconstruction of Lere MSRB was decided. NILIM is now providing 3D data of the buildings for structural analysis and an improved design.

1) Research Institute for Human Settlements,
Ministry of Public Works (Bandung)

<http://www.puskim.pu.go.id>

Now assisting in the reconstruction of houses in Lombok (June) and Sulawesi (Sept.).

Development of System for Detecting Damages by Earthquake Projected on CCTV Camera Images

(Research period: FY2014 to FY2018)

KONNO Arata, Researcher, ASHIYA Hideyuki, Research Coordinator for Advanced Information Technology, SEKIYA Hirotaka, Head, ITOUJI Toshiro, Senior Researcher, MORITA Kenji, Guest Research Engineer
Information Platform Division, Research Center for Infrastructure Management

Keywords: CCTV camera, damage grasping, image processing

1. Introduction

In the event of an earthquake, administrative organs concerned are required to grasp the situation of damage promptly. NILIM has been studying to support initial response in the event of an earthquake through detection of "changes" that may represent damage as differences by comparing images of CCTV (Closed Circuit Television) cameras installed at rivers, roads, etc. under the control of the Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") at ordinary times with those immediately after occurrence of the earthquake. This study is developing a system (the "System") that periodically collects images of CCTV cameras selected for the test at ordinary times and automatically collects images of same cameras installed near the epicenter immediately after receiving the earthquake information announced by the Meteorological Agency when an earthquake occurs.

Many algorithms for detecting differences are proposed but none of them has accuracy of 100%. In order to remove noise (e.g., moving cars), it is necessary to obtain several images from the cameras monitoring at fixed points in a certain time interval and statistically process them. For the specific method, refer to the previous report 1).

This paper describes a trial experiment of the System using the Integrated Disaster Information Mapping System (DiMAPS) of the MLIT.

2. Trial test using DiMAPS

DiMAPS is a GIS that can collect disaster information from the site and display it on the map clearly. Fig. 1 shows a screen that could be displayed as a result of the communication test conducted on February 8, 2019 between the System and DiMAPS. To display images created by the System, select the layer of "Damage images" on the right of the screen and then a list of thumbnail images of CCTV cameras that detected a "difference" on the System is posted on the bottom of the screen. Enlarged images as shown in Fig. 2 are available by selecting "Detailed screen" of the CCTV camera image that needs to be checked in detail. The System has a function to color the field in

red where a "change" that may represent damage was detected. In the example of Fig. 2, open burning at a distant location was detected from the river monitoring camera.



Fig. 1: DiMAPS screen after the communication test



Fig. 2: Example of the image created by the System

3. Conclusion

We are going to increase CCTV cameras available in the System and grasp issues in practice.

See the following for details.

1) "Method of Grasping Disaster Situations Using CCTV Cameras --- Verification of the Optimal Number of Images for Noise Rejection in Detection of Areas Damaged by Earthquake in the Background Differencing Technique," JACIC Information No. 119, Japan Construction Information Center, Vol. 33, No. 2, pp.19-24, 2019.

Improvement of the Probe Traffic Result Display System considering Large-Scale Disasters

(Research period: FY2018)

ITOUJI Toshiro, Senior Researcher, SEKIYA Hiroataka (Ph. D.), Head,
KONNO Arata, Researcher Information Platform Division, Research Center for Infrastructure Management

Keywords: probe, traffic result, ETC2.0, disaster, road traffic

1. Introduction

NILIM has developed a system for visually grasping traffic status (Fig. 1) by indicating traffic result using probe information provided from an ETC2.0 loading vehicles and private enterprises, traffic restriction information based on VICS, etc. on the same map in the overlapped state, and is studying on functional improvement, etc. through practical operation. Large scale disasters occurred in the current fiscal year, including the Northern Osaka Earthquake in June, Western Japan Heavy Rain in July, and Hokkaido Eastern Iburi Earthquake, and this system was used by Regional Development Bureaus for grasping traffic result and preparing "Passable Map." This paper studied mainly on improvement of this system by grasping / analyzing the issues manifested in these disasters through hearings etc. This paper reports one of those issues.



Fig. 1: An example of indication of the traffic result display system

2. Issues recognized and response

(1) Traffic result is displayed even in closed sections.

The issue was made clear that traffic result is displayed even in a closed section since emergency vehicles for road management pass through the closed section. As a solution, since the number of emergency vehicles that travel through closed sections is very small, we have developed a program to add information on the number of traveling vehicles to the KML file generated from ETC2.0 probe information so that traffic result can be displayed only when exceeding a certain number of traveling vehicles.

(2) Difficulty in quick identification of road administrator

Since the existing system only classified road types into expressway and ordinary road, prompt identification of the competent road administrator was difficult when considering rescue operation or detour. Then, we developed a program to determine the road type from the information of DRM (Digital Road Map) to which ETC2.0 probe information is adsorbed so that road types can be classified into expressway, urban expressway, national highway, auxiliary national highway, principal local road, and prefectural road.

(3) Failure to display closed sections accurately

Since the existing system displayed the entire link as a closed section when it includes a closed section, on-site confusion occurred due to difference from actual regulation. Therefore, we developed a program to display only actual closed sections correctly based on detailed position information from VICS Center (Fig. 2).

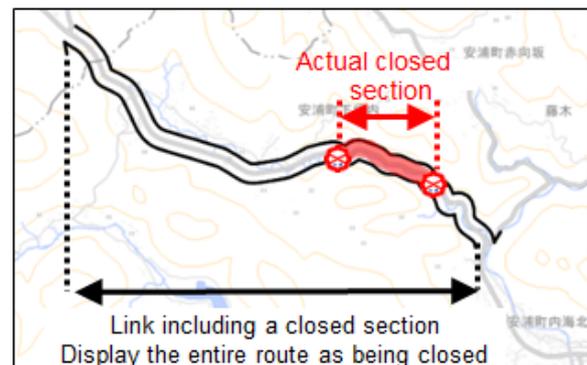


Fig. 2 Example of failure to display closed sections accurately

3. Future development

For other issues not reported herein, we developed some functions including reduction of update frequency from 1 hour to 15 minutes and additionally install them at the end of the current fiscal year.

Development of Design Techniques for Road Bridges to Minimize Effect of Ground Deformation

(Research period: FY2017 to FY2021)

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Keywords: ground deformation, damage control, bearing, loading test

1. Introduction

In the 2016 Kumamoto Earthquake, there was a case of delay in early recovery of the function because of damage to the main beam and other important parts of the bridge in



Fig. 1: Example of damage to the bridge bearing by the Kumamoto Earthquake

securing the serviceability of bridge (Fig. 1) as a result of slope collapse, ground displacement, etc. in addition to the shaking of the earthquake. From the lessons learned from this incident, Kumamoto Earthquake Recovery Division has been developing design techniques required to control breaking pattern in order to minimize the effect on functional recovery of the bridge even if the substructure of the bridge moves greatly due to slope collapse or ground displacement.

As a method of controlling breaking patterns in a bridge, this paper reports the status of study on design technique considering damage control focused on bearing and their fitting part.

2. Design concept of damage control type bearing

This study examines design techniques by determining in advance which part of bearing will be first destroyed in a condition where the bearing ultimately breaks and designing the part so that the breaking pattern is generated with a certain level of reliability. In this study, control of breaking pattern is conducted by providing a significant difference of strength (stratified strength) between members that cause bearing and other members.

3. Shear test of damage control type bearing

In order to check whether the damage control type bearing causes the breaking pattern as expected by design, a shear test of laminated rubber bearing, to which surface pressure was applied to a certain extent, was conducted. For the rubber bearing used in this test, lower-shoes fitting bolts were selected as a member causing breaking in consideration of the viewpoints of functional recovery performance, including smaller level difference at girder end caused

by breaking, certainty of damage control, and ease of replacement. Stratified strength was also designed so



(a) Damage control member

(b) Stratified strength

Fig. 2: Design concept of damage control type bearing



Fig. 3: Bearing shear test

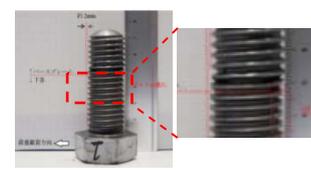


Fig. 4: Deformation of lower shoes fitting bolts

that when the shearing strain (horizontal displacement / height of the main unit of rubber bearing) of rubber bearing is 300%, lower shoes fitting bolts reach the final shearing stress but strength of over 1.3 times the stress is secured for members other than lower shoes fitting bolts (Fig. 2).

In the shear test, after conducting reversed cyclic loading at 4 stages until the shearing strain of rubber bearing reaches 300%, one-way loading was conducted until 350% considering as well safety of the test equipment used (Fig. 3). Since the test result showed that no breaking occurred at any part under the loading level of 350%, no breaking pattern could be confirmed. It was, however, confirmed that only the lower shoes fitting bolts, one of damage control members, deformed and the main unit of rubber bearing and other bolts had no damage (Fig. 4).

4. Conclusion

We intend to further study to improve damage control type bearing as required based on the test results.

Development of Estimation Method of Inner-Outer Water Integrated Inundation (Research period: FY2017 to FY2018)

Climate Change Adaptation Research Group

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YAMAMOTO Yoko, Senior Researcher, River Division, River Department

MATSUURA Tatsuro, Senior Researcher, Wastewater System Division, Water Quality Control Department

Keywords: river, sewerage, inundation estimation

1. Introduction

There are frequent occurrence of Heavy rains and flood disasters that we have never experienced. In order to implement disaster reduction measures in case of heavy rain / flood exceeding the scale of flood control facility improvement in cooperation with various local entities, it would be effective to share flood risk information (e.g., inundation estimation map) in communities and study / promote countermeasures. However, flood disaster risk information has been conventionally prepared according to each river and sewerage department and has been difficult to use for local residents, etc. For this reason, with the aim to provide easy-to-see risk information with excellent listing performance, we have developed an inundation estimation method with integration of floods from rivers and sewerage applied it to a model area on a trial basis, the results of which are introduced as follows.

2. Example of the past inundation estimation in model district

Figs. 1 and 2 show examples of inundation estimation conducted by river / sewerage departments in the model district.

3. Results of estimation of river-sewerage integrated inundation

Fig. 3 provides an example of the map for integrated estimation of inundation caused by river and sewerage floods. For the scale of rainfall, probability estimation was conducted based on the rainfall duration adopted in each past inundation estimation (river; 2 days, sewerage: 1 hour). Note that selection of maximum / median values according to the purpose of use is expected. In addition, storm surge was excluded from integration since evaluation of recurrence interval was difficult.

4. Conclusion

We intend to continue trial application to areas with different flood characteristics and study utilization method in cooperation with urban departments.

☞ See the following for details.

Technical Note of NILIM to be published

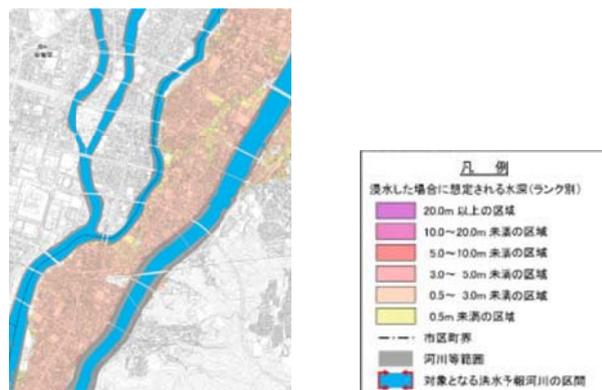


Fig. 1: Example of inundation estimation by flood from a river in the model area (2-day rainfall: about 400 mm: Probability scale: 1/200)

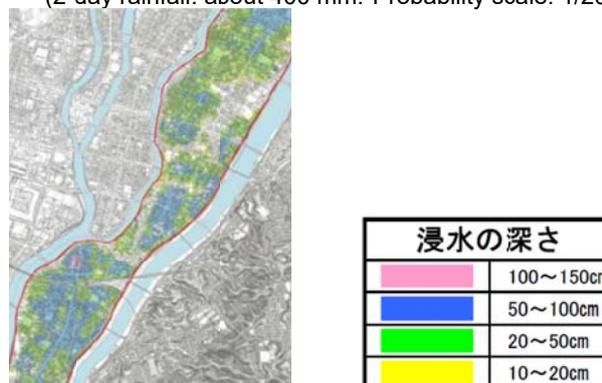


Fig. 2: Example of inundation estimation by flood from sewerage in the model area (Hourly rainfall: about 80 mm: Famous flood disaster rainfall)

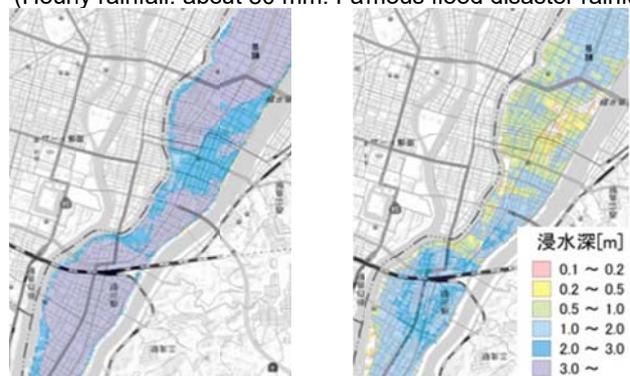


Fig. 3: Example of estimation of river- sewerage integrated inundation (Probability scale: 1/75, Left: Maximum value, Right: Median value)

Development of Technology for Collecting, Integrating, and Sharing Infrastructure Damage Information in Real-Time

Disaster Prevention and Reduction Research Committee
UEDA Akira, Research Coordinator for Land Management and Disaster Prevention
ASHIYA Hideyuki, Research Coordinator for Advanced Information Technology
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KONNO Arata, Researcher
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(key words) Disaster prevention and reduction, initial response, CCTV camera, SAR image

1. Introduction

Information on infrastructure damage is important towards making disaster response decisions. However, with large scale disasters and disasters that occur at night, collecting information is difficult and an information blackout period ensue. In order to collect information promptly and appropriately, the National Institute for Land and Infrastructure Management (NILIM) has since 2014 been developing technology to effectively use existing CCTV cameras and satellites to promptly grasp infrastructure damage, through the Cross-Ministerial Strategic Innovation Promotion Program (SIP).

Development reached the prototype stage and the technology was partially deployed in fiscal 2017. It began providing information to Regional Development Bureaus in fiscal 2018. In this report, the developed technology and situation as of fiscal 2018 are introduced.

2. Development of an initial disaster response support system

A system was developed with functions for estimating damage to road bridges and fills and determine risk of liquefaction, and automatically distributing information that enables the scale of infrastructure damage to be estimated, as well as a list of CCTV camera at the time of earthquake (Fig-1). This system is managed in a cloud environment. Users can access it via a web service, if issued a login ID and password. (IDs are issued only to persons concerned.) The automatic distribution function (Fig-1②③) does not require an ID and provides information to officials of related organizations who are in charge of disaster prevention, such as the eight Regional Development Bureaus in Japan. Moreover, the system was updated with functions for correlating seismic information

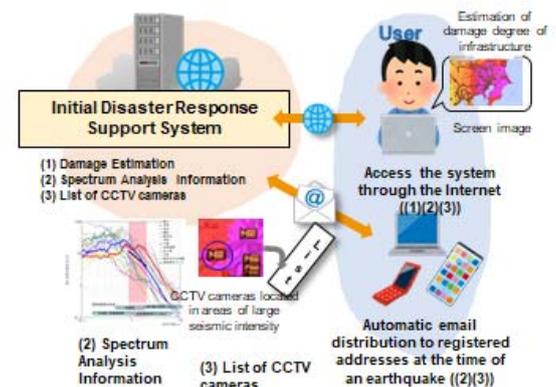


Fig-1 Illustrated view of initial disaster response support system



平成30年9月6日北海道胆振東部地震発生時の震度情報空白域 (青枠)
震度情報空白の行政界の補間 (隣接する行政界の震度のうち最も大きい値を採)

Fig-2 Updated system with list of CCTV cameras

blackout areas (Fig-2). In fiscal 2018, this system provided information that supported the disaster response following earthquakes in the northern part of Osaka Prefecture and Iburi, Hokkaido.

3. Damage detection by enhanced utilization of SAR imagery

To examine optimal ways to use SAR observation and

so forth, the initial survey conducted of the wide-area disaster and an algorithm and system for survey planning support were examined and developed. The algorithm was determined to comprehensively analyze the following conditions: the operating condition of the “sensor platform”; satellites and aircraft to be used at the time of disaster; the environmental conditions at the time of disaster such as time, weather, and the airports to be used; and prioritized items such as range and time. Based on the results of trial applications at Regional Development Bureaus that started in July 2018, this system was updated to enhance the usability and so forth.

To grasp the damage information promptly and accurately, a SAR image interpretation support system has been constructed. It has also been developed to interpret SAR image more efficiently, improve the operability of the system, reduce task processing time, and increase the processing speed.

NILIM has already used this system on a trial basis to monitor hillside collapse and other events immediately following disasters. In fact, results provided to MLIT after heavy rains in Western Japan in July 2018 were utilized in disaster response (Fig-3). Training for officials in charge of disaster prevention is carried out to advance nationwide efforts to introduce this system on a trial basis.

4. Damage detection by enhanced utilization of CCTV cameras

CCTV cameras have been installed to monitor infrastructure throughout the country by MLIT. At the time of a disaster, in order to rotate the cameras and confirm the surroundings, it is necessary to operate individual cameras manually. For this reason,

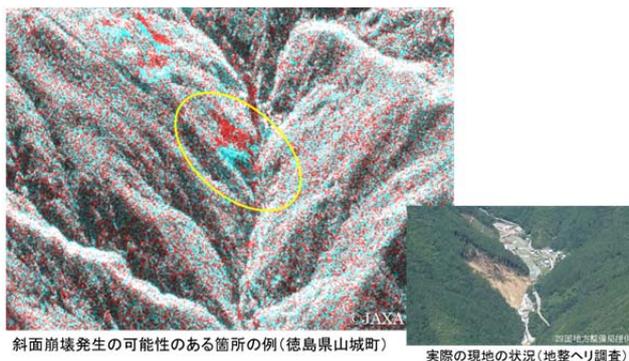


Fig-3 Prioritized locations for interpretation highlighted in red and blue in a SAR image (Fiscal 2018 heavy rain)

(1) a function that automatically rotates the CCTV cameras and captures a panoramic image and (2) an image measurement system were developed and are being tested.

(1) Test of camera panning system

Figure 4 shows a panoramic image captured by this

system. In this case, the situation across a wide area can be automatically visualized. In the future, a “Guideline for Introduction” is planned.



Fig-4 Panoramic image laid over the screen of DIMAPS (Sample image)

(2) Development and testing of an image measurement system

Technology that measures the width and height of an object on the screen from coordinate information by superimposing CCTV camera images on point cloud data was developed and is now in the prototype stage (Fig-5). This technology safely and promptly measures the damage scale by remote control without staff having to access the field. This technology was tested by using cameras in operation and surrounding data. In order to familiarize concerned persons with the system, a guideline for introduction was proposed.



Fig-5 Sample image from the image measurement system

5. Conclusion

The results of development has been managed and revised and make efforts to support disaster response after the end of SIP.

For more information

社会資本情報基盤研究室ウェブサイト

<http://www.nilim.go.jp/lab/qbg/index.htm>

土砂災害研究室ウェブサイト

<http://www.nilim.go.jp/lab/scg/index.htm>

道路地震防災研究室ウェブサイト

<http://www.nilim.go.jp/lab/rdg/>

Empirical Study on B-DASH Project (Technology to diagnose facility deterioration using ICT, Sewage treatment facility operation management with AI support) (Research period: from FY2015)

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keywords: sewerage, ICT, AI, operation management support, deterioration diagnosis, innovative technology

1. Introduction

In order to achieve cost reduction etc. in sewerage service by accelerating research and development and practical use of new technologies, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has been implementing the Breakthrough by Dynamic Approach in (B-DASH Project) since fiscal 2011 and the NILIM has been serving as an implementing organization of this empirical study. This paper introduces the outline of the technology for diagnosing sewage treatment works deterioration using ICT and the operation management supporting technology for labor-saving / automation of water treatment using AI (artificial intelligence) in view of the recent increase in the importance of facility management with stock management of sewage treatment works and the rising concern about the shortage of technical capabilities due to decrease in skilled engineers.

2. Technology to diagnose facility deterioration using ICT

(1) Empirical study on technologies for deterioration diagnosis and facility inspection by sensor continuous monitoring and cloud server concentration (Joint Research Organization of Swing Corporation and Sendai City) These technologies are used for upgrading the condition-based maintenance consisting of deterioration diagnosis technology and facility inspection technology, which analyze the data

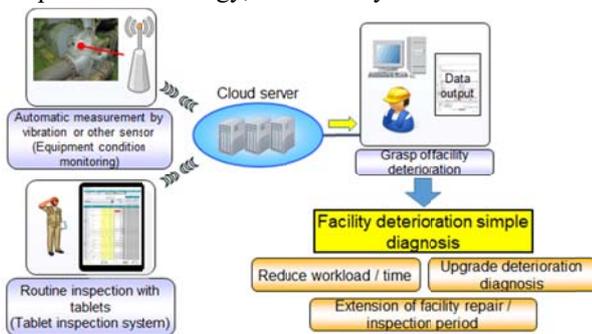


Fig. 1. Sensor continuous monitoring and cloud server concentration technique

obtained from continuous monitoring of the condition of facility using vibration sensors and the data obtained from daily inspection with tablet terminals, both of which are efficiently concentrated on the cloud server (See Fig. 1).

The empirical study aims to demonstrate the effective data extraction / analysis method for the deterioration diagnosis technology using the data collected in the cloud server, as well as the effect of workload reduction for the facility inspection technology using tablet terminals.

Use of these technologies is expected to contribute to reduction of maintenance cost in facility deterioration diagnosis, reduction of workload and time in routine facility inspection, and formulation of proper facility maintenance plan.

(2) Empirical study on technology for grasping / diagnosing deterioration of sewerage facilities by vibration diagnosis and big data analysis (Joint Research Organization of Water Agency, NEC, Asahi Kasei Engineering, Japan Sewage Works Agency, Moriya City, and Hidaka City) This technology is a combination of sensing technology and big data analysis technology and used to detect signs of abnormality and forecast deterioration by conducting an analysis (big data analysis technology) using continuous monitoring (sensing technology) data of rotating equipment using vibration sensors and a large amount of operation data

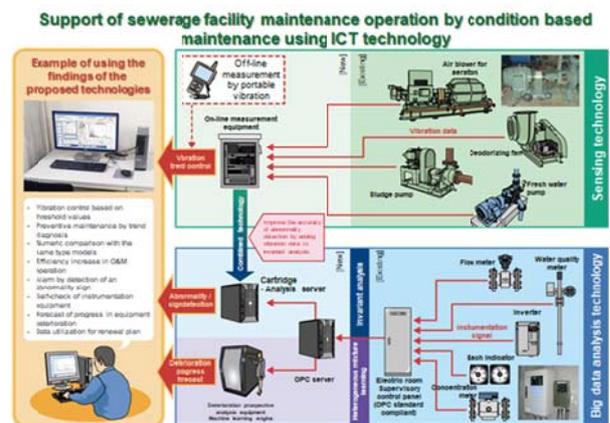


Fig. 2. Vibration diagnosis and big data analysis

in the facilities (See Fig. 2).

The empirical study aims to demonstrate (i) the equipment trend control and condition based maintenance using vibration data for the sensing technology and (ii) grasp of the sign of equipment abnormality and forecast of progress in deterioration using various types of operation data for the big data analysis technology.

Condition-based maintenance with these technologies is expected to lead to effective detection of equipment abnormality and to the effect of reducing maintenance cost.

3. Sewage treatment facility operation management with AI support

(1) Study on automation / labor-saving technology for sewage treatment facility operation with AI (Joint Research Organization of Meidensha Corp., NJS, and Hiroshima City)

With regard to AI technology for deducing automatic grasp of treatment condition, necessity for operation improvement, and response method using the historical data of sewage treatment facility operation, water quality data, image data of treatment condition, etc., this study examines verification of technical performance, possibility of automation and labor-saving, reliability for practical use, and introduction method (See Fig. 3).

This technology enables efficient operation according to treatment situations by judging operation status and treatment situation and providing necessary operation / response with operation / image processing AI and deducing causes of abnormality and response method with response & judgment AI when abnormality occurs, and is expected to be used as an operation management support technology that can solve the shortage of technological capability due to decrease in skilled engineers.

(2) Study on the technology using AI for supporting sewage treatment facility operation management (Joint Research Organization of YASKAWA Electric Corp., Maezawa Industries, Inc. and Japan Sewage Works Agency)

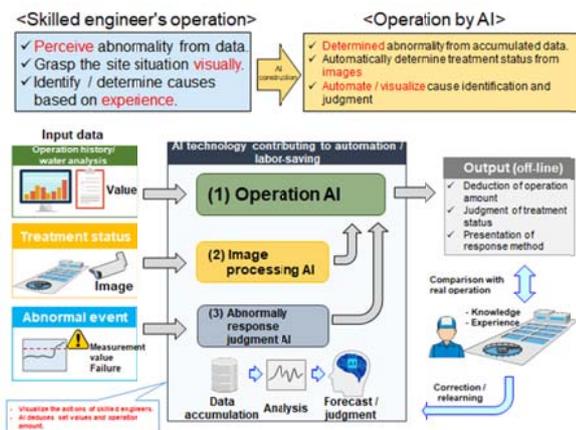


Fig. 3. Sewage treatment facility operation management with AI support

With regard to "Water treatment control support technology," which supports decision of the control set values for water treatment facilities using AI technology and "Image diagnosis technology," which supports decision of the state of activated sludge treatment, this study aims to check technical performance, etc. using operation control data and image data of actual facilities and examine the effect of introduction and possibility of dissemination (See Fig. 4).

Application of these constituent technologies to operation management of sewage treatment facilities is expected to improve efficiency / labor-saving in operation management and to contribute to realization of continuous operation management because transfer of technical know-how of skilled engineers, which has been an issue to solve, will be facilitated.

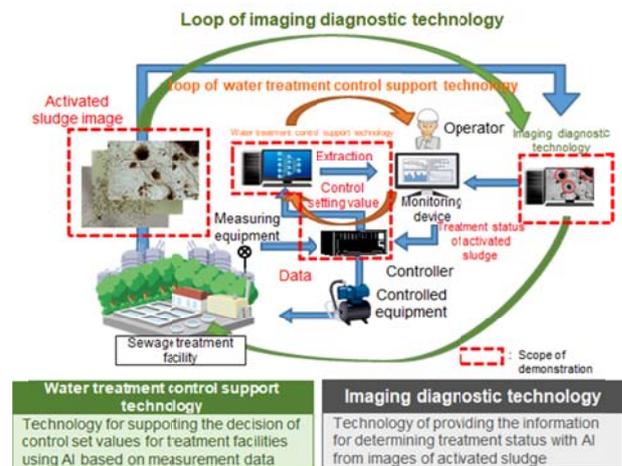


Fig. 4. Technology using AI for supporting sewage treatment facility operation management

4. Future development

NILIM continues to lead the B-DASH project and promotes dissemination of innovative technologies obtained from research findings. For the empirical study on the facility deterioration diagnosis technology using ICT and FS (feasibility) research on the sewage treatment facility operation management with AI support, we continue to collect data and organize them together with the data so far obtained. With dissemination and development of these technologies, we aim to contribute to reduction of sewage facility maintenance cost and improvement of productivity in the whole sewage works.

See the following for details.

