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National Institute for Land and Infrastructure Management

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Cultivate Technical Needs and Develop to a Story.

Koichi FUJITA,
Director-General, National Institute for Land and Infrastructure Management

Respond to "storm of new technologies" with "storm of technical needs."

In the circumstances where new technologies are successively produced from the fields other than the conventional fields of housing and building as social capital, utilization of such technologies is expected to produce great fruits and even lead to innovation.
Some words used in this 2018 NILIM Report, such as AI, CNN (a method of deep learning), and AR (Augmented Reality), were not found in the 2015 NILIM Report, which is only 3 years ago. Not only such technologies but new technologies that may be utilized have been increasingly appearing in the recent years, including robot, IoT, drone, ICT, big data / deep data construction, and block chain.
It is one of our essential roles to respond to such situation with "storm of technical needs" and build a basis for developing such technologies to practical ones that contribute to field improvement.

Importance of cultivating needs technically

Technical needs rarely exist in a specific form easily recognizable by anyone. They would not be obtained either even if you simple ask others. "Subject title + α" may not directly lead to technical needs even if it is subdivided.
Strenuous work is required for cultivation of needs, i.e., it is required to "understand multilaterally the actual status of sites and technical contents accumulated for target projects and cultivate needs for new technologies by prospecting future development of projects and grasping the key points of new technologies." As the content of new technology becomes more abundant, cultivation will become more interesting and sometimes a big task.

Concreteness and reliability first required for cultivation

It is difficult to generalize points of attention in cultivation of technical needs but "concreteness" and "reliability" should not be neglected.
Technical study on cultivation of needs would not be practical or realistic unless contents of needs are as concrete as possible, not general or abstract, (i.e., understandable by engineers of other fields), including, first of all, setting of utilization phases, then main functions / performance, restrictions / environmental conditions, cost, and maintenance labor. For this reason, it may be necessary that those having needs approach to such new technologies.
Another point "reliability" reflects the basic characteristic as social infrastructure. Some technologies for social infrastructure require great responsibility of ensuring the performance of certain functions for each unit under the conditions where "replacement" is not easy and approach for "on-site testing" of the functions when design external force is applied cannot be taken. In such a case, not only presentation of "new things possible" but sufficient information on reliability is required for new technology. There is an essential gap is between demonstration of a breakthrough under organized certain conditions and reliability confirmation of performance demonstration under the conditions encountered on the site, and the work to fill up the gap would be important.

Significance of making a "play" in technical needs

Some cases simply end up with one-way flow where a new technology that meets the needs presented is proposed and smoothly implemented. In many cases, however, "two-way flow" is required between needs and new technology presentation. The latter case

would rather give rise to the possibility of innovation. Innovation has a characteristic of causing a drastic change to the technology system itself. It sometimes happens that contact of technical needs presented on the extension of existing technology system with a responsive new technology will encourage realignment of needs and end up with general / overall solution of the issue. In order to secure the opportunity of such an emergent reaction of needs and seeds, it is also an important point of attention to include some flexibility or a "play" in presentation of needs. This will also lead to respect for the viewpoint of fostering, rather than hurrying to select the bud of technology utilization.

Interface of needs and new technology is the key.

In utilization of new technology, as stated, the key point is two-way process after cultivation of technology needs and interface to that effect plays an important role.

However, such interface is very difficult to create. Thus, processes leading to implementation through two-way flow starting with matching of needs and new technology are typified including bottlenecks and issues. In this work, the whole picture of patterns is depicted by checking each representative example of new technology implementation without regard to types of infrastructure, etc. This will make clear that importance of interface varies according to patterns. Thus, a frame consisting of various interface patterns is created, in which implementation is made, and results are fed back for update of the frame itself. This includes not only the aforementioned method of co-creation but method of filling up the gap between needs and seeds, method of technology evaluation, etc. as basic process. Various schemes for approaching without limitation to technical aspect would also be included in pattern organization.

Development to technical needs presentation with a story

Interface needs energy for operating it. Of some important energy sources, "needs presentation with the vision of technology development" is introduced herein.

Ability to cultivate technical needs concretely means nothing but having a clear image of how to utilize new technology for solution of issues or achievement of targets. It will not end up with individual presentation of needs but lead to "presentation of a concrete story" that (dramatically) improves the site of practice. Then, it is specified concretely and systematically what fruits are produced from technology utilization. As study proceeds, a ground for "self-development of needs," i.e., needs required next are identified one after another, is formed.

A story is the most effective when it makes those who know well the situation of the site concerning the new technology eager to realize it when they recall a concrete target. Further, story presentation also activates the brain of those who offer new technology.

Standard for the roles of NILIM

New technology utilization is one of the most important matters in the MLIT's technology policy and has been implemented in various forms and the intensity is increasing steadily. NILIM will participate in projects in cooperation with the MLIT, Regional Development Bureaus, etc. and further play its roles. In this regard, blessed conditions unique to NILIM should be utilized to the utmost.

NILIM is a player of R&D having a deep connection with development of individual technologies and application thereof to sites and foresees application of technologies to practice on the whole through preparation of drafts for technical standards, etc. and continues to consider next development with responsibility for technologies. NILIM is accumulating experiences in technical support by making difficult judgments in project sites. Comprehensive technical capabilities thus accumulated can and should contribute to the core part of technical needs presentation and development to a story as stated above.

NILIM continues to take leadership and make efforts so that sincere activities of many fields to improve the national land with the power of technology may be more effective.

Shorten no-information period immediately after the onset of an earthquake

Disaster Prevention and Reduction Research Committee

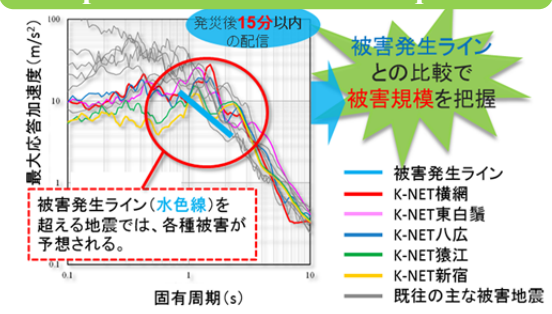
We develop information sharing systems that can provide constantly changing but necessary disaster response information to infrastructure administrators at the proper times to accelerate disaster responses and realize early recovery and restoration in disaster-hit areas.

Social background and problems

- Prompt gathering of information is essential for engaging in proper initial responses after the onset of an earthquake. Yet, there is a period during which only limited amounts and types of information becomes available (no-information period) immediately after the onset of an earthquake.
- To swiftly identify conditions in wide areas after the onset of a major earthquake, a system to gather information must be established using already available facilities and technologies, such as strong earthquake observation networks, CCTV cameras, and artificial satellites.

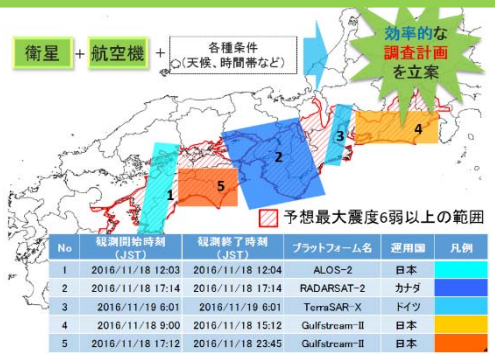
Content of this study

Automatic distribution of information upon the onset of an earthquake



Development of functions to automatically acquire records of strong earthquakes and automatically

Efficient use of SAR images

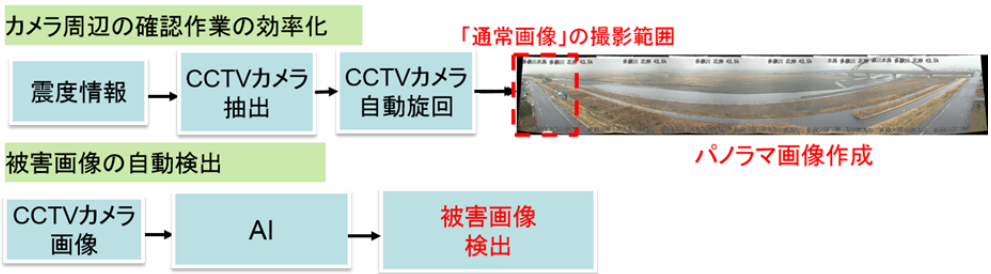


No	観測開始時刻（JST）	観測終了時刻（JST）	プラットフォーム名	運用国	凡例
1	2016/11/18 12:03	2016/11/18 12:04	ALOS-2	日本	
2	2016/11/18 17:14	2016/11/18 17:14	RADARSAT-2	カナダ	
3	2016/11/19 6:01	2016/11/19 6:01	TerraSAR-X	ドイツ	
4	2016/11/18 9:00	2016/11/18 15:12	Gulfstream-II	日本	
5	2016/11/18 17:12	2016/11/18 23:45	Gulfstream-II	日本	

1) Development of efficient observation plan proposal system by combining satellite SAR, disaster response helicopters, aircraft SAR, and other technologies
2) Development of technologies to improve the efficiency of SAR image interpretation

Functions to extract images of damages from images captured by CCTV cameras

1) Development of a technology to automatically rotate CCTV cameras installed at areas hit by intense seismic motion to create panoramic images
2) Development of a technology to automatically extract images of damages from images captured by CCTV cameras



Contribute to help prompt restoration of social infrastructures by eliminating no-information periods and areas after the onset of a major earthquake.

☞ Relevant articles

- Development of a method to create panoramic images even during night time using the rotation function of CCTV cameras
- Emergency interpretation of sediment damages using SAR loaded on artificial satellites
- Development of technologies to instantly gather, compile, and share the information of damages on infrastructures

Examination of disaster management measures covering rivers and erosion control based on the experiences of the 2017 northern Kyushu rainstorm

River Department and Sabo Department

In the intense rainstorm that hit northern Kyushu in July 2017, large volumes of water and sediment outflowed and overflowed wide areas during a short period of time in the narrow river basins consisting of mid-to-small rivers, which resulted in massive damage. NILIM dispatched three committee members to the restoration technology council installed for this disaster. Also, we are now developing technologies to implement disaster management measures covering rivers and erosion control based on the characteristics of water and sediment outflow in mid-to-small river systems.

Social background and problems

- Enough time for evacuation cannot be secured in narrow river basins consisting of mid-to-small rivers because water and sediment outflow in wide areas from the upstream to downstream sections during a short period of time. People are helpless, especially on the flatlands at the bottom of a valley, if they miss the proper timing to evacuate.
- People tend to be less aware of potential risks of disasters near mid-to-small rivers, which are not designated as expected flooding areas.
- Methods to evaluate and respond to the risks covering the upstream to downstream sections must be promptly established by taking into account the characteristics of flooding and sediment overflow in mid-to-small rivers.

Content of this study

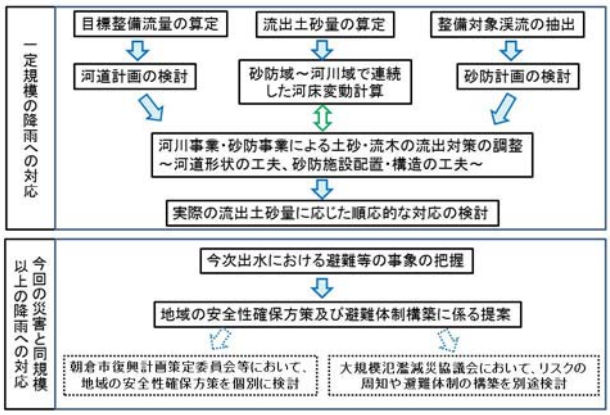
Examination of restoration support and disaster reduction measures at mid-to-small rivers

○Support for disaster investigation: River blockage using LP surveys or other measures, identification of the presence and condition of unstable soil—coarse sand, very coarse sand, and fine gravel are the main components of sediment blocking rivers. (Mid-sized gravel and large gravels are the main component of the original riverbed.)

○Support for river channel design based on planned rainfall: The amount of sediment supplied from upstream is estimated by taking into account the outflow of sediment from unstable soil accumulating on slopes—support for the design of cross-sectional and longitudinal river channel design, which is easy to maintain using riverbed variation calculation

○Support for the examination of regional safety measures targeting simultaneous collapses that may occur during the same level of rainstorm (support for examining vulnerability to flooding along rivers during a flood exceeding a designed level and information related to water hazard risks)

○Support for examining methods of adaptive responses at mid-to-small rivers reflecting chronological changes in unstable sediment in upstream sections



Concept of restoration based on cooperation among river projects, erosion control projects, and regional measures (partially modified from p. 101 of the *Report by the River and Erosion Control and Restoration Technology Council at the Right Basin of the Chikugo River* (Nov. 2017))

Improvement of the precision of the method to forecast water and sediment outflow in upstream sections

○Organize the conditions of sediment production and outflow to improve the precision of methods to forecast the amount of debris flow generated in mountain torrents where sediment is mainly generated and the amount of sediment outflow covering from debris flow zones where the river bed gradient is large and flooding zones where the river bed gradient is small.

○Organize the thickness of sediment accumulation near houses and the actual damage to the houses to improve the precision of methods to forecast damage to houses based on the thickness of sediment accumulation.

○Aim to establish methods to estimate areas where training may appear using the amount of vapor and atmospheric instability as indexes and methods to forecast the risk of the onset of sediment disasters.

The production of sediment in upstream sections and the outflow of the sediment in downstream sections

Reduction of damages caused by heavy rainstorms occurring in higher frequency and greater intensity in many of the mid-to-small rivers located around Japan without sufficient sediment and flood control measures

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☞Relevant articles

- Actual conditions of sediment outflow and damages to houses in the rainstorm that hit northern Kyushu in July 2017
- Promotion of damage reduction measures by sharing the diagrams of flooding vulnerabilities along mid-to-small rivers in mountainous regions

Improvement in the effectiveness of fire management measures based on lessons learned in the massive fire in Itoigawa City and Miyoshi Town

Building Department and Urban Planning Department

A massive fire occurred in the city of Itoigawa in December 2016 and a fire occurred at a large warehouse in the town of Miyoshi, Saitama, in February 2017. NILIM dispatched officials to the sites of these fires and conducted investigations to find the causes of the spread of these fires and the extent of damage and examinations to realize effective fire management measures.

Technical examinations to identify the causes of the spread of fire and to prevent another fire from

Based on the massive fire in Itoigawa City

A fire occurred at an urban area of the city of Itoigawa, Niigata, where an old building still remained on December 22, 2016. Strong winds caused the fire to spread in multiple directions and caused extensive damage to as many as 147 buildings that burned down.

In cooperation with the Building Research Institute, NILIM investigated the site of the fire and analyzed the situation to find to which buildings the fire had spread and how the fire had spread. They also conducted fire experiments and clarified that sparks were not likely to burn down and destroy modern-style tiled roofs. Through urban fire simulations, they also found that fire leaps and the number of buildings destroyed in the fire would decrease even with old buildings if they were equipped with fire control features.

Legislative reevaluations started based on the above findings to ensure safety in urban areas.

A wide area of urban zones burned

Experiment of scattering fire using tiled roofs

Example of calculation based on urban fire simulation

Based on the fire at a warehouse in Miyoshi Town, Saitama

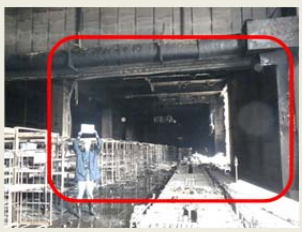
The massive fire in a distribution warehouse in Miyoshi town, Saitama on February 16, 2017 (total floor area: about 72,000 m^2) required about six days to suppress, and about two-third of the total floor area was burned down.

On-site investigations and experimental examinations conducted jointly with relevant organizations revealed that the automatic fire alarm system (analog detectors) and the short-circuit in wiring systems caused malfunctions in steel shutters, and belt conveyors blocked the closing movement of steel shutters (defect in fail-safe mechanism). These factors consequently failed to create fire control sections to localize the fire.

Based on the result above, legal systems are being revised concerning the structure fire control facilities installed in fire control zones and measures implemented on buildings with safety risks.

External appearance of the building after the fire

Collapsed roof due to the fire



Malfunction of fire shutters

Conveyors blocking the closing motion

Realization of effective fire control measures in already developed urban areas
Aim to improve the reliability of the movement of fire control facilities and to ensure fail-safe

☞ Relevant articles

- Report of examination sessions concerning fire control measures and firefighting activities based on lessons learned in the fire of warehouse in Miyoshi Town, Saitama (June 2017)
  http://www.fdma.go.jp/neuter/about/shingi_kento/h29/miyoshimachi_souko_kasai/houkoku/houkokusyo.pdf
- Report of the investigation of building damaged in the massive fire in Itoigawa City, Niigata that occurred on December 22, 2016 (NILIM Reference #980, July 2017) http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0980.htm
- The desirable status of the future building standard systems (February 2018, third report of the Council for Social Infrastructure [reference]) http://www.mlit.go.jp/common/001222680.pdf

To the second stage of road structure maintenance

Road Structures Department

We are developing technologies concerning the inspection, diagnosis, repair, and reinforcement to properly maintain and manage road structures that are rapidly aging. We are going to reflect the outcomes in the technical standards and realize a society in which roads remain safe to use by transferring the technologies and knowledge to road administrators.

Social background and problems

- To shift from reactive maintenance to preventive maintenance, inspection procedures for road structures have been developed since FY 2014, and full regular inspections have been conducted based on the procedure (the first stage of maintenance).
  The number of structures that immediately or promptly require repairs and structures at which traffic restrictions were applied has been increasing due to the progress of the inspections.
- To manage rapidly aging infrastructures that are increasing in number, including measures to implement these structures with limited financial resources, the Road Subcommittee of the Council for Social Infrastructure proposed planned implementation of maintenance as preventive maintenance and efforts to elongate the service life and reduce maintenance costs through the use of new technologies as the second stage of maintenance in September 2017.

点検要領策定状況

	H26	H28	H29
橋梁	定期点検要領＊		
トンネル	定期点検要領＊		
舗装		点検要領	
土工	ｼｯﾄﾞ・大型ﾎﾞｯｸｽ 定期点検要領＊		点検要領
附属物	門型標識・歩道橋等 定期点検要領＊	門型以外の標識・照明 点検要領	

＊5年に一度、近接目視

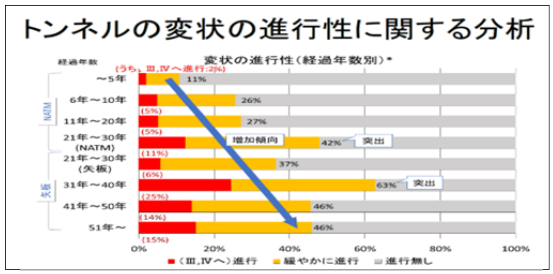
Content of this study

Research on the maintenance of bridges

Research on methods to investigate the conditions of damage, including nondestructive inspections to advance and improve the efficiency of maintenance and management through proper operation of the maintenance cycle, including inspection, diagnosis, implementation of measures, and recording; methods to check load resistance by taking damages into consideration; methods to set loads for examinations depending on actual traffic conditions; and methods to design repairing and reinforcement

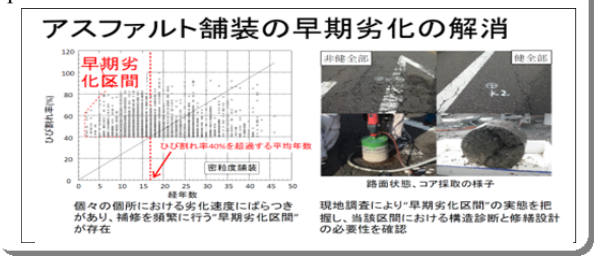
Research on the maintenance of tunnels

Research on the analysis of factors that affect deformation (external force, deterioration of materials, and water leakage) found in regular inspections of tunnels



Research on the maintenance of pavement

Research on the establishment of proper repair designs by analyzing the conditions of damage and deterioration in rapidly deteriorating sections for road management based on preventive maintenance



Realization of safe and sound citizens' lives where roads are properly maintained with the minimum life cycle cost

☞ Relevant articles
- Result of regular inspections at road tunnels
- Establishment of investigation and design methods to eliminate sections where pavements are rapidly deteriorating

Support for improvement of the efficiency of sewage maintenance and management using the data of deterioration in 280,000 spans of pipes around Japan

Water Quality Control Department

Japan has extremely long sewage pipes where the total length is long enough to circle the Earth 12 times (about 470,000 kilometers). We are conducting research to support the efficient maintenance and management of pipes to prevent accidents, such as road collapse caused by defects in aging pipes (e.g. corrosion, crack, misaligned joints) with limited budgets and human resources.

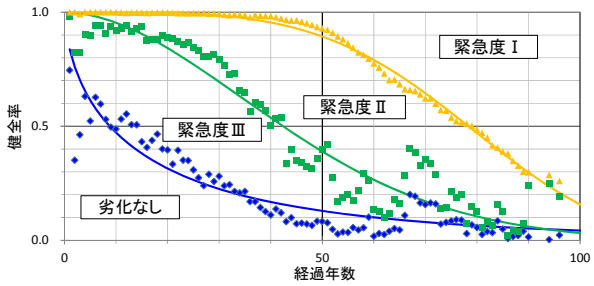
Social background and problems

- The length of sewage pipes is now as long as about 470,000 kilometers. The number of road collapses caused by sewage pipes is occurring at about 3,300 cases a year.
- The revision of the Sewerage Act in 2015 included the establishment of maintenance, management, and repair standards and mandated inspections at the proper times.
- The use of efficient maintenance and management methods is needed because sewage management is associated with problems, such as difficulty in conducting investigations in closed spaces, shortage of engineers, and tight budgets.

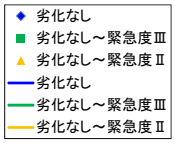
Content of this study

Tool to support the improvement of the efficiency of sewage pipe maintenance and management—Soundness forecast formula 2017

Soundness forecast formula 2017 is prepared to express age-based changes in the ratio of deteriorating pipes based on the NILIM pipe investigation data (including pipe types, age, conditions of deterioration) covering about 280,000 spans of pipes around Japan. The soundness forecast formula is released to support the establishment of inspection and investigation plans by local governments and to improve the precision of forecasting the amount of renovation work.



The soundness ratio curve of all pipe types (concrete pipe, ceramic pipe, and PVC pipe)



区　分	緊急度の区分	
緊急度Ⅰ	重度	速やかに措置が必要な場合
緊急度Ⅱ	中度	簡易な対応により必要な措置を5年未満まで延長できる
緊急度Ⅲ	軽度	簡易な対応により必要な措置を5年以上に延長できる
劣化なし	健全	―

Span refers to the interval between manholes.
Soundness ratio refers to the ratio of sound pipes among all pipes. The soundness forecast formula is the formula expressing the relationship between the soundness ratio and age.

Preparation of the pipe investigation as open data (Pipe Deterioration Database)

Pipe investigation data used to prepare the soundness ratio forecast formula (except for some data) is released as the Pipe Deterioration Database. The data from 56 organizations and about 250,000 spans of pipes are now released. The data are supporting local governments in the establishment of inspection and investigation plans, such as the preparation of soundness ratio forecast formulas based on regional conditions and the identification of prioritized sections for inspection and investigation. The data are available to the public to accelerate technological research and development by getting academia and industries involved.

Prevention of road collapse caused by sewage pipes and realization of sustainable sewage service
Promotion of technological research and development by making the data available to the public

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☞ Relevant article
- NILIM press release http://www.nilim.go.jp/lab/bcg/kisya/journal/kisya20170627.pdf

Research of ways to support roads for early realization of automatic driving

Road Traffic Department

We are developing a road-vehicle coordination system that supports driving from the roadside in complicated situations, such as highway merges, for the early realization of safe and smooth automatic driving. We are conducting experiments and evaluations to use automatic driving services in the society of mountainous regions where populations are aging rapidly.

Social background and problems

- The development of independent automatic driving technologies using sensors on vehicles is being conducted mainly by automotive manufacturers. On the other hand, under complicated traffic conditions, such as highway merges, limitations of the sensors on vehicles and other factors are resulting in difficulties in realizing automatic driving conducted independently by a vehicle.
- Mountainous regions where the population is aging and the birthrate is declining are hoping for the realization of transportation services based on automatic driving because they face decreased quality and quantity of public transportation services, and securing the flow and distribution of people is an important issue for them.

Content of this study

Experiment in an automatic driving service in mountainous regions using roadside service stations as bases

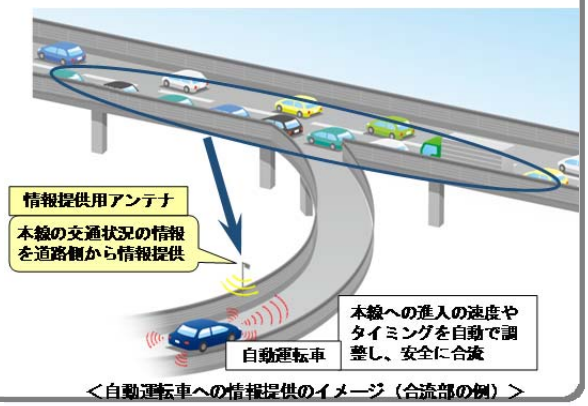
We experimented with automatic driving services connecting regional bases, such as roadside stations, with lifestyle bases to secure the means of carrying people and objects in mountainous regions where the population is aging. NILIM is publicly recruiting automatic driving vehicles to be used in the experiment. NILIM is also providing technical advice for the technical verification of road traffic, regional environment, and social acceptability for early application of automatic driving services in society and for the establishment of plans at the experimental sites.

Status of the experiment

Joint research for the realization of road-vehicle coordinated automatic driving on highways and other roads

The joint research of the public and private sectors started in 2018 for the realization of automatic driving on highways using the support system based on information provided from the road in complicated traffic environments such as road merges.

A prototype system is going to be built to verify its effectiveness in experiments on NILIM test roads. The goal is to determine the specifications and apply the technology in society.



＜自動運転車への情報提供のイメージ（合流部の例）＞

Realize safe and smooth automatic driving on highways and other roads by assisting driving from the road. Actually start a low-speed automatic driving service to secure the flow and distribution of people in mountainous regions.

☞ Relevant articles

- Experiment of automatic driving in mountainous regions using roadside service stations as bases
- Joint research concerning next-generation coordinate ITS

Realize the sense of security in houses for vulnerable people

Housing Department

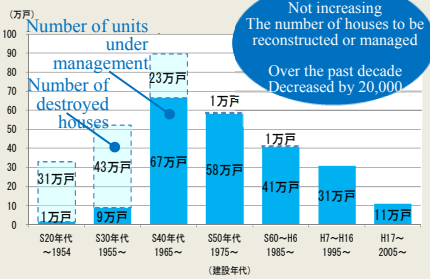
We propose methods to plan efficient management of the stock of public housing and effective use of vacant private houses for rent to realize stability and a sense of security for vulnerable people, such as those in the low-income group and senior citizens who live alone who often face difficulty in keeping proper places to live on their own.

Social background and problems

- Public housing used to accept people in the low-income group. However, the number of public housing units is not expected to increase because of financial restrictions on the national and local governments. More rational management of public housing than ever is needed as the population ages.
- Meanwhile, the number of vacant private houses for rent has been increasing. Many owners of rental houses tend to reject renting their houses to vulnerable people, such as single elderlies, because of the risk of failure to pay rent and dying alone. An issue here is that the vacant houses for rent are not effectively being used.

The increase in vulnerable people who face difficulty in securing proper places to live on their own (Example: The number of single elderly people is expected to increase by about one million over the next decade.)

Public housing



Not increasing
The number of houses to be reconstructed or managed
Over the past decade
Decreased by 20,000

Increased stock of aged housing

Private houses

Increased number of vacant houses for rent

Stock not being used effectively
The number of vacant houses for rent is about 4.29 million around Japan (2013).
About 70% of owners are reluctant to rent their houses to single elderlies (due to the risk of failure to pay rent and dying alone).

Content of this study

Rational method to manage public housing

○Establishment of the following methods to support local governments in establishing longer life expectancy plans

1) Method to establish mid-to-long-term plans to manage and utilize the stock of public housing units
2) Method to establish programs for the details and timing to implement repairs and improvements based on the characteristics of apartment buildings and houses
3) Method to identify the relationship among the details of repairing and improving houses (performance categories), sections, and costs

Example of improving accommodations for elderlies by installing an elevator between two houses

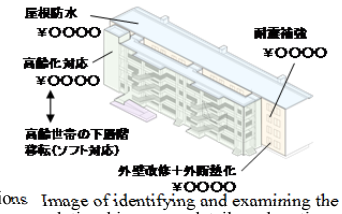


Image of identifying and examining the relationship among details and sections to improve and their costs

Method to plan the use of vacant private houses for rent

○Development of the following methods to support local governments in establishing plans and operations associated with the use of private vacant houses and establishment of technical guidelines

1) Method to estimate the number of private houses for rent that are available in a given region
2) Method to plan matching between households and vacant houses based on sizes and other conditions of the houses (⇔Sharing of the role to accept tenants with public housing)
3) Method to construct systems to provide a housing assistance service to eliminate concerns that owners have for the effective use of vacant houses

Example of concerns that owners have in relation to accepting single elderlies as tenants and providing housing assistance services to eliminate the

	Concerns	Housing assistance service (example)
Upon contracting	-Difficulty in securing	-Co-signer agency service
	-Unable to understand the contents of contract	-Contract procedure support service (e.g. accompanying a tenant when signing a contract)
	-Contract with the risk of failure to pay rents	-Rent guarantee obligation service -Rent assistance and the payment of social assistance for housing in place of a tenant
While living in a house	-Risk of sudden illness/injury or accidents inside a house, inability to understand contents of contracts	-Daily assistance service (observation, checking if a tenant is fine, lifestyle consultation, etc.), furniture and remaining items disposal service, loss compensation insurance
	-Risk of dying alone	
When leaving a house	-A concern over troubles related to reinstatement	-Reinstatement rules, third-party witness and assessment service upon leaving a house

Realize the sense of security for housing among vulnerable people by wisely using the stock of public housing units and vacant private houses for rent

☞ Relevant article

- Planning of housing safety net using private houses for rent

Attitudes towards Research

-- In order to upgrade skills and advance better research efficiently

Masahide ITO, (Dr. Eng.) Executive Director for Research Affairs

keywords: *researches and development, research policy, research management, raising productivity, social implementation*

1. Each researcher's potential is essential.

As measures to properly follow the rapid socioeconomic changes and technical innovation in the recent years, multi-sector collaboration, industry, academia and government cooperation, and open innovation are often mentioned. However, these are only methodologies. Management of collaboration with other organizations, determination of the effectiveness of various technologies, and proper incorporation of technologies are possible only when based on the ability / potential of individual researchers.

In the 2017 NILIM Report, R&D procedure for raising "productivity" in R&D was described. In this report, I would like to describe the mechanism and points of attention for enhancement of the potential of individual researchers.

2. Necessity for mechanism of cultivating potential

How to enhance the potential of researchers --- this is a very tough issue. Previously, it was possible to cultivate skills by observing behaviors of seniors, studying steadily, and repeating failures, but such "leeway" is decreasing. Such method is dependent on the experiences and know-how of individual researchers and a mechanism of skill improvement need to be established as an organization.

As part of the effort to improve research management on the whole, NILIM started a system to visualize, share, and hand down experiences and know-how. As one of the activities under this system, "Attitudes towards Research" based on the experiences of senior researchers were described in the Research Policy revised in November 2017. Another activity is to hold "Experiences / Know-how Handover Seminar" to share hard work stories of researchers in NILIM.

3. "Attitudes towards Research" --- Visualize common points of attention

"Attitudes towards Research" generalized and specified points of attention and devices that are difficult to come to the fore and aims to serve as a basic manual for young and middle level researchers to apply the contents to their fields and consider them efficiently / effectively. In NILIM's internal evaluation, etc., it has also begun to be used as a tool for research guidance and discussion centering on the viewpoints described herein. In accordance with the flow of research, the points are described below.

1) Set a subject of research accurately.

Many of NILIM's researches are based on requests from administration and sites and all of them are not always accurate requests. Such requests should not be accepted as they are but it is desirable to be able to speak concretely administrative needs, necessity of research, and technical issues in their own words.

In addition, research findings are reflected in standards, etc. and function in the real world as a system combined with various institutions, etc. It is desirable to make a habit of recognizing the position of research theme from a broad view in the frame of related policies on the whole.

Further, various adjustments are essential for social implementation of researches and findings. Thinking on both sides, i.e., observing facts on the site and conceiving realistically while grasping them in a bird's eye view as a policy, will lead to various assumptions automatically and facilitate actions to take in the future.

2) Draw up a necessary and feasible research plan

Research plan reflects objectives in a specific hypothesis and element issues and provides a road map showing the structure to reach conclusion, and is therefore required to be technically consistent and feasible.

Skills to make a research plan are brushed up by visualizing (make a table of contents for) thinking process. Additionally, it may seem to be cumbersome work to research existing studies and hear the opinions of third parties but it leads to identification of issues that should be focused on and prevention of a "blooper." It should be recognized as an effective means to supplement the knowledge that cannot be covered by a single person.

3) Perform research steadily along with the plan.

Next, reflect the research plan in annual action plan. Specify the conclusion that should be obtained for the present and proceed with the plan by making a monthly schedule specifying what research, test, and analysis are made and when. However, everything may not progress as planned. Sometimes, it may proceed to next step after undertaking what is possible

or search for direction of solution after repeating failures. Trial and error is also important as experience value.
Care should be taken so that results obtained are objectively interpreted and conclusion is not unreasonably deduced from limited knowledge.
Note that data literacy (ability to analyze phenomena from values) is cultivated through observation of reality and hands-on experiences with tests, analysis, etc.
In the end, knowledge obtained is used for modeling and generalized as a written procedure. In such case, if a thought experiment by conceiving various scenes of utilization is repeated, practical applicability and effectiveness will be made clear.

4) Evaluate the results obtained and adjust findings

The mission of NILIM is to support policy making and sites but it is also required as researchers to document research findings and grounds systematically together with derivation process as papers or books. This would be understood as reasonable when such information is considered necessary for hand-over of research findings and support for operation of standards, etc.
Further, since the value of good research findings is dependent on social recognition, external presentation and publicity should be considered as a primary operation in research. Preparation for that purpose will also lead to upgrading the ability to present researches.

5) Advance utilization of findings and social implementation

NILIM cannot end up with "We have obtained research findings and hope they are widely used." It is unavoidable that we are responsible for involvement until their use is rooted in administration and sites.
However, there is a limit to what researchers can do. Draw an implementation process for research findings, identify entities concerned, consider sharing of roles based on each jurisdiction / fields of expertise, and make coordination. It is possible to learn these skills by listening to the voices of administration and sites and exercising imagination about practical work.
It should also be understood that participation in social implementation as a person concerned will lead to finding matters to be improved and new issues.

4. Hand-over of experiences and know-how

While "Attitudes towards Research" is a written procedure that generalized experiences and know-how, it is also necessary to provide opportunities to speak experiences in specific hard work and devising means. Stories based on actual experience are full of reality and memory of listening to stories remains clearly.
Since we are generally reluctant to speak our device and failures to others, it is necessary to build a system that facilitates derivation thereof as an organization.
In addition, since speakers make considerable efforts to tell their thought, speaking their experiences has led to their skill improvement an unexpected byproduct,

5. Conclusion

Skill improvement focused on researchers has been so far described by introducing some systems in NILIM. There would be many contents common to general researches in housing and social capital fields. I hope this would be of any help to those concerned.

☞Research policy
http:// www.nilim.go.jp/lab/bcg/busyoukai/kenkyuhoushin/00index.htm

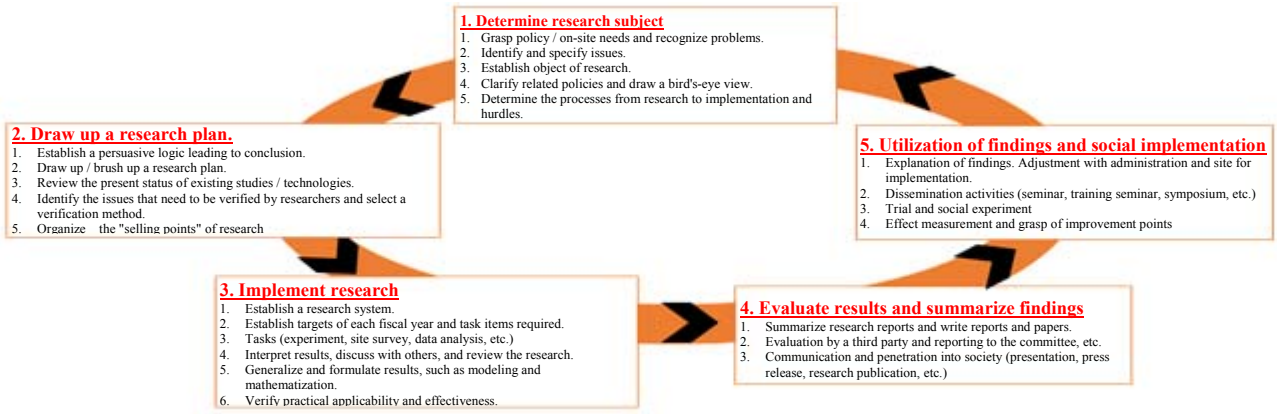


Fig. Basic Action Process and Points of Attention for Researches

Sewerage Technology Development and Introduction Dissemination

Shigeharu INOUE, Director, Water Quality Control Department

keywords: vision, new technology, Technical Conference, introduction dissemination

1. Introduction

As the trends of declining birthrate and aging and depopulating society are accelerating, it is required to establish a society enabling sustainable development while addressing the issues of shortage of energy, global warning, increasing risk of major disasters, aging of infrastructure, deterioration of financial conditions in the central and local governments, etc. In order to such changes in socioeconomic conditions, Sewerage Works has been working for development, introduction, etc. of low-cost and highly efficient technologies to promote energy creation, energy saving, inundation control measures, aging countermeasures, etc. In development, introduction, etc. of such new technologies, not only support of technology development but management enabling local governments as sewerage administrators to introduce smoothly new technologies for solving their issues is important. NILIM is indicating the direction of sewerage technology development as a vision to promote technology development for issue solution and considering for introduction dissemination of new technologies through follow-up on the vision, etc.

2. Vision and follow-up for technical development

In technical development, it is important to share the direction of policy, consistency with on-site needs, etc. among the persons concerned, etc. In development of sewerage technologies, in response to the policy vision "New Sewerage Systems Engineering Vision" (formulated on July 2014), "Sewerage Technology Vision" ("Technology Vision") was formulated in December 2015 in order to solve technical issues. This Technology Vision aims to promoted steady technical development by showing technical goals and technical development items needed to achieve the goals with road maps for 11 technical development fields and by specifying the issues that should be addressed by persons concerned in the central government, business entities, private-sectors, research institutions, etc. in order to solve important issues in the future sewerage work, including measures for aging of sewerage facilities, inundation control measures responding to torrential rain etc. that frequently occur in recent years, and promotion of the effective use of sewage resources. Of the road maps, particularly those for which R&D is urgently required or those that indispensably required mid- to long-term solution of issues continue to be published as priority issues on road map, and the direction indicated by the Technology Vision is to be realized by concentrating the central government's support for development, etc.
In addition, progress control, such as confirmation of achievement, is important for promotion of technical development, As an opportunity of follow-up on the Technology Vision, "Conference on Technical Development of Sewerage Systems" ("Technical Conference"), established in January 2016 and composed of industry, academia and government, has been utilized for progress control of the Technology Vision, review reflecting the trend of up-to-date R&D, etc. In fiscal 2017, in response to the 2017 basic policy on economic and fiscal management and reform and the 2017 future investment strategy, the sewage heat utilization technology was positioned as a technical development item in order to further study energy creation and energy saving in the sewerage service. In addition, in response to the New Sewerage Systems Engineering Vision Acceleration Strategy, formulated in August 2017, technical development etc. contributing to improvement in labor productivity, such as ICT technology, were also included in the technical development items. NILIM intends to continue to support the realization of policies from technical viewpoint.

3. Introduction dissemination of new technology

As a measure to support introduction dissemination, etc. of new technologies by the central government, Breakthrough by Dynamic Approach in Sewage High Technology ("B-DASH") has been implemented since fiscal 2011. This project aims at nation-wide development by demonstrating innovative sewerage technologies in real sewage treatment facilities, etc., creating guidelines, and utilizing the know-how and funds of private enterprises. Until now, 34 technologies were demonstrated, for 18 of which guidelines were created. In addition, research etc. in the scale of pilot plant have been conducted to demonstrate technologies for issue solution. Note that since B-DASH is an empirical study, it should be promptly disseminated after

the research is finished. To this end, we continue to establish a dissemination strategy at the beginning of research and further clarify introduction dissemination targets during research so that we are able to effectively explain details of technology and examples of dissemination / development to local government personnel etc. and respond to consultation from them about introduction of technology after making guidelines, and thereby promote understanding, introduction dissemination, etc. for new technologies.
NILIM is also making consideration etc. for introduction dissemination of developed technologies centering on six activities through operation of the Technical Conference, etc. (see Figure). In this regard, it is important to conduct technical development etc. strategically according to the importance and urgency of technical issues through proper matching of needs, i.e., issues facing local governments, and seeds owned by universities, private enterprises, etc., i.e., technical elements that serve as the core of development, etc. Accordingly, we first of all investigated necessity for technical development and issues on technology introduction in local governments and grasped details through hearing, etc. From the results of the questionnaire surveys conducted for local governments, etc., it was found with issues of new technology introduction that the main hurdle in introduction is a concern about procurement or performance of technology in big cities, such as "Estimation / technical standard" and "Uncertainty about reliability" and starting point of consideration of introduction in small cities, such as "Shortage of information" and "Difficulty in selecting technology." Under such circumstances, to solve "shortage of information" and other issues, we are considering wide transmission of information on good examples from local entities using the Technical Conference as platform, while mapping systematically the contents of studies in the water environment field and collaborating with the activity of "Project GAM" of the Sewerage and Wastewater Management Department of MLIT, which is implemented to strengthen cooperation of industry, academia and government. For "Estimation / technical standard, etc.," we are going to establish a subcommittee in the Technical Conference, where persons concerned make discussion based on specific examples including new technical development methods.

4. Conclusion

Almost three years have passed since formulation of the Technology Vision. We are going to grasp in detail the progress in activities in each field and review it on the whole. In addition, in future development, etc. of sewerage technologies, considering that an "era of management" has already begun, the following five viewpoints are also important --- (i) CAPD starting with stock evaluation, (ii) Utilization of civilian power including residents, (iii) Return to society through excavation and utilization of information, (iv) Awareness of time as a valuable asset, and (v) Flexible and mobile response to uncertainty. We intend to communicate widely the Technology Vision, etc. and use them for technical development etc. from new viewpoints including cooperation with other fields.

☞See the following for details.

1) 2016 Sewerage Technology Development Report
http://www.nilim.go.jp/lab/eag/gesuidougijyutsukaihatsureport.html

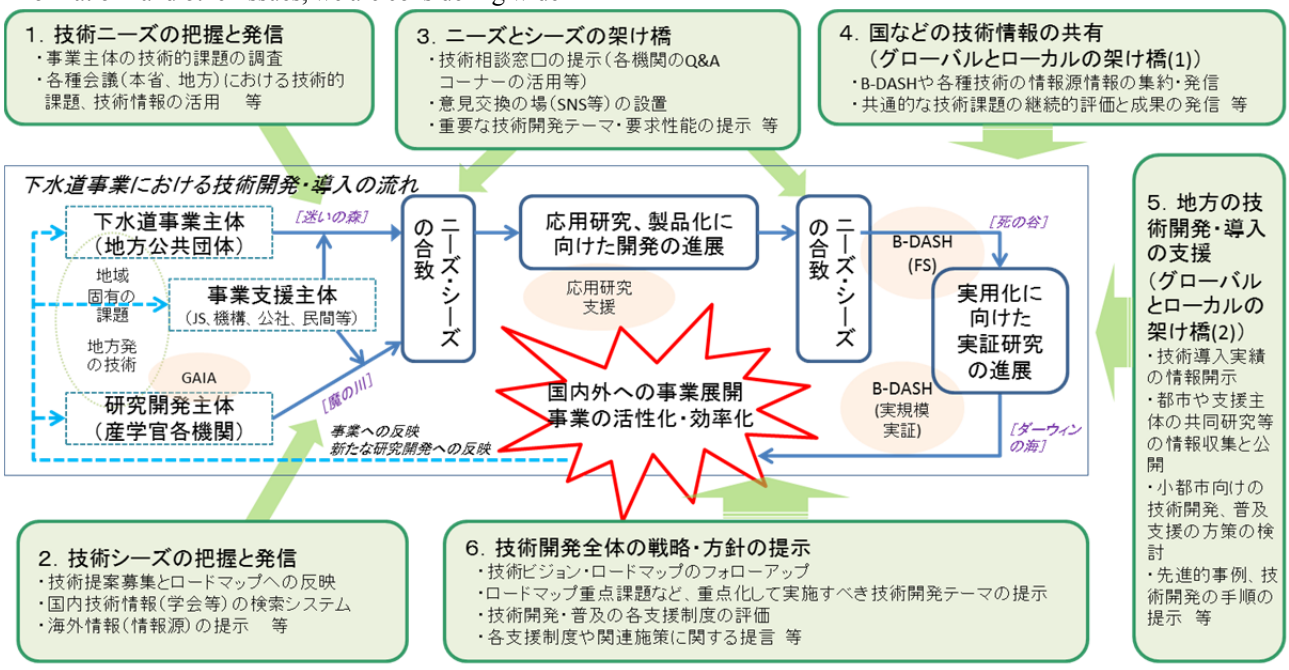


図 下水道技術開発会議における活動の柱

Development and Maintenance of River Environment in the Future

Kunihiko AMANO, (Dr. Eng.), Director, River Department

keywords: river environment, Nature-oriented River Management, channel design

1. Introduction

Since the River Law was revised in 1997, 20 years have passed. One of the aims of this revision was addition of "Development and maintenance of river environment" to the purpose of the River Law. After the elapse of 20 years, how has the added purpose been implemented?
In June 2017, "20 years after the revision of The River Law --- Proposal from the Nature-oriented River Management Promotion Committee [For Sustainable and Practical Nature-oriented River Management]" (the "Proposal") was published. With reference to the Proposal, this paper considers development and maintenance of the environment in future river management.

2. Nature-oriented River Management

In 2016, "Basic Guidelines for Nature-oriented River Management" (the "Basic Guidelines") was notified and gave the following definition to "Nature-oriented River Management" as a form of universal river environment development --- "River management performed with the aim of conserving or creating the life habitat, growth, and breeding, which is inherent to rivers, and diverse riverscapes, taking natural river system processes into account and giving consideration to harmony with community life and local history and culture."
Nature-oriented River Management has been implemented in accordance with the Basic Guidelines and related technical standards and manuals, and the Proposal mentioned the following five issues on Nature-oriented River Management and provided responsive policy to each of them --- (i) Goal setting for river environment, (ii) Process of activities from specific technology and research to maintenance, (iii) Human resource development and dissemination / awareness raising, (iv) Sustainable Nature-oriented River Management, and (v) Expectation of future image of river environment in Japan.
Almost 30 years have passed since the start of nature-oriented type river management in 1990, and over 10 years have elapsed since Nature-oriented River Management was adopted as a universal form of river environment development by removing "type." Accordingly, examples for advanced management have been reported but there still remain some issues. In addition, the responsive policy to each of the issues mentioned in the Proposal shows a broad direction, rather than presentation of a specific method for advancing Nature-oriented River Management. Such approach may suggest the difficulty in considering Nature-oriented River Management or development and maintenance of river environment. Next, development and maintenance of river environment in the future is considered based on the Proposal.

3. Development and maintenance of river environment in the future

(1) River environment should be considered in the basin space scale and long-term time scale.
Tree growth in river channel is often indicated as an example of deterioration in the river environment. Restoration of river plain seems to be a typical menu item in river environment development. As the causes of tree growth in river channels, river-bed degradation in low water channels due to river channel improvement works or gravel digging from rivers in the period of high economic growth and the effect of dam construction are indicated. These causes are considered to have contributed to the tree growth in river channels to some extent, while the recent drastic decrease in sediment supply from mountains [1] and changes in lifestyle, as known from and little use of riparian forest as a wood supply source (no need to be cut down), have also a great effect [2]. Ohta [1] indicated that the forest of Japan, which went to ruin remarkably at the beginning of Meiji Era, and immediately after World War II, has dramatically recovered and is "full of green for the first time in 400 years" and has a concern about further river-bed degradation due to decrease in sediment flowing into rivers. When tree growth is taken up as an example of changes in the river environment, it is known that countermeasures should be devised considering not only direct impact on the river but changes in the sediment transport system in a basin scale from mountains to the sea, changes in the ambient environment in a very long time scale, such as forest change, and changes in social conditions, such as little use of riparian forest as a fuel source. (Besides tree growth, Ohta [1] also points out the

increase in driftwood in the case of a flood due to recovery of forest and resulting increase in trees.) As the example of tree growth shows, when considering development and maintenance of the river environment, it is necessary to evaluate the site conditions in a proper spatiotemporal scale including not only the river but ambient environment and to discern clearly the driving force of river environment change to ensure development / maintenance.

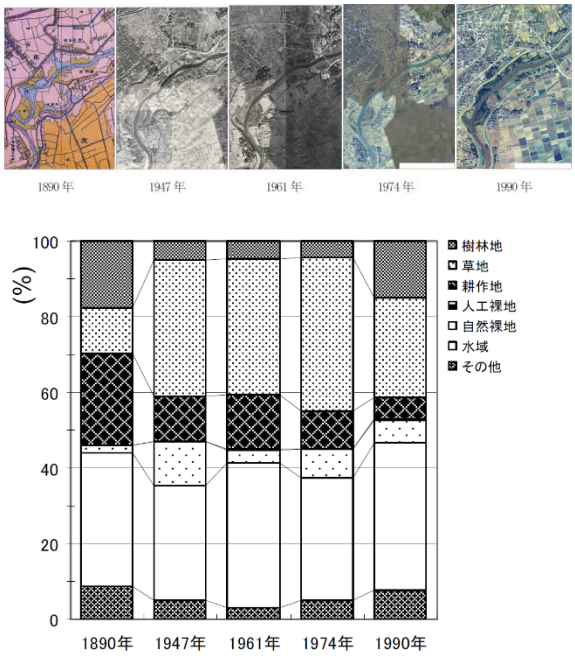


Figure: Vegetation changes in the Kokai River (10-30kp)[2)]

(Measured the ground cover condition between levees from the quick maps and air photos)

(2) Data use for multi-lateral river environment evaluations

When trying to evaluate the river environment, even the physical environment elements that are relatively easy to index are multi-lateral, such as channel shape, flow regime, water quality, sediment transport and combination of these elements is numerous. Further, even if the biotic environment elements (flora and fauna, ecosystem) are indexed, quantification thereof is often difficult. As known from these, with regard to river environment, far from goal setting, evaluation itself is not easy.

It is therefore strongly desired to improve the methods for evaluating the river environment. To this end, it is first of all necessary to integrate available information and grasp the situations of river environment as accurately as possible, e.g., by relating the increasing data of the Census of Rivers and Riparian Areas with physical environment elements data. It is also desired to develop techniques to analyze the river environment using newly available mass data, such as three-dimensional channel shape information.

(3) Flood control project is a good opportunity for river environment development

The physical environment element that define river environment, including channel shape, flow regime, water quality, and sediment transport, are also important elements to be set in river development and management for flood control. River channel improvement and development of flood control facilities to make a river resistant to floods often accompany changes in physical environment elements and are therefore likely to be considered inconsistent with development or maintenance of river environment. However, the channel condition after improvement work is also desirable in the environment and requires less effort for maintenance, it will be the optimal river development. Additionally, river development for flood control can be led to the environmental development including the ambient environment of the river, e.g., a flood control basin developed for disaster prevention can be the one with high environmental value as swamp environment.

It is difficult to satisfy many requirements at the same time but channel design techniques that also lead to river environment maintenance will be established by avoding excessive development of river channel from the beginning, designing a river channel in reference to the sections of the same river with good environment, and implementing adaptive mangement. River channels expanded by channel improvement work are designed considering safe runoff at desigend flow rate but river channels constantly change, e.g., channels may become smaller due to deposit of sediment after a flood, including small to medium-sized channels. Technical development of adaptive management is therefore required including condition monitoring and maintenance after improvement work.

4. Conclusion

River management aimed at by "Nature-oriented River Management the Basic Policy" will be realized by adaptive establishment of an improvement method that contributes to river environment development / maintenance and is easy to maintain from a mid- and long-term viewpoint for each river, for which river improvement continues to be implemented to improve the safety from flood.

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To reduce the risk of landslide damage

Atsushi Okamoto, Director of Sabo Department

Keywords: Debris flow, satellite SAR, Act on Sediment Disaster Countermeasures for Sediment Disaster Prone Areas, human resources development, measures to control massive landslide damage

1. Introduction

In the heavy rainstorm that hit northern Kyushu in 2017, hills collapsed and debris flow occurred simultaneously along the Akatani River in the right basin of the Chikugo River and other areas. The large amount of debris and driftwood flowed down rivers with increased water due to the torrential rain that was recorded as 511.5 mm in 12 hours (AMeDAS Asakura) and accumulated, causing massive damage that killed many people and damaged properties.

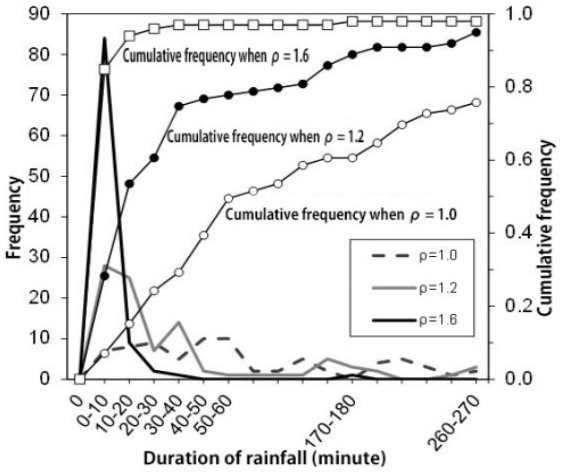
Extensive damage caused by the debris flow occurs almost every year in association with rainstorms, earthquakes, and volcanic activities, such as the Kumamoto Earthquake in 2016, landslide damage in Hiroshima and the eruption of Mt. Ontake in 2014, and massive flooding on the Kii Peninsula in 2011.

This document introduces representative examples of research and development conducted to reduce the risk of damage caused by debris flows that the Sabo Department is implementing.

2. Advancement of the investigation of debris flows and technologies to control them

As a result of analyzing conditions before and after the onset of debris flow using data with detailed time-space distribution, such as LiDAR (aerial laser survey) and precipitation measurements using radar, it was found that rainfall that would affect the amount of debris discharged in a debris flow lasted less than one hour.[1] In the conventional planning and design of debris flow control facilities and the setup of special warning zones for debris flows, the amount of debris discharged in a debris flow was estimated by multiplying 24-hour precipitation by sediment concentration by taking into account the discharge rate. From now on, we are going to further accumulate cases and analyses to consequently revise relevant technical guidelines.

In the debris flow that occurred in the Fukaminato River in Kagoshima in 2015, surveillance cameras captured the entire footage from the onset of the debris flow to its flow and accumulation. In addition, in the Illgraben valley in the canton of Valais, Switzerland, observation facilities of the Swiss Federal Institute for Forest, Snow and Landscape Research records data, such as the concentration and speed of debris flows down the valley. The use of these data and the improvement of debris flow calculation methods are enabling the reproduction of flow rates and debris concentrations, in addition to the range of debris flow deposits and overflow. We are going to continue research to reflect these findings in the design of debris flow control facilities and other necessary facilities.



Note) ρ: Pore fluid density of debris flow

Figure 1. Result of estimating the length of rainfall that resulted in debris flow

3. Technology to gather information on damage using satellite SAR data

Satellite synthetic aperture radar (SAR) is an effective wide-area observation method that remains available even when it is difficult to identify conditions using optical images, such as during heavy rains or at night. Regional Development Bureaus are developing observation and interpretation support tools and preparing interpretation manuals to use SAR as a standard investigation method to be used immediately after the onset of a massive disaster.

As the high resolution SAR conducts observations in high frequencies, and the past observation data accumulate, the opportunity to identify damage using two time periods, including before and after a disaster, has been increasing. The NILIM has been proposing interpretation investigations of massive soil movement using a single image captured after the onset of a disaster. From now on, the NILIM is going to verify the precision of the interpretation method using images captured before and after a disaster through joint research with JAXA. The outcomes will be reflected in the interpretation investigation guideline. The NILIM is also going to further improve the efficiency of interpretation investigation using image analysis method based on coherence among three periods (a certain period before, immediately before, and immediately after the disaster) and explore ways to apply the technique.

An example of interpretation conducted during an actual disaster was the disastrous rainstorm in Sri Lanka in May 2017 (Figure 2), the heavy rain in Shimane to which a

special warning was issued in July 2017, and the heavy rain that hit northern Kyushu, Japan, in July 2017.[2] The NILIM is now providing technical support, such as providing the outcomes of interpretations to Regional Bureaus to be used during helicopter investigations in cooperation with the Sabo Department of the Ministry of Land, Infrastructure, Transport and Tourism and JAXA.