[Reference] Website introducing B-DASH
<http://www.nilim.go.jp/lab/ecg/bdash/bdash.htm>

Challenge for Accuracy Improvement of Beach Deformation Prediction by Simulating Sand Movement in the Sea

(Research period: FY2017 to FY2019)

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Keywords: beach management, beach deformation prediction, amount of longshore drift sand, hydraulic model experiment

1. To management of beach

Since the Coast Act was revised in 1999, beaches may be designated as coastal protection facilities but have never been designated so far mainly because there is no clarified method to control beach, which changes the shape every day, as a facility. In order to break this situation, the Water and Disaster Management Bureau, Ministry of Land, Infrastructure, Transport and Tourism is discussing the introduction of beach management scheme by PDCA cycle (Cycle of the large frame in Fig. 1) in the "Round-table Conference on Disaster Prevention Community Development and Beach Maintenance" ("Round-table Conference"). The discussion encourages change of awareness from the conventional "maintenance / recovery of beach by facility development" to "permanent management of beach."

2. Utilization of beach deformation prediction in management scheme

In the management scheme, project promotion and maintenance on the site will be conducted in the "nested project group" that promotes DO as shown in Fig. 1. The nested project group includes projects and operations in various timings and spaces required to achieve objectives and plays important roles to activate the PDCA cycle.

In making judgment on management, review, etc. of the nested project group, survey results for each profile of periodic sounding are compared with the predicted shape of beach profile for the year prepared at planning. Calculation of the predicted shape of beach profile (predictive calculation of beach deformation) needs to cover the whole coastal region because it simulates changes in sediment balance and predicts for a period of tens of years.



Fig. 1: System of the management scheme

3. Improve the accuracy of beach deformation prediction from sand movement

For predictive calculation of beach deformation, the method of obtaining topographic changes from the balance of longshore drift sand passing each profile is generally used. Amount of longshore drift sand is calculated by the distribution formula of water depth direction obtained from the experiment, etc.

In order to improve the accuracy of this distribution formula, this study conducted a hydraulic model experiment considering multiple wave conditions and installation of artificial reef / pier. Movement of sand in the coast was quantitatively grasped from measurement of plane flow around the artificial reef, etc. and direct measurement of sand movement in coastal direction with drift sand trap. As shown in Fig. 2, the distribution type differs between the conventional formula and the experiment result. In addition, floating of sand by wave breaking according to wave conditions, wave run-up, and flow by artificial reef affect distribution of the amount of longshore drift sand. Grasping these from the experiment, we are updating the distribution formula of the amount of longshore drift sand.

See the following for details.

1) NOGUCHI Kenji et al., (2018), "Hydraulic Model Experiment on Changes in Longshore Drift Sand with Installation of Artificial Reef," Journal of Japan Society of Civil Engineers, B2 (Ocean Engineering), 2018, Vol. 74, No. 2, p. I_943-I_948.

https://doi.org/10.2208/kaigan.74.I_943

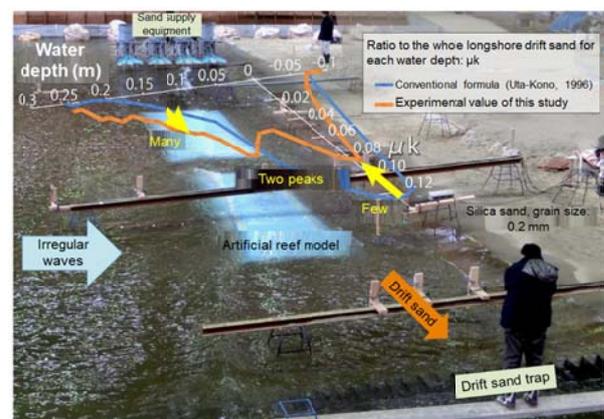


Fig. 2: Experiment condition and example of the longshore drift sand distribution in the water depth direction

New Evaluation Method of Dam Reservoir Sedimentation Countermeasures based on Estimation of Mid- to Long-term Effect and Cost

(Study period: from FY2017-FY2018)

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Keywords: dam, maintenance, reservoir sedimentation countermeasures, economic evaluation

1. Introduction

Dam reservoirs are normally designed to secure the required capacity considering the sedimentation estimated for 100 years in future. However, in the event of sedimentation exceeding such estimation due to change of raininess or other factors, study of countermeasures for sedimentation may be required in order to maintain the dam function over the long term. Then, we studied a new evaluation method for sedimentation countermeasures based on the mid- to long-term effect in flood control and estimation of countermeasure cost so that a reasonable countermeasure method may be selected from various countermeasure methods according to the characteristics of individual dam reservoirs.



Fig. 1: Example of sedimentation countermeasures (from the Guide to Dam Reservoir Sediment Management (Draft))

2. Estimation of mid- to long-term effect and cost

The concept of basic study on dam reservoir sedimentation countermeasures is provided in the Guide to Dam Reservoir Sediment Management (Draft) (2018, Ministry of Land, Infrastructure, Transport and Tourism (MLIT)). The Guide (Draft) states that economic evaluation should be conducted by comparing life cycle costs in selecting a countermeasure method, but does not provide specific methods for evaluation. For this reason, we studied the estimation method of mid- to long-term effect and cost for conducting reasonable evaluation from the viewpoint of economic efficiency in selecting superior countermeasure methods for individual dam reservoirs.

For effects, we decided to estimate the accumulated flood damage prevention (mitigation) benefit, which is lost when forecasting the progress of sedimentation over time when no countermeasures are taken, by applying the project evaluation method for dam projects. Cost was estimated from the sum of initial

cost of countermeasure facility construction and maintenance cost by listing general cost items for each countermeasure method based on past cases and organizing estimation methods.

For reference, Fig. 2 shows an example of estimation / comparison of long-term effects and costs for (i) Proposal for constructing a sediment bypass as drastic measure and (ii) Proposal for implementing sedimentation excavation / dredge continually in reference to past countermeasures in Japan (An example of calculating the effect and cost that are generated each year when scale of countermeasures is taken so that sedimentation is within the planned sedimentation capacity for 100 years after starting the countermeasures, as well as accumulated total of such effects and costs). Fig. 2 suggests that the effect of countermeasures is estimated to be greater as the evaluation period is taken longer and that the advantageous countermeasure method can vary according to the length of evaluation period due to difference in cost generation characteristics, such as ratio of initial cost to total cost.

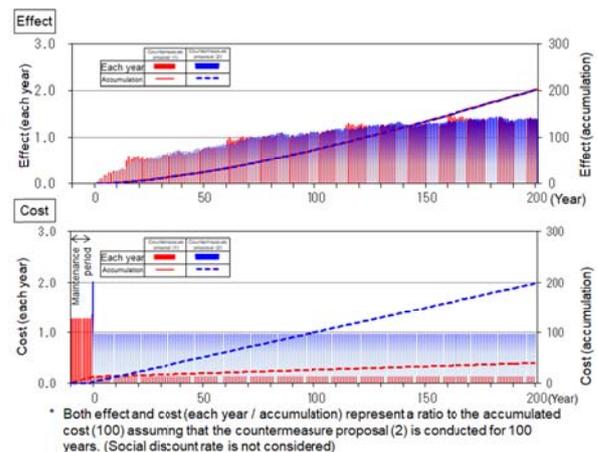


Fig. 2: Estimation of the effect of sedimentation countermeasures in flood control and countermeasure cost

3. Future development

We intend to organize study findings as engineering data. It is important to evaluate sedimentation countermeasure methods from a mid- to long-term viewpoint according to characteristics of individual dam reservoirs and we hope that our study will be helpful in considering reasonable countermeasure methods.

Development and Implementation of the Performance Evaluation Method of Nondestructive Testing Techniques

(Research period: FY2018 to FY2019)

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 Bridge and Structures Division, Road Structures Department

Keywords: nondestructive examination, concrete structures, performance evaluation, new technology, table of specifications

1. Introduction

Non-destructive inspection is effective as a method for detecting damage that cannot be directly checked by visual inspection, such as truss material and fixed part of anchor. However, non-destructive test techniques includes various inspection principles and devices, terms of application, etc. and detailed structure, surface condition, etc. of test objects are different, all of which affect detection accuracy and error characteristics. For this reason, users need to select a technology that meets their purpose and site conditions, after understanding the characteristics of various nondestructive testing techniques. It is also important to reflect the above in interpretation of results obtained (Fig. 1).

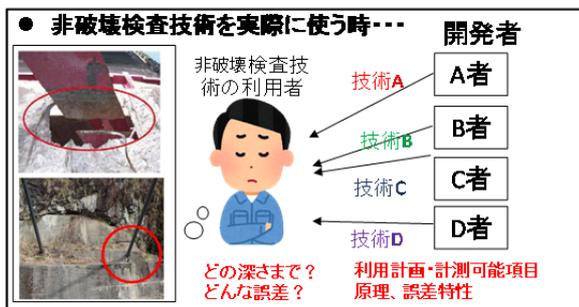


Fig. 1 Relationship between users and techniques

NILIM conducted a joint research from FY2013 to FY2014 with 19 parties from industry and academia using concrete structures with regard to the test method for performance evaluation of nondestructive testing techniques and indication of test results and summarized results, which were reflected in some of "Theme setting types (public solicitation for technology)" of the FY2018 new technology utilization system. Then, this paper introduces the outline of joint research performance and examples of reflection.

2. Outline of joint research performance

In this joint research, we obtained a methodology for evaluating basic performance (by detectable damage type, measurement limit thickness, depth, etc.), applicability, workability, etc. concerning the nondestructive testing techniques for internal damage in concrete structures. There are two points. The first

one is that we verified the effectiveness of conducting a step-by-step test according to the depth / size of damage and the complexity of inner / outer surface structure in order to clarify various principles and technical characteristics. The second is that we verified the effectiveness of indicating performance so that error characteristics are clarified under various conditions, such as change in error characteristics according to the depth / size of the relevant damage.

The concept of a step-by-step test is summarized in Fig. 2. Test results are only examples of measurement with certain examples / conditions. Therefore, since performance of each technology should be provided by the developer, we decided to clarify the relevant damage, indicators to be obtained, technology use conditions, and error characteristics

under use conditions. This is Step 1. The following shows that applicable conditions and error characteristics under each condition could be clarified by conducting a step-by-step test, such as a test (Step 4) using specimens (Step 2) in which types of simulating inner damage are limited and inner bar arrangement etc. are simple or specimens that have complicated bar arrangement like actual one or of which surface material has deteriorated due to aging. In addition, measurement is always accompanied with errors. Accordingly, users need to know this before they interpret test results. Fig. 3 provides an example of the scatter diagram showing how measurement



Fig. 2: Test flow

error at damaged position will change when the depth of damage changes. Then, simple indicators, such as "right or wrong," cannot represent the principles / characteristics for each device, but if the relationship between changes in the parameter likely to be related to measurement errors and changes in errors are clarified as shown in Figure, it would become possible to choose test techniques from various viewpoints, such as those with a wide scope of application even with large errors.

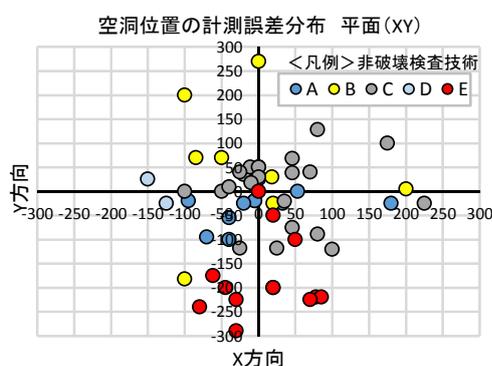


Fig. 3: Example of test result indication

3. Example of reflection (Activities of Regional Development Bureaus and utilization of Technical Note of NILIM,)

"Theme setting type (public solicitation for technology)" of the FY2018 new technology utilization system is conducted in order to accelerate on-site introduction and evaluation of new technologies by using / evaluating technologies publicly solicited in response to technical needs determined based on on-site needs. There are multiple projects of public solicitation for technology in FY2018, including "Technology for simply grasping corrosion in steel material, steel bar, etc." by Chubu Regional Development Bureau and "Technology for non-destructive detection of deformations under the post road surface boundary of road accessories" by Kanto Regional Development Bureau. Both projects aim to create a method of integrated indication of detection accuracy according to conditions and error characteristics regardless of types of technologies and technical data ("table of specifications") indicating the performance of various technologies using the method above so that various technologies are utilized according to their characteristics since non-destructive testing techniques include various inspection principles, devices, and terms of application. For study to this end, it is necessary to conduct public solicitation for technologies and organize the parameters given to the performance of each technology and examine the method of expressing error characteristics, etc. The solicitation projects above require implementation of a test using specimens and plan the provision of characteristics of each technology and implementation of a test under limited conditions, with respect to the factors that affect the performance of each technology,

such as inspection principles and detailed structure of target object, and its surface, and error characteristics related to them. These are based on the results that incorporated the findings obtained from the joint research by NILIM.

The table of specifications aims to organize clearly information necessary for users, including performance of each technology, scope of application, and use conditions, and NILIM is making discussions with each Regional Development Bureau so that it will be useful for users according to items and contents of preliminary survey.

4. Conclusion

For the public solicitation for technology conducted by Regional Development Bureaus, we intend to organize actual tests and the table of specifications from the end of FY2018 to the first half of FY2019. NILIM also intends to use the knowledge obtained from this public solicitation for technology and propose further improvement / enhancement of the performance evaluation method of nondestructive testing techniques and standardization of the performance test method.

Lastly, we'd like to express our gratitude to the persons concerned in the Chubu and Kanto Regional Development Bureaus with whom we are implementing the public solicitation together.

☞ See the following for details.

1) Technical Note of NILIM, No. 981

<http://www.nilim.go.jp/lab/bcg/siryou/tmn/tmn0981.htm>

2) MLIT's website: Results of public solicitation for opinions and public solicitation for technology concerning the performance requirements of the press release "Technology for simply grasping corrosion in steel material, steel bar, etc."

http://www.mlit.go.jp/report/press/kanbo08_hh_000517.html

3) MLIT's website: Results of public solicitation for opinions and public solicitation for technology concerning the performance requirements of the press release "Technology for non-destructive detection of deformations under the post road surface boundary of road accessories (traffic signs, lighting facilities, etc.)"

http://www.mlit.go.jp/report/press/kanbo08_hh_000543.html

Activities to Improve Reliability of and Streamline Periodic Inspection of Road Tunnels, Bridges, etc.

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Keywords: tunnel, bridge, periodic inspection, maintenance

1. Introduction

Obligation of periodic inspection once in five years was stipulated by law in 2014 with respect to about 10,000 tunnels, 700,000 bridges, etc. all over the country. In fiscal 2019, the second cycle of this periodic inspection started. The Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") updated the technical advice (periodic inspection procedure) and notified road administrators across the country in March 2019 in order to improve the reliability of periodic inspection and contribute to streamlining of inspection operations etc. using new technologies etc. Accordingly, NILIM analyzed the results of past periodic inspections etc. and the draft of revised version with the Road Bureau. This paper introduces an example of the study conducted by NILIM to improve the reliability of periodic inspections and streamline the inspection operations.

2. Study for improvement of reliability

In periodic inspection of tunnels and road bridges under national control, detailed conditions are recorded in addition to the data required by law in order to use inspection results for quality improvement and streamlining of the maintenance of road structures in the country. NILIM has been conducting various analyses using this record.

Fig. 1 shows the result of probability calculation as to what extent of damage occurs due to aging to the members of which condition was altered in repair / reinforcement and to the members standing since the beginning. In each year, red (e) represents the probability of damage being serious, and blue (a) represents the probability of damage remaining minor. Fig. 1 also shows increase in the probability of leading to serious damage according to the elapsed years. It is also found that there is a probability of serious damage even if the number of elapsed ears is relatively small. For the members repaired / reinforced, distribution of the degree of damage is inclined to blue (a) or red (e), unlike the members remaining since the beginning, which suggests the trend of being vulnerable to damage.

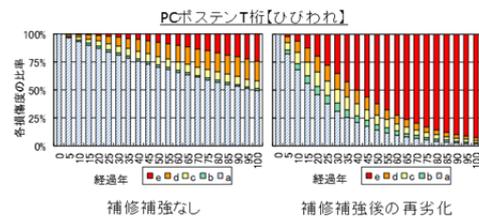


Fig. 1: Example of re-deterioration of the repaired / reinforced member

Fig. 2 shows results of the organization as to what extent of damage is caused to the member in next periodic inspection (5 years after) that had no or minor damage in the previous periodic inspection. It is found from this that even a sound member may have damage to some extent.

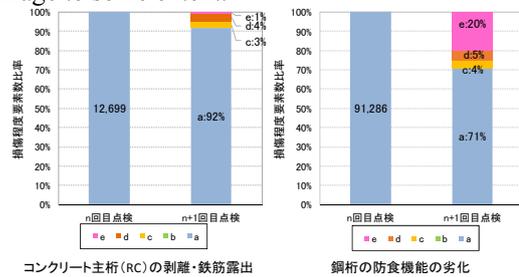


Fig. 2: Example of change in the element with "a" after five years

We conducted various analyses on other structures. For example, as a result of analyzing the spots of floating / peeling / exfoliation of concrete, which were confirmed in the tunnel periodic inspection, they were concentrated on the joint part at 65% and damaged part and repaired part at 34%, as shown in Fig. 3.

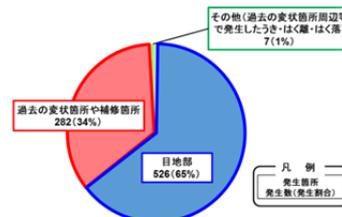


Fig. 3: Occurrence trend of floating / peeling / exfoliation

As known from the above, it was confirmed anew that periodic condition check is important to detect abnormality and carry out timely actions, without depending on the elapsed years or condition confirmed in the previous inspection. Further, including the above-mentioned results and the results of analyzing other various damages, technical considerations in grasping damages to tunnels, road bridges, etc. were improved. For example, from a viewpoint of preventing peeled concrete from falling onto road users etc. and causing injury, examples of the structure / part that requires focused inspection or that allows for labor saving, according to structural characteristics were improved.

3. Study for streamlining

It was also suggested from the aforementioned analysis of periodic inspection results that nondestructive inspection etc. are desirable in addition to short-range visual observation for some parts or damages and other method could be taken in some cases. It was also found from the examination of actual periodic inspection records by each road administrators that many road administrators have detailed record of conditions such as crack drawings and photos by typically classifying types and sizes of damages and are quantitatively recording their occurrence range etc. Accordingly, it is also important to maximize the effect of data accumulation by each administrator through streamlining of their work and utilization of their data.

Hence, it was decided in accordance with the scheduled renewal of technical advice to support the grasp of detailed condition and disseminate reference information for utilization of equipment etc. contributing to laborsaving in recording work. For example, in selecting equipment etc. on the site, it is desirable that the specifications and capability of various equipment etc. are indicated in a unified manner and can be compared and that errors etc. should be clarified for interpretation of results. Then, technical data providing the specifications and characteristics of machines in a unified manner was prepared for the equipment etc. that have been tried by the government. NILIM has conducted joint studies and proposed as findings the methods of grasping and indicating capabilities in using equipment etc. that support condition detection at narrow part, etc. (See Fig. 4). These proposals were referred to in indicating the specifications and capability of equipment etc.

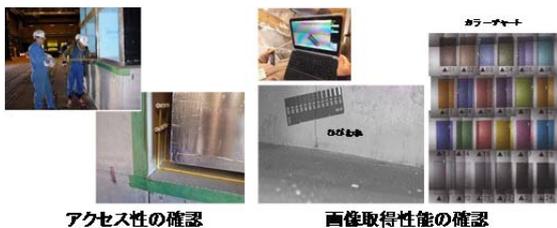


Fig. 4: Verification items for using supporting

equipment

It was also found that local governments often keep records, as symbols, of not only soundness diagnosis results but damages to each part of road bridge following the "Basic data collection procedure," which is one of the detailed damage recording methods. Then, NILIM has published deterioration curves (see Fig. 5) created from the data accumulated on national roads under control according to the types of members and damages for comparison with average aging of the road bridges under national control when the condition is recorded following the procedure above. These deterioration curves are expected to serve as reference when studying the priority of actions for a lot of structures that need preventive maintenance, e.g. by comparing the average trend of aging with the condition of the target structure.

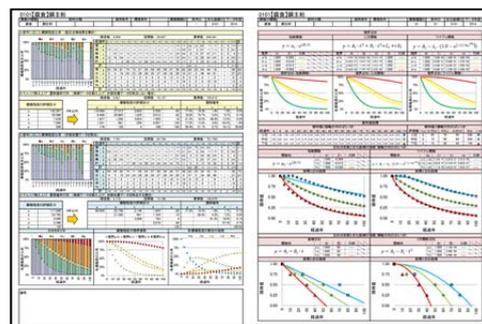


Fig. 5: Example of deterioration curves (corrosion of main girder)

4. Conclusion

The issues in repair / reinforcement design were also clarified from the results of periodic inspection. For repair / reinforcement, we intend to improve technical standards in turn since improvement thereof is urgently required.

☞ See the following for details.

- 1) Material for the 10th meeting of the Road Technology Subcommittee, 2) Technical Note of NILIM, No. 1030, 3) Technical Note of NILIM, No. 381, 4) 2018 NILIM Report "Analysis of deterioration characteristics of road bridges based on road bridge periodic inspection data", 5) 2019 NILIM Report "Development and Implementation of the Performance Evaluation Method of Nondestructive Testing Techniques"

A Study on Efficiency Increase in Road Management Using Point Group Data

(Research period: FY2018 to FY2019)

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Key words: point group data, MMS, road management, pothole

1. Introduction

For the purpose of speeding up the examination process for permitting the passage of oversize/overweight vehicles on roads, etc., the Ministry of Land, Infrastructure, Transport and Tourism (the "MLIT") has been collecting three-dimensional data on ordinary roads since August 2018, including roads managed by local governments, by installing sensing equipment in the road management vehicles of Regional Development Bureaus, etc.

In this study, in view of utilization of this data as well for upgrading and efficiency increase of road management, we assumed detection of potholes, which are frequently created, out of the items of "checking road surface deformation," use of which is highly needed by on-site offices, and conducted an experiment to clarify the relationship between traveling conditions, such as traveling position and speed at measurement, and detectable size.

2. Collection of 3D point group data

Based on the depth and size of potholes analyzed from the annual patrol log kept in the office, 15 types of potholes were created on the test course. 3D point group data was collected from the vehicle equipped with the sensing device (MMS-AT220) owned by the Kanto Regional Development Bureau, which run on the test course in 9 patterns, two times for each pattern, in combination of 3 patterns of traveling speed (20 km/h, 40 km/h, 60 km/h) and 3 patterns of traveling position (normal lane, adjacent lane, and opposite lane) were expected) (Fig. 1).

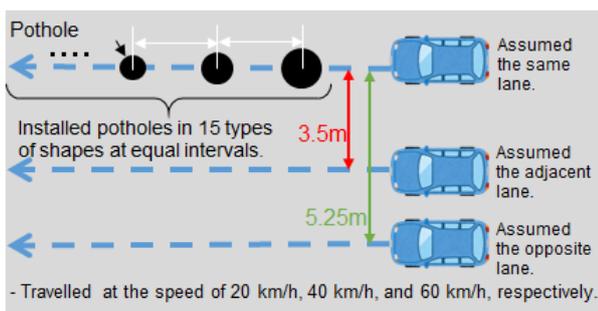


Fig. 1: Outline of the experiment

3. Analysis using pothole detection methods

Four types of methods (RANSAC, PCA (principal component analysis), scan line tracing, and point group density variation) were used for analysis, and parameters were adjusted to optimize the ratio of detection / misdetection of potholes for each method. Of these methods, when the RANSAC method was used, the optimum ratio of detections and misdetections in areas other than planted area was obtained when traveling on the same and adjacent lanes, although there was misdetection of planted area. Accordingly, as an example of analysis results using this method, Table 1 shows the results of detection of potholes in the shape specified in the same Table.

Table 1: Results of detection of mortar-shaped potholes, 20 cm in diameter and 5 cm in depth.

		Travelling position		
		Same lane (0 m)	Adjacent lane (3.5 m)	Opposite lane (5.25 m)
Traveling speed	20km/h	○	○	×
	40km/h	○	△	×
	60km/h	○	△	×

○ : Detected at both times △ : Detected once.
 × : Not detected.

The following knowledge was obtained: "Potholes on the same lane are detectable even in high speed traveling (60 km/h)", "It is necessary to travel at a low speed (20 km/h) to detect potholes on adjacent lane certainly", and "Potholes on the opposite lane cannot be detected even when traveling at a low speed (20 km/h)."

4. Future development

We intend to specify conditions for use by Regional Development Bureaus in road management by clarifying the relationship between traveling conditions and detectable size in the fields other than potholes, including detectable conditions based on the difference in the performance of sensing equipment (point group density) and slope deformation.

Promotion of Study on Maintenance of Social Capital

Maintenance Research Committee

SASAKI Masahiko, Research Coordinator for Construction Management, Research Center for Infrastructure Management

HASHIMOTO Toshikazu, Research Coordinator for Wastewater Energy Management and System Restoration, Water Quality Control Department

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Keywords: social capital, maintenance, sustainability, management

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") released the "Estimation of future maintenance / renewal cost of social capital in the fields under the control of the MLIT" in November 2018. In this release, long-term cost is expected to increase from 5.2 trillion yen in fiscal 2018 about 1.3 times in 20 years and 30 years, respectively, and to 7.1 trillion yen at maximum, about 1.4 times, in 26 years. This estimation is based on implementation of infrastructure maintenance in accordance with the concept of preventive maintenance, while much more increase is expected when based on the concept of breakdown maintenance. Accordingly, R&D activities are continuously required that contribute to realization of sustainable / effective infrastructure maintenance by improving efficiency such as active use of new technologies and data.

2. Maintenance research in NILIM

Under the aforementioned circumstances, in order to establish a maintenance cycle, the NILIM is promoting R&D of technologies for maintenance with attention to the viewpoint of management. NILIM is also working for information sharing among individual fields in order to contribute to solution of common issues in maintenance. In addition, the NILIM is promoting R&D for maintenance using the framework of the government's science and technology innovation policy, such as the Cross-ministerial Strategic Innovation Promotion Program ("SIP") and the Public/Private R&D Investment Strategic Expansion Program

(PRISM), as well as methods in cooperation with private sectors, such as the Breakthrough by Dynamic Approach in Sewage High Technology" (B-DASH) Project.

The table below shows policies in each field and activities based on the viewpoint of promoting maintenance cycle establishment.

3. Conclusion

While continuing to grasp on-site issues and needs and trend of up-to-date technologies, we intend to implement R&D activities on maintenance and technical guidance for site workers after reviewing existing study results and strive to transmit externally results, progress, etc. of R&D activities.