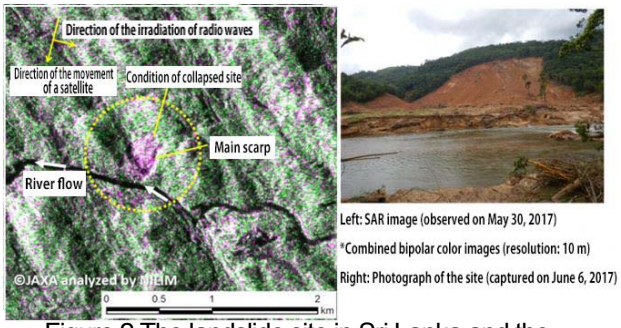


Figure 2 The landslide site in Sri Lanka and the outcome of SAR interpretation

4. Support for the improvement of technologies to respond to massive disasters by Regional Development Bureaus

The Act on Sediment Disaster Countermeasures for Sediment Disaster Prone Areas was revised in 2011. The revised Act stipulates that in an eruption or the creation of a landslide dam, the national government would conduct emergency investigations and notify local governments of the areas and timing when a landslide might occur as emergency landslide information. To improve the ability of the officials of Regional Development Bureaus who perform this operation, chief-level officials of the Bureau have been also assigned to the NILIM since 2013 to participate in lectures, practices, and on-site training concerning the early detection and measurement of landslide dams, debris flow outflow simulations, surveillance and observation, and emergency constructions.

In addition, in the case of the onset of a massive landslide, they accompany experts dispatched from NILIM from immediately after the onset of the disaster to learn ways to respond to actual disasters, such as by organizing the results of investigations and observations about evacuation and emergency responses, providing technical advice to the heads of local governments in the area of the disaster, and participating in handling the mass media. A total of 38 officials have been participating in this program so far and worked at the actual sites of disasters along with dispatched experts in the disastrous heavy rain in Hiroshima, the Kumamoto Earthquake, and rainstorms in northern Kyushu.

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

In the extensive flooding on the Kii Peninsula in 2011, deep-seated landslides occurred, and many landslide dams and debris flows occurred in Nara, Wakayama, and Mie that caused great damage. Therefore, the Kinki Regional Development Bureau installed Technical Center for Large-scale Sediment Disaster Countermeasures in Nachikatsuura Town, Wakayama, in 2014 to promote research and development concerning large-scale landslide damage. The NILIM has been assigning staff from the Sabo Department to this Center to support the investigation and research activities. Since 2017, one chief researcher from the NILIM has been stationed at the Center full time to engage in the following research jointly with the prefecture of Wakayama.

(1) Research concerning surface failure and debris flow

The team is conducting topographical, geographical, hydraulic, and hydrological investigations, geophysical explorations, and experiments using hydraulic models at the basin of the Nachi River where simultaneous landslides occurred in the extensive flooding on the Kii Peninsula to clarify the mechanisms of the onset of surface failure and debris flows, as well as the mechanisms of the accumulation and outflow of debris flows containing driftwood.

(2) Research concerning deep-seated landslide

The team is conducting hydraulic and water quality investigations of spring water and aerial electromagnetic explorations in the basins of the Totsu River and the Arita River to develop methods to evaluate the risk level of deep-seated landslides.

(3) Research concerning soil movement

The team is observing suspended sediment by water sampling and bedload using hydrophones in rivers in the mountains of Nachikatsuura Town and conducting research to identify the relationship between the timing of sediment production and the response characteristics of the changes in the amount of sediment transport.

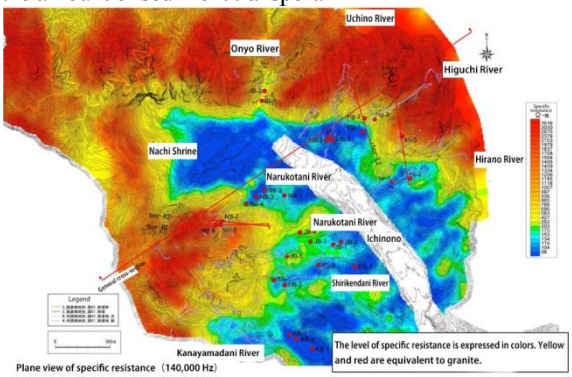


Figure 3 An example of specific resistance distribution found through aerial electromagnetic exploration

6. Summary

The NILIM is reinforcing its cooperative relationship with relevant organization, such as the Public Works Research Institute and Japan Society of Erosion Control Engineering, to promote research and development by incorporating the needs of organizations responsible for actual sediment control administration and operations, such as the Ministry of Land, Infrastructure, Transport and Tourism, Regional Development Bureaus, and individual prefectures.

☞For detailed information

1) Observation concerning rainfall indexes that regulate the amount of sediment outflow in debris flow using LP difference data and rainfall data measured by radar. Tsukasa Kudo et al., *Journal of Japan Society of Erosion Control Engineering*, Vol. 70, No. 3, p. 3-12. 2017

2) -Emergency interpretation of sediment damages using SAR loaded on artificial satellites (p. 189)

Activities of Road Traffic Department for Productivity Revolution

Kazuhide Kiyasu, Director of Road Traffic Department

(Keywords) Productivity revolution, big data, ETC 2.0, automatic driving

1. Introduction

The road is the foundation of all types of productive activities. Road development has played a major role in the economic development of Japan.

The Ministry of Land, Infrastructure, Transport and Tourism is now conducting twenty productivity revolution projects to realize the economic growth of Japan through the improvement of productivity at a faster rate than the declining worker population. Especially, in terms of road traffic, some projects aim to realize economic growth by effectively using the current stock of roads while utilizing ICT and big data. Many of the research themes of NILIM are related to these projects.

This paper discusses the activities of NILIM by focusing on the use of big data in the field of road traffic and automatic driving, including aspects related to the productivity revolution projects.

2. The use of big data

Road traffic investigations are the foundation of establishing road policies and have been conducted through observations by humans and surveys. Yet, ETC 2.0 enabled road administrators to directly gather the driving history of individual vehicles and the information of their movement as probe data. ETC 2.0 is the system that NILIM developed jointly with the private sector. It gathers the driving history of vehicles and their movements, which are accumulated in vehicles carrying ETC 2.0 through roadside devices installed by road administrators (Figure 1).

The number of vehicles carrying ETC 2.0 has been increasing to about 2.35 million vehicles as of the end of December 2017. The probe data gathered from these vehicles are now being available for use as big data.

NILIM is conducting research on methods to gather and utilize ETC 2.0 probe data and ways to advance the investigation and analytical methods using the characteristics of probe data as shown in Figure 2. The outcomes are being used in productivity revolution projects such as pin-point traffic congestion control and traffic safety measures using big data.

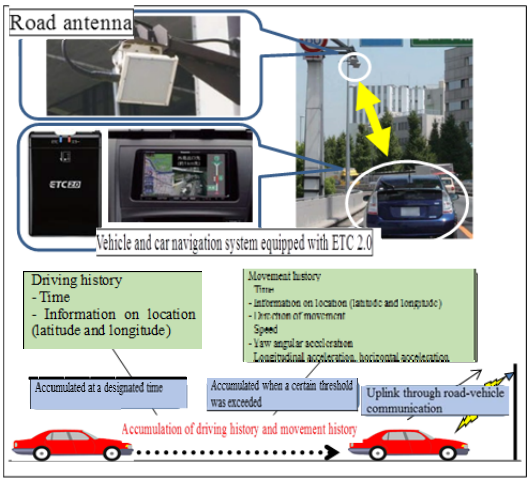


Figure 1 Collection of the ETC2.0 probe information

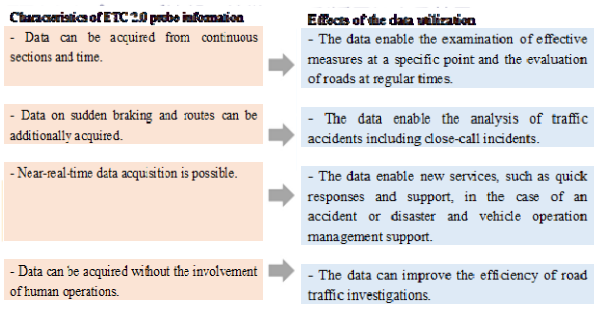


Figure 2 Characteristics and effects of ETC2.0 probe information

(1) Traffic congestion mitigation measures using big data

ETC 2.0 probe data, such as the speed and location of vehicles, can continuously be gathered in terms of time and space regardless of road types that vehicles are driving on. It enabled the examination of implementation of pin-point traffic congestion control, which can specify the timing and location of the onset of traffic congestion in detail to implement more effective traffic congestion mitigation measures as a productivity revolution project.

NILIM is also organizing methods to calculate indexes to evaluate the reliability of travel time without being limited to the average value based on the distribution of travel time.

Other research by NILIM includes research of the

traffic condition monitoring method that uses ETC 2.0 to establish traffic demand management (TDM) to optimize traffic flows, such as through strategic fee systems based on the conditions of congestion through real-time identification of road traffic conditions.

(2) Traffic safety measures realized using big data

The data of longitudinal and horizontal accelerations from ETC 2.0 allow the identification of the time and location when and where sudden braking or rapid turns occur. NILIM has been conducting research to extract locations with an increased risk of traffic accidents through these data.

In the identification of locations with an increased risk of traffic accidents on arterial roads conducted in 2017, NILIM analyzed locations with frequent high-risk movements based on ETC 2.0 data and designated about 460 locations around Japan as potentially high-risk areas. Also, the productivity revolution project titled Traffic Safety Measures Using Big Data is specifying high risk areas on community roads, such as where sudden braking often occurs, by analyzing ETC 2.0 data and other information. Traffic safety measures, such as speed restrictions and measures to restrict through traffic, are being implemented in the high risk areas.

(3) Road distribution innovation

Improved productivity, such as shortened cargo waiting times, can be expected in private businesses, such as distribution companies, when a central office identifies the real-time location of trucks and manages their operations. NILIM has been conducting social experiments with private businesses since 2016 to start a service in FY2018 that would provide ETC 2.0 data on specific trucks and vehicles to businesses, such as distribution companies, to support vehicle operation and management.

3. Activities of automatic driving

Automatic driving is a project that can improve safety and transportation efficiency and create new transportation services. It is also positioned as one of the productivity revolution projects as the ICT revolution of automobiles.

Technologies that work autonomously in individual vehicles to support safe driving, such as automatic braking, are advancing as automatic driving technologies. Yet, the autonomous type alone is not enough to identify sufficient information, such as the traffic conditions of a mainline at a merge point. Information provided from the road is also considered necessary.

NILIM has been conducting research on effective services with highway companies, automobile manufacturers, and electrical device manufacturers since 2012 to support automatic driving through the coordinated exchange of information between roads and vehicles (road-vehicle coordination) and to advance road management. As a specific service provided through road-vehicle coordination, a new joint research among the government, the private sector, and academia just started in FY2017 to explore services to provide information at highway merge points and services to provide information on accidents ahead on a road (look-ahead information).

Meanwhile, in mountainous areas where the population is rapidly aging, automatic driving service experiments are being conducted using low-speed vehicles and roadside stations as bases to secure the flows and distribution of people to revitalize rural areas. Experiments have been conducted at 13 locations around Japan mainly by Regional Development Bureaus since 2017. NILIM is providing technical assistance, such as the implementation of the experiments and verification and evaluations.

Photo: Automatic driving experiment at Roadside Station Nishikata

4. Summary

NILIM is going to continue research on methods to gather and utilize big data, such as ETC 2.0 data, and ways to assist and use new technologies for automatic driving based on road-vehicle coordination to realize economic growth through the improvement of productivity.

NILIM is also going to engage in research to realize safe, smooth, and comfortable road traffic based on proposals raised in the subcommittee of the Council for Social Infrastructure in August 2017.

Training of core engineers who lead road structure maintenance and management

Yoshitomi Kimura, Director of Road Structures Department

(Keywords) Road structure, maintenance and management, engineer, training

1. Introduction

Road structures, such as bridges, tunnels, earthworks, and pavements, support a safe, secure, and productive society by providing road functions. Since road structures will soon enter the deterioration phase in the near future, regular inspections have been increased since FY 2014. The inspections found that 11% of bridges (about 42,000 bridges) and 44% of tunnels (about 2,000 tons) urgently need prompt repairs.

The Road Structures Department is developing technologies to diagnose, repair, and reinforce these road structures as the second stage of maintenance to support proper management and efficient renewal (see "Close-up" at the beginning). The training of core engineers who support the maintenance and management is also essential. We are also working on this aspect by accepting personnel, providing training, and sharing knowledge with them. The NILIM research policy that was revised last year also positioned the improvement of on-site technology as one of the four main activities. This paper discusses the training of engineers.

2. Acceptance of personnel

One of the characteristics of the NILIM is that many researchers have experience working in government. In terms of research, they are reflecting their work experience in the Ministry of Land, Infrastructure, Transport and Tourism, Regional Development Bureaus, and local governments in their research activities and producing practical outcomes. Meanwhile, a certain number of engineers with experience working in research facilities are working at the actual sites of maintenance and management through personnel reshuffling between these worksites and NILIM.

Photo: On-site investigation after the onset of a natural disaster

The research activities of NILIM are observed from the perspective of human resource development through OJT. At NILIM, researchers are conducting research through experiments and inspection data analyses and preparing drafts of technical standards based on the outcomes of the research and analyses. They are also conducting on-site investigations and providing technical assistance in case of a natural disaster or the onset of defects as shown in the photograph. These activities provide valuable opportunities for them to gain hands-on experience and an understanding of the destruction and damage to actual structures and to become involved with the proposal of specific measures to respond to the damage. After improving their skills through these experiences and returning to on-site assignments, they are then able to provide technical assistance in their assigned work and to other organizations as experts.

3. Support in trainings

The maintenance and management of road structures involve a wide range of operations, including legally required regular inspections and repairs and reinforcement. Engineers assigned to these operations must have the necessary knowledge and skills to perform them. Thus, NILIM has established a training system in cooperation with the Ministry of Land, Infrastructure and

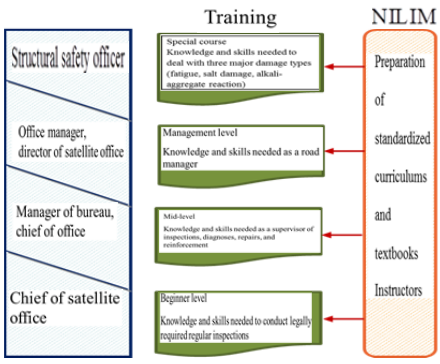


Figure 1 Training on the maintenance and management of bridges

Transport and training facilities.

As shown in Figure 1, bridge maintenance and training include the following three levels depending on the positions: beginner level, where engineers become able to perform legally required regular inspections; mid-level, where engineers become supervisors of inspections, diagnoses, repairs, and reinforcement; and management level where engineers make decisions of what to do as road managers including traffic restrictions. In addition, there is a special course to respond to fatigue, salt damage, and alkali-aggregate reactions that may result in more serious damage. NILIM supports the training by preparing a standard curriculum and textbooks and dispatching instructors along with proposals.

Among the training levels, the goal of the beginner level training is to train 5,000 people in five years from FY 2014. More than 1,000 participants attend more than 20 training sessions offered every year. Training textbooks used in the training sessions are made available to the public as NILIM references. In addition, test problems from achievement tests and points of practical tests are posted on NILIM websites so that the participants can refer to them in actual work settings after they complete their training.

4. Technical support

NILIM supports the challenges that engineers encounter at the actual sites by providing advice from the position with the knowledge of technical standards and actual operations. While support is offered to overcome actual on-site problems, it is also an opportunity to transfer the technologies and skills of the NILIM to the actual sites.

Most road structures are under the management of local governments. Some road structures require urgent responses using advanced technologies. The Ministry of Land, Infrastructure and Transport supports the local governments in such cases as directly managed diagnoses. NILIM participates in the directly managed diagnoses as the technical group for road maintenance and offers proposals for investigations and proposals for the method of soundness diagnoses, repairs, and reinforcement methods. Directly managed diagnoses have been conducted at ten facilities since FY 2014, and many have been repaired by the Ministry of Land, Infrastructure and Transport in place of local governments.

NILIM also provides technical support through on-site investigations and meetings when requested in case of the onset of defects or natural disasters.

Figure 2 Maintenance learned at actual sites

5. Sharing of knowledge

NILIM organizes the knowledge gained through technical support. The organized knowledge is shared by regularly hosting meetings of people assigned to specific structures, such as bridges, tunnels, pavements, and earthworks.

In addition, as shown in Figure 2, NILIM shares the knowledge in the column titled “maintenance learned at actual sites” in the civil engineering technical reference in which NILIM cooperates in the preparation. This column not only shares the results of diagnoses and the details of repairs but also discusses the technical points and precautions to keep in mind when one encounters a similar incident. It is like a doctor describing the thinking process for the decision to use a certain examination or treatment rather than simply introducing the treatment and prescriptions the doctor provided.

This column started in FY 2009, and more than 20 cases have been described here. Articles that passed more than one year after the publication are posted on the NILIM website for many people to see.

6. Summary

A TV program on NHK introduced NILIM as the special doctor of the land in Japan who protects infrastructures with passion three years ago. It is not the technology but engineers who protect the infrastructures. We will continue to support the improvement of technologies used at the actual sites and work together with many engineers who are involved in this process.

Activities of the Building Department in response to dynamically changing social needs

Hiroshi Fukuyama (PhD in Engineering), Director of the Building Department

(Keywords) Building standards, social needs, revitalization of rural communities, safety and sense of security, functional continuity

1. Introduction

The mission of the Building Department is to respond to the various needs of the citizens and society, which are dynamically changing in response to the movement of the world and to realize a safe, secure, and comfortable building environment. We are, therefore, providing administrative support for the planning, proposal, establishment, and revision of various technical standards, including the Building Standards Act based on scientific and technical knowledge. Other activities include investigations in areas damaged in natural disasters, exploration of future measures to implement, reflection and spread of outcomes of investigations and research to society, and provision of technical support for organizations inside and outside Japan. The section below introduces the themes of the main research projects we are now conducting. The goal of research projects 1 to 2 is to create and revitalize the attractiveness of rural communities, which are one of the recent needs of society, and projects 3 to 5 are for the realization of a safe and secure society, which have been the conventional needs.

2. Themes of main research projects now underway

1) Technological development to support the use of already available buildings by rationalizing fire control and evacuation regulations (General Technical Development Project: 2016–2020)

The national government has set the year 2015 as the first year of the rural community revitalization to promote efforts to ensure that safe, secure, and emotionally fulfilled lifestyles would continue further into the future by overcoming issues, such as a declining population and the shrinkage of rural economies. To realize such a goal, local governments and private businesses, which are building their communities, demand the use of currently available buildings, such as historical buildings, which are valuable assets for the rural communities, by turning them into hotels and restaurants so that they would revitalize tourism and the local economies. The environment needs to be developed to smoothly support such activities. Thus, the goal of this research is to develop technologies to rationalize fire control and evacuation regulations and uses and to streamline operations to realize smooth use of already available buildings.

Photo: Example of changing uses (switch from a school to elderly housing with services and nursery school)

(*Smoke extraction systems and restrictions on interior materials become requirements depending on facility sizes, which often makes it difficult to realize such projects.)

2) Development of design and construction technologies for mixed-structure buildings using new types of wooden materials (General Technological Development Project: 2017–2021)

The Basic Policy on the Creation of Town, People, and Work that was adopted as a cabinet decision in 2015 clearly set a goal to further reinforce the promotion of the development and the spread of CLT and other materials, and the switching of public facilities into wooden buildings to promote the use of wood in buildings for the purpose of (1) accelerating the revitalization of the rural economy, (2) solving environmental problems, and (3) creating spaces where wooden materials are used. The purpose of this research is to conduct technological development concerning the structure, fire control, and durability to develop design and construction technologies for mixed-structure, mid-rise buildings in which different structural types are combined, such as the combination of wooden structures using large wooden panels, such as CLT with RC structures and steel structures, to further accelerate the transformation of buildings into wooden buildings to realize the various needs for the use of wooden materials, expansion of versatility, reduction of construction periods, and response to the need to show wooden materials on the surface based on this Basic Policy.

3) Research concerning the evaluation of safety and reusability of buildings damaged by fire caused by earthquakes (Categorical research: 2015-2017)

This research theme aims to support the establishment of an emergency risk assessment manual (draft) targeting mid-to-high-rise fireproof buildings damaged by fire caused by earthquakes, to secure evacuation shelters immediately after an earthquake through the construction

and systematization of evaluation technologies for repairs and reuses, to prevent secondary damage, and to reuse damaged buildings.

4) Development of simple method to evaluate the performance of wooden houses (Categorical research: 2016–2018)

This research aims to develop and spread easy methods to evaluate the structural performance of wooden houses based on information obtained through precut diagrams used during the production of wooden houses to promote performance labeling (earthquake resistance grade).

5) Development of technologies to renovate facilities to secure the health and safety of evacuees in evacuation shelters (Categorical research: 2017–2019)

This research aims to present the necessary performance, renovation technologies, and emergency response technologies concerning the power, water, toilets, acoustic environment, optical environment, thermal environment, privacy, and other aspects of evacuation shelters by taking into account of chronological changes from the onset of a disaster to the period where the livelihood of the people is secured for the purpose of reducing physical and mental health damage during the time spent in shelters.

3. Continuous usability becomes a major theme in future activities

Since the 2016 Kumamoto Earthquakes, the Ministry of Land, Infrastructure and Transport is conducting focused efforts to realize a safe and secure society that is resistant to natural disasters.[1] One of such efforts include the Functional Continuity Guidelines concerning Buildings to be Used as Disaster Management Bases that the Housing Bureau is now examining with the support of the Cabinet Office, Ministry of Education, Culture, Sports, Science and Technology, Ministry of Health, Labour and Welfare, and Government Buildings Department. The Building Department is also playing a major role in the preparation of the draft. This is considered to be the effort to respond to the need for a modern and mature society demanding to prevent social confusion and disorder caused by the inability to use buildings that are damaged in a major earthquake unlike the conventional regulations that are based on minimum standards. The continuous usability is likely to become one of the main points of our future activities. Their outlines are introduced below.

Many of the government buildings and evacuation shelters that were expected to function as disaster management bases after the onset of an earthquake became unusable after an earthquake even though they did not collapse nor were they destroyed. The Building Standards Act stipulates the minimum standards for buildings. Its purpose is to prevent the collapse or destruction of buildings after a major earthquake. On the other hand, buildings to be used as disaster management bases are expected to have higher performance to keep providing their functions after a major earthquake.

These Guidelines provide the basic and common

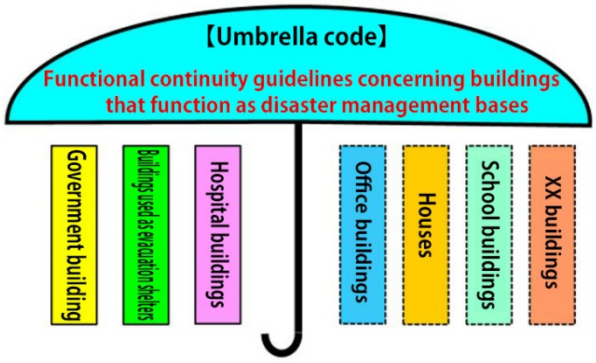


Figure: Position of the Functionality Continuation Guideline concerning Buildings to be Used as Disaster Management Base (concept)

among owners, architectures, and administrators of buildings. The guides for the design and construction of functional continuity to suit the purposes of specific buildings, such as government offices, evacuation shelters, and hospitals, are expected to be organized based on the principles of the Guidelines and applied to society. In addition, these guides should also be used as the reference for private houses and business offices to create a resilient society with a higher level of safety and security. These are essential tasks to prevent evacuation shelters from becoming overwhelmed and ending up rejecting people evacuating from damaged houses in the case of major earthquakes, such as the Nankai Trough Earthquake and large earthquakes directly hitting Tokyo, and to prevent offices and factories from being damaged and becoming unable to continue operations, consequently affecting economic and social activities in and outside of Japan.

The continuous usability of buildings is currently based on an examination method in which seismic design force is gradually increased to find a force that would not collapse or destroy a building. Yet, this method is not enough to find the condition of damage in buildings after a major earthquake. It is not easy to propose business continuity plans (BCP) with this method, either. In the future, a shift is expected to new examination methods based on response deformation and/or other factors that can estimate response conditions in the different parts of a building after an earthquake and judge whether the conditions are tolerated from the perspective of functional continuity expected from the building. This is a meaningful challenge to respond to new needs.

☞For detailed information

1) Building Guidance Division, Housing Bureau, Ministry of Land, Infrastructure, Transport and Tourism Review Committee on Functional Continuity Guidelines for Buildings Used as Disaster Management Bases Guidelines
http://www.mlit.go.jp/jutakukentiku/build/jutakukentiku_

house_tk_000088.html

Progress of production research in the field of housing research

Naoji Hasegawa (PhD in Engineering), Director of the Housing Department

(Keyword) Housing production, architectural production, quality assurance

1. Shift from securing quantity to quality of housing

We cannot stress enough that one of the most important issues in housing policy and housing research is the measure to reduce vacant houses.

When the Ministry of Construction was established in 1948, post-war restoration was the most important issue facing the nation. Housing was in an absolute shortage due to the many houses destroyed in the war by fire and people returning to Japan from overseas. Then, the production of housing mostly focused on volume due to the increased housing demand among young workers of which the population increased through the policy to gather them in large cities during the rapid economic growth period. In other words, the number of housing units available in 1948 was 13.90 million, while the number of households was 15.98 million, meaning there was a shortage of 2.08 million houses.

Yet, the House and Land Census in 1968 found that the number of housing units was larger than the number of households. The number of housing units became larger than the number of households in all prefectures by the census of 1973. Since then, housing availability has been an excess (vacant houses) up until today.

Research Team I of the Building Research Institute of the Ministry of Construction, the former organization of the NILIM Housing Department, responded to the housing policies that have been changing with changes in the housing situation based on social movements through its research.

Around 1965 to 1974, when housing was in short supply in terms of quantity, our predecessors advocated the concept of architectural production in their housing research ahead of others.

2. The start of housing and architectural production research

Architectural production is a concept that regards the series of architectural actions of plans, designs, and construction of architectures as an industrial production process. It also includes maintenance and management, renovation, and the disposal phase, which is considered downstream of production in recent years. This concept is used when discussing the relationship between the factory production of architectural parts and on-site construction work, as well as the function of architectural production organization (e.g. architecture, subcontractors, and specialized contractors).

Research themes include the economic efficiency of use of already available items in architectural production (1965), the relationship among architectural industries and the improvement of the efficiency of contracted construction (1966), the residential standard of housing and the economy of the mass production of housing (1966), and the modernization of architectural production organizations (1967–1968).

The relationship among architectural industries and the improvement of the efficiency of contracted construction was conducted under the following assumptions. To improve rationality in housing and architectural production, the unit of orders should be expanded to a suitable level as industrial production under the condition where buildings, such as public housing, can be planned based on relatively the same quality and standards to ensure continuity, stability, and plannability of the construction periods. The research also suggested recognition of the contribution of producers (contractors) in the design phase to improve the rationality of production designs based on research findings. It also proposes the setup of active conditions in which factors other than prices are taken into consideration in the bidding when placing orders for public buildings, while not selecting the lowest bidder as the winning bidder. These are not new ideas from today's standards. Yet, these were innovative ideas back then.

The residential standard for housing and the economy of the mass production of housing that was conducted as a part of the industrialization of architectural production and the modernization of architectural production organizations was the applied research conducted when the prefabrication of housing production was regarded as a major challenge of the housing policy. This research was conducted under the following idea. While the demand for prefabricated housing has not sufficiently expanded among owners (buyers of houses), rapid progress in the establishment of a production and sales system for prefabricated housing could not be expected only by waiting for prefabricated housing manufacturers to make the effort; instead, there was public demand for research by the only public research institute that studied housing and construction to look into this matter. From today's perspective, the role of public research facilities

seem different. Meanwhile, the points of nurturing housing-related industries, which are still weak, and the bottom-up of technological ability of the industry are still in the exploration phase today.

The concept of architectural production that our predecessors advocated became a common concept in the Proposal for an Architectural Production Theory (Architectural Production Division, Architectural Economy Committee, Architectural Institute of Japan) a few years later. Also, investigations and research at the research facility became useful as data that supported the architectural design modernization investigation conducted by the Ministry of Construction (1967–1969) and the report of the Housing and Residential Lot Council. Then, in 1971, the Architectural Production Laboratory was installed in Research Department I (Housing).

3. Development of production research

The rationalization of housing and architectural production again became a major research theme after the 1990s. In response to the aging of workers at construction sites, the occupation was associated with the image of being dangerous, dirty, and hard, as well as representing a shortage of skilled workers, so developments were made to produce easy and high-precision structural work methods using robots at construction sites and using various ideas to join architectural components. Research was simultaneously conducted on the digitalization and automation of construction using advancing IT technologies to realize unmanned construction sites or reduce the number of workers at construction sites. These research projects were conducted as a part of the development of new construction technologies to be used in construction projects (field of architecture) (1990–1994) as a part of the General Technology Development Project. The aim was to rationalize the production of reinforced concrete building structures. These are probably based on the same concept as the productivity revolution that is being advocated for construction projects today. Yet, the author believes that the essential point is to secure the quality of architecture, which is the final product of all efforts.

We use the terms “upstream” and “downstream” for architectural production. Multiple experts and companies, including the client, organize a team for a specific project and workflow. An architecture is eventually produced as the item that reflects the demand (goal) of the client, who started the entire flow. Not all architectures are necessarily sound, however, and some architectures have defects. The defects are assumed to occur when information or communication is omitted or mistaken while the team is working in a flow. A model connecting the goal and methods covering from upstream to downstream of production is created to reduce the omission or mistake as much as possible (Figure). Humans are the executor of specific architectural designs. Omissions and mistakes are therefore unavoidable as long as humans are involved in the design, construction, maintenance, management, and renovation. Yet, such mistakes result in a situation where the final product has defects, or enough quality is not secured in the final product. We cannot stress enough that we definitely need to use robotic technologies and IT technologies, as well as support by AI, which will work along with people engaging in production. We would like to work toward securing and improving the quality of the final products by exploring how these technologies play important roles in the flow of architectural production while coming to terms with the human factors of maintaining the sense of satisfaction for the work.

It is important and indicative that architectural production research started in Research Division I (Housing) at the Building Research Institute of the Ministry of Construction just when housing availability reached a sufficient level in terms of volume around 1965 to 1975. This is because the author believes that the essential point was to secure the quality of housing and buildings.

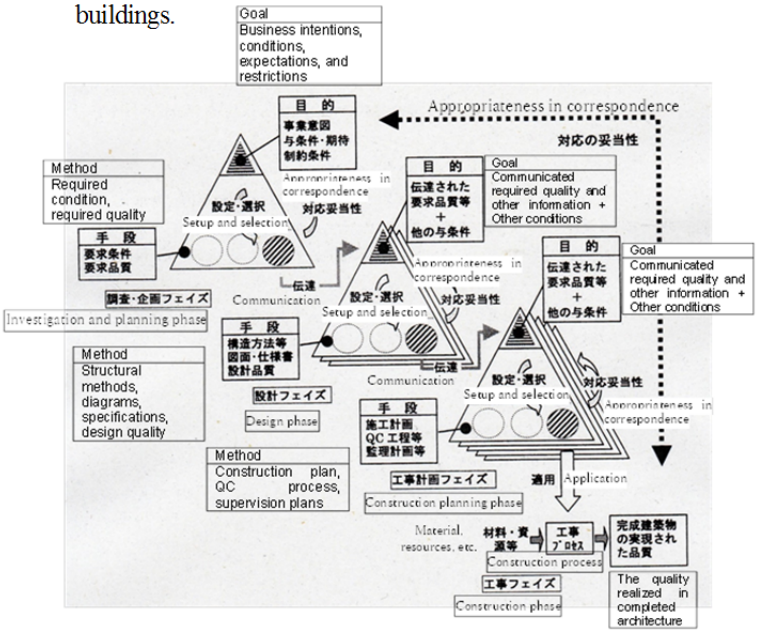


Figure: The concept of the quality and the link between the purpose and method for architectural production

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☞For detailed information

建築研究所50年 *(Fifty years of the Building Research Institute)* issued by the Architectural Research Institute of the Ministry of Construction, October 1996

1) pp. 16-21. Chapter 3, Housing and Construction Economy Department. Matsujiro Suda and Hideyuki Kobayashi

2) pp. 138-141. From Housing Supply Policy to Comprehensive Housing Policy. Gyo Takahashi

Tradition and revolution of urban fire management research

Kenichi Sato, Director of the Urban Planning Department

(Keywords) Urban fire management, disaster investigation, the major fire in Itoigawa City, major fire in Sakata

1. Disaster investigation

On December 22, 2016, a fire that started in a shopping arcade in front of a station in Itoigawa City, Niigata, spread in a strong wind and resulted in a massive fire that burned down about 4 ha of the urban area and 147 buildings (3 ha) in nearly half a day. The scale of this urban fire was the largest since the major fire in Sakata in 1976, except for fires caused by earthquakes or tsunamis. It resulted in the public recognition that urban areas crowded with houses and stores were associated with the risk of massive fires when conditions were met.

Upon the request for an investigation from the Housing Bureau of the Ministry of Land, Infrastructure and Transport, the NILIM immediately dispatched a team of researchers jointly with the Building Research Institute and released the first report in January 2017. The team consisted of five members, including midlevel and young researchers in the fields of urban fire management, fire management standards, fire management research, and housing and urban research in both organizations.

The team then conducted hearing investigations, analyses of recorded fire images, reproduction experiments, and simulations and analyses and released the report to the press in July. The report discussed the following: the process of the spread of the fire as flying sparks in strong winds, the phenomena in which sparks entering from the gaps of old roof tiles constructed in the early Showa period (1920s to 1930s) spread to the roof underneath, and the effect of fire management measures on roofs and the outer walls of individual buildings on the fire safety of urban areas. The report supported the effectiveness of fire management measures that the national government had implemented thus far. It also gave hints to fire management measures for the era of keeping stock of the currently available buildings and became one of the factors that resulted in the revision of the Building Standards Act.

Disaster investigations like this are one of the main activities of the NILIM (and Building Research Institute of the Ministry of Construction, the predecessor of the NILIM). The NILIM has investigated various disasters without being limited to urban fires, explored the causes and preventive measures, and reflected the findings in measures, research, and development. Among them, this paper focuses on the investigations and research that the Building Research Institute of the Ministry of Construction conducted on the major fire in Sakata to compare the findings with the major fire in Itoigawa.

2. *Quick Investigation Report on the Major Fire in Sakata* (1976)¥

The major fire in Sakata started from a busy section of Sakata City, Yamagata, in the late afternoon of October 29, 1976. The fire kept burning until the next morning and destroyed 22.5 ha of the urban section, 1774 buildings, and damaged 15.2 of the area. The total financial loss from the fire was 40.5 billion yen. The government designated the fire as a serious disaster. It is also known for the surprisingly quick restoration; the preparation of a restoration plan started immediately after the fire, and the restoration plan was established in 51 days, followed by complete restoration in two years and six months. The lessons from this fire are kept in many records and investigation and research reports, which were used as the reference for fire management urban constructions in many areas and restoration after the Great Hanshin-Awaji Earthquake.

Urban fires back then were a more severe problem than today, and prevention measures were in high demand since it was an urban problem that threatened the lives of citizens. The Building Research Institute of the Ministry of Construction dispatched six officials as the first team for an on-site investigation from October 31 to November 3. It conducted four additional follow-up research projects, and 13 officials in total investigated the site of the fire. Researchers from various research divisions were involved in this investigation, such as urban fire management, urban planning, urban development, fire management, smoke management, organic materials, inorganic materials, isotopes, and planning. The City Bureau of the Ministry of Construction also dispatched officials to support the establishment of restoration plans, and the National Research Institute of Fire and Disaster of the Fire and Disaster Management Agency dispatched officials to investigate aspects related to the fire, firefighting, and evacuation.

The outcomes of the investigations were compiled as the *Quick Investigation Report on the Major Fire in Sakata* (1976) (December 1976, Building Research Institute, Ministry of Construction). The preface at the beginning of the report said that the investigation of massive urban fires would provide various topics to the research of urbanization and construction, which was because the outline of the disaster must be promptly provided to relevant officials to make use of them for future actions. The overall structure of the report

included: (1) an outline of the fire, (2) overall condition of the urban area, (3) damage to fireproof buildings, (4) overall condition of damage to the trees, (5) condition of evacuation, and (6) a summary and problems. It summarized the causes of the fire and preventive measures in a short period.

The research has progressed since then. A lecture session in 1977 presented the results of estimating the spread of the fire and the outcome of a survey on evacuation behavior and the lecture session in 1979 discussing the result of the experiment on trees in regard to fire management effects.

In addition, *Araka*, the first compilation of the result of architectural research published in 1979 introduced research titled "Simulation analysis of a major urban fire" about the analysis of the progress of the spread of the fire in Sakata using a computer simulation. This was about when the development of computers and the accumulation of knowledge was finally enabling computer simulations of massive urban fires. The simulation analysis of the spread of the fire exposed new research topics, which were taken over in the Development of Methods to Prevent and Control Urban Fires, the General Technology Development Projects of the Ministry of Construction that started in 1977.

3. Traditions of an organization and the creativity of individuals

The comparison of the investigation and research of the two urban fires clarifies many similarities. ◇Prompt on-site investigation and the release of findings immediately after the fire, ◇a flexible system to examine the situations in cooperation among different fields and organizations, ◇emphasis on identifying actual on-site conditions, ◇multilateral analyses using various methods including experiments and simulation, ◇feedback on policies, ◇continuous development of researches and discovery of new research themes, ◇ reflection of advanced research outcomes in the future disaster management and policies, and ◇the cycle of the above.

Various demands and needs raised both directly and indirectly from society, such as through the experience of disasters, became the source of energy to engage in research at the NILIM. As we continue and advance research activities in response to such demands and needs, new research themes and technologies emerge, and their advancement will start responding to new needs in the future. The repetition of this process will deepen and systematize the research. Such a process of research projects and investigations are now the tradition of the NILIM.

On the other hand, in terms of the differences observed from the perspective of investigations and research besides the fact that needs have changed along with changes in the times and socioeconomic environment, differences include the ◇available technologies differ due to technological advancement, and the ◇people involved with the research have been replaced.

In the fire in Itoigawa, the research team conducted experiments that reproduced strong winds in a fire tunnel experiment facility in Tsukuba (completed in March 1998) that was not available before. Still, an ideal condition that researchers desire seems to be experimental facilities with higher performance. In addition, the drastic advancement of computer technologies and applied theories also resulted in rapid progress in simulation analysis. Someday, an innovative forecasting method based on AI may be available.

The replacement of human resources is associated with both advantages and disadvantages. Still, the NILIM would like to positively accept it as a research facility that emphasizes creativity because the creativities of individual researchers will bring a revolution in research. Having said that, the accumulation of human resources with abundant experience is the precondition to this, and a long-term perspective is the key. The analysis focusing on flying sparks in the fire in Itoigawa was realized as a result of the combination of the ideas and steady progress of each of the young researchers and the instructions and guidance given by experienced midlevel researchers. It is the outcome of the overall ability of the teamwork of the midlevel and young researchers, or the power of individuals and the organization.

In the end, the greatest difference is the difference in the socioeconomic environment, which is the background to the other aspects. The needs that society will expect from the NILIM are also changing. Needs are the source of the power to engage in research. Thus, the constant goal of the NILIM is to be ready to respond to needs. The tradition of the organization is therefore important, and the creativity of individuals supported by technologies are also needed. We have especially high expectations from challenges that young researchers go through.

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

Yoshiyuki IZUMI, Director, Research Center for Infrastructure Management

keywords: work using ICT, CIM, public bidding / contracting methods, green infrastructure, Kumamoto Earthquake

1. Introduction

This year is the second year of Social Capital Management Research Center (the "Center"), which was newly opened in NILIM. The first research center organization concerning construction management techniques is Estimation Technical Research Center, installed in Public Works Research Institute in 1991. In 1997, this organization was expanded to Construction Management Technical Research Center to study construction management techniques under the further improved system and has been studying for 20 years since then. During this period, research areas have changed and expanded according to realignment of the organization in response to changes in social conditions. The present subjects of research comprise various fields, including estimation, public bidding / contracting methods, project evaluation, analysis of economic effects, ICT utilization / total optimization of concrete works for construction productivity improvement, information infrastructure such as CIM, landscape and ecology, 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 second year, including future prospects.

2. Productivity improvement of construction works

When Japan is faced with depopulation and super-aging society, in order to enhance growth potential by improving productivity, the MLIT is working on 20 projects including i-Construction. The purpose of i-Construction is to improve the productivity of construction site by 20% not later than fiscal 2025 using ICT in the whole construction production process, which also contributes to working-style reforms for development / securing of workers on a mid- and long-term basis.

(1) Works using ICT

Technologies to obtain three-dimensional position data using satellite positioning, 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 to promote on-site introduction of such technologies and implemented study in the current fiscal year on revetment, tunnel, maintenance work, etc. to expand work items. We intend to continue the study on further expansion of work items, continual improvement of standards, new technology utilization methods, etc.

(2) Introduction / dissemination of CIM

CIM (Construction Information Modeling /Management) contributes to efficiency enhancement / upgrading of a series of construction production systems using three-dimensional models and is expected to produce the effect of productivity improvement as shown in Figure.

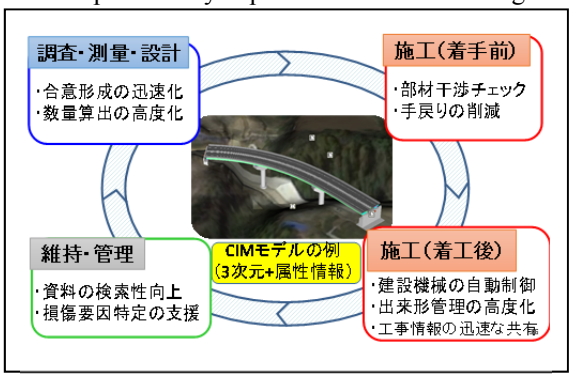

Figure: Effects of CIM

The Center has been studying procedures and standards for introduction / dissemination of CIM, and implemented study in the current fiscal year on creation of standard specifications to utilize CIM models for construction contract documents and drawings, quantity calculation method using CIM, etc. In order to further promote introduction and dissemination, we also continue the studies on formulation of specifications / standards for data exchange, simple three-dimensional model creation methods for existing structures, specific utilization methods in maintenance phase, etc.

3. Improvement of public bidding / contracting methods for public works

Public bidding / contracting methods have been continuously improved according to the demand of the

times and changes in social situations. As a recent example, the Act on Promoting Quality Assurance in Public Works ("Quality Assurance Act") was revised in 2014 to add quality assurance for the present and future public-works and development / securing of human resources on a mid- and long-term basis 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. Utilization of CIM is also expected to advance total optimization more efficiently. In order to increase the cases where this public bidding / contracting method is applied, the Center is proceeding with the study leading to revision of the operation guidelines, including analysis of projects that adopted this method and organization of the matters to be improved.

In July last year, "Guidelines for application of public bidding / contracting methods in disaster restoration" (MLIT) were established so that appropriate recovery projects are promptly undertaken after disaster in response to the recent disasters that are intensifying and frequent. The Center investigated and analyzed the disaster cases in the past projects under direct control and organized the basic concept for application of public bidding / contracting methods that contribute to early recovery so that the concept is reflected in the content of the guidelines above. In view of the recent disasters that frequently occur in the country, significance of working for disaster restoration appropriately is increasingly rising regardless of project owners and dissemination / utilization of these guidelines for local governments' projects is therefore becoming important. We intend to follow up as appropriate while watching the status of utilization.

4. Green infrastructure contributing to urban disaster prevention / mitigation

In the National Spatial Strategies, decided by the Cabinet in 2015, green infrastructure was defined to advance the sustainable and attractive national land and regional development utilizing the various functions of natural environment in both structural and non-structural aspects, such as social capital development and land use. The Center prepared "Guidelines for Planning / Design / Administration of Disaster Prevention Park (revised, second version)" in September last year by adopting the concept of administration based on the state of use in the Kumamoto Earthquake so that the function of city parks as one of green infrastructure is sufficiently demonstrated. The Center is also proceeding with the study on the planning / realization method contributing to disaster prevention / mitigation, not only parks but the whole green area for disaster prevention including roads, rivers, and private wood land. We intend to increase knowledge on more effective management of green infrastructure while proceeding with example collection and analysis and return findings to society.

5. Measures for restoration from the Kumamoto Earthquake disaster.

In the works for restoration from the Kumamoto Earthquake disaster, which happened in April 2016, advanced technical knowledge about bridges etc. has been required and a division was installed in April last year by stationing research personnel on the site in order 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 August last year, 16 months after the occurrence of the Earthquake, service of the Aso Choyou Great Bridge Route, which was seriously affected by the disaster, was resumed, which gave great momentum to restoration of the region (Photo). We intend to provide technical support to restoration works, including the Aso Great Bridge and advance the study on aseismic structure enabling easy functional recovery by collecting and analyzing information obtained on the site according to the progress of work and reflecting it in technical standards.

Photo: Resumed service of the Aso Choyou Great Bridge Rout (Aug. 2017)

6. Conclusion

We intend to continue the study on social capital management according to on-site needs so that study findings are applied to practical activities using up-to-date ICT technologies, which are remarkably progressing, including AI, IoT, and high-speed large capacity communication.

Formulation of Guidelines for B-DASH Project (Stormwater management technology for local torrential rain in urban area) (Study period: Fiscal 2015 and 2016)

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NAKAMURA Yumi, Research Engineer Kondo Hiroki, Guest Research Engineer

Water Quality Control Department, Wastewater System Division

Keywords: B-DASH, urban inundation control measures, self-help and mutual help

1. Introduction

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 project.

We have formulated guidelines for new technology introduction in January 2017 based on the results of empirical study on "Stormwater management technology for local torrential rain in urban area" (the "Technology"), an innovative technology adopted in fiscal 2015 for urban inundation control measures, considering the views of local governments and experts.

2. Outline of the demonstrated technology

The Technology implements rainfall prediction and runoff analysis on a real time basis based on the information collected from radar rain gauges and water gauges and provides facility administrators and local residents with information on predicted water levels in sewer pipelines and inundation by inland water. Accordingly, the Technology enables effective operation of existing inundation control facilities including rainwater storage pipes and mitigation of damage by inundation of inland water through promotion of self-help and mutual help activities (See Figure 1).

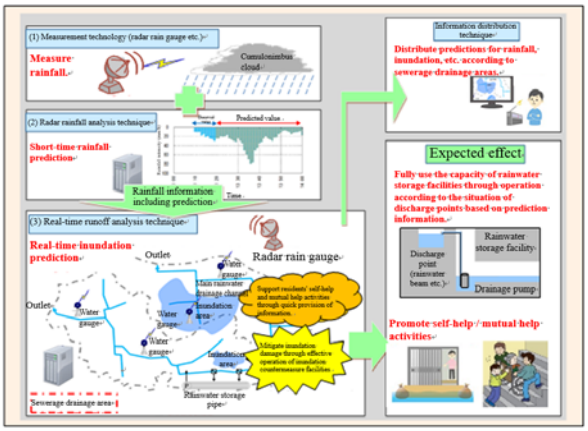

Figure 1: Outline of the Technology

3. Structure of the Guidelines

Figure 2 shows the structure of the Guidelines formulated. First, Chapters 2 and 3 provide the characteristics, performance, etc. of the Technology and confirm the assessment items. Next, Chapter 4 estimates the effect of introduction in target areas and studies specific introduction plans and system establishment based on Chapter 5 when the effect of introduction is considered high. Chapter 6 describes how to operate and maintain this Technology after introduction.

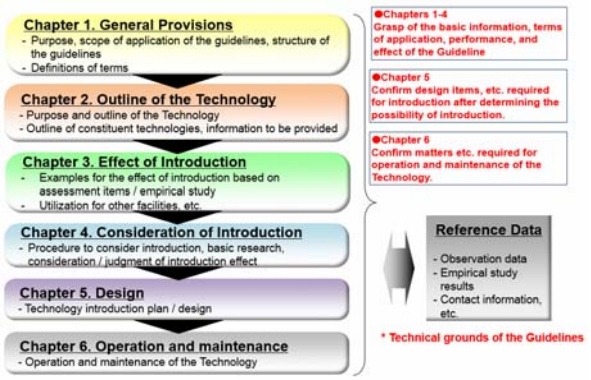

Figure 2: Structure of the Guidelines

4. Utilization of results and future development

In order to introduce these Guidelines to local governments that actually manage sewerage facilities, sewerage-related enterprises, etc., we held Guidelines Presentation at Tokyo Big Sight in August 2017, attended by about 80 people. We are going to hold such a meeting, etc. to actively introduce the Guidelines and disseminate the technologies that contribute to mitigation of inundation damage in urban areas.

☞See the following for details.

1) Technical Note of NILIM, No. 998
http://www.nilim.go.jp/lab/ebg/b-dash.html

Analysis on Difference in the State of Catch Basin According to Whether Roads are Flooded / Non-flooded

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Wastewater System Division, Water Quality Control Department

keywords: catch basin, fallen leaves, road flooding, inundation damage

1. Introduction

Some cases were reported where accumulation of fallen leaves in catch basin or on basin cover or gutters decreased the drain capacity of catch basin and caused road flooding or inundation damage near the road. It is known that the rainwater fall rate of catch basin cover that affects drainage of catch basin varies according to type of basin cover, gutter flow rate, and cross / longitudinal slope of the gutter [1)], but effect of accumulated fallen leaves on drainage of catch basin is not clarified.

We therefore analyzed effect of accumulated fallen leaves on drain capacity of catch basin for the roads ever flooded by comparing the amounts of fallen leaves in catch basin and on basin cover and gutters for sections ever flooded ("flooded section") and sections never flooded adjacent to or facing flooded sections ("non-flooded section").

2. Outline of the survey

We conducted a field survey on catch basins with focus on accumulated fallen leaves and a hearing from road administrators and selected two routes (Municipal road A, National road B) from flooded roads. Main survey items are accumulation of fallen leaves on basin cover and gutters, diameter of pipes in the basin, and coverage ratio of pipe openings (ratio of the area of pipe openings covered by fallen leaves in basin to the area of pipe openings). The survey period is from December 2015 to January 2016, when fall of leaves was coming to an end.

3. Survey results

As accumulation of fallen leaves on basin cover and gutters, we organized the data on the weight of accumulated fallen leaves per meter (Total weight of accumulated fallen leaves (kg) / Total extension of the survey section (m)) (Fig. 1). Figure 1 shows that the accumulation of fallen leaves was larger in flooded sections than non-flooded sections by approx. 6.6 times in Municipal road A and approx. 1.4 times in National road B.

Next, in order to check the accumulation of fallen leaves in basins, we organized the data on the average coverage rate of basin pipe openings for flooded and non-flooded sections ("average coverage rate") (Table 1). In Municipal road A, fallen leaves have not accumulated up to pipe openings in flooded sections, while average coverage rate reached about 50% in non-flooded sections. In addition, average coverage rate was not less than 80% in both flooded and non-flooded sections in National road B.

4. Consideration and future schedule

The survey results show that coverage rate is not higher in the flooded sections than non-flooded sections and suggest the possibility that the accumulation of fallen leaves in the basin may not affect decline in drain capacity. Since the accumulation of fallen leaves on basin cover and gutters is larger in flooded sections than non-flooded sections in both routes, fallen leaves on basin cover and gutters may have prevented drainage.

It is therefore important to grasp the effect of accumulation of fallen leaves on basin cover and gutters against drain capacity. Accordingly, we are conducting an experiment with a real-scale model to study how the accumulation of fallen leaves on basin cover and gutters affects the fall rate of catch basin cover by changing the type of basin cover, flow rate corresponding to rainfall, and road incline.

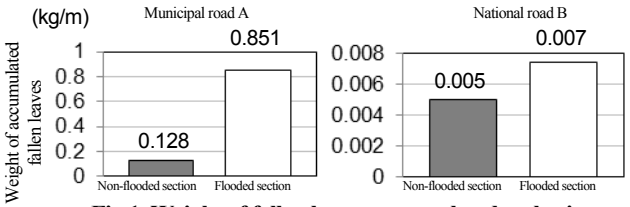

Fig 1. Weight of fallen leaves accumulated on basin cover and gutters

Table 1. Average coverage rate of pipe openings in the basin Rate

	Municipal road A	National road B
Non-flooded section	47.5%	85%
Flooded section	0%	100%

1) "Experimental study report on the fall efficiency of rainwater of road drain basin cover" Public Works Research Institute, No. 3341, Jan. 1995

Verification of Disaster Process in the Bridge Exposed to a Large-scale Flood and Study of Disaster Reduction Measures based on Verification Results

(Study period: FY2016 to FY2017)

NISHIMURA Yusuke, Researcher; SUWA Yoshio, Head; River Division,

TAKEUCHI Yoshinori, Senior Researcher

Flood Disaster Prevention Division, River Department

keywords: bridge damage, disaster reduction measures

1. Characteristics of damage caused by 2016 Typhoon No. 10, etc.

Heavy rain by the 2016 Typhoon No. 10 etc., caused damage to many river bridges in Hokkaido and Iwate Prefecture. The forms of damage found in these disasters include damage caused by inundation of flood flow over bridges or approach embankment and damage caused to abutments due to expansion of bank erosion not accompanying flood. If bridge body (beam, pier, abutment) is damaged, traffic network in stricken area is interrupted for a long time and recovery takes much time, which may cause a mid- and long-term impact on stricken area. There was also a case where a car fell when traveling on the road collapsed by flood in Hokkaido. Thus, necessity for stopping traffic on the bridge in case of a flood and timing of determination are also mentioned as issues to address.

Since the scale of rainfall has been increasing due to the effect of climate changes, it is urgently required to study how to prepare countermeasures for a large number of bridges with limited budget, including disaster reduction measures for avoiding critical damage to bridge body and non-structural measures for ensuring the safety of bridge users.

This study examined the process of damage to abutments with a movable bed model experiment for the forms of damage to abutments by river erosion, on which few studies were conducted for the bridges damaged by the 2016 heavy rain in Hokkaido and Iwate.

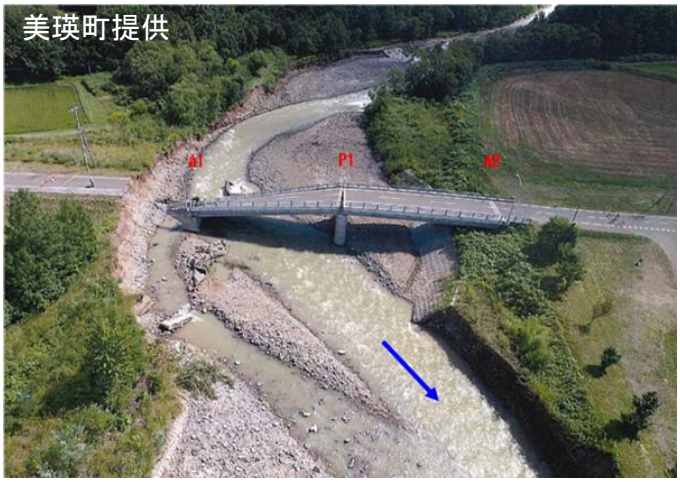

Fig. 1 Damage to Kyusen Bridge (Bebetsu River, Hokkaido)

2. Movable bed model experiment for grasping the basic damage mechanism of abutment accompanying bank erosion

As a result of the model experiment, when bank erosion from the abutment upstream proceeded near the abutment, back fills of the abutment were lost and the abutment sank eventually (Fig. 2). It was confirmed that the bed height near the abutment changed in the following three conditions according to the elapse of time due to erosion / scour leading to abutment displacement and that the height decreased in each state (Fig. 3).

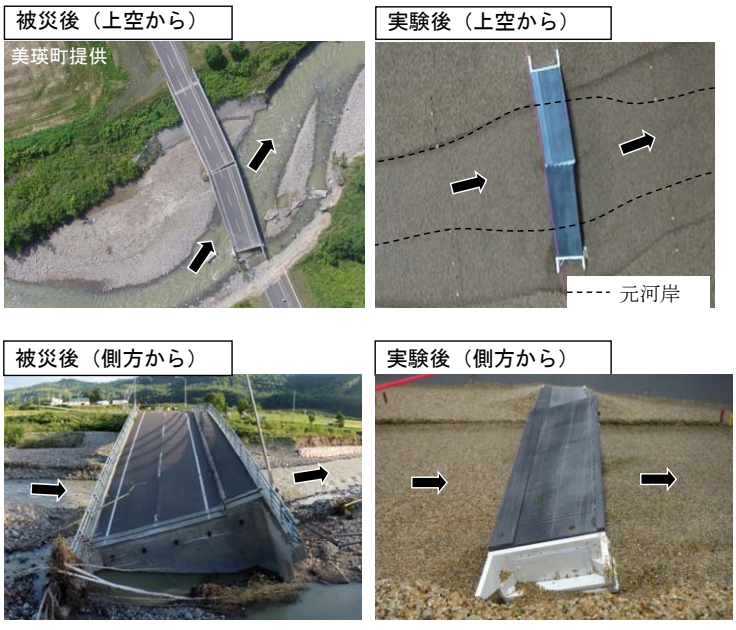

Fig. 2 Comparison of model experiment and site damage

Condition 1: When bank erosion reached near the abutment, the height fell to the low water channel bed height.
Condition 2: Part and front face of the abutment were exposed by erosion, and local scour proceeded.
Condition 3: Bed height was lower than the height of abutment foundation and the abutment sank and inclined.