Table. Organization of activities in each field

Activity type	Maintenance related matters	Road	River	Sewerage	Housing / building
Policy	Legal stipulation etc.	<ul style="list-style-type: none"> Legal stipulation of inspections (Sep. 2013) Visual proximity inspection 	<ul style="list-style-type: none"> Legal stipulation of inspections (Dec. 2013) Inspection by visual inspection or other proper method 	<ul style="list-style-type: none"> Legal stipulation of inspections (Nov. 2015) Inspection by visual inspection or other proper method 	<ul style="list-style-type: none"> Revision of the periodic reporting system (Apr. 2018) Obligation of overall sounding and other examinations every 10 years from completion, outer wall repair, etc. in addition to conventional periodic examinations
Promotion of maintenance cycle establishment	Standard / manual development	<ul style="list-style-type: none"> Setting of soundness judgment types Formulation of periodic inspection procedures (road bridge, road tunnel, etc.) 	<ul style="list-style-type: none"> Setting of judgment standards for inspection result evaluation Revision of the inspection procedures for levees and other river management facilities and channels, and formulation of comprehensive dam inspection procedures 	<ul style="list-style-type: none"> Setting of judgment standards for inspection survey evaluation Revision of sewerage maintenance guidelines Formulation of B-DASH (Sewer Management System Technology) guidelines 	<ul style="list-style-type: none"> Tile outer wall / mortar finish outer wall diagnosis guidelines for preventing disasters by peeling off
	Inspection supporting technology development	<ul style="list-style-type: none"> Visual proximity inspection of road bridge Demonstration of robots etc. (Social infrastructure maintenance SIP, FY2014-FY2018) 	<ul style="list-style-type: none"> Demonstration of maintenance / inspection technology with 3D laser scanner and 3D multibeam scanning sonar and of robots etc. that efficiently conduct scouring grasp of river bed, and reconnaissance survey of river revetment (FY2014-FY2016, Social infrastructure maintenance SIP) 	<ul style="list-style-type: none"> Development of screening techniques for telecamera survey (FY2010-FY2012, comprehensive project) Research on required level of new type pipeline examination equipment (FY2013-FY2016, comprehensive project) Development of sewer pipe examination priority judgment system (FY2013-FY2016, comprehensive project) 	<ul style="list-style-type: none"> Developed the outer wall diagnostic equipment that automatically runs on walls (FY2010-FY2012, preventive maintenance comprehensive project) Study on rationalization of the wet outer wall examination method (Standard improvement / promotion project, FY2015-FY2016)
Actions	Maintenance	<ul style="list-style-type: none"> Implementation of bid contract method, etc. with technical proposal / negotiation responding to technical issues of construction works and repairs at scattered sites (MLIT) Development of an estimation method of maintenance / repair work cost responding to on-site conditions etc. (FY2013-FY2016, comprehensive project) 		<ul style="list-style-type: none"> Estimation material for sewerage control by organizations concerned (Sewerage Works Association, etc.) 	<ul style="list-style-type: none"> Development of information tools for prompting building owners / administrators to improve / repair outer walls (FY2013-FY2016, comprehensive project)
Record	Centralized control and utilization of information	<ul style="list-style-type: none"> Use of tablets in inspection, etc. Renewal / use of the data of national road bridge database, etc. (bridge specification information, inspection results) 	<ul style="list-style-type: none"> Use of tablets in inspection, etc. Renewal / use of the data of river maintenance database (RMDIS) Renewal / use of the data of dam maintenance database 	<ul style="list-style-type: none"> Use of tablets in inspection, etc. Engineering material preparation for accumulation and utilization of sewer pipeline information (FY2013-FY2016, comprehensive project) 	<ul style="list-style-type: none"> Engineering material preparation for creating electronic data and database of periodic reports (FY2013-FY2016, comprehensive project)
		<ul style="list-style-type: none"> Development of facility information collection / summarization technology (FY2013-FY2016, comprehensive project) 			

Source: Report on General Technology Development Project "Development of Technologies for Accumulating and Utilizing Information in Order to Streamline and Upgrade Maintenance of Social Capital" (modified in part)

Utilization of 3D Topographic Data in the River Field and Expected Effect

(Research period: from FY2017)

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Keywords: laser survey, 3D topographic data, levee inspection

1. Progress of surveying technology and utilization in the river field

At present, for inspection of river levees, two or more inspectors walk along the levee to find deformation in the levee surface, such as slope collapse or animal nests. This method, however, requires a lot of personnel and time, so that establishment of an effective and efficient inspection method is sought.

On the other hand, a remarkable technical progress is seen for laser surveying instrument, including improvement in survey accuracy and miniaturization of equipment. The following reports the result of applying 3D topographic data obtained with the laser surveying instrument to inspection of the river levees as an example of utilization in the river field.

2. Detection of deformation in levees using 3D topographic data

We tried to detect deformation in the levee of the Maruyama River, running through the north-eastern part of Hyogo Prefecture (right levee, 9.2 km -10.2 km) with the 3D topographic data obtained from an unmanned aerial vehicle equipped with a laser surveying instrument ("UAV laser") and a large weeder ("weeder laser"). Specifically, we prepared five types of maps from the obtained 3D topographic data, "Contour map", "Inclination map", "Gradient tints map", "Shade map", and "Underground openness map," which were all checked by 5 engineers who are skilled in levee inspection and have a qualification of river inspector or other to confirm whether any deformation as target of inspection could be read from them. As a result, the mapping method by which the maximum number of deformed spots was found out was the inclination map (Fig. 1). The inclination map represents the amount of tilt in the topography and was found to easily detect mole holes, gullies, subsidence, etc.

Fig. 2 shows the types and number of deformed spots that could be read from the inclination map above. Fig. 2 also provides, for comparison, the result of normal visual inspection. Deformation with long depth compared with area, e.g., mole holes, is often found, while deformation with short depth compared with area, e.g. temple roof slope (a slope that is steeper and bends more upward as closer to the top, like the roof of a temple) is difficult to detect since the amount of tilt does not greatly change.

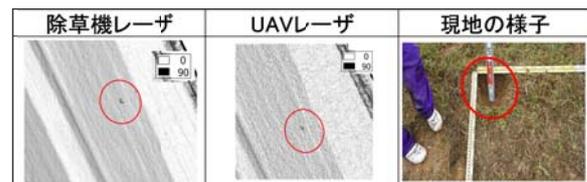


Fig. 1: Inclination map showing the periphery of deformed area and state of the site

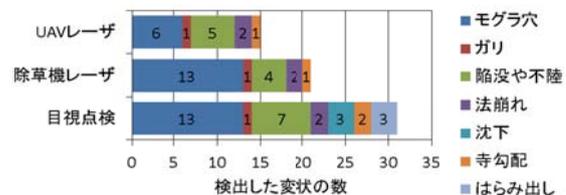


Fig. 2: Comparison of the result of interpreting the inclination map of deformation and the result of visual inspection

It was also found that the number of deformed spots detected was different in the weeder laser surveying because its survey score is about 100 times that UAV laser and enables creation of an inclination map representing small deformation.

3. Prospect of future utilization

The result of this study suggested the possibility that deformation of levees could be detected from the 3D topographic data. In order to use 3D topographic data for improving the efficiency of conventional inspection, further improvement in detection accuracy and detection of deformation without topographic changes, such as poor vegetation are required. We intend to continue the study including the possibility of technique for automatic detection of deformation in levees with machine learning of 3D topographic data.

See the following for details.

1) "River levee condition visualization technology", SAT TECHNOLOGY SHOWCASE 2019

http://www.science-academy.jp/showcase/18/pdf/P-081_showcase2019.pdf

Empirical Study on B-DASH Project (Practical use of methane collection with occlusion containers, Local production for local consumption type energy system, Global warming countermeasure type sludge combustion technology, Technology for improving sewage treatment capacity at low cost)

(Study period: from FY2015)

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Wastewater and Sludge Management Division, Water Quality Control Department

Keywords: sewerage, energy saving, cost reduction, greenhouse gas reduction, innovative technology

1. Introduction

In order to promote energy saving and energy creation in sewerage, low-cost and efficient innovative technologies need to be developed. Accordingly, the Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") has been promoting the "Breakthrough by Dynamic Approach in Sewage High Technology" (B-DASH) project since fiscal 2011 in order to realize cost reduction, creation of renewable energy, etc. in sewerage projects through acceleration of R&D and practical use of innovative technologies and to support overseas development of the water business by Japanese enterprises. In addition, National Institute for Land and Infrastructure Management (NILIM) has been studying innovative technologies as a commissioned research in the B-DASH Project. This paper outlines (i) "Empirical study on the technology for practical use of collection with methane refiner and occlusion container," which was adopted in fiscal 2015 as real-scale demonstration, (ii) Empirical study for practical use of the technology using local production for local consumption type energy with high-efficiency digestion system, "which was adopted in fiscal 2017 as real-scale demonstration, (iii) Empirical study on the generation type sludge combustion technology considering greenhouse gas reduction, and (iv) Empirical study on the technology for improving the treatment capacity of final settling tank.

2. Outline of real-scale demonstration technologies

(1) Empirical study on the technology for practical use of collection with methane refiner and occlusion container

(Joint Research Organization of JNC Engineering Co., Ltd., Adsorption Technology Industries Ltd., Kyudenko Corp., Sinko Co., Ltd., Yamaga City Gas Co., Ltd., Prefectural University of Kumamoto, Otsu-cho, Mashiki-cho and Yamaga-shi)

In order to conduct stable gas purification and power generation stable throughout the year, demonstration is proceeding for the technology of power generation

from surplus biogas that is generated, purified, and stored into occlusion containers at multiple small-and-medium-size sewage treatment facilities, and then transported by vehicles for concentration at one location.

Introduction of this technology is expected to promote effective use of sewage resources in small-and-medium-size sewage treatment facilities, reduction of maintenance cost by energy creation, etc.

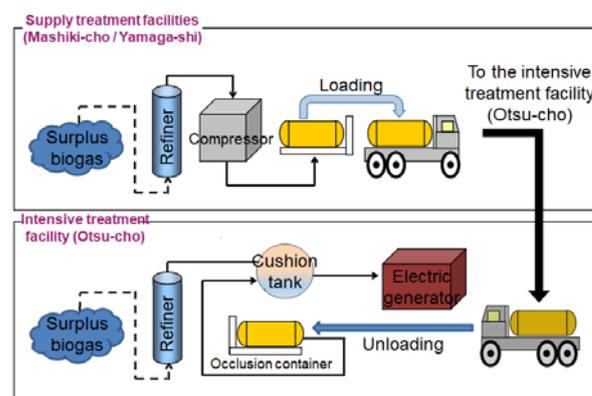


Fig. 1: Outline of the technology on practical collection using methane refiner and occlusion container

(2) Empirical study for practical use of the technology using local production for local consumption type energy with high-efficiency digestion system (Joint Research Organization of Mitsubishi Kakoki Kaisha, Ltd., Kyushu University, Japan Sewage Works Agency, and Karatsu-shi)

In order to verify stable digester operation, increase in gas yield, etc., demonstration is proceeding for the highly efficient digestion system technology developed in combination of utilization of unused biomass such as kitchen garbage, non-powered digester stirring equipment, sludge solubilization equipment to increase biogas generation, and a fuel cell that generates power with high generation efficiency using biogas.

Introduction of this technology is expected to reduce

sludge disposal cost due to concentrated treatment and to improve energy self-sufficiency rate in sewage treatment facilities.

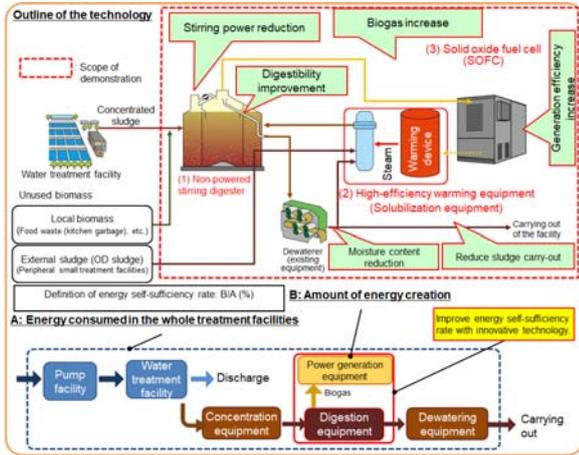


Fig. 2: Outline of technology for empirical study for practical use of the technology using local production for local consumption type energy with high-efficiency digestion system

(3) Empirical study on the generation type sludge combustion technology considering greenhouse gas reduction, and

(Joint Research Organization of JFE Engineering Corp., Japan Sewage Works Agency, and Kawasaki City)

This empirical study aims to demonstrate the effect of improvement in power generation against heat input and the effect of reducing NOx / N2O emissions for the system technology in combination of the high-efficiency power generation technology utilizing unused waste heat from the sludge incinerator and the local stirring air blowing technology that reduces NOx / N2O emissions and is applicable to existing sludge incinerators (fluidized bed).

Introduction of this technology is expected to improve power self-sufficiency rate and greatly reduce greenhouse gas emissions in sewage facilities.

(4) Empirical study on the technology for improving the treatment capacity of final settling tank

(Joint Research Organization of Metawater Co., Ltd., Japan Sewage Works Agency, and Matsumoto City)

Demonstration for checking the stability and the cost reduction effect of effluent quality is conducted using the existing final settling tank frame about the technology which ["which is improved quantitatively or qualitatively"] * make processing capacity at low cost by installation of a filtration part, without extending a final settling tank.

Introduction of this technology is expected to realize low-cost and efficient renewal of equipment in sewage

treatment facilities that are insufficient in treatment capacity and need to renew its equipment as well as stable water treatment when flow rate increased due to integration / abolition etc.

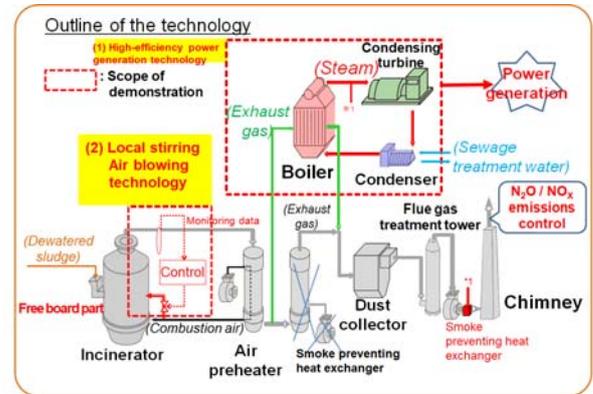


Fig. 3: Outline of the generation type sludge combustion technology considering greenhouse gas reduction

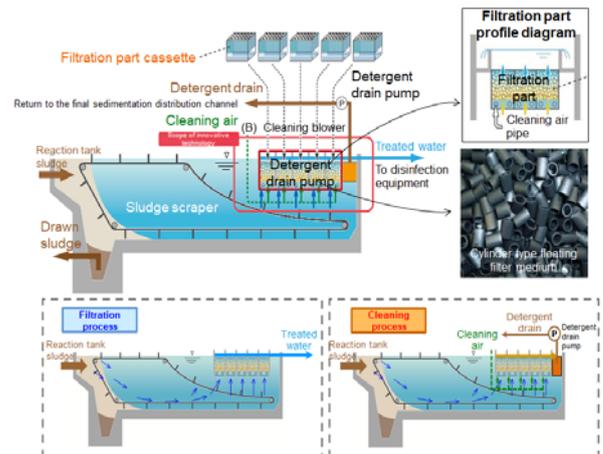


Fig 4: Outline of the technology for improving the treatment capacity of final settling tanks

* Quantitative improvement:

Water treatment in a volume twice the estimated daily max sewage flow without degrading the quality of treated water.

Qualitative improvement:

Water treatment to quality similar to rapid filtration water in estimated daily max sewage flow.

3. Future development

We have generally confirmed the effects for the four technologies introduced above.

NILIM is going to formulate guidelines for considering introduction of technologies based on study results, and promote dissemination and development of the guidelines.

See the following for details.

[Reference] Website introducing B-DASH
<http://www.nilim.go.jp/lab/ecg/bdash/bdash.htm>

Empirical Study on B-DASH Project (high efficiency resource energy utilization, low-cost / energy-saving high concentration methane fermentation, sewage treatment facility management cycle) (Research period: from FY2018)

TAJIMA Atsushi, Head, OHTA Taichi, Senior Researcher, YAMOTO Takatoshi, Researcher, AWATA Takanori (Ph. D.), Researcher, SATO Takuya, Guest Research Engineer, Wastewater and Sludge Management Division, Water Quality Control Department

Keywords: sewerage, resource energy utilization, methane fermentation, sewage treatment facility management, innovative technology

1. Introduction

In order to promote energy saving and energy creation in sewerage, low-cost and efficient innovative technologies need to be developed. Accordingly, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has been promoting the "Breakthrough by Dynamic Approach in Sewage High Technology" (B-DASH) project since fiscal 2011 in order to realize cost reduction, creation of renewable energy, etc. in sewerage projects through acceleration of R&D and practical use of innovative technologies. In addition, National Institute for Land and Infrastructure Management (NILIM) has been studying innovative technologies as a commissioned research in the B-DASH Project. We also started to study further three technologies in fiscal 2018. This paper introduces the outline of three studies that started in fiscal 2018 ---"Empirical study on efficient energy utilization technology by high concentration digestion / energy-saving biogas purification", "Empirical study on low-cost / energy-saved high concentration methane fermentation technology for small sewage treatment facilities," and "Empirical study on continuous stock management realization system technology based on maintenance and using cloud service."

2. Empirical study on efficient energy utilization technology by high concentration digestion / energy-saving biogas purification (Joint research organization of Kobelco Eco-Solutions Co., Ltd., Japan Sewage Works Agency, and Fuji City)

Introduction of biogas utilization technology is not proceeding in small- to medium-sized sewage treatment facilities because initial investment (construction cost) is large for introduction and their personnel and finance are insufficient. This empirical study aims to demonstrate that improvement in operational stability and effect of cost saving are obtained through installation / operation /

measurement of real-size facilities from the efficient energy recovery technology by high purity gas purification, biogas use, etc. (energy recovery technology for middle-scale treatment facilities). Specifically, real-size facilities are installed for the efficient energy recovery / utilization system from sewage sludge by combining a compact digester, low-powered biogas purifier in order to verify small hydrogen production / feeding equipment, and digestion performance, biogas purification performance, hydrogen production performance, and maintainability. Introduction of this technology is expected to reduce total cost (construction cost per year + maintenance cost) and improve energy recovery rate by low-powered and efficient supply of high purity biogas and biogas-derived hydrogen.

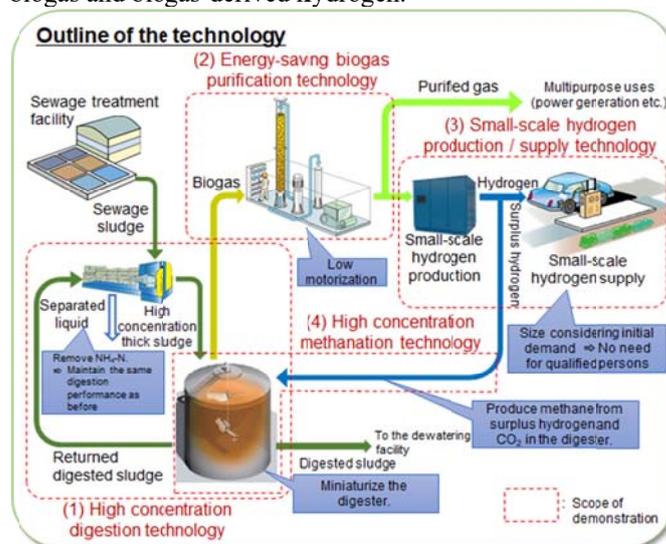


Fig-1: Outline of the efficient energy utilization technology by high concentration digestion / energy-saving biogas purification

3. Low-cost / energy-saved high concentration methane fermentation technology for small sewage treatment facilities (Joint research organization of Ohara

Corporation, Nishihara Environment, NJS, Nagaoka University of Technology, Hokkaido University, and Nagaoka City)

Small- and medium-sized sewage treatment facilities are faced with the issue of low rate of energy recovery due to little progress in introduction of digesters, which is attributable to the lack of economy of scale, large initial investment (construction cost), etc. This empirical study aims to demonstrate that improvement in operational stability and effect of cost saving are obtained through installation / operation / measurement of real-size facilities from the efficient energy recovery technology by high purity gas purification, biogas use, etc. (energy recovery technology for small-scale treatment facilities). Specifically, demonstration facilities in almost real size are installed to verify digestion performance, concentration at the time of concentration operation, dewaterability at the time of dewatering operation, maintainability at the time of both operation, and performance of biogas power generation concerning the technology to reduce sludge / recover gas by conducting high concentration digestion of high concentration thick sludge, obtained from two-tier use of dehydrator as concentrator, in a unitized compact horizontal digester.

Introduction of this technology is expected to bring reduced total cost (construction cost per year + maintenance cost), stable treatment, improvement in digestion efficiency, etc.

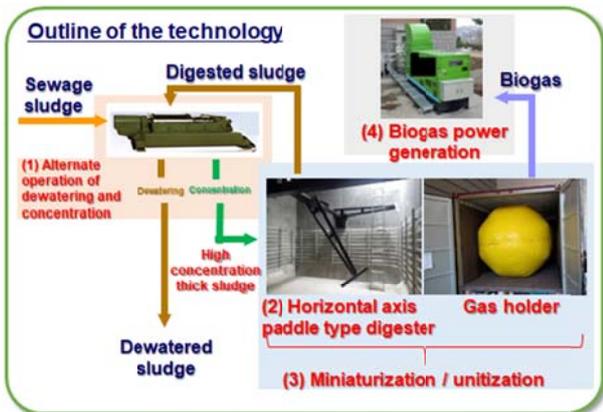


Fig-2: Outline of the low-cost / energy-saved high concentration methane fermentation technology for small sewage treatment facilities

4. Empirical study on sustainable stock management realization system technology based on maintenance and using cloud service (Joint research organization of Metawater Co., Ltd., Ikeda City, and Ena City)

Since many sewerage systems need to be renewed in the near future, it is required to practice effective stock management. However, local governments are faced with the issue that deterioration of equipment is not reflected in the stock management plan because information concerning facility management is not integrally collected / summarized. This empirical study demonstrates the technology for efficient sewerage system (treatment facilities / pump station) management using ICT, which contributes to efficiency increase of stock management, aiming to realize proper and sustainable management of deteriorating sewerage system. Specifically, the study aims to verify cost leveling by optimal maintenance, possibility of wide-area / joint management of sewerage service, business profitability, and cost effectiveness by introducing a system for conducting sustainable stock management into actual sewerage treatment facilities through integral control of maintenance data in cloud service and continual implementation of soundness evaluation. Realization of efficient stock management, etc. is expected from introduction of this technology.

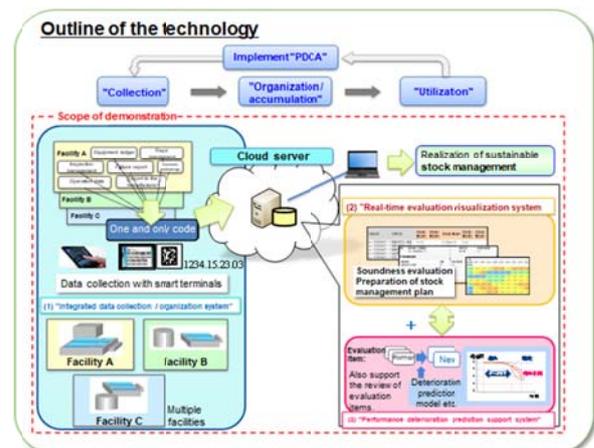


Fig-3: Outline of the continuous stock management realization system technology based on maintenance and using cloud service

5. Future development

For the three technologies introduced herein, we intend to continue empirical study in fiscal 2019 to verify operation performance, service profitability, etc. In addition, the NILIM continues to lead the B-DASH project and aims to contribute to cost reduction and productivity improvement in sewerage service by promoting dissemination of innovative technologies.

See the following for details.

[Reference] Website introducing B-DASH <http://www.nilim.go.jp/lab/ecg/bdash/bdash.htm>

A Study on B-DASH Project (sewage sludge intra-regional circulation system, energy-saving sewage advanced treatment, volume reduction of excess sludge)

(Research period: from FY2017)

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Wastewater and Sludge Management Division, Water Quality Control Department

Keywords: sewerage, energy saving, resource saving, cost reduction, greenhouse gas, innovative technology

1. Introduction

Sewerage is a social capital essential to public life and measures for reducing greenhouse gases are also sought as response to the issues of global warming. In addition, there is increasing expectation for effective use of sewage resources as sewage sludge was introduced in the Productivity Revolution Project as "Japan's original resource that can be used variously, such as biogas and sludge fuel."

For this reason, the Sewerage and Waste Water Management Department of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) launched the "Breakthrough by Dynamic Approach in Sewage High Technology" (B-DASH) project in fiscal 2011, and the Water Quality Control Department of NILIM serves as an executing agency of this empirical project. The objective of B-DASH is to realize cost reduction in sewerage projects, creation of renewable energy, etc. through the demonstration and dissemination of excellent innovative technologies and to support the overseas development of the water business by Japanese enterprises.

In the B-DASH Project, the NILIM has been implementing real-scale demonstration for technical verification by building real-size facilities and FS (feasibility survey) (, which had been called "Preliminary survey" until fiscal 2016,) as a preliminary stage of the real-scale demonstration in order to confirm the profitability and technical performance including introductory effect. This paper introduces the technical summary of FS survey adopted in fiscal 2017.

2. Outline of the FS survey adopted in fiscal 2017

(1) Technology for sewage sludge intra-regional circulation system

Outline of the research and study on the intra-regional circulation system centering on straw, high concentration mixture and thermophilic digestion of sewage sludge, and carbonization (Contractor: Joint Research Organization of Kanazawa University, Tottori University of Environmental Studies, Meiwa Industries, Ltd., and BIOGASLABO Co., Ltd.) Business profitability and technical performance are under verification for the intra-regional circulation system technology centering on high-concentration

thermophilic digestion by mixing straw in dewatered sludge and production of carbonized sludge fertilizer. Fig. 1 shows the flow of this technology.

The characteristics of this technology, including innovation, are as follows.

- 1) Downsizing and efficiency increase of facilities and reduction of sludge generation by high concentration mixture and thermophilic digestion of sewage sludge using straw.
- 2) Increase of digester gas generation by straw treatment before swelling & softening
- 3) Promotion of intra-regional circulation of biomass using straw-mixed sludge as carbonization fertilizer.
- 4) Study of proper collecting/ complementing system considering usage of straw

(2) Energy-saving advanced sewage treatment technology

Outline of the study on the energy-saving advanced sewage treatment technology using anammox bacteria (Contractor: Joint Research Organization of Meidinesha Corp. and Kobe City)

In order to realize advanced treatment with energy used in the standard method, business profitability and technical performance are under verification for the technology for reducing total energy usage by removing nitrogen efficiently through treatment using anammox bacteria to reduce energy consumption and recovering energy from organic matter contained in sewage sludge more efficiently. Fig. 2 shows the flow of this technology.

The characteristics of this technology, including innovation, are as follows.

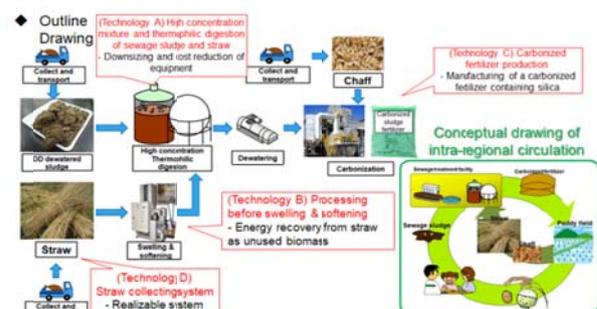


Fig. 1 Flow of the intra-regional circulation system technology

- 1) Power consumption reduction by highly efficient nitrogen treatment using anammox* bacteria
 * Anammox (anaerobic ammonium oxidation; anaerobic ammonia oxidation) reaction is one of the nitrogen gas conversion reactions of ammonia. Compared with the general nitrification denitrification process ($\text{NH}_4 \rightarrow \text{NO}_2 \rightarrow \text{NO}_3 \rightarrow \text{N}_2$), the process until ammonia is converted into nitrogen gas is shorter ($\text{NH}_4 \rightarrow \text{NO}_2 \rightarrow \text{N}_2$) and less oxygen is required.
- 2) Improvement of the energy recovery rate by extracting much organic matter in sewage and increasing digester gas with the organic matter sludge adsorption treatment*, which applied the oxidative dissolution reaction of organic matter by activity sludge
 * In the oxidative dissolution reaction caused by aeration, i.e., "(i) Adsorption of organic matter onto the surface of activated sludge" → "(ii) Intake of organic matter into activated sludge" → "(iii) Oxidation of an organic matter," treatment of remaining at (i) adsorption above by controlling retention time.