In addition, it was confirmed in the eroding process that when the bed height near the abutment is lower than the height of abutment foundation, back fills of the abutment are sucked out of the lower part of the abutment foundation in the channel direction and cavity is formed in the back fills (Fig. 3). This suggests necessity to stop traffic on the bridge quickly since damage may be proceeding in the channel even if the abutment seems sound in case of a flood.

3. Countermeasure based on the findings of the experiment

Based on the results of the model experiment, the following disaster reduction measures are for example mentioned for bridges that may be exposed to a large-scale flood and suffer damage due to progress of bank erosion.

- Develop revetment that prevents progress of bank erosion near the abutment in order to prevent progress to Condition 1,
- If bridge renewal is possible, develop the foot protection works or consider the depth of embedment corresponding to scour when the abutment is partially or its front face is exposed and then develop the abutment in order to prevent progress to Condition 2,
- If renewal of the existing bridge is difficult and there is a concern about progress to Condition 2 or further, install sensors for detecting the fall of bed height around the abutment and inclination of the abutment and stop traffic on the bridge with an automatic crossing gate when abnormality is detected, (Response to Condition 3)

4. Future activities

In cooperation with Road Structures Department, we are going to accumulate findings of the experiment and organize systematically disaster reduction measures for the bridge body in addition to abutment by analyzing bridge disaster cases confirmed in the past.

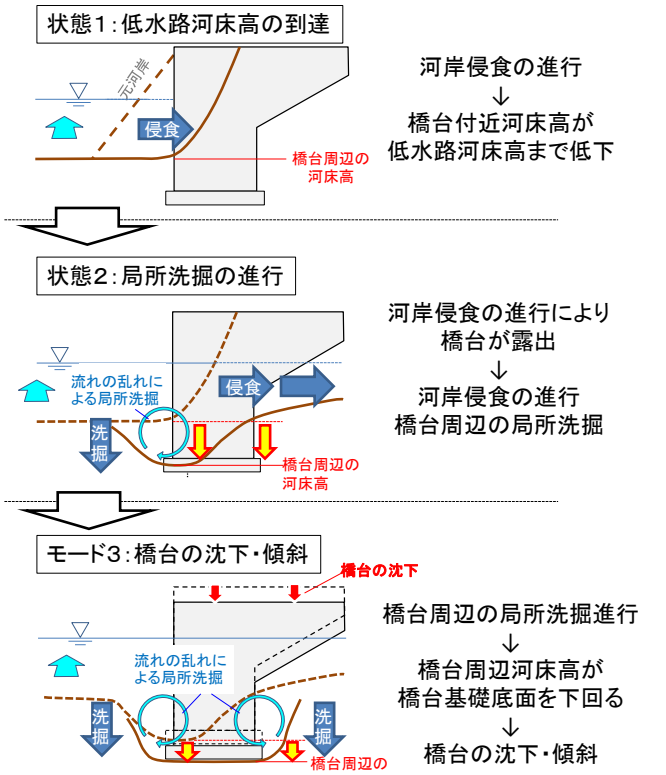

Fig. 3 Changes in bed height around the abutment due to progress of bank erosion

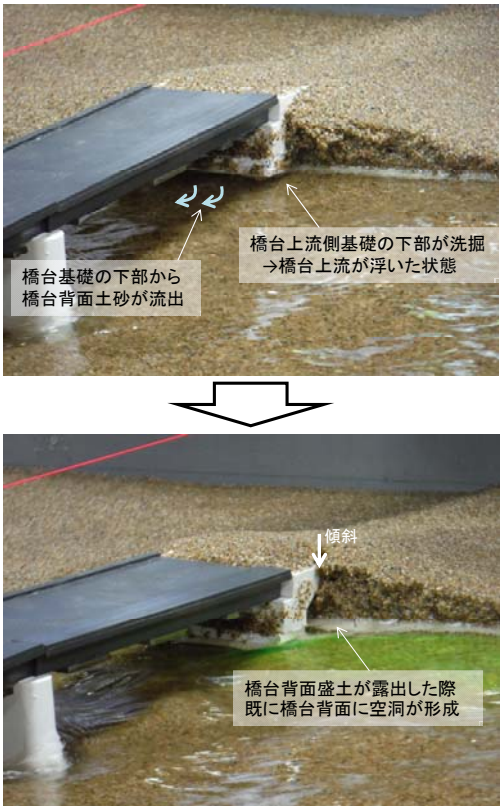

Fig. 4 Cavitation of the abutment back by sucking from under the abutment

Aiming for coastal dikes that are not collapsed by earthquake before arrival of tsunami (Study period: Fiscal 2015 and 2016)

- Creation of technical note on seismic performance evaluation of coastal dikes mainly made of soils -

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River Department, Coast Division

Keywords: seismic performance evaluation, earthquake motion, coastal dike

1. Introduction

When "Technical standards for coastal protection facilities" was revised in 2015, evaluation of the seismic performance of coastal facilities against "earthquake motion that causes design tsunami" was newly introduced. In addition, an administrative notification of coastal authorities in 2015, titled "Basic concept of engineering documents to be followed in design of coastal dikes," provides as follows.

[Structure mainly made of concrete]
→ Technical documents for fishing port facilities and harbor facilities shall be basically followed.
[Structure mainly made of soils]
(Except for the structure mainly made of concrete above)
→ Technical documents for designing river levees shall be basically followed.

Further, it is required to explain the concept of the Technical standards above, common methods, etc. for coast administrators to evaluate seismic performance properly. Because ground conditions and required performance differ between coastal dikes and river levees and no detailed description about "earthquake motion that causes design tsunami" is found in the seismic performance evaluation guidelines, etc. for river structures.
For this reason, Coast Division of NILIM collected case data on earthquake disasters involving coastal dikes etc. and established a workshop of academic experts (see **Table 1**) to organize the concepts of seismic performance evaluation, etc. for coastal dikes mainly made of soils, and completed "Technical note on seismic performance evaluation of coastal dikes mainly made of soils" in July 2017.

2. Outline of technical note on seismic performance evaluation of coastal dikes mainly made of soils

(1) Organization of critical conditions against earthquake action

We organized critical conditions against earthquake motion in coastal dikes in reference to the content of seismic performance in **Table 2**, "Basics of design for civil engineering and building" (2002, MLIT), and existing papers on seismic performance and critical conditions of banking structures (see **Figure 1**).

Table 1 Members of the workshop on seismic performance evaluation for coastal dikes mainly made of soils

IAI Susumu	Professor, Disaster Prevention Research Institute, Kyoto University
ICHII Koji	Associate Professor, Division of Social Environment and Space, Graduate School of Engineering, Hiroshima University
YASUDA Susumu	Vice president and professor of the Department of Science and Engineering, Tokyo Denki University
KATAOKA Shojiro	Head, Earthquake Disaster Management Division, Road Structures Department, NILIM
SASAKI Tetsuya	Team Leader, Soil Mechanics and Dynamics Research Team, Geology and Geotechnical Engineering Research Group, Public Works Research Institute

* In random order (honorifics omitted, as of March 2017), Coast Division excluded

Table 2 Seismic performance which should be filled for each earthquake motion

Earthquake motion	Seismic performance
Level 1 earthquake motion (Earthquake motion with a probability of occurrence once or twice during the service period of the dike)	The required structural safety is secured and the function of coastal facilities is not impaired.
Earthquake motion that causes design tsunami (Design tsunami: Tsunami that occurs with a relatively high frequency --- about once during several tens of years to a hundred and several tens of years.) <Added when the standards were revised>	Even when an earthquake causing design tsunami has an intensity exceeding level 1 earthquake ground motion, disaster caused by the earthquake is minor and the required structural safety is secured against tsunami coming after the earthquake and the function of coastal facilities is not impaired.
Level 2 earthquake motion (Earthquake motion with the greatest strength considered for the site at present and in future)	Disaster caused by the earthquake is minor and prompt recovery of functions after the earthquake is possible. (only those determined to require higher seismic performance)

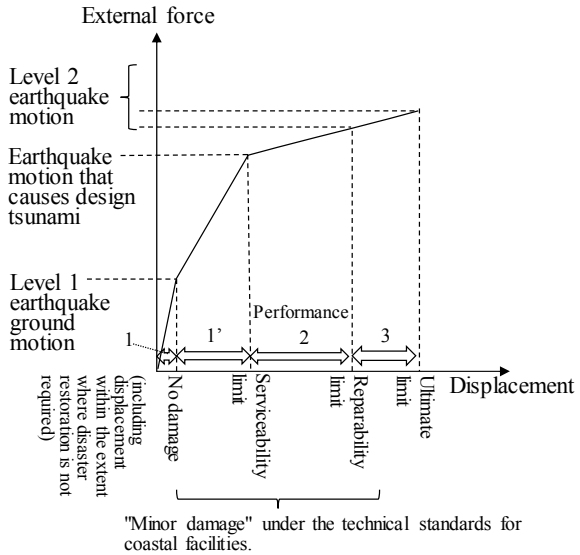

Figure 1 Image of critical conditions in coastal dikes mainly made of soils

We also classified the seismic performance of each earthquake motion into "safety performance" and "performance to achieve objectives" and organized data for each of them together with evaluation standards (see **Table 3**).

(2) Organization of conditions for applying various evaluation methods

We also organized conditions of application, etc. for the static analysis method and the dynamic analysis method, which enable calculation of settlement, as methods used for seismic performance evaluation of coastal dikes in addition to the seismic coefficient method (method of evaluation with safety factor assuming circular slip) (see **Table 4**). We also described the use of the simple analysis method, with which settlement can be calculated simply, in order to reduce the burden of coast administrators since both the static and dynamic analysis methods require much effort to calculate settlement. Note that the basic concept for setting evaluation standards and external forces for seismic performance evaluation is consistent with that of methods applied to river levees (see **Figure 2**).

(3) Information useful for seismic performance evaluation

In addition to the above, we organized the following in the part of Reference Material as information useful for seismic performance evaluation.

- Microtopography that should be considered in seismic performance of coastal dikes
- Important points in conducting a ground investigation
- Examples for earthquake disasters and seismic performance evaluation, etc.

3. Future schedule

For coast administrators, we distributed this technical note in 2017 and explained in the meeting of personnel in charge in each regional block. In the future, we continue to support the efforts of coast administrators to conduct seismic performance evaluation of coastal dikes using this technical note. Additionally, in future revision of "Technical standards and commentaries for coastal facilities and commentary (2004)," which is a commentary of "Technical Standards for Coastal Facilities," this technical note will be used as one of reference materials together with other findings concerning coastal facilities.

☞See the following for details.

1) Technical Note of NILIM, No. 977

Table 3 Organization of seismic performance

Earthquake motion	Safety performance	Performance to achieve objectives
Level 1 earthquake motion (Performance 1)	Secure the required structural safety. → No damage from the effect of seismic force. [Evaluation standard] Safety factor concerning the seismic coefficient method	The function of coastal dike is not impaired. - Function to prevent sea water invasion (storm surge / tsunami) - Function to prevent wave overtopping (waves) - Erosion control function [Evaluation standard] Safety factor concerning the seismic coefficient method
Earthquake motion that causes design tsunami (Performance 1')	Secure the required structural safety against tsunami (design tsunami) coming after the earthquake → Minor damage (Displacement within the extent where stability of the coastal dike and the functions on the right are not impaired by the action of tsunami.) [Evaluation standard] The crown height is beyond the water level of design tsunami. Structure where parapet work (and continuous armor, etc.) can withstand the action of tsunami	The function of coastal dike is not impaired by the tsunami (design tsunami) coming after the earthquake. → Function to prevent sea water invasion (limited to tsunami) [Evaluation standard] The crown height is beyond the water level of design tsunami. Displacement of the parapet work after the earthquake is under the tolerance determined from the thickness of parapet work, etc.
Level 2 earthquake motion (Performance 2)	(only those determined to require higher seismic performance) → Minor damage (Displacement within the extent where prompt recovery on the right is possible) [Evaluation standard] Same as on the right	(only those determined to require higher seismic performance) Prompt recovery of functions after the earthquake is possible. [Evaluation standards] To be set individually, such as "HWL + 1/10 stochastic wave."

Table 4 Evaluation methods and conditions of application

Earthquake motion	Evaluation method	Outlines (conditions of application, etc.)
Level 1 earthquake motion	Seismic coefficient method	Deemed to be no damage when safety factors (inertia force, liquefaction) are met (same as before).
Earthquake motion that causes design tsunami	Simple analysis method	Method of easily calculating settlement, which is used for screening of coastal dikes for static / dynamic analysis method should be conducted preferentially.
	Static analysis method	Method of analyzing the impact of earthquake statically, not considering destruction by inertia force.
Level 2 earthquake motion	Dynamic analysis method	Method of analyzing seismic behavior dynamically, enabling the analysis of inertia force and liquefaction.

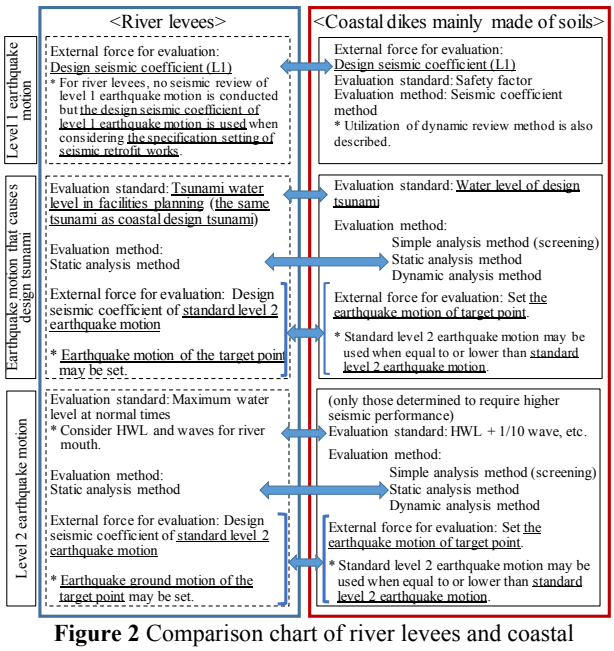

Figure 2 Comparison chart of river levees and coastal concerning seismic performance evaluation

A Study on the Method for Raising the Yield of Beach Nourishment in Beach Erosion Control Measures

(Study period: FY2016 to FY2018)

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Coast Division, River Department

Keywords: beach nourishment, yield, beach nourishment material, structure of beach nourishment fills, hydraulic model experiment

1. Introduction

In recent years, beach erosion has been becoming serious across the country. For the seashores where erosion is proceeding seriously, effect of erosion control measures only by structures is limited and beach nourishment is also required. In beach nourishment, sand and gravels, which constitute beaches, are laid onto the eroded seashore as shown in the **photo**. The total area of beach nourishment conducted in the country was 2.37 mil. m^3 in 1996 and increased to 23.51 mil. m^3 in 2016.

2. Experiment of yield improvement by changing material and structure of fills

Beach nourishment fills are collapsed by high waves to the offshore side, and some of the materials are stocked under the sea and returned by surging waves to the beach. In this study, decrease in the cross-sectional area of beach from the shore line is considered as "yield" in the process of changes in fills, and a method of optimizing yield changes was examined. "Yield" affects the width of recovery of wave run-up area and sand beach and the total cost of countermeasures. This study hence evaluated improvement in the yield by devising the selection of material for beach nourishment and structure of fills by conducting a hydraulic model experiment.

In this experiment, three types of materials, i.e. sand, fine gravels, and medium gravels, were used to create fills consisting of single-type material, fills mixed with multiple materials, and fills consisting of alternate layers of sand and gravels, and erosive waves with short length and depositing waves with long length were applied. **Figure** shows representative results of the experiment. In the case of only gravels as shown in the upper row of **Figure**, the fills were only eroded, while in the case of mixture of three types of materials in the lower row, the position of shore line shifted forward.

3. Conclusion

Table shows the results of organizing the factors improving yield by devising material selection for beach nourishment and structure of fills as slow decrease in cross-sectional area of beach nourishment fills, progress of the shore line by collapse of fills, and recovery of deposit in wave run-up area. With these results, efficient beach nourishment can be realized by selecting materials according to purposes, such as only gravels for urgent prevention of shore line retreat or mixture of sand, fine gravels, and medium gravels for recovery of beach. We aim to enhance the initiative to implement beach nourishment and recover sand beach by showing efficient beach nourishment methods based on reasonable support.

Photo: Gravel nourishment in Fuji Coast, Shizuoka

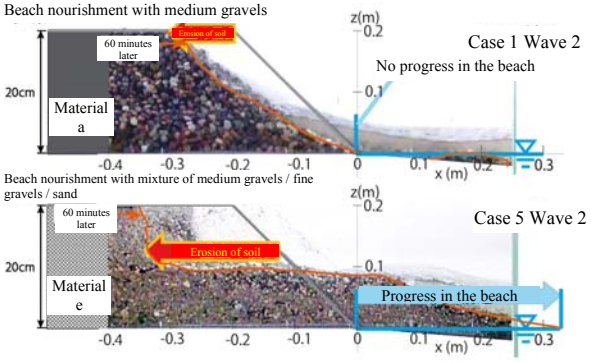

Figure: Profile changes according to difference in material and structure of beach nourishment fills

Table: Evaluation of yield improvement concerning the material and structure of nourishment fills

Material and structure	Erosion of fills	Shore line progress	Recoverability	Overall judgment	Reasons
Only sand	△	◎	○	○	Not resistant against high waves.
Only gravels	◎	X	△	△	Fills are hard to erode but beach cannot be recovered.
Alternate layers of sand and gravels	X	○	△	X	Collapse easily
Mixture of sand and gravels	△	◎	○	◎	Form a berm on the off-shore side to strengthen resistance to waves.

☞See the following for details.

1) NOGUCHI Kenji, KATO Fuminori, SATO Shinji, 2017, "Sand-gravel Mixed Foreshore Nourishment to Improve Erosion Resistant Performance," Japan Society of Civil Engineers Collection of Papers B-2 (Coastal engineering), vol. 73, No. 2, pp.I_799-I_804.

Utilization of natural / local infrastructure in development of tsunami disaster prevention communities (Study period: FY2014 to FY2016)

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Keywords: development of tsunami disaster prevention communities, natural / local infrastructure, tsunami inundation simulation

1. Introduction

Dunes or banking structures may prevent or reduce the run-up of tsunami and mitigate damage in land area. They are not the infrastructure facilities aiming at disaster reduction but considering them as such facilities may lead to more certain demonstration of the effect of disaster reduction. This study defined such planimetric features as "natural / local infrastructure" and examined points of attention in using dunes etc. considered to have effect on reducing the force of tsunami for development of tsunami disaster prevention area as well as procedure to consider maintenance / improvement of such infrastructure. [1)]

2. Points of attention in using for development of tsunami disaster prevention area

It should be attended that the effect of natural / local infrastructure on reducing the force of tsunami is limited by some reasons, e.g., dunes may be eroded and lowered by overflow of tsunami, tree stems may be broken, or trees may be uprooted by attack of tsunami. In addition, since maintenance and improvement of natural / local infrastructure require mid- and long-term efforts, it is necessary to examine systems etc. that can be used continuously under related laws and regulations.

3. Procedure to consider maintenance / improvement of natural / local infrastructure

Figure 1 shows the procedure to consider maintenance / improvement of natural / local infrastructure effective to reduce the force of tsunami. First, necessity for using natural / local infrastructure is considered based on the tsunami inundation estimation map prepared through basic survey, and dunes etc. likely to have force reduction effect are identified as candidates for natural / local infrastructure. Next, in order to evaluate the disaster reduction effect of the identified natural / local infrastructure, tsunami inundation is simulated for multiple cases with different conditions including presence of a dune and plantation to compare inundation area, planar distribution of the maximum inundation depth, etc. in each case. In this step, topographic changes by tsunami are taken into consideration. Lastly, specific measures for maintenance and improvement are considered based on the systems available for maintenance, etc.

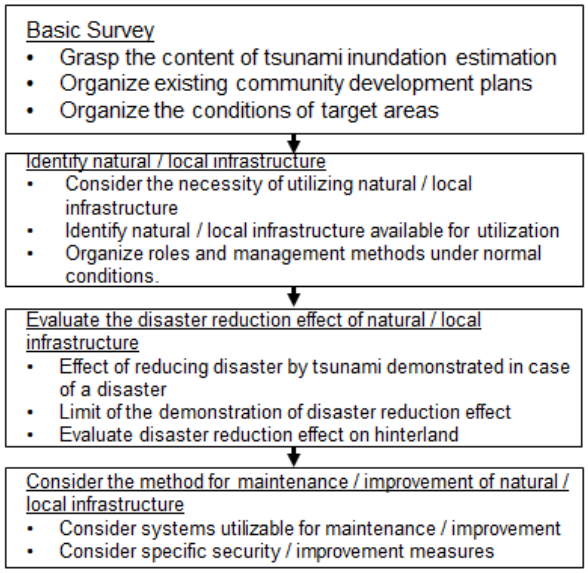

Figure 1: Procedre to consider maintenance / improvement of natural / local infrastructure effective to reduce the force of tsunami

4. Holding of symposium

From a viewpoint of social implementation of natural / local infrastructure, we held an open symposium [2)] for the persons in charge of the development of tsunami disaster prevention communities. The following opinions were developed in the comprehensive discussion including academic experts and persons in charge.

- Since dunes have various ecosystem services and constitute a resilient space, they should be maintained by considering them as a buffer zone.
- Since the disaster reduction effect of dunes can vary with sediment migration phenomena, prediction of sediment migration phenomena with high accuracy and sharing the usability and significance of the disaster reduction effect of dunes by communities will lead to enhancement of regional disaster-prevention capability.
- In using natural / local infrastructure, it is necessary to clearly explain local people so that they understand, including uncertainty of effect, and to improve environment and disaster prevention education so that local people can make a choice and consensus.

4. Conclusion

We intend to work for dissemination and technical support so that results of this study are utilized in development of tsunami disaster prevention communities.

☞See the following for details.
1) Technical Note of NILIM, No. 986
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0986.htm
2) Outline of Symposium (NILIM HP)
http:/www.nilim.go.jp/lab/fcg/labo/abstract_20170907symposium.pdf

Forecast and Visualization of Floods with River Level Forecast Basic System (Study period: FY2015 to FY2018)

- Installation of the river level forecast technology and visualization method -

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Water Cycle Division, River Department

Keywords: flood risk visualization, river profile water level, river level forecast basic system

1. Introduction

In light of the incident of delay etc. in escape from the flood of the Kinu River caused by the 2015 Kanto-Tohoku Heavy Rain, NILIM launched "Flood Risk Visualization Project." In this Project, NILIM is also developing a method of visualizing flood risk for transmitting the risk and urgency of flood at a nearby site in real time and, as a core technology for realizing such a method, a technology for grasping / forecasting the profile water level. [1)]

It has recently been decided to build a river level forecast basic system provided with the method of flood risk visualization and the technology to grasp / forecast river profile water level, which NILIM has been studying.

The river level forecast basic system consists of indication system and forecasting system. This paper outlines the visualization method and the technology to grasp / forecast river profile water level, both of which are to be installed in the indication and forecast systems, and describes the background for construction of the river level forecast basic system.

2. Development of water level information from dots to lines and indication of flood risk

Water level information on rivers is important as one of the information for grasping the river condition in case of a flood. The present system in operation indicates forecast water levels as dots based on observation data from each gauging station. The river level forecast basic system indicates (visualizes) when, where and to what extent a flood could occur consecutively in the upstream / downstream (flood rsik) by analyzing the relationships between river profile water level, levee height, and flood danger water level, etc. Accordingly, more effective evacuation behavior abd crisis management are expected from grasping the urgency of flood, extent of damage in case of flood, etc. under this system.

3. Grasp / forecast technology of river profile water level and accuracy enhancement

The present flood forecasting system in operation forecasts river levels in the reference gauging station with the flood forecasting model mainly consisting of runoff models. The river level forecast basic system is provided with the flood forecasting model consisting of runoff, river channel model, and multipoint water level data assimilation technology. Introduction of the river channel model enables the grasp and forecast of river profile water level. In addition, grasp and forecast of river profile water level with higher accuracy are expected from the incorporation of observed water level data and successive model optimization with the multipoint water level data assimilation technology.

4. Acceleration of actions to upgrade river level forecast

Since no standard method is established for flood forecasting method, different models are used according to each river. It is therefore difficult to share the findings etc. from the flood forecasting methods used for other rivers, and improvement has been conducted independently in each river. Hence, introduction of the river level forecast basic system also aims to raise the levels of forecast technology and accuracy and to improve the efficiency of accuracy management, model improvement, and new technology introduction, etc. by forecasting river floods in the country with the same flood forecasting method and accumulating / sharing findings collected across the country.

The flood forecasting system has been established and operated by each river office, while the river level forecast basic system will be established in each Regional Development Bureau and flood forecast will be conducted for all the rivers in each region.

5. Future plan

Each Regional Development Bureau is constructing the river level forecast basic system for completion by the end of fiscal 2018. NILIM is going to continue various studies to provide technical support and install the technology for Regional Development Bureaus.

☞See the following for details.

1) 2017 NILIM Report, p.62

Utilization of Ensemble Forecast Precipitation in Special Disaster Prevention Operation in Dams

(Study period: FY2016 to FY2018)

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keywords: special disaster prevention 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. The MLIT has therefore decided to accelerate the development, utilization, etc. of social capital with high stock effect leading to productivity improvement of whole society, and selected "Dam renovation -- Early improvement of water utilization and flood control ability to support local economy" as one of "Productivity Revolution Projects." As one of the measures to achieve this theme, dam operation with utilization of forecast precipitation is mentioned.

Here, since forecast precipitation always accompanies an error, small or large, it is important to consider the width of forecast. As dam operation considering the width of forecast, there has been a method using the recoverable water level table in prior discharge operation. This method adopts a case where the forecast precipitation was the most different from actual precipitation in the dam basin and determines the reserve volume of the dam at that time as prior discharge volume considering for secure recovery of water use capacity after flood.

Meanwhile, as means to express the width of forecast, attraction has been paid in recent years to "ensemble forecast precipitation" (multiple forecast precipitations outputted from forecast calculation under multiple initial / boundary conditions) and NILIM has also been considering utilization of ensemble forecast precipitation for prior discharge operation. [1] This paper introduces a new approach to using ensemble forecast precipitation with focus on special operation for disaster prevention.

2. Decision making method for special disaster prevention operation using ensemble forecast precipitation

Special disaster prevention operation means to further increase reserve volume and utilize reservoir capacity more effectively in order to reduce damage in the downstream of the dam. In decision making for special disaster prevention operation, it is necessary to determine the extent of reducing discharge volume, and as decision elements, we devised two indicators --- "Whether dam reservoir level exceeds the water level to start disaster prevention operation in case of an extraordinary flood" and "Whether the level exceeds the normal water level in the downstream river". Using ensemble forecast precipitation, relationship between discharge volume of the dam and the above-mentioned indicators and data can be organized as shown Figure 1.

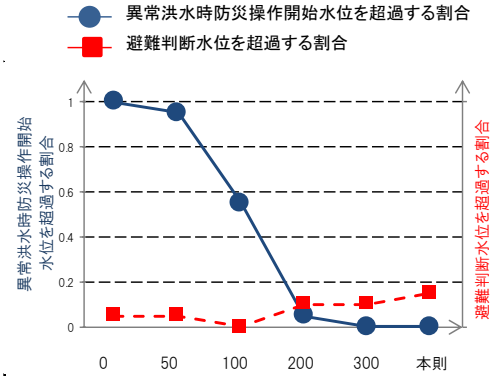

Fig. 1 Relationship between discharge volume and each indicator

As an example for use of the Figure, when considering decrease of the downstream water level to the extent possible without implementing disaster prevention operation in case of an extraordinary flood, discharge volume of 300m^3/s, at which the "ratio of exceeding the evacuation decision level" is the smallest when the "ratio of exceeding the level to start disaster prevention operation in case of an extraordinary flood" is zero.

Thus, expression of the indicators as decision standard for special disaster prevention operation as a ratio converted from ensemble forecast precipitation is expected to reduce the burden of dam administrators in decision making and contribute to effective / efficient operation.

Based on the study ever made on prior discharge operation and special disaster prevention operation, we are going to verify applicability as a decision-making support system for a series of dam operations from before to after flood.

References

1) KUDO Shun, KAWASAKI Masaki, "Possibility of Application of Ensemble Rainfall Forecast to Preliminary Dam Release", Civil Engineering Journal, Vol. 59, No.12, pp. 38-41, 2017.

Further Utilization and Introduction of AI (Artificial Intelligence) in River Management Practice.

(Study period: FY2017 to FY2018)

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KAWASAKI Masaki , Head
Water Cycle Division, River Department

Keywords: runoff analysis, river level forecast, CNN, LSTM, Autoencoder. GAN

1. Introduction

The scope of application of Artificial Intelligence (AI) has been expanding. It is used in various fields including medical care, automatic driving, and agriculture, as well as in the fields of image recognition, speech recognition, etc., which have conventionally been developed in machine learning. In the field of river management, further utilization of AI is also expected since observation and measurement data that contribute to river management are being accumulated enormously, including the data of radar rain gauges, crisis management type water gauges, aerial laser, and MMS (Mobile Mapping System). Accordingly, we have been reviewing the trend of studies on AI, which has been rapidly expanding in recent years, and conducting a research for further utilization of AI, targeting the field of hydrology, where AI utilization has been more often discussed in the practice of river management.

2. Progress of AI technology

Since the study by G. Hinton, 2006, AI, particularly neural network technology, has rapidly developed. [1)-3)] **Figure 1** provides the number of papers contributed according to the main models of AI.[4)] **The Figure** shows that the trend of increase in the number of papers contributed is particularly recognized in the models of Convolution Neural Network (CNN)[5)], which is mainly used in the field of image recognition, Long / Short Term Memory (LSTM)[6)], suitable for handling time series data, AutoEncoder [5)], one of the prior learning approaches for multilayer network, and Generative Adversarial Network (GAN)[7)], which enables formation of high-definition images.

3. AI utilization in the field of hydrology

In the field of hydrology in Japan, shallow Artificial Neural Network (ANN) has mainly been studied. [8)] As issues that arise in application of shallow ANN, no assurance of accuracy of calculation for unprecedented rainfall, increase in calculation error according to increase in the number of input data, etc. have been known, while efforts have been made to improve the accuracy of calculation by building multi-layer ANN.[9)]

4. Conclusion

In the future, it is necessary to evaluate applicability in the field of hydrology for the aforementioned CNN, LSTM, AutoEncoder, and GAN.

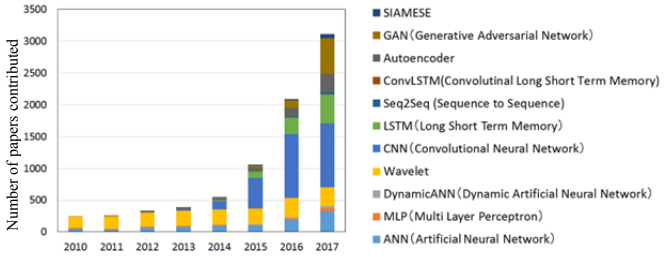

Fig. 1: Number of papers contributed according to each model

☞See the following for details.

1) G. E. Hinton, S. Osindero, Y. Teh: A Fast Learning Algorithm for Deep Belief Nets, Neural Computation, Vol.18, pp.1527-1554, 2006.
2) Takayuki Okaya: "Deep Learning," Kodansha Scientific, 2015.
3) Osamu Okada, Kazuhiro Kakizawa, Masaaki Nakayasu, Tadashi Tadokoro: "Flood Forecast and Detection of Abnormal Water Level Data using AI," Collection of Presentations in the River Information Symposium, pp. 5-1-5-16, 2017
4) Cornell University Library: arXiv.org https://arxiv.org/
5) G. E. Hinton, R. R. Salakhutdinov: Reducing the dimentionality of data with neural networks, Science, Vol.313, No.57866, pp.504-507, 2006.
6) S. Hochreiter, J. Schmidhuber: Long Short-Term Memory, Neural Computation, 9(8), pp.1735-1780, 1997.
7) I. J. Goodfellow, Y. Bengio, A. Courville, Deep Learning, MIP Press, 2016.
8) e.g., Isamu Isobe, Teruo Ohkohdo, Hidehiko Hanyuda, Seiichi Oda, Yusuke Gotoh: "The Development of a Forecasting System of the Water Levels of Rivers by Neural Networks," Journal of the Japan Society of Hydrology and Water Resources, Vol.7, No.2, pp. 90-97, 1994.
9) Masayuki Hitokoto: "Flood Forecast using AI --- Accuracy improvement by application of deep learning," Journal of the Japan Society of Civil Engineers, Vol.103, No.2, pp. 30-31, 2018

Promotion of disaster reduction measures by sharing the flood-prone area map for small and medium-sized rivers in hilly and mountainous areas (Study period: FY2017)

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MIYOSHI Tomohiro, Researcher　NISHI Hiroki, Researcher
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Keywords: small and medium-sized rivers in hilly and mountainous areas, flood risk map, disaster reduction measures

1. Issues on flood risk information of small and medium-sized rivers in hilly and mountainous areas

The July 2017 Northern Kyushu Heavy Rain caused serious sediment and flood disasters in the Akatani River in the Chikugo River system and other rivers flowing through hilly and mountainous areas. Such river (and sediment) overflow in small and medium-sized rivers of hilly and mountainous areas often occurred in other areas, including the 2016 flood in the Omoto River of Omoto River system in Iwate Prefecture, and could occur at any time and place in light of the present level of development in small and medium-sized rivers in the country.

However, it is difficult to say that flood risk information has been shared in society; e.g., flood-prone areas are not specified in most of the small and medium-sized rivers in the country.

Therefore, Flood Disaster Prevention Division has been studying methods for social sharing of flood risk information on small and medium-sized rivers in hilly and mountainous areas.

2. Development of flood-prone area map (tentative name)

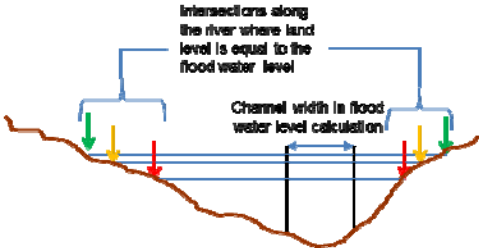
Heavy rain in a scale exceeding the river flow capacity will increase the possibility of flood, inundation, scouring/erosion, sediment deposition, etc. Since heavy rain in such a scale could occur at any time, it is considered significant for reduction of flood damage to share in society flood risk information in advance for each site near rivers and to use land based on the risk.

However, since total length of small and medium-sized rivers of hilly and mountainous areas is enormous, data required for risk analysis, such as channel shapes, is often insufficient and it is considered unreasonable in terms of cost, etc. to conduct risk analysis on such enormous length using flood simulation etc.

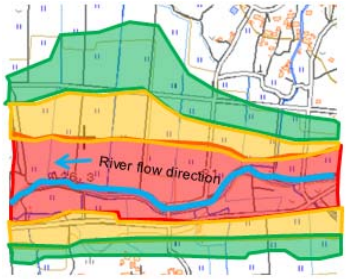
For this reason, we developed a flood-prone area map (tentative name) as a method for simply sharing the minimum flood risk information for small and medium-sized rivers in hilly and mountainous areas.

In developing the map, we used the evaluation system for the safety level of flood control in small and medium-sized rivers [1)] for labor saving, which was developed in fiscal 2005, and adopted a method simpler than the simple method provided in the "Guide to preparation of flood-prone area map for small and medium-sized rivers" (Mar. 2016, by Flood Risk Reduction Policy Planning Office, Water and Disaster Management Bureau, MLIT).

Figure shows the concept of flood-prone area map (tentative name). This map represents the points (lines) of intersection between the ground surface and the river water levels that were obtained by rough calculation（assuming a vertical wall on each river bank） for each excess flood flow in multiple cases (3 cases in the map) and extended over the land along the river, and this was applied to some model rivers on a trial basis.



(a) Cross section



(b) Plan view (background map from the Geospatial Information Authority of Japan)

Figure: Concept of flood-prone area map (tentative name)

3. Future schedule

Based on the results of trial application, we are going to study the method of using the map in considering city planning, etc.

☞See the following for details.

1) Outline of the evaluation system for the safety level of flood control in small and medium-sized rivers

http://www.nilim.go.jp/lab/rcg/newhp/seika.files/lp/index.html

"River Development for Easy Escape from Flood " in Valley Bottom Plain of Hilly and Mountainous Area

(Study period: FY2017)

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FUKUSHIMA Masaki, Senior Researcher (Dr. Eng.)　SUWA Yoshio, Head, River Division
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Keywords: hilly and mountainous area, valley bottom plain, secure a time for evacuation, disaster reduction system

1. Reluctance to escape in actual evacuation behavior and flood characteristic that water level rises very quickly

It is reported as an actual evacuation behavior in case of a flood that many residents begin evacuation when they confirm change of status, such as inundation, with their eyes. Such evacuation behavior is psychologically interpreted as attributable to normality bias or cognitive dissonance, and may put local residents into a situation where they cannot begin "evacuation in a situation where enough time for safety is secured," which starts with evacuation recommendation etc. On the other hand, rivers flowing through hilly and mountainous area have a characteristic that concentration time is shorter and the speed of water level rising is faster than downstream alluvial river. Accordingly, inundation occurs "in an instant" and evacuation in enough time may be first of all difficult.

2. Viewpoint for preventing human damage by failure to escape

Considering such actual evacuation behavior and characteristic of flood flow as stated above, what measures should be taken in order to prevent human damage by failure to escape in hilly and mountainous areas?　We consider the following to be important --- (i) Easy recognition of a critical situation that comes into view, (ii) Secure some lead time necessary for evacuation even after recognizing a critical situation, and (iii) realization of these measures with facilities as a structural measure.

3. Attempt to create an "environment preventing failure to escape"

We attempted to create an environment for preventing failure to escape with numerical calculation assuming a large valley bottom plain where an open levee exists in a hilly and mountainous area over the years (discontinuous levee often installed in a rapid river). Specifically, we examined with numerical calculation whether the above-mentioned lead time would be secured for a long time by constructing a secondary levee behind the open levee. As shown in **Figure**, we focused on the time (two types of lead time) until inundation reaches the community after the start of inundation from the opening in the open levee or the start of flooding from the embanked reach of the open levee in the upstream. Even at the time when inundation would have reached the community in the case of no secondary levee (Left **Figure**), inundation does not reach the community when a secondly levee is constructed. Thus, increase in the two types of lead time is recognized (Right **Figure**).

4. Points of river development for easy escape

The following are the points in facility design to secure some time during which escape is possible even after recognizing a critical situation, such as nearby inundation.　(i) Extend lead time by limiting the inundation area for certain time even after flooding; (ii) Consider design suitable for the conditions of the target area, such as local scale; (iii) Demonstrate the effect in a wide range of excess external force; (iv) Secure an evacuation route effective even in case of a large-scale flood; (v) Combine non-structural measures for reporting the occurrence of critical situation more certainly; and (vi) Consider for the impact on daily life.

☞See the following for details.

1) Takeuchi et al.: Proposal of a Structural Design to Ensure Evacuation Time during Floods in Valley Plains, Civil Engineering Journal, Dec. 2017, etc.

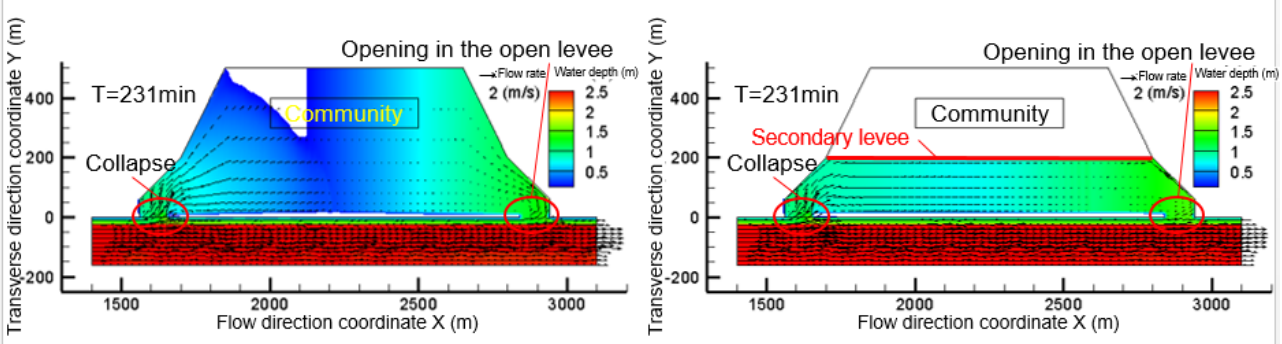

Figure: Changes in the inundation depth distribution by construction of secondary levee (increase in lead time)

Inundation Forecast for Reducing Urban Flood Damage

(Study period: FY2014 to FY2018)

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ITAGAKI Osamu, Head
Flood Disaster Prevention Division, River Department

Keywords: torrential rain, inundation forecast, real time information system, social experiment

1. Introduction

In recent years, sudden torrential rains etc. have frequently caused a large amount of rainfall that exceeds the rainwater drainage capacity of cities and resulting flood disasters.

The purpose of this study is to establish an inundation forecast system covering the basins of Kanda River and Shakujii River, which can process inland and river floods data integrally and distribute the results of inundation forecast calculation with real time data for one hour ahead to the website or system users by alert mail when inundation depth exceeds a pre-set depth determined freely by users, within 10 minutes after receiving data, and to support flood damage prevention/ reduction activity, evacuation guidance, etc. by using the system, and thereby strengthen flood risk reduction measures.　Figure 1 shows the image of an alert mail and the system screen accessible from the mail.

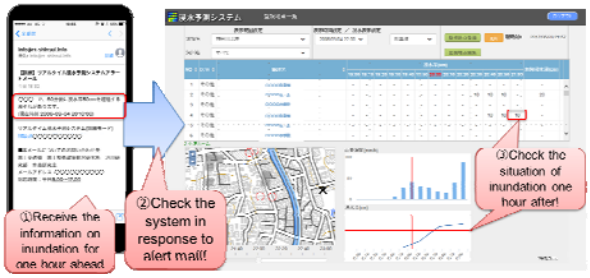

Figure 1: Alert mail and system screen image

2. Social experiment in the Kanda River basin

We surveyed availability of the system, matters to improve, etc. by investigating about 50 persons who were introduced from the local governments in the basin of the Kanda River (about 20 local residents, about 15 facility administrators, about 15 employees of local governments).　It was learnt from the survey that the content, volume, and accuracy of inundation forecast information required differ according to the positions of users and that few people used the system to check information after receiving an alert mail, while not a few people confirmed relevant information after receiving an alert mail.

3. Example of inundation forecast

On August 19, 2017, an area of social experiment was inundated by rainfall.　Figure 2 shows the rainfall (observed) and inundation depth (one-hour forecast value in every 10 minutes by numerical simulation based on forecast rainfall) in the area.　According to the information from residents and local government employees, the inundation time was around 17:00 and inundation depth was about 70-80 cm. On the other hand, the numerical simulation of inundation depth based on observed rainfall showed that the peak inundation depth in the area was 126 cm around 17:30. The alert mail was distributed at 16:02 to system users who had registered the area of inundation as a target area of the alert mail.　However, inundation depth forecast values based on rainfall forecast values tend to be larger than the numerical simulation values based on observed rainfall, which suggests that there is a problem with rainfall forecast accuracy.

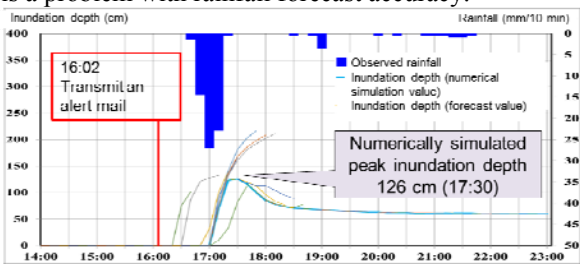

Figure 2: Example of inundation forecast

4. Future perspective

We intend to improve the accuracy of inundation depth forecast through data assimilation with the observation results of water level inside the sewage pipe, utilization of forecast rainfall data with a new type weather radar, etc. and continue to develop information distribution methods, system management methods, etc. for social implementation.

☞See the following for details.

1) Civil Engineering Journal Vol. 59, No.12, 2017, pp.18-21

Research on Supporting Technology to Make Flood Damage Reduction Activities More Effective (Study period: FY2017 to FY2019)

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Flood Disaster Prevention Division, River Department

Keywords: flood damage reduction activities, flood-fighting team, flood risk reduction

1. Flood damage reduction activities play a very important role in realizing local disaster prevention / mitigation

In recent years, floods exceeding the capacity of levees and disaster prevention facilities (excessive flood) frequently occurred due to intensified rainfall. In light of the forecasted increase in the frequency of flood due to future climate changes, it is important to root an effective and sustainable system of flood damage reduction in society to prepare against excessive flood, as well as to promote steady development of disaster prevention facilities.

Accordingly, with focus on "structured flood damage reduction activities for self-defense," which has been considered important since the old times in Japan, NILIM has been researching to clarify what technological support river administrators should provide in order to further improve the disaster reduction effect by flood damage reduction activities.

2. Severe circumstances of flood-fighting teams and flood disaster risk

For flood-fighting teams as a self-defense organization, the trend of difficulty in transfer of flood damage reduction techniques, etc. is recognized across the country due mainly to decrease in team members, difficulty in gathering resulting from increase in office employee members, and decrease in new members. It is further concerned about a gap between the total amount of necessary flood damage reduction activities (left axis in the Figure) and the practicable amount of flood damage reduction activities (right axis in the Figure) due to the diversified roles required for flood-fighting teams, such as evacuation guidance and rescue relief, in addition to the patrol of levees and disaster prevention facilities and flood damage reduction works during flood. This can be referred to as "increase in local flood risk due to inability to conduct sufficient flood damage reduction activities."

3. Search for technological support which river administrators should provide in order to ease the bottleneck of flood damage reduction activities

For identifying technological support which river administrators should provide for flood damage reduction activities, we first conducted interviews of flood-fighting teams actually engaged in flood damage reduction activities about details and current condition of the flood damage reduction activities process. Consequently, important issues were identified, including a case where a flood-fighting team had to start flood damage reduction activities without sufficient preparation when informed by residents of occurrence of flood damage in a branch river, etc. prior to the issuance of flood warning in the main river. It is accordingly identified as important contents of support to provide river water level monitoring and forecast information including branch rivers, which is necessary in securing preparation/ activity time. In addition, even for excessive flood, it is also important to execute flood damage reduction activities.

We are therefore researching the methods for providing information on the sections requiring priority flood damage reduction activities through clarifying characteristics, such as flood water level rising rate in the flood plain, with high-resolution flood simulation reflecting detailed levee height and microtopography near the river using LP (laser profiler) data.

We continue to research on technologies for supporting prioritization of areas requiring flood damage reduction activities to reduce flood risk and forecast / monitoring technologies for supporting enhancement of flood damage reduction activities efficiency.

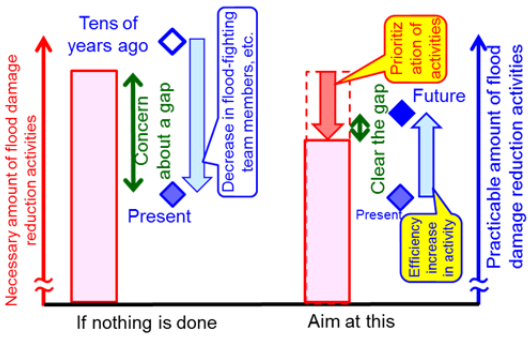

Fig. Image of the future direction of flood damage reduction activities

Evaluation of the Mid- and Long-term Impact of Flood Damage (Study period: FY2017 to FY2019)

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

Keywords: ripple effect, damage evaluation, extreme-scale flood

1. Spread of the impact of flood damage

It is known that the impact of flood damage will not end at the stricken area but spread spatially through breakdown of infrastructures, supply chains, etc. ("ripple effect"). It is also considered that the impacts of flood damage are exerted in a medium-to-long-term on the stricken area ("mid- and long-term impact") by causing physical / social changes to the area. For example, in the Tokachi District, Hokkaido, which suffered enormous damage mainly by Typhoons Nos. 7, 9, 10, 11 in 2016, the soil of farmland was eroded away by flood in a large scale and there is a concern about fall of productivity even after completion of farmland recovery. Thus, the impact of flood damage in some cases does not end immediately after disaster but continues in the community for a medium-to-long-term.

2. Issues in evaluation of mid- and long-term impact

In order to evaluate impact of flood damage and consider disaster prevention / mitigation measures properly, it is necessary to evaluate the ripple effect and mid- and long-term impact of the damage. In such evaluation, however, it is often difficult to eliminate the factors other than the flood damage in the spreading process of impact, and evaluation is therefore difficult since the ambiguity of causal relationship between the consequence and the flood damage and the uncertainty of spreading process are both high. In development of evaluation methods, some progress is seen, e.g. publication of "Guide to Flood Damage Index Analysis (Trial version)" in 2013 (Water and Disaster Management Bureau, MLIT). However, there are not so many findings, particularly about mid- and long-term impact, and it is also necessary to review what kinds of impact should be evaluated based on further research and study.

3. Selection of impacts to be evaluated and estimation of spreading process on a trial basis

NILIM surveyed impacts of damage for extreme-scale flood disasters in the past that are considered to have a mid- and long-term impact on the stricken area, and tried estimation of the spreading process of impact. In the survey, we also considered the presence/absence of counter disaster plans, such as disaster restoration support plans, and of organizations considered to contribute to the resilience of local communities, such as agricultural cooperative association. In the current year's survey, through interviews of local governments, enterprises, financial institutions, etc., specific mid- and long-term impact and spreading process thereof were clarified, including a case where a food production company which temporarily stopped operation due to flood damage is still unable to recover income even after recovery of productivity due mainly to the loss of customers.

4. Impact of flood damage on local decline

Evaluation of the extent of macroscopic decline in the stricken area as a result of the mid- and long-term impact caused by flood damage is also considered an important research issue.

In the areas stricken by flood, declines, such as population outflow, have been observed. However, evaluation of damage impact is difficult since it is unclear to what extent flood damage influenced local declines. NILIM has been developing an analytical method for evaluating the extent of the impact of flood damage on local area by estimating the time variation of indexes, such as population when not suffering flood damage and comparing with actual results, using the multiple correlation analysis that considers as comprehensively as possible the factors considered to have effect on the time variation in population, such as distance from the train station or presence/absence of nearby highways for each grid. In the current fiscal year, we tried probationary application of this method in case study areas (Figure below) and found, as an example, that zonings and Floor Area Ratio should be considered as explanatory variables in order to raise the interpretability of objective function. In next fiscal year, we intend to develop a method for producing more interpretable objective functions, etc. while utilizing the findings described in 3 above.

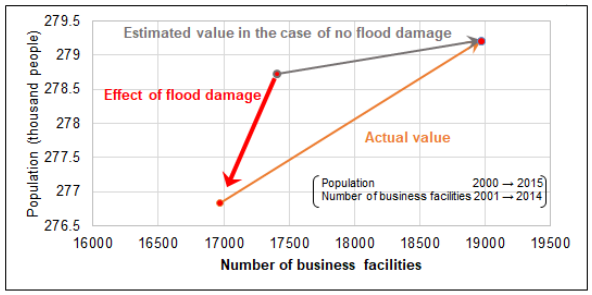

Figure: Image of evaluating the impact of flood damage on local decline

Method of estimating damage caused by large-scale landslides originating in deep-seated landslides

(Research period: FY 2017)

Taro Uchida, Senior Researcher Kiyotaka Suzuki, Guest Research Engineer
Wataru, Sakurai Head Sabo Planning Division, Sabo Department

Keywords: Deep-seated landslide, method of estimating damage

1. Introduction

Deep-seated landslides occur less frequently than regular landslides. Yet, they are extremely large landslides and sometimes cause massive damage, such as the major water hazard that occurred on the Kii Peninsula in 2011. Meanwhile, conventional measures to prevent landslides are probably not sufficient to reduce the damage caused by deep-seated landslides, which means that the appropriateness of mitigation measures needs to be examined.

2. Past measures implemented to control deep-seated landslides

The key to any examination of deep-seated landslide mitigation measures is to expect the phenomena and damage that occur in a deep-seated landslide in areas with a high risk of deep-seated landslides. The Ministry of Land, Infrastructure, and Transport released the Deep-seated Landslide Frequency Estimation Map in 2010 and the Stream (small basin) Level Evaluation concerning the risks of deep-seated landslides in 2012 to identify areas where the risk of deep-seated landslide is considered high.

Meanwhile, the estimation of phenomena and damage that occur in a deep-seated landslide has not been sufficiently done, and its method has not been organized. Thus, the Sabo Department of the National Institute for Land and Infrastructure Management established a method of estimating large-scale landslide damage originating in deep-seated landslides based on the outcomes of recent research and examinations conducted by regional development bureaus.

3. Outline of this method

Based on examinations concerning methods, it is probably often difficult to conclusively set phenomena originating in a deep-seated landslide that will occur in the future with current research and technology levels. Thus, this method estimates deep-seated landslide phenomena with high probabilities based on past records in individual areas with similar conditions for triggering deep-seated landslides as shown in the figure. The expected categories here include the characteristics of the site of onset (terrain, geological structure), scale of landslide, style of flow, and frequency.

On the other hand, recent studies have revealed that numerical simulations were effective in estimating the range of damage caused by deep-seated landslides. Therefore, this method also uses a method based on numerical simulations to estimate the range of damage caused by a highly likely deep-seated landslide. This method also presents a method to narrow down computation cases to implement efficient simulations.

4. Summary

Regional development bureaus are starting examinations using this method. The method is going to be refined by finding problems in the execution.

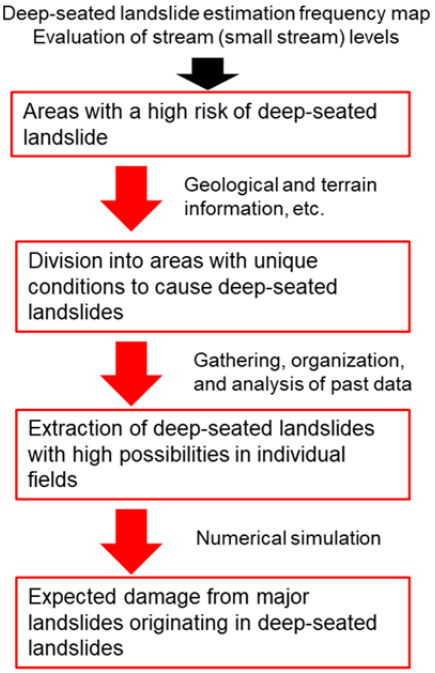

Figure 1. Examination flow for this method

☞For more detail

1) National Institute for Land and Infrastructure Management Reference No. 983
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0983.htm

Conditions of debris flood and damage to houses from heavy rain in northern Kyushu in July 2017

(Research period: FY 2017)

Wataru Sakurai, Head　Taro Uchida, Senior Researcher　Naoki Matsumoto, Senior Researcher

Teruyoshi Takahara, Researcher,　Sabo Planning Division, Sabo Department

Keywords: Debris flood, sediment production, sediment outflow

1. Introduction

The heavy rain in norther Kyushu in July 2017 caused extensive damage to people and houses in many areas along river basins due to landslides, debris flow, and the flooding with a large amount of sediment and driftwood in Asakura City and Toho Village in Fukuoka and Hita City in Oita. Therefore, the Sabo Planning Division identified the conditions of debris flood and damage to houses focusing on areas where intensive debris damage occurred. The Division also organized locations and conditions around houses, such as the gradient of the riverbed near damaged houses and the degree of damage to improve the precision of the method of estimating damage to houses in case of sediment flooding.

2. Gathering of references and on-site investigation

To identify the accumulation of sediment and driftwood in the target areas, the Division gathered references, such as aerial photographs, photographs taken on the ground, images captured with drones, and the interpretation of areas with landslides and flooding. It also conducted on-site investigations to identify the overview of damage to houses. This investigation categorized damage to houses as follows: [1] washed away (a house above the foundation is completely washed away); [2] significant damage (extensive damage to a house due to the collision with and the inflow of debris requiring reconstruction or repairs to continue daily lives); [3] medium to minor damage (limited damage, such as flooding above or below the floor requiring no major repairs to continue living); and [4] no damage.

3. Distribution of damaged buildings

Houses damaged from sediment left after flooding were distributed in large areas, although the degree of damage and the numbers of damaged buildings differ among river basins (figure 1).

Next, the organization of the relationship between the gradient of the riverbed near houses and the degree of damage found that the ratio of houses with extensive damage, such as washed away, among all the houses found in the references (about 9,778 houses) was higher when the riverbed gradient increased. In particular, about one-third of houses in the investigated areas were either washed away or were significantly damaged in areas where the riverbed gradient was two degrees or more, which were the areas with debris flow. Meanwhile, less than 10% of the houses were washed away or significantly damaged in areas where the riverbed gradient was less than two degrees (figure 2). This indicated that in this flooding, the main cause of damage was the direct impact of sediment and debris in debris flows or landslides and that the increased speed of flood flows containing sediment and driftwood in areas with large riverbed gradients was associated with significant damage.