(3) Technology for excess sludge volume reduction
 Outline of the study on the volume reduction technology for excess sludge in the advanced treatment by introducing high-pressure jet equipment (Contractor: Joint Research Organization of Tokyo University of Agriculture and Technology, Ishigaki Company, Ltd., and Public Works Research Institute)
 The effect of reducing the production of excess sludge and oxygen supply is under verification and business profitability is under evaluation by introducing high-pressure jet equipment that reduces excess sludge at low cost into the flocculant addition / nitrified liquid circulation activated sludge system. Fig. 3 shows the flow of this technology.
 The characteristics of this technology, including innovation, are as follows.

- 1) Effect of crushing microbial cells in activated sludge using the crushing / shearing / collision effect of high-pressure jet equipment. (Sludge volume reduction is possible with lower cost and higher efficiency than conventional technology)
- 2) Aeration assist effect from the return of sludge generated by jet with detailed air bubbles attached, into the aeration tank. (Expectation for reducing aeration power cost)

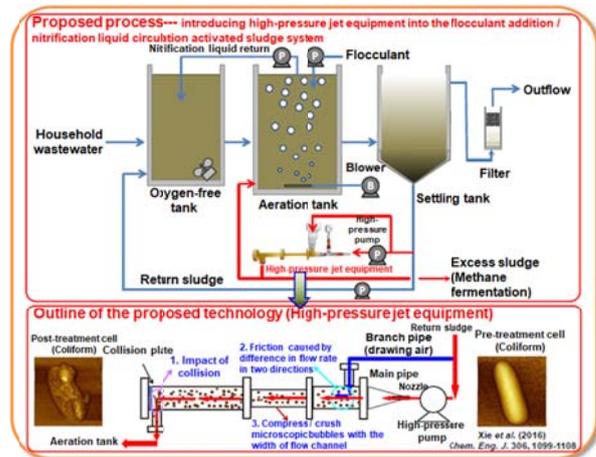


Fig. 3 Flow of the excess sludge volume reduction technology

4. Future development

Studies on the three technologies above were finished in fiscal 2018 but the NILIM is going to continue to lead the FS survey and identify the possibility of dissemination and technical performance including the possibility of theme setting as real-scale verification technology.

See the following for details.

[Reference] Website introducing B-DASH
<http://www.nilim.go.jp/lab/ecg/bdash/bdash.htm>

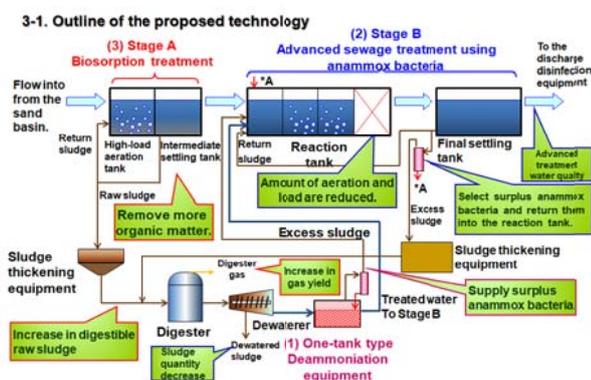


Fig. 2 Flow of the energy-saving advanced sewage treatment technology

Formulation of B-DASH Project Guidelines (Sludge drying technologies, Water treatment technologies [Waste sludge reduction type and water volume variation responsive type])

(Research period: FY2016 to FY2017)

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Keywords: effective use of sewage resources, use as fertilizer / fuel, waste sludge reduction, depopulation

1. Introduction

Sewerage is an essential social capital for the life of citizens, and as response to the global warming and tight supply of resources / energy, effective use of sewage resource is required. Sewage sludge is introduced in the Productivity Revolution Project as "Japan's original resource that can be used variously, such as biogas and sludge fuel, due mainly to the recent technical progress, although it had been disposed of as waste to be used for landfill, etc." In addition, the New Sewerage Vision Acceleration Strategy (August 2017, Sewerage and Sewage Purification Department, Ministry of Land, Infrastructure, Transport and Tourism (MLIT)) has placed importance on the promotion of development of water treatment technologies that can flexibly respond to changes in social situations including depopulation.

Development of new technologies considering such social demand and administration needs is going on but many sewerage service providers are prudent in introduction because of little performance. For this reason, the Sewerage and Sewage Purification Department, Water and Disaster Management Bureau, MLIT, launched the "Breakthrough by Dynamic Approach in Sewage High Technology" (B-DASH) project in fiscal 2011, and the Water Quality Control Department of NILIM serves as an executing agency of this empirical project. The purpose of this project is to demonstrate excellent and innovative technologies, formulate guidelines for introducing them, and disseminate them in order to realize cost reduction in sewerage service, creation of renewable energy, etc.

3. Outline of the guidelines

Guidelines were formulated for each technology based on the results of the empirical study and opinions of local governments and evaluated by experts. The proposed structure of guidelines is as follows (Table 1). The following sections introduce part of the contents of guidelines, including outline of demonstrated technology.

Table 1. Structure of proposed guidelines

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

3. Outline of demonstrated technology, etc.

(1) Highly efficient sewage sludge drying technology with self-heat recuperative heat pump
 A sludge drying technology for collecting / using the vapor latent heat in the sludge drying exhaust gas by incorporating the dryer into the heat pump cycle for integration. With this technology, it is possible to dry sludge with reduced energy and use the dried sludge generated as fertilizer or fuel. This technology is expected to be introduced into small and-medium-sized treatment facilities etc. considering renewal of dryers and promote the effective use of sewage resources (Fig. 1).

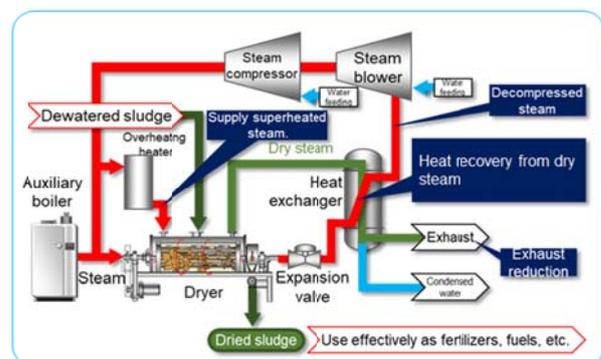


Fig. 1. Outline of the technology

(2) Technology to convert sewage sludge to fertilizers / fuels with the dewatering drying system
 This technology is a combination of the inside double coagulation type centrifugal dehydrator, which discharges low-adhesion granular dewatered sludge, and the annular flash dryer, which adjusts moisture content of dried sludge by adjusting hot blast temperature. In addition to the drying of sludge with reduced energy, this technology enables the use of dried sludge generated as fertilizer, fuel, etc. according to demand season etc. by adjusting moisture content widely (10-50%). This technology is expected to be introduced into small and-medium-sized treatment facilities etc. considering renewal of dehydrators and dryer and to promote the effective use of sewage resources (Fig. 2).

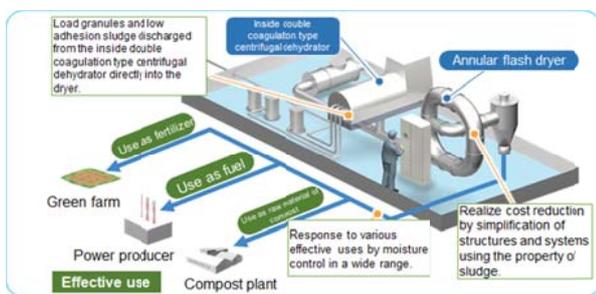


Fig. 2. Outline of the technology

(3) Water treatment technology with excess sludge reduction using special fiber carrier
 This is a water treatment technology to conduct aerobic treatment by installing a multistage type special fiber carrier unit in the treatment tank to hold microorganisms in the unit. Adoption of multistage treatment causes habitat segregation of microorganisms from upstream to downstream of the reaction tank, i.e. "bacteria → protozoa → metazoa," as well as food chain, and thereby controls the generation of excess sludge. This technology can be used for reaction tanks with existing oxidation ditch process and is expected to be introduced into small to medium-sized municipalities where the process above is applicable and to reduce total treatment cost as a result of reduced sludge treatment cost.

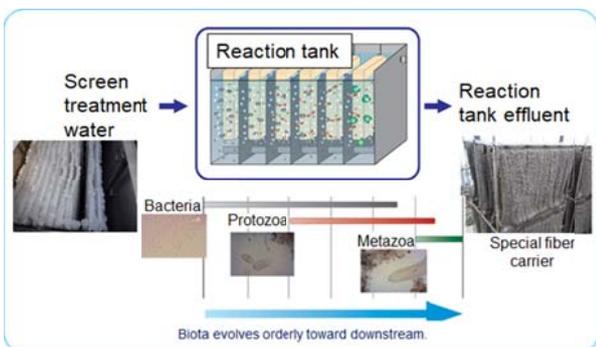


Fig. 3. Outline of the technology

(4) Water treatment technology responsive to water volume variation using DHS system
 This water treatment technology consists of "primary settling tank", "filter bed filled up with spongy carrier (DHS filter bed)", and "biofilm filtration facility." With this technology, it is possible to reduce the number of units on DHS filter bed and the amount of filling carriers in accordance with decrease in influent quantity, which leads to reduction of construction cost at the time of water treatment facility renewal and maintenance cost. It is also possible to use existing reaction tanks with conventional activated sludge process for cost reduction. The technology is expected to be introduced into small to medium-sized municipalities where influent quantity is expected to decrease as a water treatment technology responsive to changes social situations including depopulation (Fig. 4).

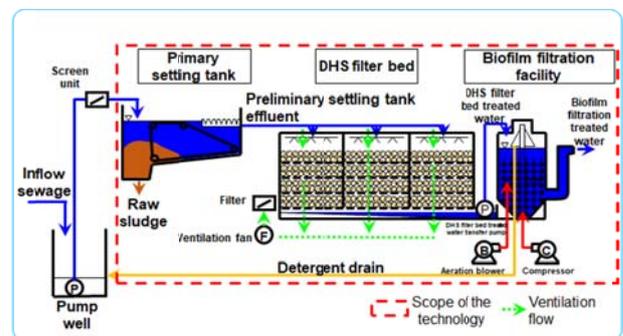


Fig. 4. Outline of the technology

4. Utilization of findings and future development

NILIM formulated guidelines based on results of empirical studies and held the guideline presentation meeting in the Kitakyushu International Conference Center in July 2018 to introduce them to local governments, sewerage related companies, etc., attended by more than 60 persons. We intend to introduce the guidelines actively through presentation meeting etc. and continue to strive for dissemination of innovative technologies.



Photo: Guidelines Presentation Meeting

See the following for details.

[Reference] Guidelines posted:
<http://www.nilim.go.jp/lab/ecg/bdash/bdash.htm>

OD Traffic Volume Inverse Estimation Method Development of Hourly Variation Coefficient Model

(Research period: FY2018 to FY2020)

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Keywords: traffic survey, OD traffic volume inverse estimation, traffic network analysis, road traffic census

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") conducts a research to grasp one-day OD traffic volume ("census OD survey") once in five years in general. On the other hand, to study congestion control measures and road traffic measures responding to emergent events such as accidents or disasters, it is desired to be able to grasp OD traffic volume according to days and time zones. As a means for estimating the daily OD traffic volume from the daily observation link traffic volume constantly observed with the device, the daily model of OD traffic volume inverse estimation method has been developed. In this study, proposal of an hourly variation coefficient model, verification of the applicability to actual area, and improvement of the method were conducted as a method of grasping OD traffic volume according to time zones, which was developed from the daily model.

2. Proposal and verification of the hourly variation coefficient model

Fig. 1 shows the estimation flow of the hourly variation coefficient model of the OD traffic volume inverse estimation method. Specifically, hourly variation coefficient is estimated using the hourly link traffic volume obtained from the results of census, daily OD traffic volume, and hourly observation link traffic volume constantly observed with the devices on the road.

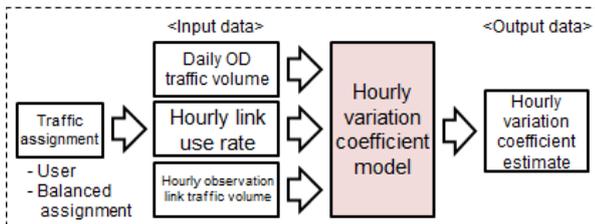


Fig. 1: Flow of hourly variation coefficient model estimation

First, in the Kinki Region, five patterns were set from the hourly variation trend of OD traffic volume and applicability of the model was verified for each pattern. Of the five patterns, Fig. 2 shows the results concerning the ODs located in Osaka-fu and part of Hyogo-ken ((Kobe, South Hanshin, and North Hanshin) ("OD within Hanshin area")). Comparison

of the estimated values and the Census values showed that the former had small hourly variations and a deviation from actual traffic condition. This would be because classification of OD traffic volume into 5 patterns complicated the distribution of OD traffic volume among the patterns within the same time zone and unreasonable estimated values were likely to arise, while the hourly variation trend could be reflected according to each OD.

3. Improvement and verification of the model

In order to clear the cause of this problem, the model equation was added with a term to consider the hourly OD traffic volume of the census OD survey results ("Term of census prior information"). The ratio of weight of existing terms and the term of census prior information" was set using the weight coefficient α . Of the results of applicability verification of the improved model, Fig. 2 shows OD within Hanshin area. Compared with the model before improvement, the hourly variation coefficient closer to the census value was estimated, which shows the effectiveness of the improved model.

4. Conclusion

The influence of weight coefficient on the estimation results in the improved model is different according to each pattern of OD traffic volume. Aiming to develop application of the model across the country, we intend to continue the study on the method of setting proper weight coefficient.

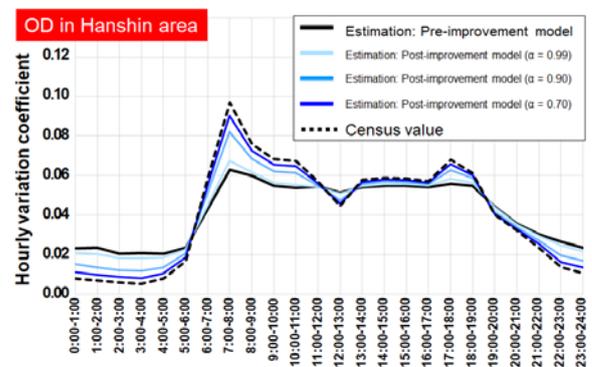


Fig. 2: Results of hourly variation coefficient estimation

Traffic Volume Measurement Technology using AI

(Research period: FY2016 to FY2018)

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SETOSHITA Shinsuke, Head, Road Division, Road Traffic Department

Keywords: AI, traffic volume measurement, constant observation, image analysis

1. Introduction

In recent Japan, big data can be collected efficiently thanks to the progress of ICT, and advanced image analysis has also become possible due to the progress of AI (artificial intelligence) technology. In response to the progress of such technologies, the Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") installed "Workshop on new road traffic survey system using ICT"¹⁾ in October 2018 aiming at shift from "Survey system focused on vehicles based on the road traffic census to be conducted once in five years" to "Survey system based on constant observation, whether at ordinary times or the time of disaster, using ICT in full scale.

In realization of this new road traffic survey system, the traffic volume measurement using monitoring camera (CCTV) images for road management and AI is considered an effective means since it enables the use of existing equipment and is expected to be applied to measurement of pedestrians etc. other than cars. Then, the Road Division conducted a trend survey to six companies developing traffic volume measurement technology using AI in order to grasp the current level of domestic technology for traffic volume measurement using images and AI.

2. Trend of traffic volume measurement technology using AI

The traffic volume measurement technology using AI discussed in this paper is a technology using the vehicle detection function based on deep learning. With this technology, AI, which has learned the characteristics of moving objects (cars, pedestrians, etc.) caught in various directions, recognizes moving objects with images in road space and measures their traffic volumes.

This trend survey was conducted on measurable moving objects and accuracy in each company as of the end of 2018. Table 1 shows the outline of survey results. As regards distinction of moving objects, it is possible to distinguish two vehicle types, small or large, and two-wheeled vehicles, while a system to distinguish pedestrians, bicycles, and motorbikes was developed only by a few companies ((1)(2)(3)). For accuracy of traffic volume measurement, high accuracy is obtained in the daytime but it is difficult to detect moving objects in the night time when there is no road lighting, etc. and only the area illuminated by car light is visible, and many of the companies above are unable to measure traffic (also impossible to

Table 1: Trend of the traffic volume measurement technology using AI (6 companies)

Item		Maximum performance	Minimum performance	Number of companies with a certain level of performance or more
(1) Vehicle type distinction	Daytime	7 type distinction Passenger car, van, SUV, light truck, midsize bus, large-size bus, large-size truck	2 types (small size / large size)	2 types Small size / large size measurement 6/6 companies
	Night time (with streetlight)	Indistinguishable	Indistinguishable	Small size / large size measurement 0/6 companies
	Night (without streetlight)			
(2) Pedestrian measurement		Possible to observe pedestrians (possible to measure vehicles simultaneously)	Unmeasurable	Impossible to measure pedestrians 5/6 companies
(3) Bicycle / motorbike measurement		Bicycle and motorbike are distinguishable.	Collective measurement as two-wheeled vehicle	Measurable / distinguishable 3/6 companies
(4) Measurement accuracy	Daytime	99%	90%	Accuracy of 95% or more 4/6 companies
	Night time (with streetlight)	99%	90%	Accuracy of 95% or more 3/6 companies
	Night (without streetlight)	80%	Unmeasurable	Accuracy of 80% or more 1/6 companies
(5) AI for each image Additional learning		Not required (Not mandatory)	Required	Not required: 2/6 companies
(8) Effect of rain / snow (weather) on measurement		Almost no effect	Not verified. (Accuracy is expected to fall)	Almost no effect 2/6 companies Not verified [4/6 companies]
(7) Other Matters affecting accuracy		- Overexposure due to direct projection of light to the camera lens. - Shielding of measurement objects due to overlap of vehicles		

distinguish car types)⁴⁾.

For images to be analyzed, various photographic areas are expected (according to height of cameras, depression angles, and other conditions). To secure high accuracy of traffic volume measurement in such environment, highly accurate vehicle detection ability using AI is required. To this end, many of the companies above need additional learning by AI about visual perception of moving objects according to the photographic areas of images to be analyzed ((5)). Effect of weather, including as rain and snow, has been verified by two companies, and it was confirmed that there is almost no effect on accuracy unless rain or snow falls on the lens ((6)). Additionally, it was confirmed that AI measurement is also difficult in a situation where recognition by observation is difficult, such as "overexposure" of images due to direct projection of vehicle light or sunlight to the lens (i.e., image turns all white) or continuous situation where the object of measurement cannot be recognized at all due to overlap of vehicles ((7)).

3. Conclusion

The present level of domestic technology with AI was found to have widely reached a practical stage for daytime measurement but have some problems for night time measurement. We are going to study to solve issues in night-time measurement, etc. for application of road traffic survey to practice.

[Detailed information]¹⁾ Workshop on new road traffic survey system using ICT

<http://www.mlit.go.jp/road/ir-ir-council/ict/index.html>

Analysis of the Effect of Improvement in Traffic Smoothness on Additional Passing Lanes using ETC2.0 Probe Information

(Research period: FY2016 to FY2018)

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Keywords: ETC2.0, additional passing lane, two-way two-lane road, traffic volume, smoothness improvement

1. Introduction

In Japan, the stage construction system has been widely adopted for efficient road maintenance, which temporarily uses two-way two-lane roads and changes them into four-lane roads according to increase in traffic volume. At present, two-way two-lane roads account for about 40% of expressways. On two-way two-lane roads, when the preceding car is traveling at a low speed, passing behaviors may be restricted and the state of following the preceding car may continue, which may impair smooth, safe, and comfortable driving.

The Government Order on Road Design Standards provides installation of an additional passing lane, if necessary, on a two-way two-lane road to provide a high service speed to road users. However, quantitative effect of such an additional passing lane has not been clarified.

Then, we analyzed the effect of improvement in traffic smoothness from installation of an additional passing lane according to traffic volume using ETC2.0 probe information.

2. Setting of analysis sections

In order to analyze the effect of improvement in traffic smoothness using traffic volume and speed data, we selected two sections where an additional passing lane was installed and annual average peak time traffic is different. Table provides the outline of the sections. For analysis, as shown in Fig. 1, a total of 9 sections were set by dividing each additional passing lane and the preceding and following lanes into three sections, respectively.

Table: Outline of the analysis sections

Section name	A	B
Lane extension (km)	1.3	1.1
Annual average peak time traffic (cars/h/lane)	414	840
Regulatory speed (km/h)	70	70
Maximum longitudinal slope (%)	0.8	0.7

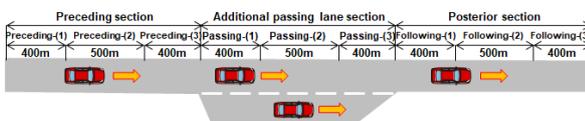


Fig. 1: Image for dividing the sections of additional passing lane, etc.

3. Analysis results

Fig. 2 shows average speed calculated according to traffic volume and 10th percentile speed for two sections A and B. Note that "10th percentile speed" means the low speed generated by one out of 10 cars. It was confirmed from the Figure that the average speed and 10th percentile speed increase in the additional passing lane section, and decrease thereafter. It was also confirmed with the 10th percentile speed that the effect of speed improvement increases as traffic is busy. On the other hand, the 10th percentile speed in the posterior section is much lower than the preceding section when traffic volume is 600 cars/h or more.

This would be because the bottleneck at the end of additional passing lane appeared and impedes traffic flow when traffic volume becomes large. Consequently, the effect of improvement in traffic smoothness would be expected from installation of an additional passing lane when traffic volume is less than 600 cars / h.

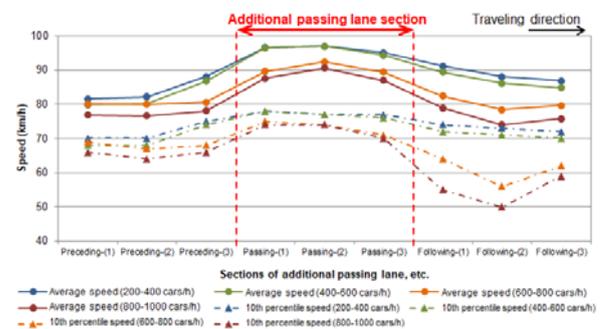


Fig. 2: Speed distribution according to divided sections

4. Conclusion

In this paper, we examined the effect of improvement in traffic smoothness by installation of an additional passing lane based on the relationship between traffic volume and speed. We also intend to continue the study on safe and smooth road planning and design methods.

Method of Using ETC2.0 Probe Information for Traffic Safety Measures

(Research period: FY2016 to FY2018)

OZAKI Yuta, Senior Researcher, KAWAMATSU Yuta, Guest Research Engineer, KAWASE Haruka, Research Engineer, KOBAYASHI Hiroshi (Ph. D.), Head, Road Safety Division, Road Traffic Department

Keywords: ETC2.0, traffic safety measures, drive recorder

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") has been studying traffic safety measures using the data showing the points of sudden deceleration (sudden deceleration data), which is obtained from ETC2.0 probe information, etc. The sudden deceleration data is considered to include not only hard braking to avoid an accident, which is one of the hazardous events close to accident, but simple hard braking in other cases. Similarly, hazardous events are considered to include actions to avoid an accident without using hard braking, situations where two cars suddenly approach to each other without evasive action, etc., as well as actions to avoid an accident by hard braking. It is therefore important to handle the sudden deceleration data properly after understanding such characteristics when using the data.

To this end, NILIM has been grasping the characteristics of occurrence patterns in sudden deceleration and hazardous events. Specifically, occurrence patterns are organized with regard to (a) Non-hazardous events collectible from the sudden deceleration data, (b) Hazardous events collectible from the sudden deceleration data, and (c) Uncollectible hazardous events.

2. Grasp of the occurrence patterns of sudden deceleration events and hazardous events using drive recorder data

We analyzed the driving recorder data from the event-recording type and constant-recording type of recorders to grasp occurrence patterns of sudden deceleration events and hazardous events (Refer to Fig. 1). In this study, "sudden deceleration event" was defined as "event where hard braking occurred with the longitudinal acceleration of -0.3 G or less" and "hazardous event" was defined as "event with risk of collision, such as action to avoid an accident or close approach of cars."

The event recording drive recorder records video, acceleration data, etc. when sudden deceleration occurred, which enables organization of the occurrence patterns of hazardous events collectible from the sudden deceleration data (B in Fig. 1) and non-hazardous events (A in Fig. 1). The constant recording drive recorder always records video,

acceleration data, etc. during traveling, which enables observation of hazardous events regardless of the extent of sudden deceleration and organization of the occurrence patterns of hazardous events uncollectible from the sudden deceleration data (C in Fig. 1). This study analyzed about 2,000 cases of sudden deceleration events recorded in the event recording drive recorder and about 500 cases of hazardous events observed during 2,000 hours recorded in the constant recording drive recorder.

The result of this analysis showed that non-hazardous events (A) collected from the sudden deceleration data include deceleration behaviors at a stoplight or before right / left turn and that hazardous events (C) uncollectible from the sudden deceleration data include contact avoidance with a bicycle / pedestrian or crossing collision with a bicycle (risk aversion by bicycle).

3. Future study

In the future, in order to use the sudden deceleration data effectively, we intend to analyze the characteristics of vehicle behaviors, peripheral environment, etc. in the event of sudden deceleration using the event recording drive recorder data and study a method of discerning whether an action of sudden deceleration corresponds to a hazardous event (distinguish whether A or B).

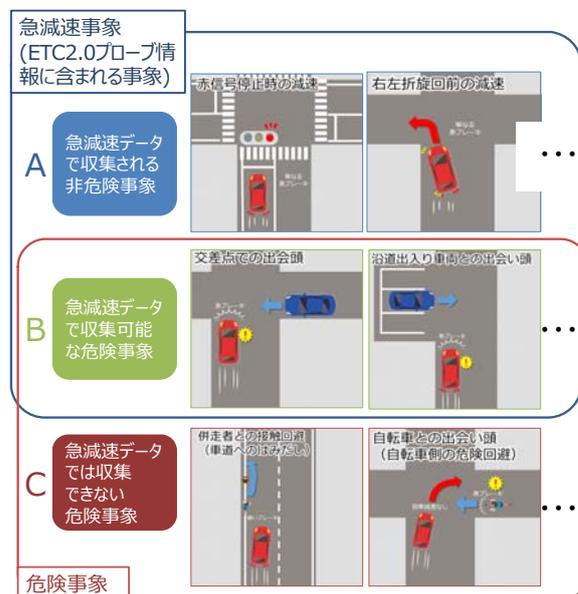


Fig. 1: Occurrence patterns of sudden deceleration events and hazardous events

Technological development for the rationalization of fire safety and evacuation regulations

(Research period: FY 2016-2020)

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Keywords: Evacuation safety, large wooden building, urban building, main structural parts

1. Introduction

Local governments and private businesses engaging in town development are seeking to effectively use currently available buildings and historical buildings by changing their uses or renovating them to revitalize their regions and promote international tourism. To ensure the smooth use of currently available buildings, the NILIM is developing technologies for the rationalization and streamlining of fire safety and evacuation regulations under the Building Standards Act (hereinafter “the Act”). This article summarizes the outcomes of examinations conducted in FY 2018.