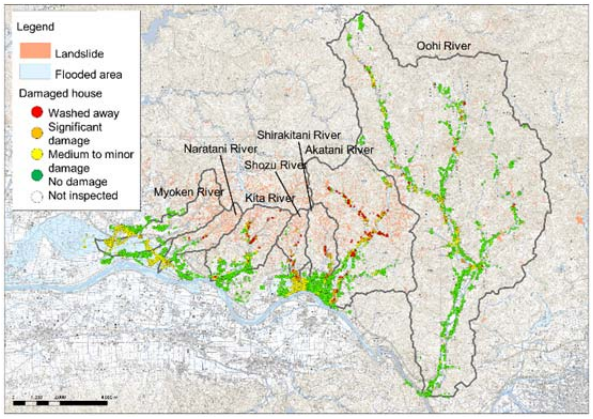

Figure 1. Distribution of damaged buildings

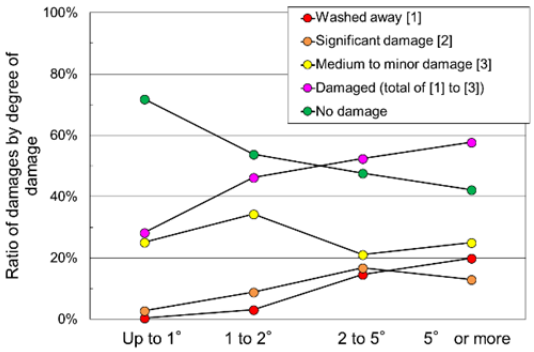

Figure 2. Ratio of damaged buildings by river bed gradient

4. Future perspective

The Sabo Planning Division is identifying conditions of sediment production and sediment outflow while analyzing the mechanism of extensive damage by analyzing the outcomes of aerial laser surveys before and after the disaster and conducting numerical simulations. The Division is going to elaborate on these analyses to make them useful in mitigating the damage caused by sediment outflows in mountainous areas.

Examinations concerning the effects of sediment control dams at land slide flow zones

(Research period: FY 2017)

Naoki Matsumoto, Senior Researcher Taro Uchida, Senior Researcher
Wataru Sakurai, Head Sabo Planning Division, Sabo Department

Keywords: Sediment control dam, effects of facilities

1. Introduction

Many studies have been conducted concerning the sediment capturing functions of sediment control dams using water channel experiments and data analyses. The outcomes of these studies have been reflected in references, such as the Guideline for Establishing Sand Control Basic Plans (for debris flow and driftwood edition). Sediment control projects are being conducted based on these guidelines and references today.

Meanwhile, the challenges found through past research include the fact that although sediment outflows that flow down sediment flow zones (stream gradient: about 2 to 10 degrees) exhibit different sediment movement, such as the lowered sediment concentration unlike debris flows that flow down the origin and the down flow sections of the debris flow (stream gradient: 10 degrees or more), the sediment capturing effect of sediment control dams that would work on sediment outflows that would flow down sediment flow zones has not been sufficiently examined.

Given such circumstances, the objective of this study is set to clarify how sediment outflows that flow down sediment flow zones would affect the effectiveness of facilities such as the sediment capture function of sediment control dams. The study included reproducibility calculations based on water channel experiments and numerical simulations to satisfy the objectives.

2. Outline of this study

The water channel experiment used a square water channel with a length of 10 meters, 30 centimeters, in width and 50 centimeters in height. The gradient is five degrees, and the sand used in the experiment is prepared based on past disasters. Three patterns of hydrograph were set, including a hydrograph with a rapid start and short duration and square-type hydrographs frequently used in past studies (figure 1). The study also used a total of three types of sediment control dams, including an impermeable type that was commonly constructed today and ones with two different widths in the permeable section. The sediment was supplied at a balanced rate based on the set hydrographs.

The experiment found that the process of sediment accumulation and the process of water outflow differed depending on dam types (figure 2). Yet, the experiment found no significant differences in the amount of sediment captured by the dams in all dam types and hydrographs.

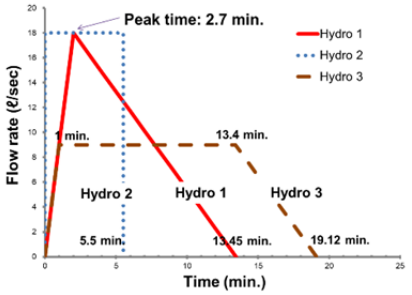

Figure 1: Hydrograph (flow rate pattern)

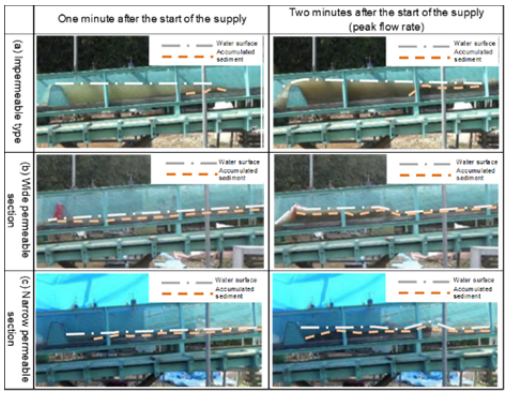

Figure 2: Accumulation process

Meanwhile, the amount of sediment outflow decreased by 80% at the peak supply rate in Hydro 1 with a rapid start and short duration when the permeation width of the permeation-type sediment control dam was narrower compared to a case in which the permeation width was wider. One of the causes was that the amount of sediment that reached the dam was smaller during the peak supply rate. The outcomes of the experiment and the outcomes of reproduction using numerical simulations are discussed in the detailed information section.

3. Conclusion

The authors are going to continue water channel experiments and data analyses to find how the differences in sediment concentration and particle size distribution would affect sediment control dams installed in debris flow sections.

☞For more detailed information

1) Civil Engineering Technology References , pp. 24-27, 2016.6

The attempt to use deep learning to forecast the frequency of landslide hazards (Research period: FY 2017–2018)

Yamato Suzuki, Researchers Tomoyuki Noro, Head Joko Kamiyama, Senior Researcher
Hikaru Todate, Guest Research Engineer Sabo Risk-Management Division, Sabo Department

(Keywords) Landslide hazard, deep learning, forecasting technology

1. Introduction

Triggers, such as rainfall and earthquakes, and factors, such as terrain and geological features, greatly affect the onset of landslide hazards. Studies have confirmed that differences in the factors, as well as the magnitude of external forces, or the factors, of course, would result in different conditions in the onset of landslides.

Forecasting of the scale of collapses in landslide hazards is extremely important in terms of both structural and operational measures in order to manage them. Specifically, operational measures to manage landslides are targeted across wide areas covering multiple river basins. Various landslide forecasting methods have been examined using different types of statistical analyses. Still, the statistical analyses reached limitations in properly extracting the characteristics of factors associated with the onset of landslides from factors based on complicated relationships among multiple elements.

Thus, this study started using deep learning as a new approach to categorize the characteristics of factors associated with landslide hazards. This paper introduces an outline of the study.

2. Content of this study

This study expresses the terrain and geological data as characteristics of the factors by adjusting and convoluting the permeation rate, colorations, and other factors and uses images in which all of Japan is divided into 1 km grids as learning data. Deep learning is conducted using convolutional neural networks without giving teaching data to form the clusters of the amount of characteristics seen in the learning data and to categorize the learning data based on whether they have similar characteristics of factors. The study then analyzes the scales and conditions of past landslides in the learning data, which are categorized into the same group to observe the characteristics of landslide hazards that may occur in association with the characteristics of factors for individual groups. For example, multiple hazards involving multiple debris flows in multiple valleys are categorized into the same group. In this case, the system forecasts the onset of multiple debris flows resulting in serious damage to communities located at the end of valleys if a similar record-breaking rainfall were to be observed in a different area categorized into the same group. The system is expected to produce similar forecasts when similar groups are formed for areas with frequent small-scale landslides and areas prone to massive deep-seated landslides.

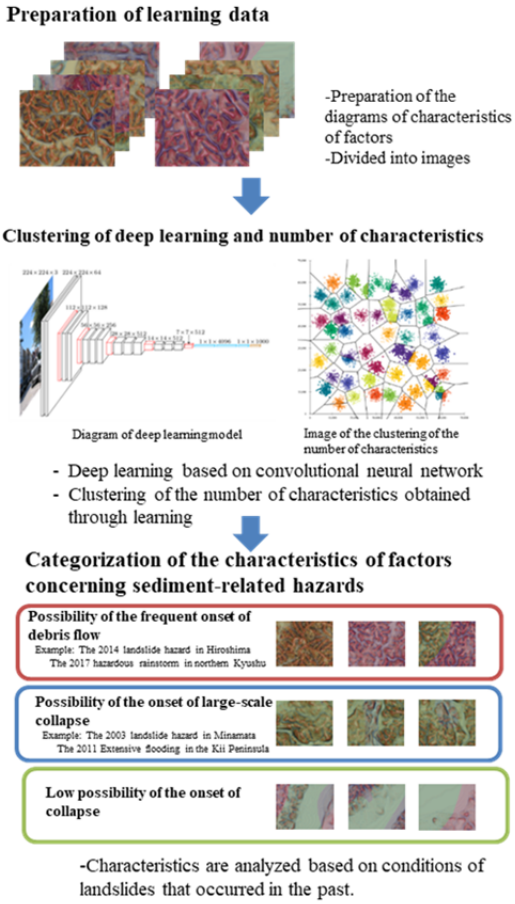

Figure: Categorization of characteristics of factors through deep learning

3. Future perspectives

Future studies will continue exploring methods to connect the types of landslide hazards, such as types of soil movement and their scales and specific ways to utilize quantitative forecasting results with the effective issuance of warning and evacuation orders along with the exploration of methods to prepare suitable learning data for extracting the characteristics of factors and learning models useful for forecasting the onset of landslide hazards.

Tendency of the occurrence of vehicles unable to climb (stuck vehicles) on winter roads

(Research period: FY 2017–2019)

Keiichi Ikehara, Senior Researcher Haruka Kawase, Research Engineer
Hiroshi Kobayashi, Head (Dr. Eng.), Road Safety Division, Road Traffic Department

Keywords: Winter road management, inability to climb, stuck, winter tire, chain

1. Introduction

Photo 1: Vehicles becoming unable to climb hills

The authors are conducting research to organize the causes and challenges associated with vehicles that become unable to climb hills on winter roads that should be shared around Japan and to set the direction to overcome the challenges specifically with improvements to road structures. In this fiscal year, the authors started analyzing data and conducting on-site interviews in areas where the first vehicle becomes stuck to organize the characteristics of locations where vehicles become unable to climb hills. This paper introduces conditions found through these activities and the outline of future activities.

2. Trend of onset seen in data

The basic trend found was based on an analytical tool for the onset of vehicles becoming stuck (2010–2016) within the Hokuriku Regional Development Bureau (figure 1). The stuck vehicles occur most frequently in January accounting for 47% of all. Among road conditions, compacted snow accounts for 63% of all. Among vehicle types, large vehicles account for 72% of all. Much of the tire data remain unclear, but the authors identified that stuck vehicles probably wore studless snow tires without chains.

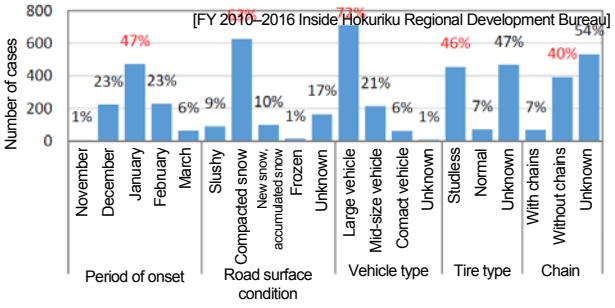

Figure 1: Basic trend of the onset of vehicles becoming stuck

3. Tendency of onset found through hearing

Since the authors could not find a direct cause of vehicles becoming stuck, they conducted interviews at eight stations of the Hokuriku Regional Development Bureau to find the causes, including detailed road structures and road management at the sites of onset.

The authors found that the causes of vehicles becoming stuck included road structures associated with slowing down (e.g., longitudinal slopes, long gradients, and sharp curves), as well as the conditions described below.

1) Condition of road surface: While compacted snow accounted for 63% of all road conditions in figure 1, the snow often contained large amounts of moisture, such as softly compacted snow and slush, which were categorized as compacted snow. These road conditions were associated with large driving resistance and often caused conditions, such as tires not grabbing the snow, inability to control the vehicle with the steering wheel, spinning tires, and the inability to restart moving.

2) Weather factor: Vehicles tend to become stuck when the amount of snowfall increases, and the removal of compacted snow becomes slow. In the case of Yuzawa, vehicles start to experience difficulty driving or starting when the hourly amount of snowfall exceeds 10 centimeters.

3) Human factor: Vehicles coming from other prefectures tend to be wearing no chains. Vehicles are sometimes without chains because the roads around mountains are equipped with snow-melting pipes and therefore enter the mountains without chains.

4. Future direction of the study

The authors are going to identify the causes of slowing down, weather factors, and human factors found from the interviews by mountain areas, inland areas, and coastal areas, which exhibit different road surface conditions, and organize the causes of the onset of stuck vehicles in a tree-form diagram (figure 2). The authors are specifically going to identify details of the factors that require on-site precautions in regard to the factor of slowing down, including the merging sections of climbing lanes, areas where drivers tend to become unaware of longitudinal slopes, and overpasses where snow cannot be removed and become narrowed down.

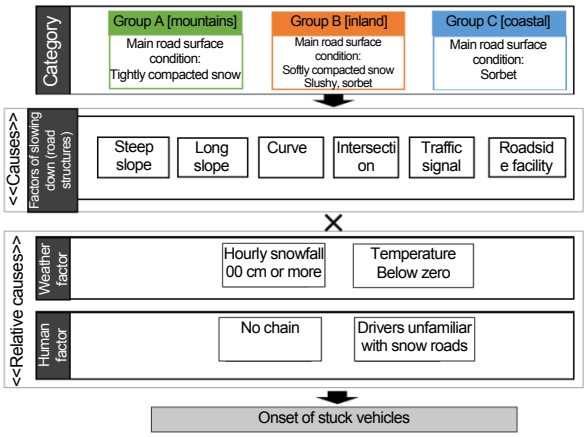

Figure 2: Causes of the onset of stuck vehicles (image of the organization)

The authors are going to identify the trends to the onset of stuck vehicles in other regions (regional differences) using the Hokuriku data as a reference during the next fiscal year.

To construct flood-resistant road structures

(Research period: FY 2017–2019)

Toshiaki Mabuchi,Head Hideaki Nishida, Senior Researcher
Takashi Kimura, Research Engineer,
Foundation, Tunnel and Substructures Division, Road Structures Department

Keywords: Road structure, flooding, scouring, load resistance

1. Introduction

Multiple typhoons landed on Hokkaido in August and September 2016. The heavy rain of the typhoons widely damaged road structures through scouring in flooding and erosion of riverbanks (photo 1). Almost all of the arterial roads connecting the central and eastern parts of Hokkaido were temporarily disconnected.

To avoid such situations and develop robust road networks, it is desirable to minimize the effects of scouring and riverbank erosion from floods on the functions of road structures, which play important roles in regional economic activities, emergency responses, and transportation of goods.

Under such circumstances, the authors are conducting research to find the structural requirements for already constructed road structures that need to be reinforced, such as the improvement in load resistance capacity to withstand scouring and erosion caused by flooding.

2. Contents of the study

Past studies have found that the likelihood of the onset of scouring and the speed of progress is strongly related to the shape of a structure, the depth of its foundation, and span length in terms of structural characteristics, as well as the shape of a river channel (e.g. whether the area where a structure is installed is level or not) and flow speed in terms of river characteristics. These findings are reflected in regulations and standards for the depth of the foundation and span lengths in the Government Ordinance for Structural Standards for River Management Facilities. Still, there are situations that cannot be put under control through local responses in the area of road facilities, such as disastrous events that result in the significant alteration of river flows during a flood. In this fiscal year, the authors are therefore organizing the relationship among structures, ground conditions, and river characteristics that are vulnerable to scouring, erosion, or other conditions based on an analysis of recent damage from the perspective of both road structural characteristics and river characteristics.

Figure 1 is an example of the breakdown of damage to the abutments where the year of construction is known among studied cases of road bridges damaged by floods from 2013 to 2016. For example, the standard span length L for a bridge with piers in a river channel was set to L = 20 + 0.005 Q (Q: planned highest flow rate) (the

Photo 1: Road bridge of a national road damaged in a flood

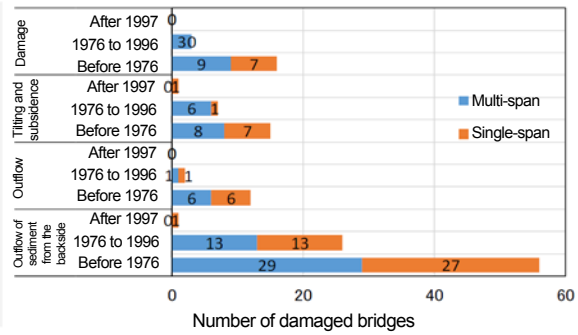

Figure 1: The breakdown of damages to abutments damaged in floods from 2013 to 2016 (by year of construction)

regulation is relaxed when Q is 2000 m^3/s or less) in the 1976 Government Ordinance for Structural Standards for River Management Facilities (hereinafter "the Ordinance on Structures"). The revision in 1997 changed the span length to 50 meters when L exceeds 50 meters. Before the establishment of the Ordinance on Structures, there was substantial damage associated with structural characteristics, such as damage to abutments and tilting and subsidence, and the ratio of damage caused by the outflow of sediment to the back of abutments regardless of the year of construction was also high.

3. In the end

The authors are going to continue analyzing the relationship among the history of applicable standards and construction technologies, river characteristics, and factors that affect the load resistance capacity of a foundation and deformability and examining the structural requirements to be applied in cooperation with the River Department.

Analysis of road bridges damaged in the 2016 Kumamoto earthquakes (Research period: FY 2016–2018)

Motoki Saruwatari, Researcher Shojiro Kataoka, Head(Dr.Eng.)
Earthquake Disaster Management Division, Road Structures Department

Keywords: Kumamoto earthquakes, damaged road bridges, earthquake proof, effects

1. Introduction

The National Institute for Land and Infrastructure Management (NILIM) has been analyzing the effects of the earthquake-proofing of road bridges focusing on the effects of reducing the damage realized through various types of earthquake-proofing work, as well as socioeconomic effects obtained through the quick restoration of road network functions using the 2016 Kumamoto earthquakes as the subject of the study.

This paper introduces the outcome of the analysis of road bridges damaged in the Kumamoto earthquakes, part of the fundamental data used in the above analysis.

2. Analysis of damaged road bridges

The authors analyzed the relationship between earthquake motion distribution and damaged road bridges using the earthquake motion distribution (SI value)[1] that the NILIM had estimated and released. The analysis targeted 537 bridges longer than two meters that were identified as damaged by earthquake motion in the emergency inspections that the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), NEXCO West Japan, the prefecture of Kumamoto, and the prefecture of Oita conducted. The SI values used in the analysis are the larger between the largest foreshock (Apr. 14, 2016) and the main shock (Apr. 16, 2016) of the Kumamoto Earthquakes.

The organized relationship between damaged road bridges and SI values indicated a trend that the ratio of midlevel or more serious damage increased as the SI value increased (Figure 1).

Next, the relationship between the degree of damage and applicable standards is organized (Figure 2). The figure indicated that the ratio of significant and midlevel damage was lower among road bridges to which the 1971 Road Bridge Earthquake Resistant Design Guideline (the 1971 Road Guideline) was applicable compared to road bridges to which the 1980 Road Bridge Instructions (the 1980 Road Instructions) were applicable. This is because the Three-year Road Bridges Earthquake-proofing Program for Emergency Transportation Roads (2005-2007) prioritized in earthquake proofing road bridges to which the 1971 Road Guideline had been applicable.

3. In the end

This paper introduced the effects of earthquake motion intensity and applicable standards among the outcome of the analysis of road bridges damaged in the Kumamoto earthquakes.

The authors are going to continue the statistical analysis of damaged road bridges administered by regional public organizations, analyze socioeconomic effects brought by the improvement of the earthquake resistance of road bridges, and examine how road bridges should be earthquake proofed in the future.

The digital data of earthquake motion distribution introduced in this paper are available in the website below.

[Reference]

1) Earthquake Disaster Management Division, NILIM website: Kumamoto Earthquakes information, http://www.nilim.go.jp/lab/rdg/index.htm

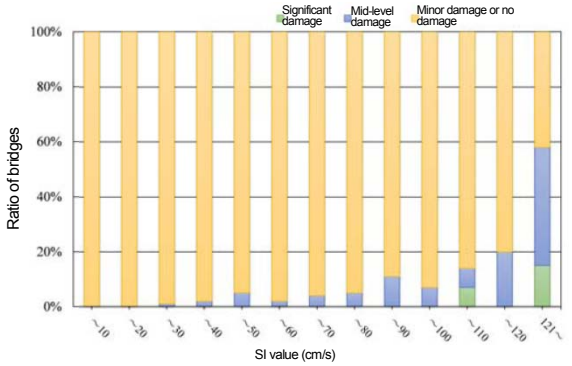

Figure 1: Relationship between SI values and level of damage

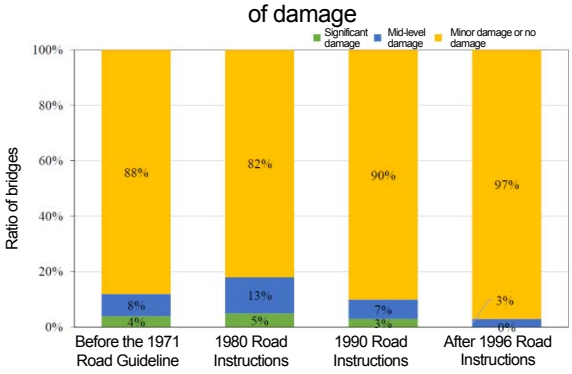

Figure 2: Relationship between the degree of damage and applicable standards

Technological verification to realize the observation of the overall movement of civil engineering structures during an earthquake

(Research period: FY 2017–2018)

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Earthquake Disaster Management Division, Road Structures Department

Keywords: Strong-motion observation, earthquake resistant design standards, earthquake movement observation system

1. Challenges that the National Institute for Land and Infrastructure Management is facing in strong-motion observation

The National Institute for Land and Infrastructure Management (NILIM) has been conducting strong-motion observations since 1958 to rationalize and advance earthquake resistant design standards for civil engineering structures and to clarify their movement during earthquakes. The findings of the study have been reflected in earthquake resistant design standards for civil engineering structures, such as roads, rivers, and lifeline facilities, in addition to the Specifications for Highway Bridges V Earthquake Resistant Design Edition.

The strong-motion observations targeted civil engineering structures and are being conducted by carefully selecting structures at about three locations because of the issue of cost. Still, the record of earthquakes at three locations was not enough to represent earthquake movements to clarify the complicated movement of structures during earthquakes, such as the movement of bridges with a horizontal force distribution structure.

In addition, the current strong-motion observations by the NILIM require the collection of earthquake records from actual sites rather than real-time observations using networks. The collection of records is delayed in the case of the onset of a major earthquake, and costs, such as labor costs, are required.

Based on the above, to ensure instant record collection and to identify the movement of structures during an earthquake at high precision, it is necessary to construct an observation system that can simultaneously conduct observations at multiple locations of a structure as shown in figure 1.

2. Experimental installation of MEMS accelerometer

Small and low-cost measuring instruments, such as MEMS accelerometers, have been developed in recent years. These instruments are expected to realize observation systems that could not be easily constructed when the strong-motion observation started. Still, MEMS accelerometers have not been sufficiently tested in regard to maintenance and management, such as testing outdoor communication technologies and securing outdoor power supplies. Therefore, MEMS accelerometers were installed as experiments to verify the measurement precision and on-site technologies to establish observation systems to clarify the complicated movement of civil engineering structures during earthquakes using recent technological renovations.

Accelerometers were installed as experiments on viaducts where the NILIM has been conducting strong-motion observations (figure 2). Specifically, new wireless systems and two types of MEMS accelerometers were installed in areas where earthquake meters had already been installed at Nos. 1 to 5 to perform simultaneous observations.

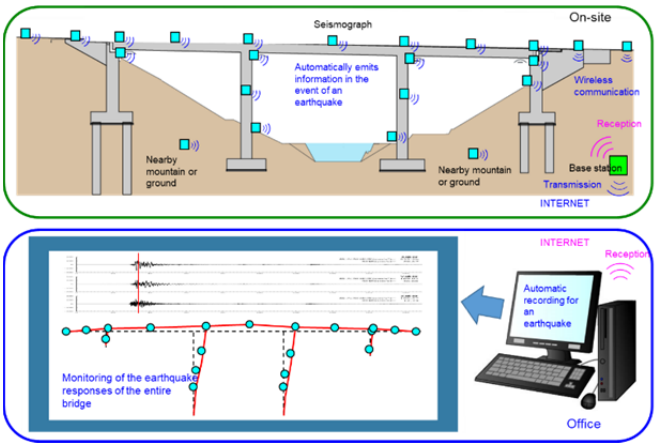

Figure 1: Schematic diagram of earthquake movement observation system

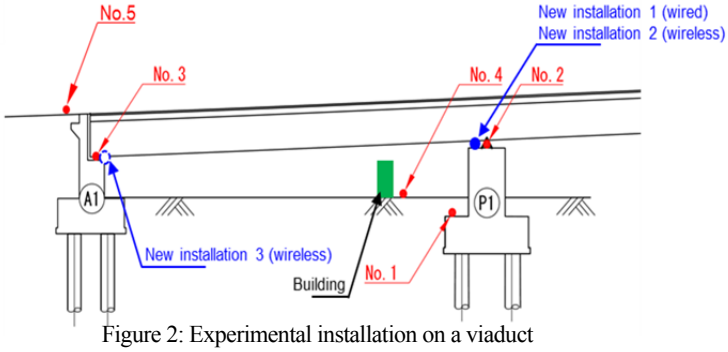

Figure 2: Experimental installation on a viaduct

3. Future activities

The NILIM is going to verify the effectiveness of the observation system using MEMS accelerometers from the perspectives of the precision of observation records obtained from individual devices, installation cost, and maintenance and management cost. The NILIM is then going to construct the observation system shown in figure 1 for the viaducts shown in figure 2. The outcome of these activities will be used as a model case to establish technologies to further improve the strong-motion observation of the NILIM to gather earthquake records that would further contribute to the rationalization and advancement of earthquake resistant design standards for civil engineering structures.

Development of technologies to improve facilities to secure the health and safety of evacuees in evacuation shelters (Research period: FY 2017–2019)

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Equipment Standards Division, Building Department

Keywords: Evacuation shelter, health, safety, building facility

1. Introduction

(PhD Engineering)

Millions of people are expected to seek evacuation shelters in major earthquakes, such as an earthquake that would directly hit Tokyo. In addition, when they have to remain in shelters for a long period of time, the living environment of the shelters needs to be improved to prevent adverse health effects, including effects on mental health, and to ensure the safety of evacuees. Specific situations, such as regional characteristics, need to be taken into consideration when preparing evacuation shelters. Current evacuation shelter guidelines often fail to provide enough information concerning specific equipment and methods of improvement.

The authors started research and development to improve such situations and overcome problems in FY 2017. This paper introduces the outline of the study, findings of the investigations of evacuation shelters damaged in earthquakes, and findings of literature searches concerning relevant problems.

2. Outline of the study

2.1 Image of the research and development

The objective of this study is to present specific methods and improvement technologies to provide the adequate living environment of evacuation shelters that include toilets, the sanitary environment, privacy, and sound, heat, and lighting environment and functions. Figure 1 shows the image of the research and development.

2.2 Investigation concerning demands in evacuation shelters such as demand for electricity

The authors conducted interviews with people who operated evacuation shelters in three locations around the Sanriku Coast that was significantly damaged in tsunamis in the Great East Japan earthquake. Table 1 shows extracts from the hearing investigation. The investigation revealed that situations varied depending on the size of an evacuation shelter and management body of the shelter, as well as that challenges and problems differed depending on the conditions of lifeline restoration.

2.3 Literature search concerning the acoustic environment in evacuation shelters

The authors searched the literature on past studies concerning the acoustic environment in evacuation shelters. The weight of problems specifically associated with lifelines was heavy in the initial phase of a stay in evacuation shelters. When the stay in evacuation shelters becomes long, however, the problem of noise, such as sound and the voices of children, surfaces as people seek the protection of privacy and improvement of comfort.