2. Outline of technological development

(1) Rationalization of standards concerning the evacuation safety of people inside buildings

From the perspective of ensuring the evacuation safety of people in buildings, special buildings, such as hotels and retail stores, with a certain size or larger are required to have fireproofed main structures. Since buildings up to three stories and 200 m² are small, the time required for evacuation is expected to be short. Therefore, as long as viable structural members found in common buildings are used, the same level of evacuation safety may be ensured as the current regulations even when a fireproof structure is not required in all the main structures if the evacuation time is short. Necessary measures for ensuring this assumption are examined so that alarm systems will be installed in buildings used for sleeping purposes where the start of evacuation may be delayed, and sections providing protection from fire and smoke will be installed in vertical columns, such as staircases, for people, such as elderly people who have difficulty evacuating by themselves (Figure 1).

Concerning fire safety facilities used to divide spaces, performances were checked using lightweight doors installed in conventional office buildings, and structural methods of fire walls that can block fire for ten minutes were clarified (Figure 2).

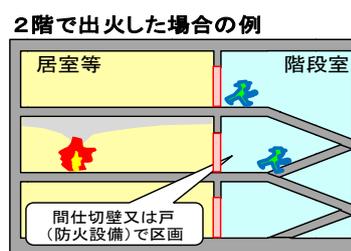


Figure 1 Image of vertical section in small buildings



Figure 2 Fire safety facility used in semi-vertical sections (blocks fire for ten minutes)

(2) Rationalization of standards for wooden buildings

In buildings in which wooden structural members are used, fire safety regulations on size (height and area) under the Act also become major restrictions. Especially, since the initial establishment of the Act, [1] restrictions on the height of wooden buildings and fire resistance performance of main structural parts (Article 21, Section 1) and [2] the installation of fire walls in wooden buildings (Article 26) have been stipulated as specifications based on past damage to large wooden buildings lost in fires and massive urban fires. Opinions have been raised claiming that these would restrict freedom of designs.

The freedom in the design of wooden buildings has been drastically expanded in regard to height restrictions since the performance standardization in 2000 when the use of wooden materials as fireproof structures became possible. Actually, however, realizing the use of wooden materials as fireproof structures faces a large burden, such as technological development and the acquisition of accreditation by the Minister of Land, Infrastructure and Transport. Thus, the NILIM conducted technological development with the goal of constructing technological standards that can enable the smooth use of new construction technologies and the flexible responses to changes in social situations by organizing the purposes of this regulation and functional requirements and setting

performance standards.

Real-scale fire extinguishing experiments supposing water discharging by firefighters during a fire were planned, and standard water discharging methods, temperature change within sections during water discharge, and carbonization of materials were examined (Figures 3 and 4). Based on the results, methods to evaluate the main structural parts of a building were constructed, and specifications that would satisfy the required performance were organized to ensure that buildings would not collapse during a fire by taking into account the effect of regular fire extinguishing measures (Figure 5).

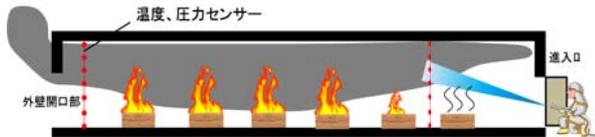


Figure 3 Conceptual diagram of the experiment



Figure 4 Actual measurement of fire extinguishing effect on main structural parts

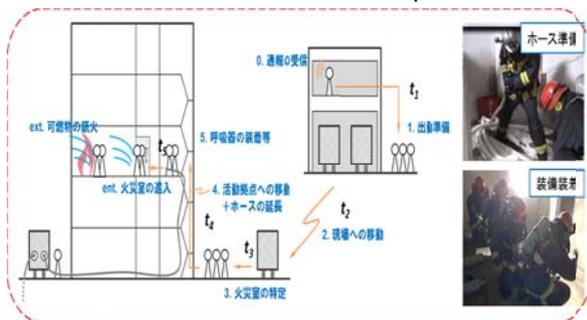


Figure 5 Production of the model of fire extinguishing measures

(3) Rationalization of standards concerning fire prevention in urban areas

When fire safety zones or quasi-fire safety zones are set, buildings within such areas must be fire-resistant buildings or semi-fire-resistant buildings depending on the floor areas and the number of floors. Attached gates and fences with the height exceeding two meters must also be constructed with incombustible materials. Since this greatly restricts the use of wooden materials while preventing urban fires, the NILIM is examining methods to evaluate the fire spread prevention performance of buildings in urban areas. Flexible use of wooden materials inside buildings can be enabled if the same or higher performance than required under current regulations is confirmed by improving the performance of the outer walls and openings, for example (Figure 6). In addition, freedom in the design of gates and fences that make up of townscapes can also be expanded, which will consequently result in the preservation of historical landscapes, by establishing structures and evaluation

methods of gates and fences that would not accelerate the spread of fire to nearby buildings (Figure 7).

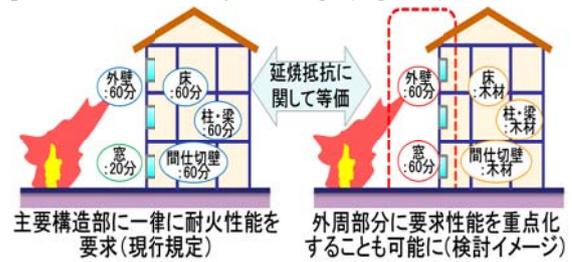


Figure 6 Image of reevaluating fire safety regulations within fire safety zones

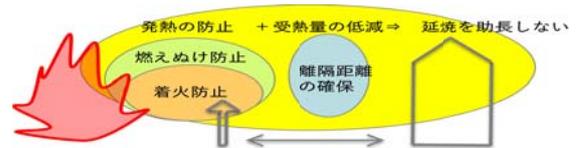
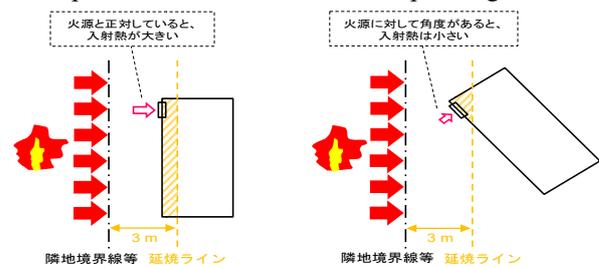


Figure 7 Image of fire safety performance required in gates and fences

The design of the facade is often regarded as important when preserving and utilizing historical townscapes. Current regulations regard areas within three meters from the centerline of a road or the boundary with an adjacent lot for the ground floor and within five meters for the second floor and up as the section with the risk of spreading fires. Measures, such as the installation of fire safety windows, are required in such sections. Still, buildings become less affected by heat depending on the spatial relationship (such as distance, angle, and height) with buildings on fire at the boundary of an adjacent lot (Figure 8). Thus, the NILIM empirically reevaluated the concept of the section with the risk of spreading fires.



a) When opposing b) with an angle

Figure 8 Effect of heat based on the spatial relationship between the source of fire and buildings

3. Future plans

The NILIM will continue cooperating with the relevant bureaus of Ministry of Land, Infrastructure and Tourism, Building Research Institute, and intellectuals and experts and continue technological development to propose technical standards and establish guidelines, such as notices. Fire extinguishing experiments were conducted with the cooperation and advice of the Fire and Disaster Management Agency of the Ministry of Internal Affairs and Communications, Fire Chief's Association of Japan, and Tsukuba City Fire Headquarters.

Research of the improvement of the efficiency and advancement of methods to investigate, analyze, and plan urban traffic using new technologies

(Research period: FY 2015-2018)

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Keywords: Big data, person trip survey, urban traffic

1. Background and objective of study

Research on the use of various types of big data and its application has been rapidly progressing in recent years in the field of urban traffic. Still, big data supplied by various businesses are assumed to contain some bias depending on user attributes. Thus, this study identifies the characteristics of different traffic-related big data through the comparison with person trip surveys (hereinafter “PT survey”).

2. Data to be compared with

Among traffic-related big data, this study uses mobile phone base station operation data supplied by company A and GPS data supplied by company B and company C as the subjects and compares them with the PT survey conducted within the urban zone of Kumamoto in 2012.

3. Results of the comparison and examination and future perspectives

Figures 1 to 3 show the results of the comparison of the OD (origin-destination) volume among small zones between trips within the same area and trips to other areas. Yet, the data of company C were compared using the component ratio of the number of trips due to data characteristics. As a result, the study found different characteristics in the data of different companies, such as separation from the 45-degree line.

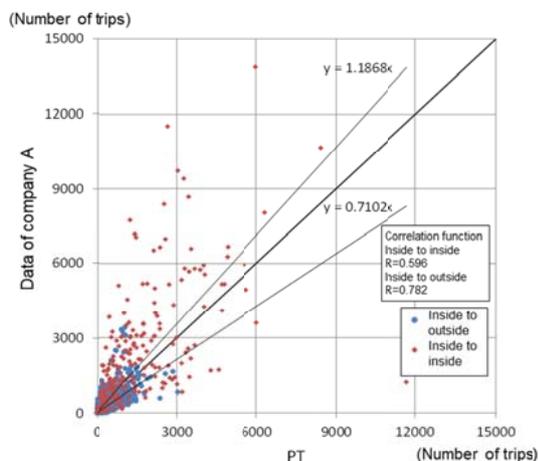


Figure 1 Comparison of the OD volume among small zones based in the data of company A

Upon the use of traffic-related big data, it is important to use such data based on an understanding of the characteristics. Thus, this study examines methods to use data based on this recognition.

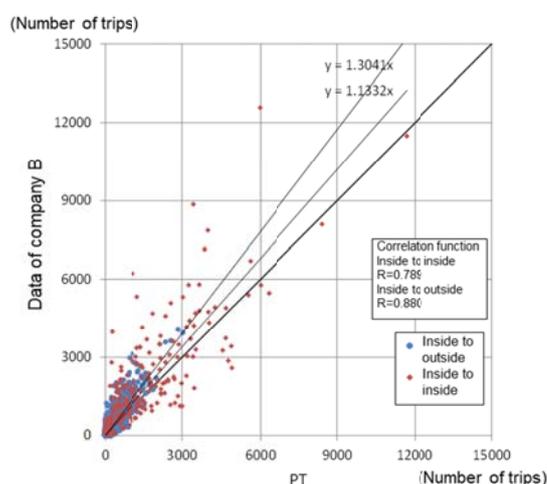


Figure 2 Comparison of the OD volume among small zones with the data of company B

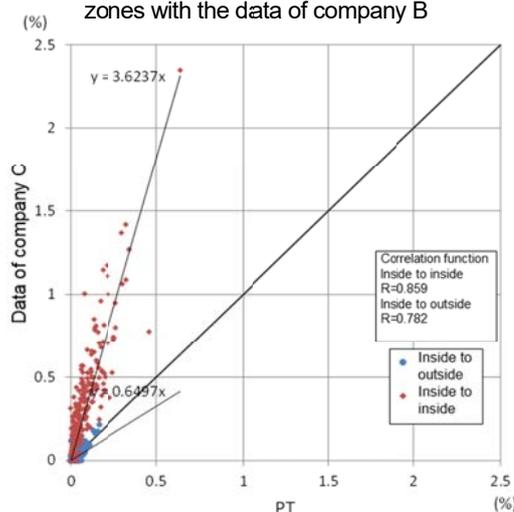


Figure 3 Comparison of the OD volume (ratio) among small zones with the data of company C

☞ For more information

1) “Comparison and examination between person trip survey data and traffic-related big data” Urban Infrastructure Technology Promotion Conference, 30th Technological Research Presentation, Nov. 2018

Upgrading of Design with Inspection Simulator

(Research period: FY2017 to FY2019)

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Keywords: BIM/CIM, design, inspection, simulator

1. Introduction

In the BIM/CIM (Building and Construction Information Modeling/ Management), which has been promoted by the Ministry of Land, Infrastructure, Transport and Tourism ("MLIT"), front loading in the design phase has been studied for the purpose of hand rework prevention.

National Institute for Land and Infrastructure Management (NILIM) is studying a simulator ("inspection simulator") that checks in the design phase whether a new bridge has a structure enabling visual inspection from a proximity distance as one of the front loading requirements. This paper reports the results of analyzing applicability of the inspection simulator in each of the items we organized concerning "certainty and ease of maintenance," which is confirmed in the conventional design stage.

2. Research of items to be checked in the inspection simulator

In this study, we surveyed the items concerning "certainty and ease of maintenance" that should be checked with the inspection simulator through existing materials including specifications for highway bridges, commentary thereof, and road bridge inspection passage installation procedure (draft) and hearings from the organizations concerned. As a result, shape of girder end, securing of work space near support, etc. were identified as items to be considered in the design phase. It was also found to be necessary to verify whether the inspection method using inspection passage, inspection vehicle, etc. can be implemented and to what extent checking with visual inspection from a proximity distance is possible, etc.

3. Analysis of the functions of inspection simulator

Based on the research results stated in section 2 above, we analyzed whether "certainty and ease of maintenance" can be verified by the inspection simulator with the reproduction image using three-dimensional models. Fig. 1 shows the image of inspection simulator. As Fig. 1 shows, use of the inspection simulator enables visual indication of girder end and work space as well as confirmation in the design phase as to whether design meets the items requiring consideration.

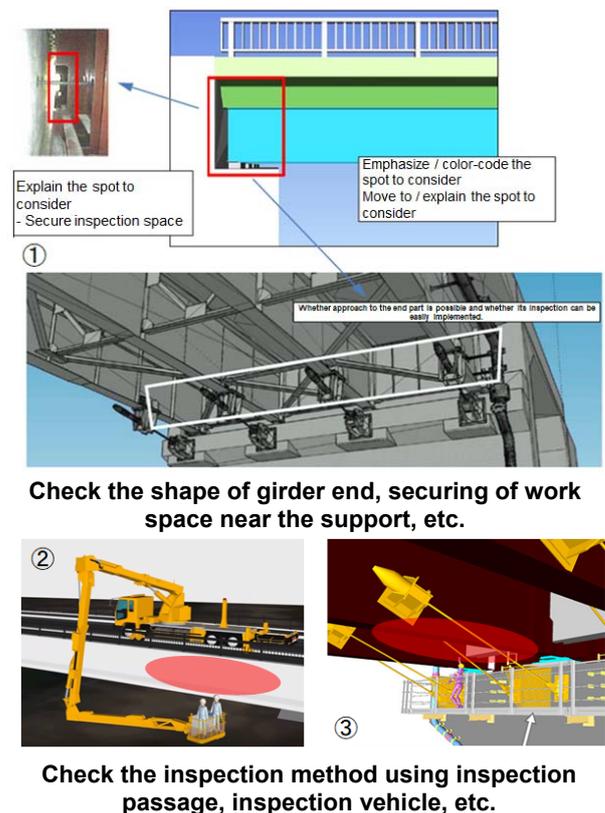


Fig. 1. Image of the inspection simulator

In addition, inspection method of structures can be examined with three dimensional images of the shapes and peripheral environment of structures. It is further possible to check whether all the spots can be inspected without omission with color-coded indication of the area that can be visually inspected from a proximity distance in a range from inspection passage or inspection vehicle.

Through the analysis above, we prepared the functions (draft) required to check the certainty and ease of maintenance with the inspection simulator.

4. Future development

We intend to produce the inspection simulator on a trial basis based on the prepared functions (draft) and confirm the effectiveness through trial use on the site. We also intend to develop the functions (draft) into functional requirements (draft) and promote installation in simulation software using CAD software and three-dimensional models.

A Study on Method of Using Work Management Records in Maintenance Stage Obtained from Construction Process of Earthquake Restriction Work

(Research period: FY2017 to FY2021)

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Keywords: road bridge, restoration, CIM, maintenance, construction management record

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") has been promoting "i-Bridge" to improve productivity and safety of bridge construction projects using ICT and applied it on a trial basis to part of the restoration work related to the Kumamoto Earthquake.

This paper introduces a study on the method of using data for maintenance, which is obtained from the earthquake restoration work for a road bridge proceeding in relation to this trial use.

2. Maintenance of data obtained from earthquake restoration work Need for utilization in stages

In earthquake restoration work, there is uncertainty in design stage which is not found in new construction work, such as determination of residual stress. For such uncertainty, it is important to check whether there is any difference from the determination in design stage by monitoring changes in the structure system in construction stage.

On the other hand, there are also matters of concern in maintenance stage, such as possibility of damage growth and secular change in repaired part. For such uncertainties, it is required to identify properly, from the information obtained from the earthquake restoration work, damage caused by the earthquake to members, repair method for the damage, and data required to secure the durable performance of the repair method applied, and to keep records and store the data by clarifying the mutual relationship of the data.

3. Example for utilization of CIM model in maintenance stage

Based on the aforementioned viewpoints, this study focuses on three-dimensional visualization of data using CIM. As a specific method, a CIM model was created for the bridge in which cracks were caused to the PC box girder by the Kumamoto Earthquake and repaired with carbon fiber sheet and data required for maintenance is input as attribute information.

Maintenance in this paper has viewpoints specific to repairing members, such as "Isn't there any progress in cracking that may affect load-bearing performance?" or "Isn't there adhesion peeling in the carbon fiber

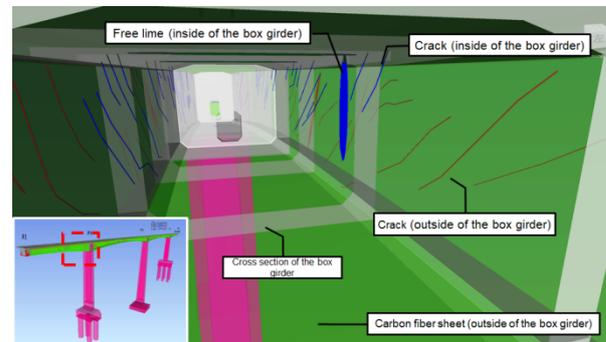


Fig. 1 View from the inside of PC box girder in CIM model

sheet?" Accordingly, for such viewpoints, it is necessary to keep records so that maintenance can be properly conducted.

For existing bridges, 3D CIM models are created from existing 2D drawing information and the level of detail required for CIM models need to be set individually according to the purpose of use. CIM model creation in this paper focused on reproduction of the shapes of members illustrated on general drawings based on the aforementioned viewpoints and enabled three-dimensional display of interrelation of information on damage inside members and repair work information as shown in Fig. 1.

4. Conclusion

We intend to further study on utilization of CIM models that contribute to maintenance through careful examination of information to be recorded in CIM models according to repair work methods considering the points of attention in maintenance of repaired members.

☞ See the following for details.

1) NISHIDA Hideaki, SUZUKI Shinya, TAKIMOTO Kodai, HOSHIKUMA Jun-ichi: Civil Engineering Journal, No.10, Vol. 60, 2018, pp.24-27

Promotion of i-Construction

i-Construction Promotion Headquarters

SASAKI Masahiko, Research Coordinator for Construction Management, Research Center for Infrastructure Management

SUWA Yoshio, Research Coordinator for River Structures, River Department

TAMAKOSHI Takashi(Ph.D.), Research Coordinator for Road Structures, Road Structures Department

Keywords: i-Construction, productivity improvement, ICT, BIM/CIM

1. Introduction

i-Construction is a part of the productivity revolution, which has been promoted by the Ministry of Land, Infrastructure, Transport and Tourism ("MLIT"). It is an activity to improve productivity in construction sites and realize an attractive construction site by optimizing the entire process including research and design, construction and test, and maintenance. The productivity improvement aims to improve productivity by 20% no later than 2025.

NILIM launched the promotion headquarters of i-Construction in March 2016 and has been working for research, development, and dissemination of productivity improvement in construction sites using ICT, 3D data, etc.

In FY2018, promotion of i-Construction was positioned as an add-on measure of "Public/Private R&D Investment Strategic Expansion Program (PRISM)" to accelerate R&D activity.

2. Expansion of ICT construction

ICT construction uses 3D data consistently in the processes of research, survey, design, construction, and inspection and aims to improve productivity with efficient construction and quality control using ICT-based construction machines and surveying instruments. Starting with the introduction into ICT earthwork in FY2016, i-Construction was introduced into pavement works in FY2017 and into dredging works in FY2018. NILIM has been conducting a research on actual use of i-Construction in construction sites and studying methods for increasing applicable types of works and use of new measurement technology. In FY2018, we prepared the draft of work progress control procedures using ICT for soil improvement works, slope works, earthwork surrounding works (curbstones, gutters, revetment), and the MLIT released new standards based on the draft in March 2019.

3. Promotion of the use of BIM/CIM

BIM/CIM (Building Information Modeling / Construction Information Modeling/Management) aims to increase efficiency in the processes of design, construction, and maintenance and to advance information linkage between processes, based on 3D

models added by attribution information, and NILIM has been studying on development and use of procedures and standards (see Fig.). In FY2018, NILIM studied on standard specifications for using CIM model for contract documents, standards for quantity calculation with CIM model, CIM utilization in the maintenance stage, etc.

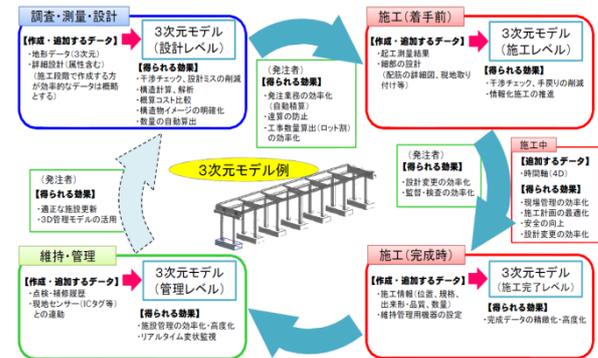


Fig.: Utilization of 3D model

4. Future development

In FY2018, as the "Project for introduction / utilization of innovative technologies for drastic improvement of productivity in construction site," the MLIT solicited from the public for new technologies expected to contribute to productivity improvement, quality improvement, or efficiency increase in check inspection, which were tried in construction sites under the control of Regional Development Bureaus, etc. While following up on the situation of trial use, NILIM intends to continue studies aiming to realize productivity improvement, including studies on use of up-to-date technologies such as AI, IoT, and robots, and formulation of procedures and standards for implementation.

Empirical Study on B-DASH Project (Road Snow Melting Technology using Sewage Heat) (Research period: from FY2018)

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Keywords: B-DASH, sewage heat, road snow melting, unused energy

1. Introduction

As a general characteristic of sewage temperature, it is warmer in winter and colder in summer than the outside air. Use of this temperature difference as heat energy is expected to reduce oil and natural gas consumption as well as CO₂ emissions. In addition, possibility of supply and demand matching with heat consumers in cities is high since there is a large amount of sewage in cities. The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is therefore implementing projects actively to promote the use of sewage heat as unused energy.

Meanwhile, the MLIT has been implementing the Breakthrough by Dynamic Approach in Sewage High Technology (B-DASH Project) since fiscal 2011 with the Water Quality Control Department of the NILIM as implementing organization, and two proposals for road snow melting technology by sewage heat were adopted in fiscal 2018. This paper introduces the outline of these two technologies adopted.

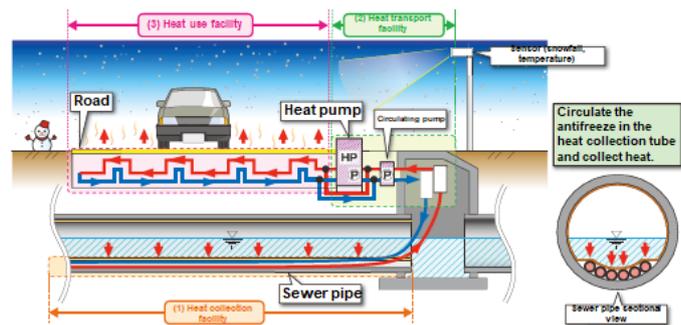
2. Outline of demonstration technologies

(1) Empirical study on practical use of snow melting technology using sewage heat from small diameter pipeline (Joint Research Organization of Toa Grout Kogyo Co., Ltd., Maruyama Komusho Co., Ltd., and Tokamachi City)

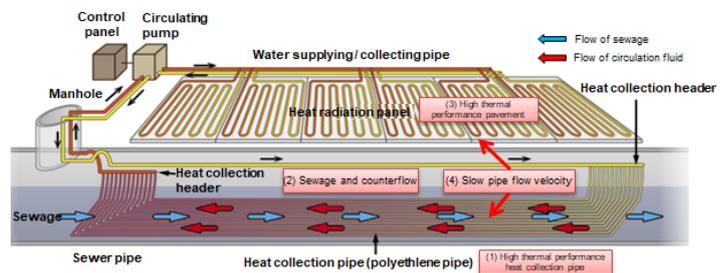
This technology enables the use of sewage heat with small and-medium-size diameter pipeline not more than $\phi 800\text{mm}$, which had been difficult, by installing heat collection pipes at the time of pipe rehabilitation work, which is one of the measures for deterioration of sewer lines. This technology also aims at more efficient road snow melting than before by automatic switching between operation using only sewage heat (only the circulating pump operates) and operation using heat pump jointly, according to weather conditions such as snowfall and air temperature (Fig. 1 (a)).

(2) A study on the sewage heat snow melting system to realize low LCC and high COP (coefficient of performance) with heat pumpless (Joint Research Organization of Kowa, Ltd., Sekisui Chemical Co., Ltd., and Niigata City)

This technology aims at road snow melting at lower cost (low LCC) and more efficiently (high COP) than



(a) Empirical study on practical use of snow melting technology using sewage heat from small diameter pipeline



(b) A study on the sewage heat snow melting system to realize low LCC and high COP with heat pumpless

Fig. 1. Outline of Technologies

before using only sewage heat, without using heat pump, by adopting heat collection pipes and pavement material with high thermal conductivity and devising the direction and velocity of the flow of circulation fluid (Fig. -1 (b)).

3. Utilization of empirical study findings

At present, installation of the demonstration facility was just completed and operation of the facility and collection of various data was started. We are going to formulate guidelines for technology introduction after checking technical performance and various costs using operation results and collected data,

See the following for details.

<http://www.nilim.go.jp/lab/ebg/b-dash.html>

Visualization of Beach Value (Part of Coast Use)

(Research period: FY2017 to FY2019)

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Coast Division, River Department

Keywords: beach, coast use, TCM

1. Background and purpose of the study

Beach maintenance is one of the important issues in coastal management. However, in evaluation of projects such as erosion control measures, only the benefit of protecting the hinterland of beach evaluated quantitatively and neither use benefit nor environmental benefit of sand has been evaluated. In recent years, however, activities for using beach as a base of tourism / leisure have started, including "Hama (beach) Tourism Promotion Project" by the Water and Disaster Management Bureau of the Ministry of Land, Infrastructure and Transport (MLIT) and it is also required to establish a method of clearly "visualizing" the benefit of beach maintenance to support such activities.

Hence, this study intends to provide a method of quantitatively evaluating the environmental and use values of beach and tried to evaluate the use value for fiscal 2018.

2. Method of evaluating the use value of beach

Previous studies on evaluation of beach are based on the travel cost method (TCM) or contingent valuation method (CVM) but coast administrators have to bear a large cost to implement such methods by themselves. Then, we decided to provide the standard value (basic unit) of beaches by TCM so that coast administrators can easily evaluate beaches without conducting new survey, and calculated on a trial basis using various means, including use of previous statistics, WEB questionnaire, and position information of mobile phones.

In the Web questionnaire, about 300,000 out of about 4,000,000 people answered the question about whether they visited any mountain, lake, beach, etc. in the last year. Of them, we obtained information in combination of departure and destination locations (OD data) from about 50,000 people (Fig. 1). The differences between prefectures in the number of travelers for sea bathing obtained by the method above were generally the same in the trend as those in the published statistics of the number of beach users.



Fig. 1: Example for the breakdown of departure locations of beach visitors

Of the respondents to the WEB questionnaire, we asked some 4,300 people in detail about destination and means and cost of transportation. With results of this questionnaire, we calculated the recreation value for each use of beach, such as 18,149 yen for Kanagawa.

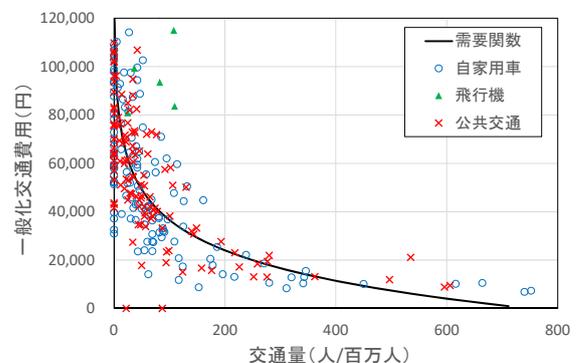


Fig. 2: Transport cost and traffic volume of travels to Kanagawa-ken for beach use (Number of travelers from each prefecture converted per million people)

3. Future development

We intend to calculate and publish the basic unit of use value attributable to beach for each prefecture and provide an evaluation method practicable for coast administrators.

A Study on On-Road Parking / Stopping Measures for Safe and Comfortable Bicycle Traffic

(Research period: FY2017 to FY2019)

KUBOTA Sayuri, Researcher, OZAKI Yuta, Senior Researcher, TAKAHASHI Ayumu, Guest Research Engineer, KOBAYASHI Hiroshi (Ph. D.), Head, Road Safety Division, Road Traffic Department

Keywords: bicycle traffic space, a bicycle traffic zone, on-road parking / stopping measures, parking / stopping stall

1. Introduction

Under the Bicycle Use Promotion Act (promulgated in Dec. 2016 and enforced in May 2017), the Cabinet decided the bicycle use promotion plan in June 2018. This plan includes "promotion for securing bicycle traffic space by developing off-street parking areas and parking space for cargo handling" as one of the measures that should be implemented.

Development of bicycle traffic space is proceeding across the country, but it is also important to take on-road parking / stopping measures as well as development of bicycle traffic space since some cars parked / stopped in bicycle traffic space obstruct bicycle traffic (See Photo).

Hence, NILIM has been studying the method of setting parking / stopping stalls using part of sidewalks as one of the parking / stopping measures.



Bicycle traffic space

Photo: Example of on-road parking / stopping in bicycle traffic space

2. Structure of planned parking / stopping stalls

Structure of parking / stopping stalls should meet the following requirements since bicycles need to travel safely through bicycle traffic spaces ((1)-(3)) and parking / stopping stalls need to have a shape that meets demands ((4) and (5)).

- (1) Possible to stop the car in the parking / stopping stall without protruding into the bicycle traffic space.
- (2) There is no problem of complication between bicycles and automobiles.
- (3) Automobiles can stop smoothly without occupying the bicycle traffic space for a long time (do not spend much time on stopping).
- (4) Space-saving so that multiple parking / stopping stalls can be set in a limited space.
- (5) Cargo handling space is secured (if necessary).

3. Experiment for studying the fine structure of parking / stopping stall

This paper introduces part of the traveling experiment on the parking / stopping stalls focused on the foregoing requirements (1) and (3) (Refer to Fig. 1 for the image of experiment). In the experiment, the

length of parking / stopping stall was set in stages within the range of 7 to 15 m in full length considering the requirements (4) and (5), and the results of 15 m, 13 m and 7 m in full length are herein reported.

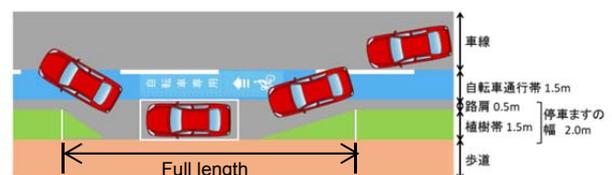


Fig. 1: Image of the driving experiment on parking / stopping stalls

The results of the experiment concerning Requirement (1) showed that more than 90% of cars were able to stop in the parking / stopping stalls, 15 m or 13 m in full length. On the other hand, about 70% of cars were able to stop in the parking / stopping stall, 7 m in full length, but about 30% of them protruded from the stall by 0-50 cm (Fig. 2).

The results of the experiment concerning Requirement (3) showed that time required for stopping was about 20 seconds for the full length of 15 m and 13 m, and about 50 seconds for the full length of 7 m (Fig. 3). Since the time required for stopping means the time when the bicycle traffic space is occupied, it would be necessary to study the applicable length of parking / stopping stalls according to the cycle traffic volume.

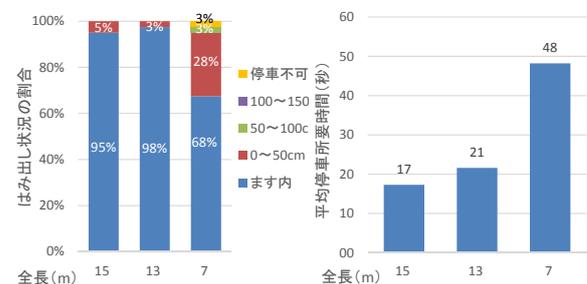


Fig. 2: Result of the experiment on the requirement (1) Fig. 3: Result of the experiment on the requirement (3)

4. Conclusion

In setting parking / stopping stalls, the applicable structure of parking / stopping stalls is considered to differ according to the volume of bicycle traffic. In the future, we intend to organize applicable conditions of parking / stopping stall structures and points of attention in setting.

A Study on Introduction of Two-stage Crossing Facility for Helping Safe Crossing of Pedestrians

(Research period: FY2016 to FY2018)

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Keywords: traffic safety, two-stage crossing facility, traffic island, pedestrian crossing

1. Introduction

The number of fatalities from traffic accidents in Japan is 3,532 for 2018 and about one-third of these accidents occurred during walking. Of the fatal accidents involving pedestrians, many of them occurred while pedestrians were crossing roads and about a half of them occurred on basic road sections. This is one of the issues requiring countermeasures. As one of the possible countermeasures for accidents during crossing the basic road section, there is a method of installing a traffic island at the center of the road so that pedestrians can cross the road in two stages while paying attention to vehicles (Fig. 1). For installation of such two-stage crossing facility, in order to discern the possibility of introduction as a new traffic safety measure in Japan, NILIM has been studying its effectiveness and organizing technical points of attention in introduction. This paper reports the study on the desirable structure of two-stage crossing facility and analysis of the impact of facility installation on traffic smoothness.

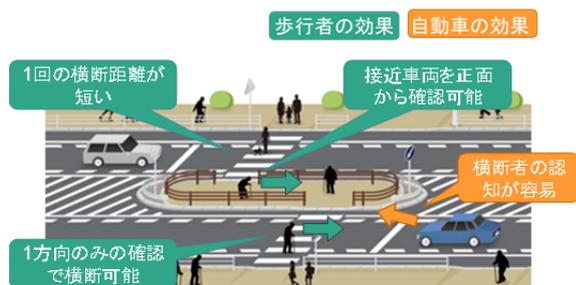


Fig. 1: Characteristics of two-stage crossing facility

2. Study on the desirable structure of two-stage crossing facility

Considering installation in a limited road space, we researched the possibility of installation with different cross-section structures by on-premises experiment, with focus on simple facility assuming installation by reviewing only the width structure of roadway section (Fig. 2). Consequently, the conditions of cross-section structure considered usable in safely, etc. could be confirmed. Based on these findings, we are organizing the cross section structure of the desirable two-stage crossing facility.



Fig. 2: Traffic experiment with a temporarily built two-stage crossing facility

3. Analysis of impact of facility installation on traffic smoothness

With focus on the traffic smoothness of automobiles / pedestrians by installation of two-stage crossing facility, the waiting time of automobiles / pedestrians was calculated with traffic flow simulation. As a result, improvement in traffic smoothness was found, including decrease in waiting time as compared with a case of no two-stage crossing facility (Fig. 3). Based on results of these calculations, we are studying the effective traffic volume in which installation is effective, etc.

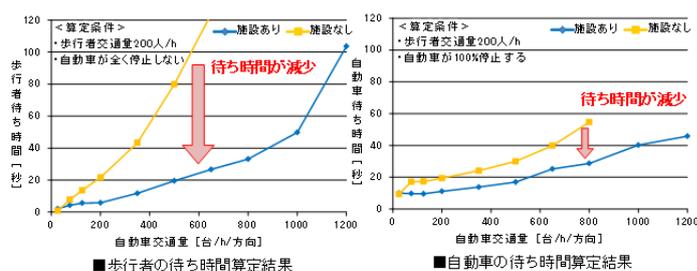


Fig. 3: Effectiveness of two-stage crossing facility (smoothness)

4. Conclusion

In addition, we have been conducting organization of domestic and overseas cases, literature survey, characteristic analysis of the sites involving crossing pedestrians, etc. Including results of these studies, we intend to organize the method of using two-stage crossing facility applicable in Japan and technical points of attention concerning installation.

Proposal of Landscape Improvement Measures in Small Construction Work, Maintenance, etc. of Roads

(Research period: FY2017 to FY2018)

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Keywords: road landscape, landscape improvement measures, small construction work, maintenance

1. Introduction

In October 2017, the Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") revised the Road Design Guidelines (Draft) and formulated Guidelines for Road Accessories Considering Landscape.¹⁾ Based on the concepts and policies provided in these guidelines etc., the NILIM has been studying specific methods for creating good landscapes and road environment while controlling cost in small construction work, maintenance, etc.

2. Concept of landscape improvement in small construction work, maintenance, etc.

(1) Proposal of the concept of reducing road accessories
There are various road accessories etc. installed by various entities in road space (guard fence, traffic signs, lighting post, soft pole, etc.). Even if the size of each of such road accessories etc. is small, the road landscape will give a disorderly impression if their number increases. Given the recent trend of reducing maintenance personnel and budget, the concept of performing required functions with minimum road accessories etc. is required. When road accessories etc. are newly installed, reduction of maintenance cost / labor and landscape improvement can be achieved at the same time by considering removal / organization of existing road accessories etc. with overlapped functions to reduce the total quantity of road accessories etc.

(2) Direction of landscape improvement in maintenance
In maintenance, specific landscape improvement measures are studied from the following five viewpoints --- "Substitution" (change to other components or facilities), "Removal" (remove duplicate facilities), "Downsizing / Scaling down" (devise ways for smaller

appearance), "Organization" (arrange and organize many accumulated facilities), and "Concentration" (integrate facilities of the same or different kinds into one) (Fig. 1).

(3) Direction of landscape improvement in provisional use

If the period of provisional use is long, the same kind of considerations for landscape are required as for use after completion since the landscape during provisional use including unused portion becomes common to local residents and road users. Accordingly, specific landscape improvement measures have been studied based on the concepts of (i) Active and effective use of space, (ii) No installation of mostly closed facilities etc., and (iii) Considerations for landscape from a viewpoint of living environment maintenance if installation of such facilities is unavoidable (Fig. 2).

3. Future schedule

Results of this study will be organized in "Collection of Devices and Hints for Landscape Improvement in Small Construction Work, Maintenance, etc. (tentative title)" and published as Technical Note of NILIM.

☞ See the following for details.

1) MLIT website: http://www.mlit.go.jp/report/press/road01_hh_000896.html



Fig. 1 Example of "Downsizing / Scaling down"
Change from the whole surface colored pavement to line painting will reduce landscape obstruction and reduced area of painting on the spots where cars are unlikely to stop will reduce frequency of repair.



Fig. 2 Example of "Active and effective use of space"
Removal of single pipes and use of road-widening site as provisional sidewalk space will greatly improve user-friendliness.

Development of method to evaluate energy conservation effects of the automatic control technology of construction facilities

(Research period: FY 2016-2018)

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Environment Division, Housing Department

Keywords: Non-residential building, energy conservation, conformity judgment, web program, automatic control, ZEB

1. Evaluation of advanced energy conservation technologies

The NILIM is developing an energy consumption performance calculation program (for non-residential buildings)¹ that judges conformity to energy conservation standards. Yet, energy conservation technologies that can be evaluated with this program are clearly defined. It is limited to technologies where the energy conservation effects have already been demonstrated. In buildings aiming to become Zero Energy Buildings (ZEB), however, cutting edge and advanced technologies that cannot be evaluated with the current program are often used. In particular, automatic control technologies are expected to produce great energy conservation effects when they are customized based on weather conditions and operational conditions for specific buildings. Yet, it is difficult to generalize the effects and reflect them in the program. Thus, a new evaluation scheme using registered energy conservation evaluation organization is going to be established to enable the separate evaluation of the aforementioned advanced technologies.

2. Preparation of evaluation guideline

Based on consultations with the Ministry of Land, Infrastructure and Transport, the NILIM was set to prepare a guideline for the evaluation of automatic control technologies so that registered energy conservation evaluation organizations can produce fair evaluations. The guideline will stipulate the definition (8 scope) of target technologies, how evaluation results will be incorporated into the current energy consumption calculation method, points of evaluation, and other aspects. Figure 1 shows the voluntary evaluation guideline concerning automatic control technologies for air conditioning and conveyance devices (draft) prepared in this study

3. Program expansion

The program was designed so that the input and calculation functions can be expanded to enter any evaluation results and to calculate the amount of primary energy consumption in design using the results. Figure 2 shows Format SP-1: Secondary pump current transformation volume input sheet. When evaluation results (the coefficient of the quartic formula in this

6. Calculation based on actual measurements taken at actual buildings
Operation data are gathered from actual buildings in which evaluation target control is installed. The following conditions must be met before gathering operation data.
[Building to be investigated]
• Building must be in usable conditions. Or, it must be an experimental facility that can simulate actual conditions of use by placing simulated heating or other conditions.
• Documents demonstrating the actual installation and use of evaluated controls must be submitted.
• System diagrams of systems to be measured and the list of equipment and devices must be presented.
• The gathering and analysis of operation data must cover buildings and systems with at least three different conditions such as external conditions, room size, and directions.
[Data gathering period, sampling interval]
• Data must be obtained at least for one week under conditions of early summer (June), midsummer (August), late summer (September), early winter (November), mid-winter (January), and late winter (March).
• The basic data sampling interval is one minute or shorter.

Figure 1 Guideline concerning air conditioning and conveyance control (draft)

example) are entered into this sheet, the program can conduct evaluations by adding the effect rate of the current transformation volume control of the secondary pump

① Name of control method	② x4	③ x3	④ x2	⑤ x1	⑥ a	⑦ Remark
Special control	0	1	0	0	0	Based on the results of optional evaluation sheets

Figure 2 Sheet for entering evaluation results (Format SP-1)

4. Use of the evaluation scheme

The use of this evaluation scheme has started mainly by the Housing Performance Evaluation and Display Association as voluntary evaluation concerning the energy consumption performance of buildings.² Only two evaluation guidelines have been released at this point. Yet, more evaluation guidelines will be gradually established by responding to the needs of private businesses.

For more information:

- 1) Technical information concerning energy consumption performances of buildings
<https://www.kenken.go.jp/becco/index.html>
- 2) Housing Performance Evaluation and Display Association: Voluntary evaluation
https://www.hyokakyoukai.or.jp/nini_hyoutei/index.html

Study on facade design to improve the energy efficiency of building (Research period: FY 2017-2019)

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 MIYATA Masato (Ph. D.), Senior Researcher,
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Keywords: Energy conservation, facade, thermal environment, optical environment

1. Background and objectives

To realize advanced energy conservation in buildings, it is important to use the design of the facade (exterior section of a building, such as outer walls, windows, and roofs), the upstream step in the building design process, to reduce loads on facilities, such as loads on air conditioners and lighting facilities. Facade design affects the energy consumption of air conditioners and lighting facilities, but its effects have not been properly evaluated. In addition, unlike the annual consumption of primary energy, no proper evaluation has been done on the indoor environment, such as thermal and optical environments that are affected by the facade and installed facilities in regard to their balance with energy conservation, which is evaluated throughout the year. Thus, this study aims to develop methods to evaluate and design the energy conservation performance of buildings and the indoor environment using the facade to increase energy efficient buildings in which both energy conservation and the proper indoor environment are realized.

2. Contents of research

This research is conducted based on the structure shown in Table 1. In FY 2018, the energy consumption performance evaluation method was developed by taking into account the combined effect of the facade on air conditioners and lighting facilities. To conduct annual examinations, a simulation was conducted to measure the load on air conditioners using the software EnergyPlus and the load on lighting facilities using the software Radiance. These software programs are known to provide good evaluations of energy conservation and the indoor environment. This section describes a case as shown in Figure 1 that mainly examined the effect of a facade designed to effectively take in daylight while cutting solar radiation heat on the annual load on lighting facilities. Figure 2 shows the annual lighting reduction effect achieved when different types of building facades were combined with blinds fixed to 45 degrees. When the building facade is combined with blinds fixed to 45

Table 1 Research contents of the entire research period

H29年度	ファサードが持つ個別性能の評価法の再構築と室内環境の指標・水準の整備
H30年度	ファサードの空調・照明への複合的影響を考慮したエネルギー消費性能評価法開発
H31年度	エネルギー消費性能の向上と室内環境の両立を目指したファサード設計法の整備

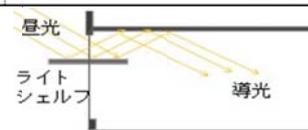


Figure 1 Example of facade which effectively take in daylight

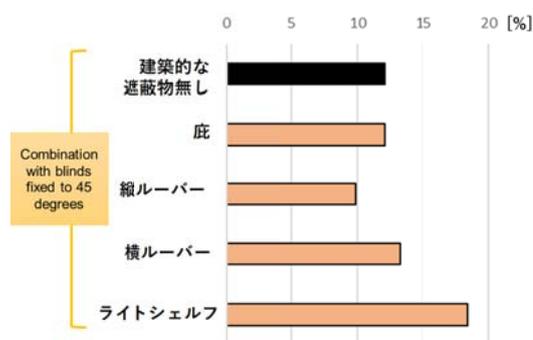


Figure 2 Annual energy conservation effect in lighting achieved by the combination of building facade and fixed blind

degrees, which is the most common use of blinds, the load on lighting was reduced with the building facade, such as horizontal louvers, and a light shelf, which would take the light in using the reflection of daylight. These facades also have a good effect on the indoor environment (effect of preventing glare) because the blinds additionally block the light. Also, the building facade has the high effect of blocking solar radiation heat, and it is expected to reduce the load on air conditioners. As discussed above, various ideas with the facade design are effective in improving energy conservation effects and maintenance of the indoor environment.

Research of city development in rural low-rise residential areas which respond to the needs of super aging society (research period: FY 2015-2017)

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KAWANAKA Takashi (Ph. D.), Researcher,

Urban Development Division, Urban Planning Department

Keywords: Super aging society, rural low-rise residential area, district planning, building agreement, needs for the relaxation of regulations

1. Introduction

In rural low-rise residential areas developed during the period of rapid economic growth in the 1960s to 1970s, the residential population is aging significantly, building regulations based on strict district planning established for the purpose of maintaining the low-rise and favorable residential environment are becoming mismatched with regional needs that seek the continuity of residential areas. In this study, surveys were conducted targeting local governments to identify regional needs for relaxing regulations and how local governments were responding to the needs.



Photo: Example of rural low-rise residential area

2. Result of the survey targeting local governments

The survey was conducted in February 2016 and February 2017 targeting 46 local governments with multiple districts of type 1 and 2 low-rise residential areas where regional planning or building agreements were established or concluded a certain period ago.

Regions often request relaxation of the regulations, such as the lowest limit for a lot area (64.3%), limitation on the use of buildings (57.1%), upper limit to floor area ratio (28.6%), and upper limit to building coverage ratio (21.4%) (Figure 1).

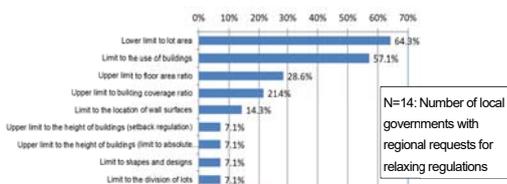


Figure 1 Category of regional requests for relaxing regulations (multiple answer)

The main reasons and background for the request to relax these regulations include the need for the installation of facilities to support the daily lives (such as shopping,

welfare, and nursing) of aging residents, division of lots to sell land and promote the inflow of young generations, and the construction of shared and tenement houses.

Upon using methods to relax regulations, most local governments wish for the introduction of case studies and examples of actual activities (61.3%) concerning urban planning systems and buildings systems such as regional planning and the improvement of their applications. This indicates that local governments are seeking opportunities to mutually exchange opinions. Other wishes include the presentation of standard procedures to relax regulations, the presentation of requirements for relaxation, the supply of tools to assess the effects of relaxation, and the simplification of relaxation procedures (Figure 2).

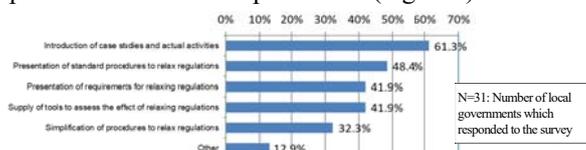


Figure 2 Expectations for urban planning systems and building systems as well as the improvement of their applications upon the use of methods to relax regulations (multiple answer)

3. Summary

The result of this survey was utilized in the national review meeting on the revitalization of residential complex. The maintenance and production of the favorable residential environment through the reconstruction of town development rules are one of the important issues of the revitalization of residential complex. Additional efforts are expected in this field.

For more information:

1) Takashi Kawanaka and Wataru Katsumata (2016) "Study on town development in low-rise residential areas which respond to the needs of super aging society (part 1) Identification of the need for relaxing regulations for areas under regional planning or building agreement" Architectural Institute of Japan, 2016 Assembly (Kyushu) Academic Lecture Collections, Urban Planning, pp. 575-576.

2) Takashi Kawanaka and Wataru Katsumata (2017) "Study on town development in low-rise residential areas which respond to the needs of super aging society (part 2) Challenges associated with the identification of needs for relaxing building regulations" Architectural Institute of Japan, 2017 Assembly (Chugoku) Academic Lecture Collections, Urban Planning, pp. 245-246

Pedestrian movement characteristics at tourist attractions

(Research period: FY 2016-2018)

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Urban Facilities Division, Urban Planning Department

Keywords: Tourism-based town development, pedestrian movement, sidewalk width, urban traffic

1. Introduction

While tourism-related measures are being increased and promoted, street spaces are becoming seriously congested with pedestrians at some tourist attractions. This study conducted observations in the areas with characteristic purposes in pedestrian movement. After obtaining data on walking speed and pedestrian density, the traffic capacity was calculated, and the data were compared between areas with many tourist pedestrians and areas with many pedestrians commuting.

2. Target of observation

Areas near Shinbashi Station and Kachidoki Station on weekday mornings were selected as sidewalks with many pedestrians commuting. Areas near Shinjuku-Sanchome Station and Keisei Ueno Station on weekdays in the late afternoon were selected as sidewalks with many pedestrians shopping. Areas near Asakusa Kaminarimon and Kamakura Komachi Street were selected as sidewalks with many tourist pedestrians. In these areas, pedestrian density and walking speed were measured at straight road sections without slopes or steps. The table shows details of the observed areas.

Table Observed areas

Name of observation point	Expected main purpose of pedestrian movement	Location of observation point	Date of observation (year/month/day) [day of the week]	Observation time	Weather
Shinbashi	Commute	Shinbashi, Mnato-ku 1-18-16	2015/11/24 [Tue.]	8:00-9:00	Cloudy
Kachidoki	Commute	Kachidoki, Chuo-ku 2-5-8	2016/12/5 [Mon.]	8:00-9:00	Sunny
Shinjuku	Shopping	Shinjuku, Shinjuku-ku 3-30-13	2016/12/5 [Mon.]	18:00-19:00	Cloudy
Ueno	Shopping	Ueno Park, Taito-ku 1-60	2016/12/5 [Mon.]	18:00-19:00	Cloudy
Asakusa	Sightseeing	Asakura, Daito-ku 1-2-2	2018/3/10 [Sat.]	12:00-13:00	Sunny
Kamakura	Sightseeing	Komachi, Kanakura City 2-7-24	2018/2/11 [Sun.]	9:00-17:00	Sunny

3. Results of the observation

As shown in Figure 1, a certain number of pedestrians were moving at a fast pace of 2.0 (m/s) or faster on sidewalks with many pedestrians commuting under low-density conditions of about 0.5 (persons/m²) or less. Meanwhile, few pedestrians were moving fast at tourist attractions even under low-density conditions. Compared to pedestrians commuting, the dispersion was low, and the overall speed was slow.

The regression analysis of the speed and density was conducted for individual purposes of pedestrian movement in regard to Figure 1. Figure 2 shows the

relationship between pedestrian density and traffic volume created using the obtained regression formula.

Based on this result, the study found that congested flows would occur under lower density conditions, and the traffic volume was low in pedestrian spaces with many tourists compared to pedestrian spaces with many pedestrians commuting.

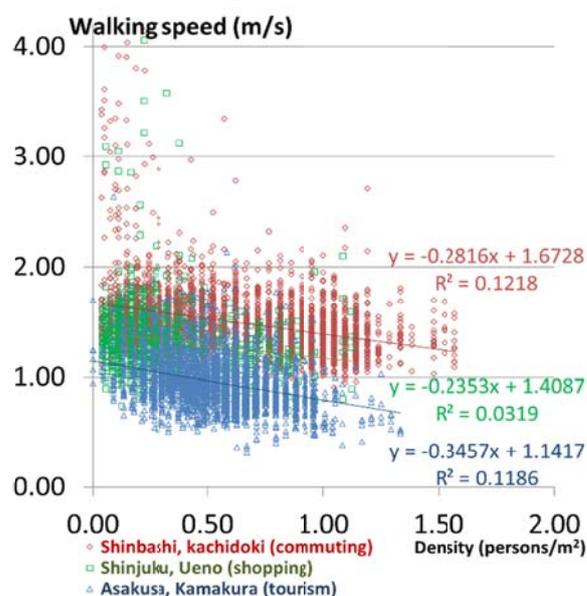


Figure 1 Relationship between pedestrian density and walking speed by purposes of movement

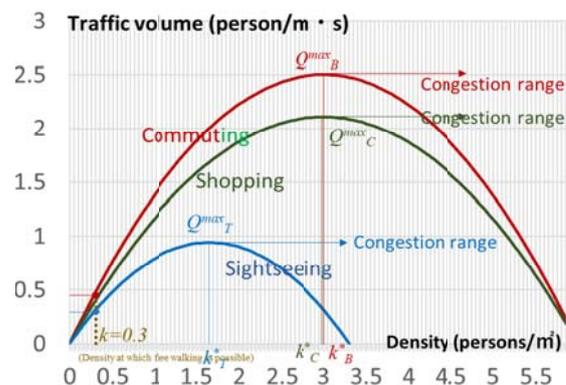


Figure 2 Relationship between pedestrian density and traffic volume by purposes of movement

For more information:

1) The 38th Presentation of the Japan Society of Traffic Engineers, compilation of papers No. 38

Various ideas to preserve and utilize historical townscapes

(Research period: FY 2016-2020)

TAKEYA Shuichi(Ph.D.), Head Urban Disaster Mitigation Division, Urban Planning Department

MIZUKAMI Tensei(Ph.D.), Senior Researcher Fire Standards Division, Building Department

Keywords: Historical townscape, historical building, alternative measure

1. Introduction

Activities to leave favorable townscapes for future generations by preserving and utilizing historical buildings and using them as the center of tourism promotion have been expanding. Yet, historical buildings were built before the enactment of the Building Standards Act and are often not in compliance with current laws and regulations. Therefore, it is sometimes difficult to leave the historical atmosphere when the Building Standards Act becomes applicable upon renovation or switching their uses. Specifically, fire safety regulations have great effects because they affect the materials and designs of the exterior walls of buildings.

Therefore, the NILIM is examining smooth and rational operation of fire safety regulations to preserve and use historical buildings and townscapes. This article introduces representative ideas from the local governments to comply with fire safety regulations and preserve and use historical buildings at the same time.

2. Ideas for buildings located along narrow roads

According to the Building Standards Act, buildings must be connected to a road with a width of four meters or more. Yet, buildings in historical town areas are often connected only to narrow roads. Therefore, buildings need to be set back by two meters or more from the centerline of a road upon a major renovation. This sometimes degrades landscapes, such as the inability to preserve the design of exterior walls and by creating irregular alignments of wall surfaces. Thus, the Nioza area in Usuki City, Oita Prefecture, permits major renovations along roads narrower than four meters by designating the area as a category 3 road under the Building Standards Act and by taking into account the low risk of a spreading fire due to height differences in properties, as well as initial fire extinguishing measures and fire spread prevention measures realized by installing fire hydrants around the area (Photos 1 and 2).



Photo 1 Designation of category 3 road



Photo 2 Fire hydrants around the town

3. Ideas related to fire safety regulations on urban planning

When fire safety zones and quasi-fire safety zones are designated under urban planning, buildings need to have fire safety performance depending on floor areas and number of floors. Thus, even historical buildings within quasi-fire safety zones are required to have fire safety structures for the exterior walls and windows. This means that buildings cannot use wood surfaces as the exterior walls and wooden window sashes. Kyoto City, Kashima City, Usuki City, and other areas are therefore cancelling the designation of quasi-fire safety zones to avoid the application of these fire safety regulations. Instead, they are securing minimum levels of safety by establishing different ordinances to require alternative measures (Photo 3).



(a) Usuki City



(b) Kyoto City

Photo 3 Historical townscape where quasi-fire safety zone designation was canceled

4. Ideas prevent the onset of fire and fire from spreading

Other ideas are also being used. For the early detection of fire, Kashima City is requiring the installation of fire alarms interconnected to three adjacent houses. Many areas, such as Usuki City and Kyoto City, are installing fire hydrants and standpipes around town for initial fire extinguishing. Kashima City is preventing the spread of fire by installing water sprinkling systems.

5. Summary

To preserve and utilize historical buildings and townscapes, the NILIM is going to prepare guidelines to evaluate various alternative measures and their effectiveness and release them while ensuring minimum level of fire safety.

To improve attractiveness through increasing greens in parks (Research period: FY 2017-2019)

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Urban Disaster Mitigation Division, Urban Planning Department

Keywords: Greening in parks, tourism promotion, improvement of attractiveness

1. Introduction

In March 2016, the Vision for Tourism to Support the Future of Japan was announced, and the entire government is working to achieve the goal of becoming a country with advanced tourism by perceiving tourism as the new main industry of Japan.

Green areas in parks are one of the main tourism resources. Many parks around the world are functioning as popular tourism attractions. Yet, green areas in parks in Japan are not very well known compared to parks around the world. It is therefore extremely important to increase the appeal of green areas in parks and actively use them for tourism promotion.

Thus, the NILIM conducted preliminary research targeting world-famous parks functioning as tourism attractions to identify and organize their characteristics as tourism resources and their effects on urban landscapes through literature searches. Based on the findings of this research, the NILIM is conducting investigations and researches on ways to use greens in urban parks in Japan for tourism.

2. Characteristics of parks that are popular as tourism

attractions

Thirty-seven examples (26 overseas parks and 11 parks in Japan that can be compared to overseas parks to promote inbound tourism) are selected based on the following three perspectives: perspective of users (selected from the ranking of Trip Adviser, the online travel site with user reviews); perspective of professionals (selected from rankings such as ones in Lonely Planet, a popular travel guide book); and academic perspective (selected through interviews with intellectuals specializing in tourism planning study, gardening study, or other relevant studies). Then, parks are categorized into seven types based on characteristics, such as park size, location, and available facilities, in addition to the appeal as tourist attractions (Table 1).

3. Plans to use outcomes

The NILIM is going to select representative parks and conduct detailed investigations of the appeal of individual parks as tourist attractions and ideas found in the parks while identifying and organizing how green areas in parks in Japan are being used. The NILIM is then going to organize findings as a compilation of cases and precautions and provide information.

Table 1 Categorization of types of parks which are popular tourist attractions

Types of parks	Characteristics and examples of applicable parks
[Type 1] Large parks designed to experience nature	Large parks mostly consisting of natural forests or other natural features This type of park offers activities to enjoy nature such as trekking and cycling. [Stanley Park and Kings Park and Botanic Garden]
[Type 2] Large urban oasis	Large urban parks with an area of about 50 ha or more People can enjoy various activities and recreation, such as walking, cycling, and picnics. [Central Park, English gardens, Yoyogi Park, etc.]
[Type 3] Small urban spots for relaxing	Smaller urban parks than Type 2 with an area of about 10 ha These parks are located in urban areas and offering businesspersons and citizens places to relax. [Millennium Park, Bryant Park, Hibiya Park, etc.]
[Type 4] Promenade-type parks	Linear promenade-type parks [The High Line]
[Type 5] Parks where multiple facilities are combined	Areas where various types of facilities, such as various types of museums and leisure facilities are combined to form one park [Balboa Park, South Bank Parklands, Ueno Park, etc.]
[Type 6] Historic parks	Areas where ancient palaces and remains of gardens are developed as parks [Luxembourg Gardens, St. James's Park, Kenrokuen, etc.]
[Type 7] Parks with specific themes (art, botanical garden, memorial)	Parks centered around pavilions and viewing facilities with specific themes such as art, botanical gardens, and memorials. [Park Güell, Singapore Botanic Gardens, Moerenuma Park, etc.]

Functional Improvement Method of Urban Parks Responding to an Aged Society with a Low Birth Rate (Research period: FY2017 to FY2018)

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Landscape and Ecology Division, Research Center for Infrastructure Management

Keywords: aged society with a low birth rate, urban park, child-rearing support, health welfare responding to aging, concentration / reorganization

1. Introduction

As declining birthrate and aging have been proceeding in society, urban parks are required to introduce functions responding to changes in social needs, such as child-rearing support functions particularly as response to declining birthrate or health and welfare functions as response to aging. This study aims to examine how to introduce such functions and direction of solutions to facing issues and create technical material for introduction procedures of such functions.

2. Research contents and results

We researched the examples of urban parks (including overseas examples) about the following (i) to (iv) and organized contents, devices in implementation, issues, etc.

- (i) Example with the child-rearing support function
- (ii) Example with the health / welfare function responding to aging
- (iii) Example of renovation / re-development of an urban park
- (iv) Example of concentration / reorganization according to functional sharing in an urban park

The following describes the outline of examples recognized in the researches (i) and (ii).

(1) Example with the child-rearing support function
Research was made on 19 examples in which a day nursery^{Note)} is located or planned and 21 examples in which any child-rearing support function other than establishment of a day nursery has been introduced. In some of the examples in which a day nursery was established, for the purpose of promoting park use, there are also facilities in the premises of day nursery, which are available by general park users and local residents other than users of day nursery facilities, including child-rearing communication salon,



Photo 1: Example of a day nursery installation (Yokohama City Sorimachi Park)

multiple-purpose toilet, roof square, free cafe, and outdoor clock (Photo 1).

In some of the examples in which child-rearing support functions other than day nursery establishment were introduced, child-rearing support facilities where various indoor child-rearing support programs, such as children playing, childrearing consultation, and child-rearing salon, are available have been established or an infant corner has been established at a corner of the existing park.

(2) Example with the health / welfare function responding to aging

A total of 33 examples were researched in which structural measures such as development of facilities with the health / welfare function responding to aging or non-structural measures such as holding of a health class are conducted. In the examples of structural measures, there was an example in which a jogging course, health appliances for the elderly, etc. were installed when opening a park or redeveloping an existing park (Photo 2) or in which an urban park was developed aiming to promote total health integratedly with adjacent medical and welfare facilities. Examples of non-structural measures include holding of a health class as mentioned above, practice of health exercise in the park, implementation of the walking program, support of activities of the elderly using the characteristics of the park, etc.



健康遊具配置図

健康遊具の例

Photo 2: Example of health play equipment installation (Metropolitan Shioiri Park)

3. Utilization of findings

Based on these research examples etc., we intend to organize points and considerations in introduction of functions, including position in the legal system such as exclusive use permission, appropriate locational conditions of urban parks, and conditions of park facilities, and to publish the results as Technical Note of NILIM,

Note) In the partial revision of the Urban Parks Act in 2017, social welfare facilities (commuting service) including day nursery were added as a target of exclusive use in urban parks.

Foundation of "Workshop on Collapse with No Rainfall etc."

(Research period: FY2018 to FY2019)

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Keywords: large-scale collapse, collapse with rainfall, pyroclastic flow plateau

1. Establishment of "Workshop on Collapse with No Rainfall etc."

Slope failure that occurs after the stop of rainfall or when there is no rainfall at all without being affected by the effect of the latest rainfall ("collapse with no rainfall etc.") is a very hazardous collapse phenomena since prior warning / evacuation is difficult, and caused human damage in the past, as sediment disaster at Yabakei-machi, Nakatsu-shi, Oita-ken on April 11, 2018 (Photo 1). In addition, the risk of secondary disaster during rescue / search / recovery / inspection activities is high.

Multiple cases of such collapse occurred in the country and the trend of frequent occurrence has recently been confirmed centering on the peripheral area of pyroclastic flow plateau, particularly in the Kyushu Region, as seen in the events at Minamiosumi-cho, Kagoshima-ken (2010) and Tarumizu-shi, Kagoshima-ken (2015). It is therefore urgently required to take countermeasures for collapse with no rainfall etc. but effective measures have not been taken sufficiently because there are many unclear points in the mechanism of collapse.

Then, in order to establish the method of detecting slopes where the risk of collapse with no rainfall etc. is high in the Kyushu Region, NILIM and the Kyushu Regional Development Bureau established "Workshop on Collapse with No Rainfall etc."



Photo 1: Collapse with no rainfall etc. at Nakatsu-shi, Oita

2. Outline of the Workshop's activity

This Workshop consists of academic experts, NILIM, and administrative organs and intends to continue study for two years. It mainly conducts the following survey activities

First, it collects and organizes data on the past events

of collapse with no rainfall etc. and grasps the characteristics of topography, geology, etc. Next, using as well aerial measurement laser and airborne electromagnetic survey, it analyzes the microtopography and the internal hydrogeologic structure of pyroclastic flow plateau, considered to relate to collapse with no rainfall etc. Particularly, it is considered important to grasp the geological structure of permeable / impermeable layer relevant to concentration of groundwater and related microtopography. In parallel, hydrological observation of groundwater that flows out of the pyroclastic flow plateau is conducted. Field survey is also conducted on the slope where collapse with no rainfall etc. occurred (Photo 2). Considering the results of these surveys comprehensively, the Workshop examines the method of detecting hazardous slopes with the risk of collapse with no rainfall etc.



Photo 2: Field survey at Shinko River (Tarumizu-shi, Kagoshima)

3. Final results of the Workshop

This Workshop aims to consider the mechanism of collapse with no rainfall etc. and create a hazardous slope detection manual focused on the Kyushu Region based on the small-scale hazardous slope distribution map, microtopography interpretation, etc. Further, based on the findings in the Kyushu Region, we intend to develop them all over the country.

☞ See the following for details.

1) Workshop on Collapse with No Rainfall etc. (in the website of Kyushu Regional Development Bureau) <http://www.qsr.mlit.go.jp/n-kawa/mukouzihoukai/mukouzihoukai.html>

Field Survey on Disaster at the Tachikawa Bridge of Kochi Expressway

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Keywords: heavy rain disaster, road bridge, superstructure, run-off

1. Introduction

The heavy rain in July 2018 caused enormous damage mainly in the western part of Japan. At the Tachikawa Bridge of the Kochi Expressway (upbound), landslide from the slope above the bridge occurred before dawn on July 7 due to the record breaking heavy rain, which had been continuing since July 3, and runoff of the bridge superstructure due to the landslide was also confirmed. On July 20, the NILIM conducted a field survey to grasp the situation of disaster with the Public Works Research Institute.

2. Outline of the survey

The bridge at issue is a PRC 3-span continuous slab girder bridge, 63.5 m long, located in the steep valley of Otoyo-cho, Kochi. The substructure of the bridge is based on wall-type abutment and wall-type pier, and the foundation is coupled-pike caisson type pile foundation. As a result of the field survey, loss of concrete was found in part of the bridge seat at the bridge pier and abutment but no serious damage, such as inclination, crack, etc., was found in the substructure frame in the visible range. Damage to the superstructure of the bridge could not be confirmed since it was run off along the valley slope together with the landslide.

It is considered from the aforementioned situation of damage that the effect of large-scale collapse acted on the superstructure and caused run-off.

We advised the personnel on the site that they needed to check soundness of the substructure by removing the sediment deposited on the slope and to consider measures for training of the space under the bridge girder for recovery.

3. Technical support for recovery

After the field survey, we participated as a member in the Technical Review Committee on Kochi Expressway Disaster Restoration, which consists of road administrators, and advised, based on the results of field survey, evaluation of the soundness of structures and restoration method.

As of February 2019, based on the results of discussion in the Committee, road administrators are conducting permanent measures for the landslide sites, including grating crib works, and restoration works for the superstructure, etc.



Disaster situation (source: West Nippon Expressway Company Limited)



Superstructure run-off



Field survey

☞ See the following for details.

1) MLIT Road Bureau's website "Results of the Technical Review Committee on Kochi Expressway Disaster Restoration and Outlook for the Time of 4 Lane Restoration."

http://www.mlit.go.jp/report/press/road01_hh_001093.html

Contribution to Early Restoration of the Road Bridge Damaged by the Kumamoto Earthquake with Comprehensive Technical Capability

(Research period: FY2017 to FY2021)

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Keywords: Kumamoto Earthquake, road bridge, disaster recovery, technical support

1. Introduction

The Kumamoto Earthquake caused enormous damage to the bridge on the prefectural road Kumamoto-Takamori Line, connecting the city of Kumamoto and Aso Region. Since restoration from the damage would need advanced technology and require urgency, the State is advancing the disaster recovery project as a proxy project under the Act on Reconstruction after Large-scale Disaster in response to the request of Kumamoto Prefecture.

This paper introduces technologies incorporated for restoration and activities of technical support by Kumamoto Earthquake Recovery Division in connection with the Kuwazuru Bridge on the prefectural road Kumamoto-Takamori Line, which resumed service in July 2018.

2. Structure of Kuwazuru Bridge and outline of the disaster

Kuwazuru Bridge is a two-span continuous cable-stayed steel bridge, 160 m in length, with a curved girder hanging, of which span is different by 40 cm at the starting point and ending point from X-type main tower. As shown in Fig. 1, the girder end at the bridge end floated up about 60 cm due to damage to the bearing caused by the Kumamoto Earthquake and the entire girder moved about 90 cm to the valley.¹⁾ In addition, tension of the cable was lost in part and the cable got twisted.¹⁾

3. Support for "Build Back Better" restoration

For restoration of the Kuwazuru Bridge, proposal for "Build Back Better (better restoration)" was made based on disaster situation and maintenance after restoration and with various technical considerations. Specifically, we proposed the countermeasure technology for preventing floating-up of the girder against the earthquake exceeding the size expected by design, monitoring method in construction stage for rectifying the uncertainty of restoration design, multiple considerations for preventing water permeation into the cable fixing part, etc., which were all adopted.²⁾

In addition, since maintenance of this bridge is succeeded by Kumamoto Prefecture, we provided technical support in planning for obtaining, in construction stage, data contributing to maintenance of the Kuwazuru Bridge after restoration.²⁾



Fig.1: Main damage to the Kuwazuru Bridge



Fig. 2: Local presentation meeting about the restored Kuwazuru Bridge

Further, in order for the aforementioned technologies for restoration measures and intention of the data obtained in construction stage to be properly succeeded, a local presentation meeting was held for the personnel of Kumamoto Prefecture before resuming service jointly with Kumamoto Earthquake Recovery Division and Kumamoto Restoration Division of Kyushu Regional Development Bureau, MLIT.³⁾ (Fig. 2). Some personnel of Kumamoto Prefecture who joined the meeting gave comments to the effect that "We'd like to utilize the restoration measure technology for maintenance of the Kuwazuru Bridge considering its intention."

4. Conclusion

Proxy projects are going on at Tawarayama Bridge and Okirihata Bridge on the prefectural road Kumamoto-Takamori Line and Aso Bridge on National Highway No. 325. Kumamoto Earthquake Recovery Division continues to work for support with advanced technologies to achieve early realization of "Build Back Better" recovery from the Kumamoto earthquake.

See the following for details.

- 1) Technical Note of NILIM, No. 967, pp. 269-272, 2018
- 2) Civil Engineering Journal, vol. 60, No. 10 pp. 24-27, 2018
- 3) Civil Engineering Journal, vol. 60, No. 9 pp. 42-43, 2018

Establishment of Use Patterns of Toolkit for Supporting Study on Disaster Control Measures

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Keywords: toolkit, disaster, disaster exercise

1. Introduction

Japan is hit by various disasters, including earthquakes and storm / flood damages. It is therefore very important to prepare for them by conducting pre-training assuming their occurrence, etc. NILIM has developed a toolkit for supporting study on disaster control measures (the "Toolkit"), which puts together various tools for examining disaster damage estimation, risk assessment, and countermeasures as a flow of serial operations, and has been studying on its improvement and utilization method from time to time based on results of use in training, drills, etc. by individual organizations. This paper reports results of study on utilization in FY2018.

2. Outline of Toolkit

The Toolkit is a disaster exercise to be conducted in the following procedures (i) - (iv).

- (i) In "Infrastructure damage data organization," assume disasters from an earthquake, storm / flood damage, etc. and plot damages to infrastructure on jurisdiction and other maps for organization.
- (ii) In "Disaster scenario establishment," organize the effect of infrastructure damage on society and economic activities.
- (iii) In "Risk assessment," assess the risk of infrastructure damage from "possibility of occurrence" and "seriousness of effect on human life and economy" and organize seriousness.
- (iv) In "Countermeasure examination," study the content of countermeasures for individual damages and organize the degrees of difficulty and priority.

3. Utilization of Toolkit

About one day is required to implement all the contents described in the outline of Toolkit. Using various tools, use patterns are being established according to the time and purpose of training. For this fiscal year, training time was set to 2 hours and use patterns were established for the following purposes (i) to (iii) with the structure shown in Table.

Table: Structure of use pattern

時間	項目	概要
約20分	【事務局】訓練概要の説明	・状況設定および訓練手順を説明
約60分	【各班】ツールキット概要①、②の内容演習 災害時の被害状況のイメージ 社会、経済活動への影響をイメージ	・個別班に分かれ、地震発生時に管内でどのような被害が発生するのか、また、発生した被害はどのような支障をもたらすのか、地図を見ながら発想し、整理
約10分	【全体】発表(1班あたり5分程度) ※班数により代表班を選出	・班毎に、以下の点について発表 >発想した被害の様相 >他分野に波及が懸念される被害のうち、特に懸念する被害
約30分	【事務局】講評、ツールキットの説明 ツールキット概要③、④の説明	・各班の成果に対して講評。 ・体系化されたリスクマネジメントの考え方について概説。 ・ツールキットを活用した検討可能事項を説明

- (i) Build the concept in addressing disasters.
- (ii) Make participants understand that infrastructure they manage may be damaged and society, economy, etc. may be greatly affected.
- (iii) Make participants understand that damages to multiple units and various fields of infrastructure mutually affect each other in the event of a disaster and that it is necessary in responding to disaster to take actions by making overall decision considering it. The use patterns were demonstrated in the technical training conducted to subsection manager or equivalent personnel with experience of 5 or 6 years at the position in Kanto Regional Development Bureau. Photo shows the training.



Photo: Disaster exercise technical training

Since the presentation material of the Toolkit, training introduction material, damaged area information, etc. were distributed before the training, the participants deepened their understanding in advance and discussed the topics actively even in a limited time and confirmed the practical applicability of the use patterns.

4. Conclusion

NILIM is going to promote the use and dissemination of the Toolkit in various organizations and further develop another toolkit that is easier to use by conducting necessary improvement and study of use patterns based on results of actual use.

Collection and Utilization of ETC2.0 Probe Information

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Keywords: ETC2.0 probe information, data collection / utilization, productivity revolution

1. Outline of ETC2.0 System

ETC2.0 provides information service for avoiding traffic congestion and driving safely in addition to the automatic toll collection service, and enables road administrators to collect "ETC2.0 probe information" that includes travelling and behavior histories of automobiles. Road administrators developed a device for collecting / processing ETC2.0 probe information based on the specifications prepared by NILIM and have been operating it since April 2011, and the activity to use ETC2.0 probe information for the MLIT Productivity Revolution Project, including pinpoint congestion countermeasures, has begun.

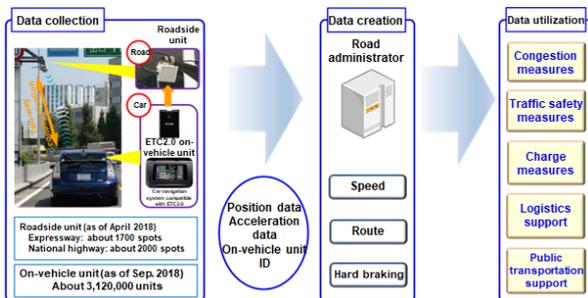


Fig. 1: Collection and utilization of ETC2.0 probe information

2. Upgrading of ETC2.0 probe information utilization

NILIM has been studying for advanced utilization of ETC2.0 probe information aiming at further efficiency increase in road management operation and facilitation / safety improvement of road traffic. This paper introduces part of our activities.

(1) Provision of operation management support service

NILIM established a mechanism of identifying vehicles and collecting probe information based on business operator's application, etc. NILIM has also conducted a social experiment of the operation management support service since 2016 to provide probe information on vehicles held by road administrators to logistics operators so that it may be utilized for increasing efficiency in operation management, securing the safety of drivers, etc. and organized results of the experiment. This service was formally introduced in FY2018 and has been widely provided to the public.

(2) Utilization for verification of the effect on measures for congestion due to tourist traffic

Since tourist traffic is an irregular traffic that does not occur frequently, it is considered difficult to collect data for analysis. NILIM has therefore been studying the method of verifying the effect of measures for congestion due to tourist traffic using the characteristic of ETC2.0 probe information that the traveling history of vehicles can be grasped constantly.

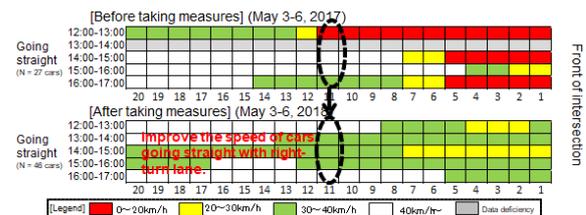


Fig. 2: Example of speed analysis at the intersection in the GW period

(3) Utilization for identifying traffic safety measures zones on the community road, etc.

For community road traffic safety measures, it is effective to conduct them integrally in an area where the risk of accident is high. As an indicator for accident risk assessment, sudden deceleration data, which is one of the behavior history of ETC2.0 probe information is useful for preventing inadvertence of potential hazardous areas. NILIM has therefore been studying a method of narrowing down areas with high risk of accident using ETC2.0 probe information and considering areal spread as well as a method of analyzing the effect of countermeasures.

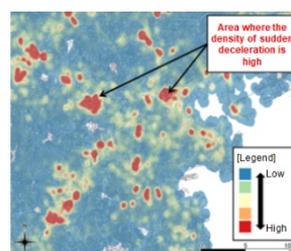


Fig. 3: Narrowing down areas where the risk of accident is high

Promotion of Global Warming Countermeasures in Sewerage

(Research period: FY2017 to FY2019)

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keywords: sewerage, global warming, nitrous oxide

1. Introduction

As global warming countermeasures in sewerage, the NILIM has been examining the emissions of nitrous oxide (N_2O), one of the greenhouse gases ("GHG"), and studying on reduction of emissions.

2. Survey of N_2O emissions in sewage treatment facilities

It is known that N_2O , a strong greenhouse gas, is generated as by-product or intermediate product when household effluent is biologically treated in sewage treatment facilities. We have surveyed N_2O generation in some sewage treatment facilities which operate in different treatment methods, and accumulated data. As a result, it was found that N_2O generation from the treatment facilities that adopted advanced wastewater treatment focused on nitrogen removal was very small as compared with other treatment methods. On the other hand, in the conventional activated sludge process ("conventional process"), high N_2O emissions were observed in the aerobic tank as compared with other treatment methods. It was also found in the last year's survey that N_2O generation tends to be less in the sewage treatment facilities that have adopted any device for operation management (staged advanced treatment operation) aiming at improvement of water quality in nitrogen etc. while using the facility structure of existing conventional process, as compared with facilities only using the conventional process. However, the number of data is still not enough for identification of causal factors and even proposal of operation under N_2O control, and it is necessary to conduct surveys in different treatment facilities.

For the current fiscal year, in the treatment facilities conducting the staged advanced treatment operation, we surveyed N_2O generation for 4 hours in the autumn and winter seasons, respectively, considering seasonal variation. From the survey results, it was confirmed that N_2O generation was smaller as compared with the conventional process. It was also found that N_2O generation varies greatly according to time zones in the same treatment facilities, and the result that suggests seasonal variation was also obtained, which is considered to indicate the possibility of multiple N_2O causal factors.

3. Study of N_2O emission factors in the conventional process

Particularly for the conventional process, which comes with high N_2O emissions, we conducted a test using the bench scale reactors under different operating conditions in order to clarify N_2O emission factors. From the experiment results, decrease in nitrous acid and nitric acid by the denitrification process was confirmed in the final settling tank installed after the 6th tank. Since it was also confirmed that N_2O was highly dissolved in the return, N_2O contained in the return sludge, as well as the oxidation process in the aerobic tank, is suggested to have also contributed to generation. It is therefore necessary to study an operating method considering not only aerobic tank but measures against N_2O contained in the return sludge.

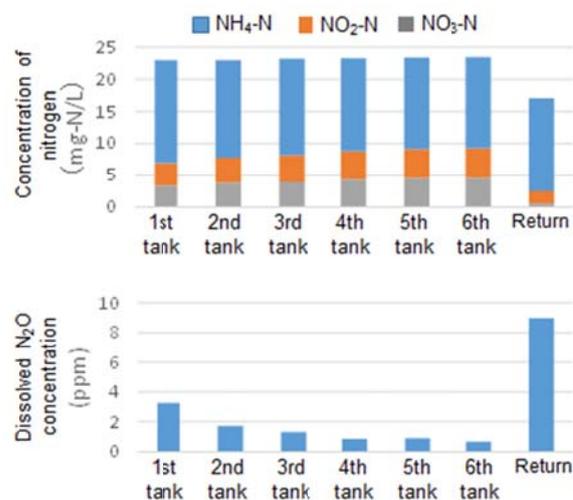


Fig.: Nitrogen concentration in each tank

4. Future challenges

We are going to continue data collection in sewage treatment facilities for identification of N_2O causal factors. Further, we work for analysis in combination of relevant N_2O generation process and the microorganisms and environmental factors that underlie the process.

Promotion of Water Treatment Technology Considering Risk Control in Energy Optimization

(Research period: from FY2016)

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MATSUHASHI Manabu, Researcher, YAMATMO Akihiro, Researcher,

Wastewater and Sludge Management Division, Water Quality Control Department

Keywords: energy saving, energy creation, energy optimization, coliform, recycled water, risk assessment

1. Introduction

The Wastewater and Sludge Management Division of NILIM has been conducting researches and studies on drainage from sewage treatment facilities from various viewpoints, including water quality, energy, cost, and hygienic risk in order to respond to social demand expected for sewage service. Of these viewpoints, this paper introduces energy and hygienic risk.

2. Energy optimization in treatment process

Sewerage greatly contributes to maintenance of good water environment by processing / removing organic matter, nutrient salt, pathogenic microorganisms, etc. in sewage, while it is urgently required to reduce a large consumption of electricity used for sewerage. We therefore organized the concepts of calculating energy balance by combining energy creation processes, including power generation by digester gas and sewage sludge solid fuelization, with the method of calculating the power consumption in the sewage treatment process, which we have organized until last fiscal year. For multiple model cases where influent quantity, sewage sludge energy usage, etc. are combined, we calculated energy balance on a trial basis by organizing material balance in the process from wastewater inflow to use of sludge as energy or disposal. Fig.1 shows the amount of energy consumption and creation in each case of the conventional activated sludge process as an example of trial calculation results.

Based on these results, we are conducting a survey of actual energy consumption, etc. in sewage treatment facilities to make further comparison with trial calculation results.

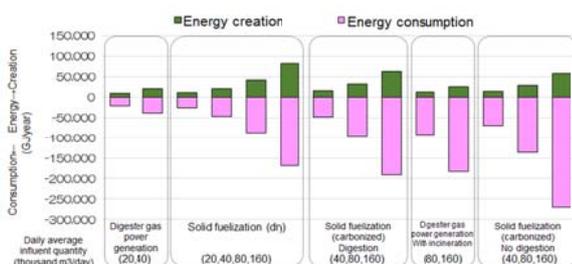


Fig. 1. Results of provisional calculation of the effect of power consumption reduction by introducing energy-saving equipment (conventional activated sludge process)

3. Evaluation of hygienic risk control technology for treated water

In accordance with the ongoing discussion about changing an item of the environmental water-quality standard from the coliform group count to coliform count, it is necessary to discuss change from the coliform group count to coliform count for the items of technical standards for effluent from sewerage. In addition, since an international standard for recycling of sewage treatment water is under consideration, it is necessary to discuss domestic applicability of such standard and assessment method of sewage treatment facilities considering hygienic risk.

Therefore, we examined the annual behavior of the number of coliforms in sewage treatment facilities (Fig. 2) and verified the ratio of coliforms to the number of coliform groups and differences according to measurement methods. We are also studying the behaviors and removal rate of microorganisms, which can be an indicator of hygienic risk control in sewage treatment facilities, and examining an assessment method considering cost and energy by setting the combination of sewage treatment facilities with which the rate of virus elimination can be achieved according to various water applications by regarding infection by norovirus as a hygienic risk.

We intend to conduct a research required in order to study revision of standards for the number of coliform groups and continue to research and study hygienic risk assessment methods considering the trend of the international standardization of recycled water usage.

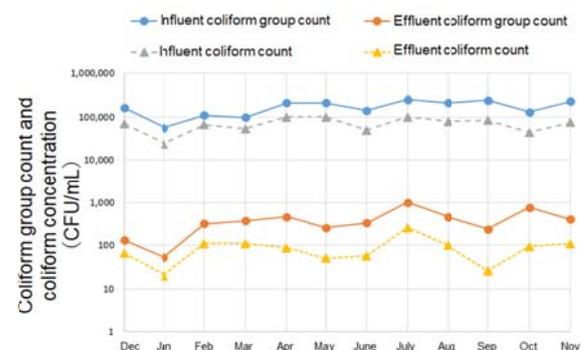


Fig. 2. Annual variation of the concentration of coliform etc.

Utilization of On-vehicle Sensing Technology for Road Management

(Research period: FY2016 to FY2018)

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Keywords: Mobile Mapping System (MMS), road management, oversize/overweight vehicle passage permission system

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") aims to shorten the number of days required to examine applications for vehicles with dimension, weight, or other exceeding the standard to travel through a road to approximately ten days in average by 2020. As one of the activities to this end, the MLIT plans to conduct automatic examination using the data collected on the shapes of roads using the sensing technology.

2. Survey of on-vehicle sensing technology by offering experiment to the public

In order to examine low-cost technologies that provide data accuracy required for the examination above, etc., NILIM conducted verification in January 2017 through an experiment offered to the public. Consequently, equipment was confirmed that meets the budget (not more than 15 million yen) and accuracy requirements (the position information of natural features measured is within the standard deviation of 25 cm).

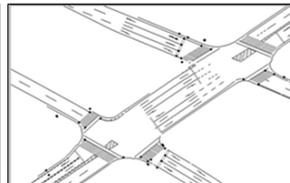


Fig. 1: Point group data image

Fig. 2: Plotting result image

Table 1: Main assessment results of the publicly offered experiment

Assessment item	Description of assessment	Number of participants that meet requirements
Accuracy	Technology available to obtain the absolute accuracy of 1/500	8 out of 9 participants
Equipment cost	Absolute accuracy of 1/500 can be obtained and equipment cost is about 15 million yen	4 out of 9 participants
Detection of natural features	Possible to detect measurable natural features at verification spot	9 out of 9 participants
Ease of installation / removal	Prepared a manual for equipment installation / removal	6 out of 9 participants

3. Drafting of functional requirements for on-vehicle sensing technology

Based on the results of the experiment in section 2 above, etc., we prepared "Proposal for functional

requirements of measuring equipment, etc." and "Drawing procedure proposal," which are both required for Regional Development Bureaus, etc. to collect measurement data and prepare drawings. Each Regional Development Bureau introduced the on-vehicle sensing technology using this "Proposal for functional requirements of measuring equipment, etc."

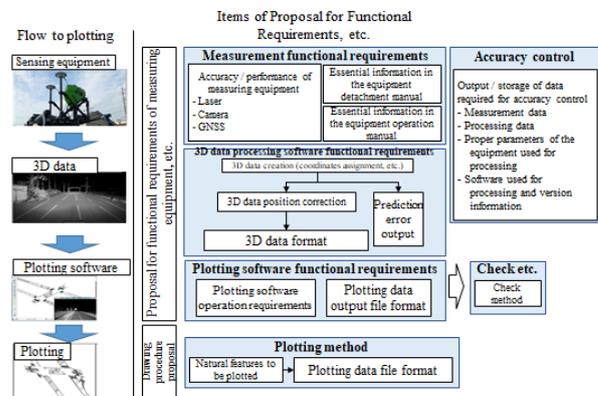


Fig. 3: Flow to plotting and relationship of items in the Proposal for Functional Requirements, etc.

Table 2: Outline of matters described in the Proposal for Functional Requirements, etc.

Proposal for functional requirements including measuring equipment	<ul style="list-style-type: none"> - Describe the requirements for measurement data processing software (post-processing) and plotting processing software in addition to the measuring device requirements. - Accuracy and performance are subject to the "Standards for the Geographical Information Authority of Japan Operation Rules" (partially revised, March 31, 2016) - Describe measurement data format and definition of items of information in possession - Describe the requirements for installation in vehicles.
Drawing procedure proposal	<ul style="list-style-type: none"> - Describe the outline of natural features to be plotted. - Outline of target natural features is described through extraction from "Road Base Map Information (maintenance promotion version) Product Specification (Draft) (May 2015 version)." - Describe the definition of the file format of plotting data and the required accuracy of plotting data.

4. Conclusion

For fiscal 2019, it is planned to collect data on local roads for which 5 or more applications are annually submitted (about 13,000 km) using the on-vehicle sensing technology introduced by each Regional Development Bureau.¹⁾

See the following for details.

1) The 18th Logistics Subcommittee --- Improvement of the oversize/overweight vehicle passage permission system http://www.mlit.go.jp/policy/shingikai/road01_sg_000421.html

Identification of the actual conditions of energy conservation designs in non-residential buildings

(Research period: FY 2018-2019)

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Keywords: Non-residential building, energy conservation, conformity judgment, web program, cloud, big data

1. Background and objective of study

Proper identification of the actual energy conservation performance of a building is necessary to examine energy conservation measures in the evaluation of energy conservation standards. Information concerning the evaluation results of energy conservation standards is based on the data of 18,000 buildings (non-residential buildings) every year and is playing important roles. Still, competent authorities are currently aggregating the data (by extracting values from paper documents) upon request from the Ministry of Land, Infrastructure and Transport. Too much of a workload is involved in this process. Also, since information collection is restricted to reduce the workload, detailed information cannot be obtained. Even though a great volume of data is available, the data are left without being used effectively. Therefore, the NILIM attempts to obtain fundamental information for revising energy conservation standards and propose research themes by entering information in the Energy Conservation Standards Conformity Judgment Program (web-based program),¹ encrypting calculation results, saving them on a server, and analyzing them.

2. Construction of a scheme to extract effective data

Data on a server contain data from the design phase, which are not the final version. Thus, effective data are extracted as follows.

- 1) Competent authorities enter “XML-ID” and “Re-output code” which are printed on submitted calculation results (the output file of the web program, printed and submitted as paper documents) in Excel files in a report to the Ministry of Land, Infrastructure, Transport and Tourism.
- 2) The NILIM receives the information from the Ministry of Land, Infrastructure, Transport and Tourism, searches data on the server (“XML-ID” is the identification name of data), and removes the encryption (“re-output code” is the cancellation password).

To reduce the workload 1), QR code for quick scanning of ID information is added. A check tool (Excel) to check for mistakes in entering information is

also developed and distributed.

3. Trial gathering and analysis

As a trial, the ID numbers of about 6,000 buildings are obtained from some of the authorities. Figure 1 shows the relationship between floor area and the area of the exterior shell as an example of the analytical result. This information was analyzed and became necessary to construct the method to evaluate small-scale buildings that are now under examination. The identification of the area of the exterior walls and windows of individual buildings becomes necessary to perform this analysis. Thus, it was not possible to conduct detailed analysis using conventional investigation methods.

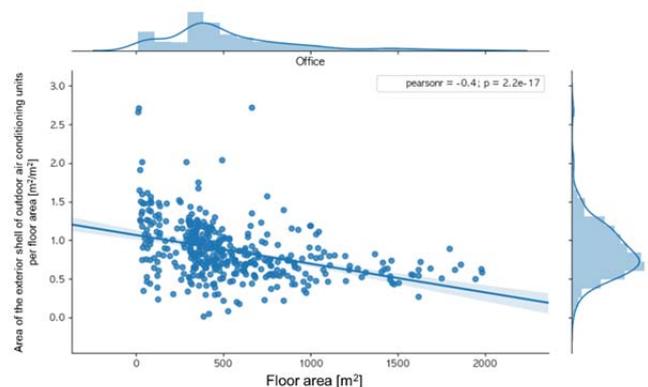


Figure 1 Relationship between floor area and the area of exterior shell (Kanto area, office buildings)

4. Summary and future perspectives

The scheme constructed in this study was found to reduce the workload of authorities and surely provide beneficial information concerning energy conservation designs. All data from FY 2018 can be obtained in the next fiscal year. Thus, the NILIM is going to analyze the actual conditions of energy conservation designs in Japan.

For more information:

- 1) Technical information concerning energy consumption performances of buildings

<https://www.kenken.go.jp/becc/index.html>

Research Coordination

1. Introduction

The research policy of NILIM provides, as a basic attitude, "Aim at new technical development by implementing technical cooperation and integration widely among industry, university and government" and, as preparedness for research, "Establish an efficient research system in cooperation with external organizations while recognizing own strengths and weaknesses." It is also one of the important roles of NILIM to coordinate researches with industry-university-government cooperation. Many researches have been conducted in collaboration / cooperation with administrative organs, private sectors, universities, etc. and this paper introduces typical systems and examples.

2. Examples of coordination / cooperation with administrative organs concerned

NILIM conducts many researches with project cost budget etc. that directly lead to policy development in cooperation with the MLIT, etc. As examples that constitute a particularly large-scale research subject, there are comprehensive technical development project (comprehensive project) and administration cost itemization budget. Of the important research subjects concerning construction technologies, comprehensive projects work on particularly urgent subjects covering wide target areas and conduct researches comprehensively and systematically in cooperation of industry, university and government under the leadership of administration departments in promoting projects. Administration cost itemization refers to the budget that is directly assessed by the Ministry of Finance and used to conduct comprehensive researches that lead to creation of government policies. **Table 1** provides the subjects of comprehensive projects implemented in fiscal 2018 and **Table 2** provides the researches based on the administration cost itemization budget.

3. Examples of cooperations with private sectors, universities, etc.

Various types of cooperations for obtaining maximum performance with limited research resources are practiced including joint and contract researches, which are typical methods of cooperation, and are classified into the patterns provided in **Table 3**.

Table 3. Patterns of examples of cooperation with private sectors, universities, etc.

I. Research established as a system in the NILIM
(1) Joint research, (2) Contract research (research publicly offered by laboratory), (3) Contract research (research public offered by council), (4) Budget of other ministry / agency (SIP: Strategic Innovation Promotion Program)
II. Research established as a system in other organizations
(5) Technical research association
III. Research not established as system but established to a certain extent
(6) Technical public offering, (7) Social experiment, (8) Workshop / study group
IV. Research conducted by devising ways of operation
(9) Cooperation with policy development by the Ministry, (10) Cooperation with municipal projects, (11) Workshop with university / private sector

Table 4 shows the number of contract researches ((2), (3)) conducted, **Table 5** provides the number of joint researches ((1)) conducted, and **Table 6** lists typical cooperation examples including contract researches (publicly offered by laboratory)((2)), for fiscal 2018.

Table 4. Number of contract researches conducted in fiscal 2018

Pattern	Name of the council, etc.	Number of cases
Research publicly offered by laboratory		3
Research publicly offered by the Ministry's council		
	New Road Technical Conference	29
	River works technology research and development	10
	Sewerage B-DASH	18
	Next-generation Infrastructure Inspection System Development Examination Committee	1

Table 1. Comprehensive technical development projects implemented in fiscal 2018

Subject	Research period	Department / center in charge	Related article
Technological development contributing to utilization of existing buildings by streamlining fire prevention / evacuation rules, etc.	2016-2020	Building / Urban	
Research on construction productivity improvement with full utilization of ICT	2017-2020	Social capital management	
Development of design / construction technologies for mixed structure buildings using new wood material	2017-2021	Building	
Research on upgrading of construction production systems using AI	2017-2020	Social capital management	
Development of suburban residential area revitalization techniques responding to mature society	2018-2022	Housing / Building / Urban	

Table 2. Researches based on the administration cost itemization budget implemented in fiscal 2018

Subject	Research period	Department / center in charge	Related article
Development of simple performance evaluation methods for wooden housing	2016-2018	Building	
Development of evaluation method of energy reduction effect by automatic control technology of building equipment	2016-2018	Housing	
Research on securing the safety of port area against storm surge disaster	2016-2018	Coastal, Marine and Disaster Prevention	
Research on practical evaluation method for life extension / effective use of existing port facilities	2016-2018	Port	
Research on field productivity improvement in social capital maintenance process	2016-2018	Social capital management	
Research on flood prevention activity supporting technology	2017-2019	River	
Development of equipment improvement technology, etc. for securing the health and safety of disaster victims in shelters	2017-2019	Building	
Research on facade design methods aiming to improve energy consumption performance in buildings	2017-2019	Housing	
Development of urban structure analysis / evaluation techniques considering diversifying life support functions	2017-2019	Urban	
Development of diagnostic techniques of trafficability in case of earthquake / fire	2017-2019	Urban	
Research on prompt inspection / restoration methods for airport pavement in earthquake disaster	2017-2019	Airport	
Research on comprehensive management of sewer pipelines	2018-2020	Sewerage	
Development of pre-analysis method for sediment disaster caused by large-scale earthquake	2018-2020	Sediment disaster	
Development of existing RC member evaluation techniques contributing to life extension / improvement of exterior / waterproofing membrane of buildings	2018-2020	Building	
Establishment of visualization method for barrier-free effect according to life stages	2018-2020	Housing	
Research on quantitative evaluation method for urban environment improving effect of green space, etc.	2018-2020	Urban	
Research on immediate damage estimation methods for port facilities in large-scale earthquake	2018-2020	Port	

Table 5. Joint researches conducted in fiscal 2018

Subject of joint research	Partner organization	Research period	Department / center in charge	Related article
Research on early detection of sediment disasters using observation / monitoring data of mountainous watershed	National Institute of Advanced Industrial Science and Technology	2016-2018	Sediment disaster	
Joint research on state prediction method utilization measures using inspection data of road bridges	Kyoto Prefecture, Kyoto University, Public Works Research Institute	2016-2018	Road Structures	
Research on technical standards etc. in building, housing, and urban fields	Building Research Institute	2016-2021	Building / Housing / Urban	
Joint research on development of sediment disaster monitoring methods using Advanced Land Observing Satellite No. 2 "Daichi No. 2"	Japan Aerospace Exploration Agency	2017-2019	Sediment disaster	
Joint research on technological development for practical use of the next-generation Cooperative ITS	29 entities and 32 organizations including automakers, electrical equipment manufacturers, related foundations, and expressway companies	2017-2019	Road Traffic	
Joint research on seismic performance verification experiment of mixed structure buildings using new wood material	National Research Institute for Disaster Prevention	2017-2021	Building	
Joint research on an international logistics model on a global scale to be established from the positions of shippers and shipping companies	University of Tokyo	2017-2018	Administrative Coordination	
Joint research on utilization of AIS data for port maintenance / use	Service Center of Port Engineering (SCOPE)	2017-2019	Port	
Joint research on utilization of construction management record obtained in seismic restoration of bridges for maintenance	Japan Association of Steel Bridge Construction, Japan Prestressed Concrete Contractors Association	2017-2019	Social capital management	
Joint research on inundation forecast system in Tokyo	Waseda University	2018-2021	River	
Joint research on ETC 2.0 data distribution service	ITS Technology Enhancement Association	2018-2021	Road Traffic	
Joint research on life extension of weather proof steel bridges	The Public Works Research Institute, Japan Association of Steel Bridge Construction, Japan Iron and Steel Federation, Nagaoka University of Technology, Nippon Steel & Sumikin Anti-corrosion Co., Ltd.	2018-2020	Road Structures	
Joint research on upgrading bridge performed evaluation / restoration techniques	The Public Works Research Institute, Japan Association of Steel Bridge Construction, Japan Iron and Steel Federation, Nagaoka University of Technology, Waseda University	2018-2021	Road Structures	
Joint research on maintenance of concrete floor slab bridges	The Public Works Research Institute, Japan Prestressed Concrete Contractors Association	2018-2020	Road Structures	

Table 6. Typical examples of cooperations with private sectors, universities, etc. conducted in fiscal 2018.

Pattern	Subject	Purpose and form of cooperation	Participants	Research period	Department / center in charge	Related article
(3) (4)	Research and development of infrastructure and inspection devices for upgrading inspection of social infrastructure	- Provide fields by utilizing robot technologies developed by private sectors - Utilize expert organizations for technical adaptability	Joint research organization (Public Works Research Institute, private-sector organizations)	2016-2018	Social capital management	
(3)	Breakthrough by Dynamic Approach in Sewage High Technology Project (B-DASH Project)	Utilize local governments, private enterprises, a universities, etc. for practical use of innovative techniques that are not generalized	Joint Research Organization (universities, private enterprises, other national research centers, local governments, etc.)	2011-	Sewerage	
(4)	Strengthening resilient disaster prevention / mitigation functions "Development, introduction, etc. of observation / analysis / forecast techniques for flood disasters"	Utilize expert organizations with advanced meteorological observation and heavy rain forecast techniques for social implementation of heavy rain disaster forecast techniques	National Institute of Information and Communications Technology, Osaka University, National Research Institute for Earth Science and Disaster Prevention (NIED), Japan Weather Association, Railway Technical Research Institute, etc.	2014-2018	River / Sabo	
(6)	Project for introduction / utilization of innovative technologies for drastic improvement of productivity in construction site	Publicly offer a project for improving productivity with new technologies such as IoT and AI by obtaining real-time digital data from construction sites.	Consortium consisting of private enterprises, universities, etc. (33 entities)	2018-	Social capital management	
(8)	Local Road Economic Strategy Workshop and local workshops	- Discuss issues specific to regions and utilize needs of administration and wisdom of university. - Match with administrative needs to promote innovation of road policy.	University, Ministry, Regional Development Bureau	2015-	Road Traffic	
(9)	Cooperation with local governments that implement area measures in research on traffic safety measures for community roads	Technical cooperations in effective implementation of traffic safety measures (local government: Implement measures, NILIM: analysis, technical consultation, etc.)	Yokohama, Hamamatsu, Kurume	2016-	Road Traffic	
(10)	Cooperation with local governments in research on grasping road traffic situation	- NILIM conducts transportation analysis etc., and local government (road administrator) conducts the project and consultation with organizations concerned to solve issues in proper sharing of roles.	Ibaraki Pref.	2013-	Road Traffic	

4. Conclusion

In addition to the above, various types of cooperations and coordinations are conducted, including examples of working for research activities and revision of technical standards in industry-university-government cooperation as committee activity of academic societies and associations and

participation of committee members in various types of technical public offering by the MLIT and Regional Development Bureaus. We intend to continue researches while devising and utilizing various cooperations among industry, university, and government, aiming at better research results and social implementation.

International Research Activities

1. International research activities at NILIM

NILIM has been promoting international research activities based on the following three viewpoints.

(1) Improvement in the quality of research findings: In order to produce worthy research findings, we closely follow the trends in overseas technical policies concerning "Disaster prevention / mitigation and crisis management", "Infrastructure maintenance", "Production innovation", "Improvement of livability", etc., which are important research subjects for NILIM. To this end, we collect information broadly by actively participating in international conferences. In particularly important fields, we go deeper through bilateral meetings and a framework of research cooperation among many countries.

(2) Infrastructure system export: As a governmental organization, we implement activities to export high quality infrastructure in accordance with measures that benefit Japanese companies and revitalize domestic industries. For this purpose, we participate in projects and provide information thereto from the conceptual phase (upstream), develop soft infrastructure, support companies that export infrastructure, and cooperate in bilateral research with developing countries.

(3) International contribution: We dispatch experts for technical cooperation projects conducted by JICA in developing countries and factfinding missions to support reconstruction efforts overseas after large-scale natural disasters. We also welcome engineers and administrative officers from developing countries for training programs conducted by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

2. Main international research activities in fiscal 2018

Of the international research activities implemented in fiscal 2018 based on the three viewpoints above, representative cases are introduced as follows.

(1) Activities related to the "Improvement in the quality of research findings"

We attended international conferences including the following to collect and share the latest information in the respective research fields.

1) Meeting on Flood Control and Water Resources Management between USACE and MLIT and visit to related organizations (USA: May 16 to 26, 2018)

Through participation in the 13th Meeting on Flood Control and Water Resources Management between USACE and MLIT and visits to the World Bank and the U.S. Army Corps of Engineers on Water Resources, we collected information about the latest flood disaster risk reduction measures under the pressures of climate change and examined Japan's flood disaster risk reduction measures.

The following are the matters identified as a result of this research.

- It is important to formulate a practical flood disaster risk reduction / crisis management plan based on regional characteristics, evacuation status, etc.
- Regarding the future rise in sea level due to climate change, study and coordination are necessary to introduce methods to be considered in flood control plans.

2) Meeting on measures against aging sewerage infrastructure (France, June 10-17, 2018)

As measures against aging of sewerage facilities, private sector utilization and area expansion are claimed also in Japan. In France, which is advanced in taking such measures, we held a meeting (Photo 1) with the France Conference of Mayors, water treatment companies, sewerage management associations, and urban communities in the Bordeaux Region to collect information about the current status and future direction including their subsidy system.

3) Japan-US Bridge Workshop (USA: July 15-20, 2018)

In the Japan-US Joint Bridge Workshop held under the Japan-US Science and Technology Cooperation Agreement (Transportation Science and technology Field), opinions were exchanged with a focus on standardizing matters for which no specific standards were established in either country or were due for revision. Agenda items included "Standards for periodic inspection and durability design", "Needs for monitoring", "Standardization of advanced numerical analysis", and "Standardization of repair / reinforcement and new materials".

(2) Activities related to "infrastructure system export"

1) Cooperation in formulation of national harbor standards in Vietnam



Photo 1: Control center in Bordeaux

NILIM is providing cooperation to Vietnam under the "Memorandum of Understanding for Cooperation in Formulation of National Technical Standards for Port and Harbor Facilities", which was executed in March 2014 between the MLIT and the Department of Transportation of Vietnam and revised in June 2017. Standardization has been discussed mainly in workshops held between the two countries and three parts of the Vietnam National Harbor Standards (General Provisions, Load and Effect, Construction / Inspection Criteria) have been issued by the Ministry of Science and Technology Vietnam and one part of the Ministry Standards (Breakwaters) by the Ministry of Transport Vietnam. For fiscal 2018, we focused work on the remaining 5 standards (materials, foundation, soil improvement, mooring facilities, and maintenance) with the institutes of both countries jointly editing the content through a total of 6 workshops (Photo 2) held in Japan and Vietnam.



Photo 2: Workshop

2) Joint research in the road field of Indonesia (Indonesia: March 4-7, 2019)

NILIM and the Institute of Road Engineering (IRE) of the Republic of Indonesia have been conducting joint research since the execution of a Memorandum of Understanding in November 2009. For the current fiscal year, the fields and content of research were updated based on the results of research to date and needs of IRE, and a new memorandum was executed.

(3) Activities related to "International contribution"

1) Short-term dispatch of experts to the Disaster Risk Reduction Training Program for Latin America and the Caribbean (Chile: Sep. 30 - Oct. 8, 2018)

At the request of JICA, we provided technical cooperation to train human resources from Latin America and the Caribbean in disaster prevention via a program implemented in Chile. In the PUC-KIZUNA Seminar (Photo 3) held mainly for young researchers in the Pontificia Universidad Catolica de Chile (PUC), we gave a lecture on response to the recent issues in the structural design of buildings, introducing some examples in Japan including the structural design method for tsunami evacuation buildings and measures against long-period ground motion.



Photo 3: PUC-KIZUNA Seminar

2) Sulawesi Earthquake field survey (Indonesia: Nov. 1-5, 2018)

For the earthquake that hit Sulawesi, Indonesia on September 28, 2018, we conducted a field survey for the purpose of future safety measures and support for the reconstruction of houses, etc. We surveyed the damage situation centering on seriously-damaged medium and high-rise buildings and made improvement proposals for construction works including reinforcement bar work.

3) River sediment management workshop (Italy: Nov. 6-16, 2018)

At a workshop on sediment observation and management in mountainous rivers, we learned international trends and know-how about sediment observation technologies, and introduced, in the discussion, findings from a "study on the method for forecasting sediment disasters with high accuracy using real-time observation / monitoring data", which was a study project that ended last fiscal year.

☞ See the following for details.

1) International activities on the website of NILIM

<http://www.nilim.go.jp/lab/beg/foreign/kokusai/kokusaitekikatudou.htm>