3. Future perspectives

To solve these problems, the authors are going to explore current facility plans by focusing on school facilities that are used as evacuation shelters, examine methods to operate and manage shelters after the onset of a disaster, and develop partitions with sound absorption functions to protect privacy.

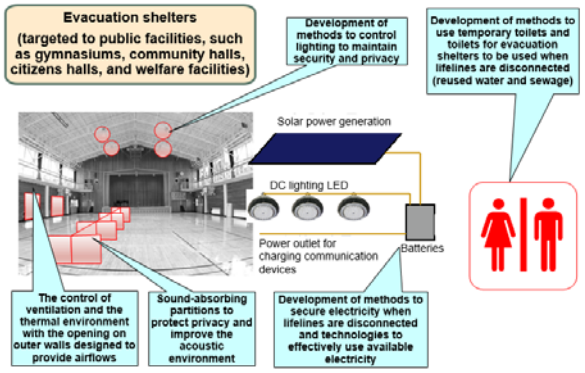

Figure 1: Image of the development of technologies to protect health in evacuation shelters

Table 1: Outline of the findings of hearing investigation (extracted)

	Evacuation shelter A	Evacuation shelter B	Evacuation shelter C
Building outline	Junior high school	Elementary school	Former convenience store
Maximum capacity	About 1,600 people	About 300 people	Dozens of people
Operation system	A headquarter system of principals and volunteers is organized.	Voluntary operation by evacuating local residents	Voluntary operation by evacuating local residents
Electricity restoration period	Three days after a natural disaster	About one month after a natural disaster	About two weeks after a natural disaster
Water supply restoration period	About three months after a natural disaster	About four months after a natural disaster	About four months after a natural disaster
Measures to protect privacy	Cardboard partitions were installed in early May.	A manufacturer provided 100 table tennis fences.	None
Problems and challenges	Whiteboards and large pieces of papers become useful. Toilets need to be provided, etc.	Importance of autonomous operation Disparity in supports available at different evacuation shelters, etc.	Septic tanks are useless unless water is available. Power generators are needed, etc.

Research concerning impeding factors and measures to overcome them to improve living safety (Research period: FY 2016–2017)

Hiroshi Nakanishi, Head Housing Stock Management Division, Housing Department

Keywords: Impeding factor, natural disasters and accidents, already constructed houses, self-support, renovation

1. Background of the study

In recent years, the demand for ensuring and improving the safety of residents has been growing with the increased number of natural disasters and accidents associated with a super-aging society.

Past studies have accumulated knowledge in specific fields of housing, including earthquake resistance, fire control, prevention of accidents within houses, and crime prevention. The analyses of causes have produced outcomes that would reach solutions, some of which have been useful in preparing and revising laws, regulations, and standards.

Since houses are private property, however, the progress of improve measures is often slow, especially in already constructed houses due to impeding factors, such as that most of the safety measures in houses are up to the self-support of residents and that the knowledge of construction and cumbersome procedures are required for ordinary residents.

2. Outline of research findings

The author extracted effective measures that residents could implement as focused implementation points of safety measures by presenting the chain of impeding factors (hazard)*1 in ETA*2 or FTA*3 for specific types of natural disasters and accidents related to houses and then disconnecting the links to prevent natural disasters and accidents from becoming connected (table 1).

Then, focusing on already constructed houses, the author presented points to overcome to eliminate impeding factors for residents to autonomously implement safety measures and make it easier for them to engage in voluntary actions (table 2).

The author also explored effective measures based on hearing investigations with those who are assigned to already constructed houses and surveys responded to by residents who renovated their houses (table 3).

*1 Impeding factor (hazard): Factors that produce causes of natural disasters and accidents. Impeding factors are sometimes called the source of potential hazards and risks in JIS Q 0073. It is roughly categorized as ones that come from the natural environment, ones that come from the social environment, and ones that come from individual people. For example, major earthquakes and tsunamis are impeding factors that come from the natural environment and occur first. Then, as impeding factors that come from the social environment and individual people become linked, the level of damage increases and forms a major disaster. A large earthquake in areas without people, such as on the moon, does not become a major disaster.

*2 ETA (Event Tree Analysis): A method that traces the link of impeding factors to analyze expected damage. This method becomes useful when analyzing natural disasters. It is also used to examine measures to prevent specific disasters and the progress or the spread of accidents.

*3 FTA (Fault Tree Analysis): A method to analyze natural disasters and accidents by tracing the origin of impeding factors that cause the disasters and accidents. It becomes useful when analyzing daily disasters where the disasters and accidents can be artificially prevented. It is sometimes used to calculate the probability of onset in addition to the analysis of causes.

Timing to implement measures	Type of measures	House-related disasters in major earthquakes	House-related accidents (tripping, falling, crushing, drowning, heat shock)
Measures before onset	Measures to prevent disasters and accidents	Select location for building houses. Ground improvement New construction or reconstruction Earthquake resistance diagnosis, earthquake resistance renovation Keep inside built-in storages organized. Prevent furniture from falling. Avoid placing furniture in bedrooms. Measures to prevent falling objects Installation of a breaker with earthquake detection function (already installed microcomputers) Crime prevention measures	Maintain good health and strength. Eliminate steps on floors. Install something to hold on to such as handrails. Remove obstacles. Use non-slipping floors or apply non-slipping materials on stairs. Improve lighting devices. Keep balconies organized. Reduce temperature difference among rooms by insulating a house. Avoid hot bath or long bath. Keep bathrooms and dressing rooms heated. Warm up a body by pouring hot water on the body first.
	Measures to reduce damages	Store food, water, and dairy goods. Have emergency bags ready. Purchase fire/earthquake insurance. Carry whistles.	Use soft floor materials. Reduce obstacles. Notifying someone before taking a bath Install emergency call system.
Measures to implement at onset	Measures to reduce damage	Protect oneself from collapsing houses or falling furniture. Rescue victims. Evacuate to the height. Initial fire responses	Call 119 Emergency measures (e.g. CPR, recovery position)

Table 1: Example of focused points to implement safety measures in houses (self-support)

Timing	Main impeding factors	Issues to be examined
Prior phase	The effectiveness or necessity of renovation is not recognized.	Advertisement and public relations to report the effectiveness and necessity of the improvement of earthquake resistance, improvement of the thermal environment of a house, and measures to prevent accidents in a house
	Lack of opportunity to renovate (a wish to wait until the next reconstruction or remain living in the current house as it is)	Avoid missing a good opportunity for renovation (when a used house is purchased or when preparing for a house as one's final abode)
Preparation phase (consultation)	Uncertainty as to which should be prioritized Lack of knowledge and information concerning renovation	Advice from neutral third parties (e.g. architects, physicians, care managers) Advice from those who renovated in the past Distribution of information of actual renovations through the Internet
	It is difficult to accept renovations where the effects are not visible, and customers become reluctant (especially earthquake resistance and thermal environment.)	Effective use of technologies to make the thermal environment visible (thermography cameras) Observation of renovated houses (to experience actual houses and use talks of those who renovated houses based on their experiences)
	Procedures are troublesome.	Enrichment of information concerning systems and procedures
	Monetary burden (especially for those who live on national pension)	Enrichment of subsidy, financing, tax incentives Improvement of priority areas (limited to the first floor) and implementation procedures (reduction of load through integrated construction)
Implementation phase	Uncertainty in the quality of construction Anxiety toward responses to problems	Improvement of contractor information, introduction of examples of constructions Use of inspections and defect liability insurance

Table 2: Main impeding factors and challenges associated with the renovation of already constructed houses

- ♦Increase the recognition and interest toward the necessity of renovation.
- ♦Increase the number of experts and those with experiences in renovation who can provide proper advices.
- ♦Use technologies that make invisibles visible.
- ♦Publicize excellent examples of renovations.

Table 3: Main measures that are effective when specifically worked on

3. Summary

The author successfully narrowed down effective ways to promote safety measures as he organized impeding factors for implementing safety measures in already constructed houses and associated challenges and examined them through investigations targeted to those who were in charge of construction and those who renovated their houses.

Challenges to business activities of private companies in crowded urban areas and examples of unique activities

(Research period: FY 2016–2018)

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Shuichi Takeya, Head(Dr.Eng.), Urban Development Division, Urban Planning Department

Keywords: Crowded urban area, urban area development, private company, physical improvement, advanced example

1. Introduction

The improvement of the disaster management capability in crowded urban areas is an urgent task. There is a need for effective ways to solve various problems, such as buildings that are not connected to roads that may slow down urban area development, such as reconstruction and issues related to complicated rights. In addition, under the strict financial limitations of administrations, private companies need to develop the environment through their daily business activities to accelerate physical improvements.

This paper reports the challenges of business activities of private companies in crowded urban areas that NILIM found through the investigation of private companies and examples that solved problems and resulted in physical improvement through the unique activities of private companies.

2. Challenges to business activities of private companies in crowded urban areas

NILIM conducted surveys through questionnaires and hearings with private companies (major house manufacturers, regional builders, developers, real estate companies, design offices, etc.) about the challenges they are facing when conducting businesses in crowded urban areas (received responses from 47 companies). The survey found the challenges that kept private companies from conducting businesses, such as the increased construction cost due to insufficiently developed roads, low profitability and marketability, difficulty in complying with laws and regulations in small lots and lots that are not connected to roads, complicated rights of leased land and housing, and lowered motivation to rebuild buildings due to the aging of landowners as well as inheritance and financial problems (see the figure).

3. Examples of unique activities of private companies to solve problems

This section would introduce examples of the unique activities of private companies that solved the problems of crowded urban areas and realized physical improvements found through hearings with private companies.

[1] Realization of the improvement of lots (connecting roads to lots that had no road connections, expansion of small lots) through the reorganization of the series of small blocks using vacant lots and lots after removing vacant houses and the improvement of road conditions (widening of narrow roads, elimination of dead ends)

[2] Realization of the arrangement of rights associated with leased land through the purchase of leasehold or land rights and the reorganization of lot borders and reselling the lots

[3] Realization of rebuilding in lots without connections to roads by providing consultation on acquiring agreements and permits from the landowners of roads in regard to the Application for Permission under Article 43 of the Building Standards Act

[4] The organization of the group of experts (experts in design, law, tax, real estate, finance, welfare, and other fields) to respond to various problems in crowded urban areas and landowners to coordinate problem-solving processes

4. Summary

The researchers are going to examine the development of the environment to solve problems while learning from challenges to conducting businesses in crowded urban areas and examples of unique activities of private companies found through surveys and plan to spread the know-how of urban development in crowded urban areas.

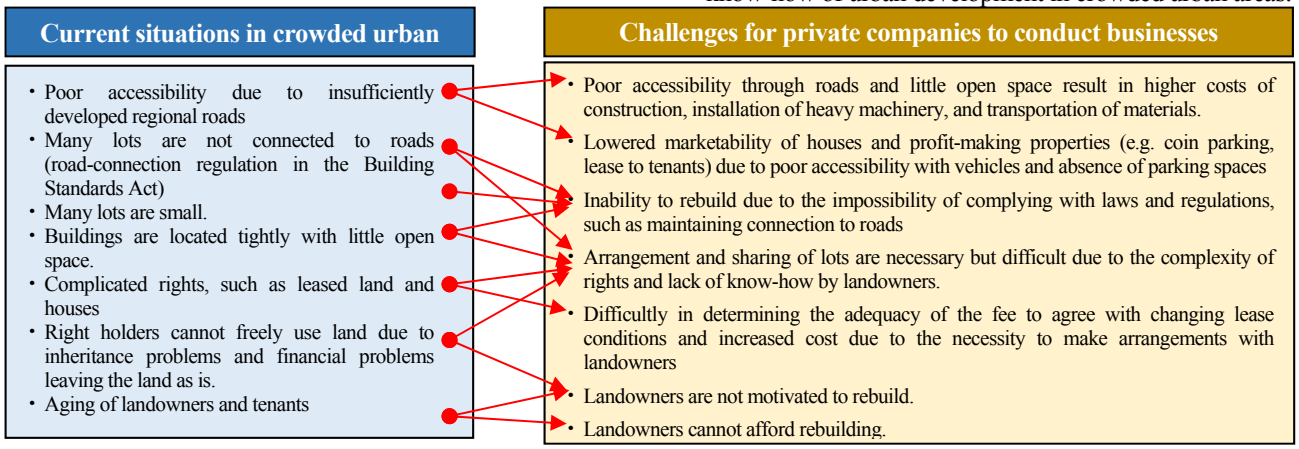

Figure: Current situations in crowded urban areas and challenges to conduct businesses found through questionnaires and hearing surveys with private companies

Development of a Method to Render Panoramic Images Even at Night Using the Function of Devices Equipped with CCTV Cameras (Research Period: 2014–2018)

Arata Konno, Researcher, **Yasunobu Maeda**, Research coordinator for Advanced Information Technology, **Hirotaka Sekiya**, Head, **Toshiro Itouji**, Senior Researcher, **Kenji Morita**, Guest Research Engineer, Information Platform Division, Research Center for Infrastructure Management

Keywords: CCTV cameras, understand damages to infrastructure, image processing

1. Introduction

Almost 20,000 closed circuit television (CCTV) cameras managed by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) are deployed on roads and rivers. When a natural disaster occurs, we utilize them to understand the damage to the infrastructures, such as bridges, pavements, slopes, and so on. To complete the checking of all images obtained by cameras in disaster areas, it takes time because each camera must be being panned individually. Especially, the larger the scale of the earthquake, the longer it takes to complete the checking of all images.

The National Institute for Land and Infrastructure Management (NILIM) has been studying an automatic system to select CCTV cameras in municipal areas where seismic intensity detected by the Japan Meteorological Agency (JMA) exceeds a preset level and to render panoramic images by stitching together camera images obtained during panning CCTV cameras.

In this paper, we report the outline of a method to render panoramic images even at night based on the study results up to the year 2015.

2. Outline of the method

In the earlier method, we extracted multiple still images from a movie taken by CCTV cameras that were automatically panned, while making approx. 30 percent of the overlapping ratio between adjacent images (Figure-1: upper row). Panoramic images are rendered based on invariant features between adjacent images. Extracting invariant features at night is difficult because bands of light (tails of residual image) are observed in images resulting from the electron multiplier tube to acquire light.

In our newly developed method, we extract still images while panning and stopping little by little. The bands of light in the images vanish when we stop panning CCTV cameras (Figure-1: lower row). This makes it easier to extract invariant features.

We conducted an experiment to validate the effectiveness of the new method in which a number of CCTV cameras managed by the Keihin River Office are tested by obtaining panoramic images at four different times during the night of February 9, 2017. We show an example of panoramic images in figure 2. We confirmed that we can render panoramic images at night with the bands of light by iterating panning and stopping.

3. Conclusion

In FY 2017, we worked to establish a method to render panoramic images using CCTV cameras that are deployed in high places, such as a tower of each Regional Development Bureau.

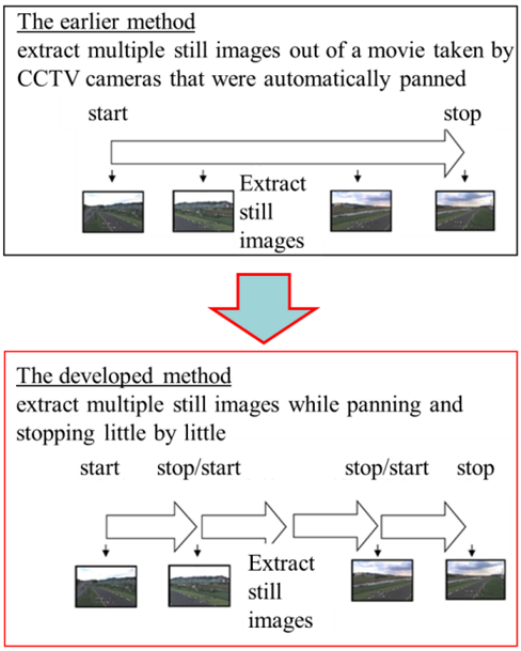

Figure-1: Difference between the earlier method and the developed method

Figure-2: An example of panoramic images

Development of technologies to minimize the effect of ground deformation on bridges

(Research period: FY 2017–2021)

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Keywords: Ground deformation, damage control, supporting section

1. Introduction

In the Kumamoto earthquakes, there are reports of cases in which important parts of bridges to support the function of bridges, such as main girders, are damaged because of the effects of earthquake motion, as well as the collapse of slopes and ground deformation. The earthquake resistance of road bridges is basically designed to provide enough resistance against the effects of vibrations to withstand the largest level of earthquake on record. Meanwhile, it is important to design bridges from the perspective of reducing the effects of uncertain risks, such as ground deformation. Therefore, the authors are developing design technologies to improve the certainty of generating fracture morphology with small effects on the restoration of bridge functions when a major change occurs to the lower structure of a bridge in case of ground deformation, such as the collapse of slopes and ground deformation. This paper introduces the concept of designs to control the fracture morphology that occurs to a bridge focusing on supporting parts based on actual damage to bridges in the Kumamoto earthquakes.

2. Damage to the supporting section of bridges in the Kumamoto earthquakes

In the Kumamoto earthquakes, ground deformation caused large shifts in both the upper and lower structures, and large relative displacement occurred between the upper and lower structures. Therefore, damage occurred to the main girders near the supporting sections between the upper and lower structures. Figure 1 shows the characteristics of the damage indicating that areas of damage varied among bridges.

Figure 1: Examples of damage to bridge supporting sections in the Kumamoto earthquakes

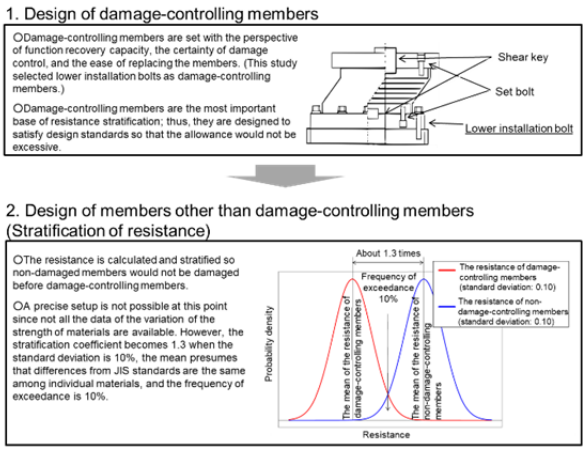

Figure 2: Concept of damage-control-type support (proposal)

3. The organization of the concept of damage-control-type support

Supporting sections consist of various types of members, which are individually designed based on bridge design standards. The authors examined the support design method to first satisfy the standards and then to control the parts that are to be damaged in the end so that the effects on the recovery of bridge functions would be minimized. Figure 2 shows the idea of the damage-control-type support design. Members that are damaged in the end (damage-control members) are set with the perspective of providing function restoration capacity, such as reducing differences in levels, as well as to increase the certainty of damage control and the ease of replacing the members. This study set the lower set bolt as the damage control member based on these perspectives. The idea is to control damage by designing a bridge by providing a significant difference in resistance between the lower set bolt and other members (the stratification of resistance).

4. In the end

The authors are planning to create pilot versions based on the concept of the damage control support design discussed above and conduct experiments with them. The authors are going to continue necessary examinations to apply damage-control-type support on actual bridges.

Risk information and proposal of a method to examine it for specific purposes of measures to reduce flood damage (Research period: FY 2015–2017)

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Yoko Yamamoto, Senior Researcher , River Division
Hideyuki Yamaji, Researcher, Water Cycle Division , River Department

Keywords: Information of flood risks, flood depth, average scenario

1. The necessity of the information on flood risks for specific purposes of measures

When examining measures to reduce flood damage, it is necessary to examine measures to reduce risks to reduce the onset of damage in case of a heavy rain and flooding that exceed the designed capacities of facilities, in addition to the development of disaster control facilities that are expected to be effective for certain until the level of a disaster reaches the designed capacity. The proper understanding of regional risks is necessary as preparation. It is also necessary to note that there are different factors and flooding scenarios that are closely related to damage, and the risk information to be identified varies depending on the targets to be protected (figure 1).

2. Development of risk analysis method based on an average scenario

The examination of the risk information based on an average flooding scenario (figure 1) requires the implementation of Monte Carlo simulations or other methods to comprehensively extract various types and scales of expected flooding. The precision and reliability of risk information would not necessarily improve for the cost it requires, however, because of the uncertainties that are unavoidable in the expectation of external forces based on limited amount of data. The cost should be as low as possible as the method is going to be used around the nation.

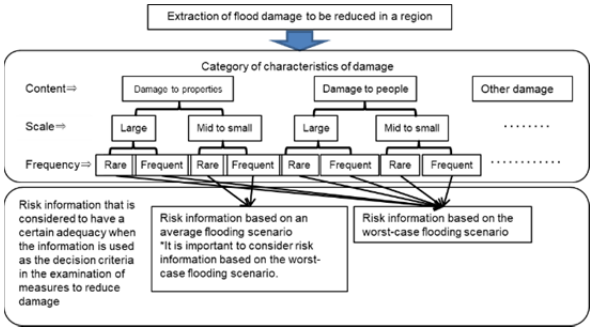

Figure 1: The relationship between targets to be protected and necessary risk information

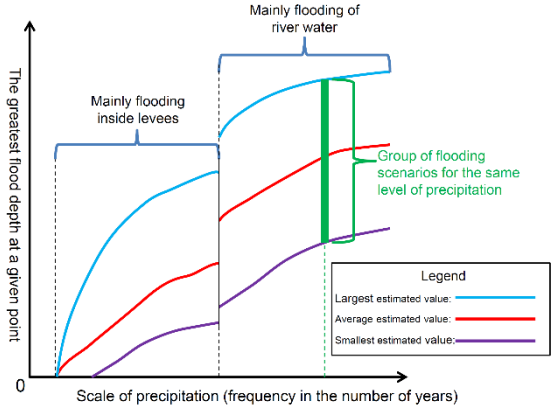

Figure 2: The conceptual diagram of risk information based on the group of flooding risks

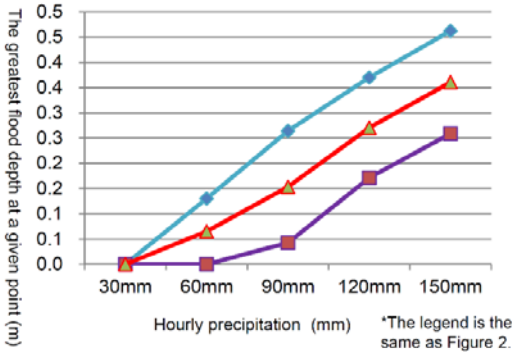

Figure 3: Example of estimating flood depths based on flooding inside levees by the scale of heavy rain

Therefore, the authors developed a method to set up multiple cases (e.g. high tide and low tide) for expected external forces and other conditions (e.g. chronological distribution of precipitation and starting water level in a river), estimate the outline of largest, smallest, and average flooding scenarios, and specify and provide risk information for specific purposes (figure 2). Figure 3 shows the example of estimation in model districts.

3. Future research activities

The authors are going to continue researches on methods to prepare, provide, and use information of flood risks for specific purposes.

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Flood control measures linked to town development, local residents, and businesses

(Research period: FY 2015–2017)

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Water Quality Control Department
Climate Change Adaptation Research Group

Keywords: Climate change adaptation measures, damage control management, flood, urban disaster control

1. Introduction

An important action to respond to the increasing risks of flooding caused by climate change is to implement flood control measures linked to town development, in addition to conventional flood control using flood management facilities. Cities contain various types of residences and various business activities. The authors consider that the awareness among residents and businesses will increase, and the implementation of flood control measures will be accelerated as risks of expected hazards to human lives, and assets are evaluated based on the characteristics of houses, business establishments, and cities that consist of houses and businesses, and when possible flood damage and the effects of flood control measures are presented.

This paper introduces investigations concerning examples of flood control measures linked to town development and the details and results of investigations concerning changes in actions and awareness toward flood control by presenting the information of overall flood risks to houses and businesses.

2. Example of flood control measures linked to town development

Western Europe has been under a relatively stable climate. Because of the concern over increasing precipitation caused by climate change, however, flood control measures linked to town development are being implemented, such as the reduction (retention) of rainwater outflow using urban spaces and the development of flood control facilities combined with urban functions (photo 1), and the development of flood control facilities using multiple town development methods (photo 2).

Similar activities in Japan are organized as follows: [1] regulations on the use of buildings and lands (designation of high-risk areas under the Building Standards Act: photo 3); [2] planned guiding (e.g. consideration of flood risks in the process of establishing land optimization plans); and [3] cooperation in development projects (activities conducted in cooperation among the government and private sector in urban redevelopment: figure 1). This paper summarizes these activities by gathering and analyzing relevant references and conducting interviews and on-site inspections and by organizing and examining the outlines of research, concept of risk reduction (water control safety target to satisfy), consensus building process, allocation of roles to the government and private sector, and factors for success.

Photo 1: Development of a park (upper section) and stores (lower section) that function as a levee in Rotterdam, the Netherlands

Photo 2: Flood control facility development in the BID city development method in Sheffield, England

Photo 3: Raising of the foundation of buildings in high-risk areas in the city of Sapporo

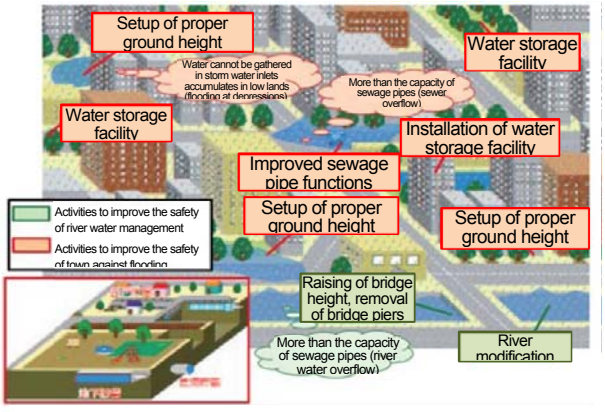

Figure 1: Image of flood control method conducted in cooperation between the public and private sectors (Source: City of Yokohama, Excite Yokohama 22 December 2009)

Many of these activities have been successfully implemented with the background of actual flooding, which triggered such activities. In addition, the cooperative relationship and the allocation of roles among the public and private sectors are often clearly defined. Local flood management departments and relevant sectors have high expectations for implementing flood control measures linked to town development. Meanwhile, the authors found challenges, such as the proper identification of actual risks and cost effectiveness, reevaluation based on changing situations, and proper hazard evaluations that were the foundation of all activities.

3. Presentation of general flood risk information to residents and businesses and awareness toward flood control actions

The presentation of general flood risk information (the information of the depth of flooding at individual locations based on the frequency of the recurrence and interpretation as to the damage to the assets of individual houses and businesses and effects of measures) is necessary to accelerate the implementation of measures to prevent flood damage to building-level properties. The authors are examining ways to present risk information in an easy to understand manner and facilitate reactions with the expected depth of flooding by recurrence frequencies, which is estimated in another study.[1]

The authors investigated 12 houses and businesses located in large cities in the delta areas in the lower reach of large rivers. The authors then presented the following based on the flood damage risk evaluation method[2] using a model building developed up to the previous fiscal year: [1] investigation of the vertical distribution of main assets within a building; [2] presentation of risk information combined with the outcome of calculating flood depth (limited to flooding inside levees) at a given location based on different recurrence frequencies; and [3] presentation of simple proposals based on actual conditions, such as asset distributions within buildings and their effects (monetary amount of damage reduced as an annual average). Then, the authors conducted interviews concerning the ease of understanding information, its reliability, and changes in awareness toward engaging in flood control measures (figure 2).

A quick summary of the findings of the investigation up to this point was that many subjects of the investigation gave good evaluations when the information of risks, measures, and effects for specific conditions of individual buildings was presented in an easy to understand way. In particular, businesses on the lower floors (many of them on the ground level) exhibited increased motivation toward implementing simple measures to respond to frequently occurring floods with low flood depths. The presentation of such flood risk information seems effective in encouraging people to engage in measures to control damage from floods inside levees. The study also found challenges, including comments, such as that the presented values did not match how people actually felt, inability to understand expressions of expected values, and details of the effects of proposals to prevent flooding were unclear, as well as that most of the subjects of the investigation were reluctant to implement measures to control damage from floods that were expected to occur at low frequency.

4. Summary

Throughout this study, the authors found that the presentation of the information of general flood risks in an easy to understand manner would encourage residents and businesses to engage in measures to control flood damage in the process of promoting effective measures to protect their assets from damage. Such information was also effective in activities linked to district-level town development.

The findings of this research titled the "Development of Measures to Strategically Reduce Disaster Risks in Cities under Climate Change" (to be completed in FY 2017), including contents introduced in this paper, are going to be summarized and published in a future NILIM reference.

☞Relevant information

1) "Risk information and the proposal of a method to examine it for specific purposes of measures to reduce flood damage" NILIM Report 2018, 93p

2) "Evaluation of urban flood damage using model buildings/evaluation of effects of measures" NILIM Report 2017, p. 99

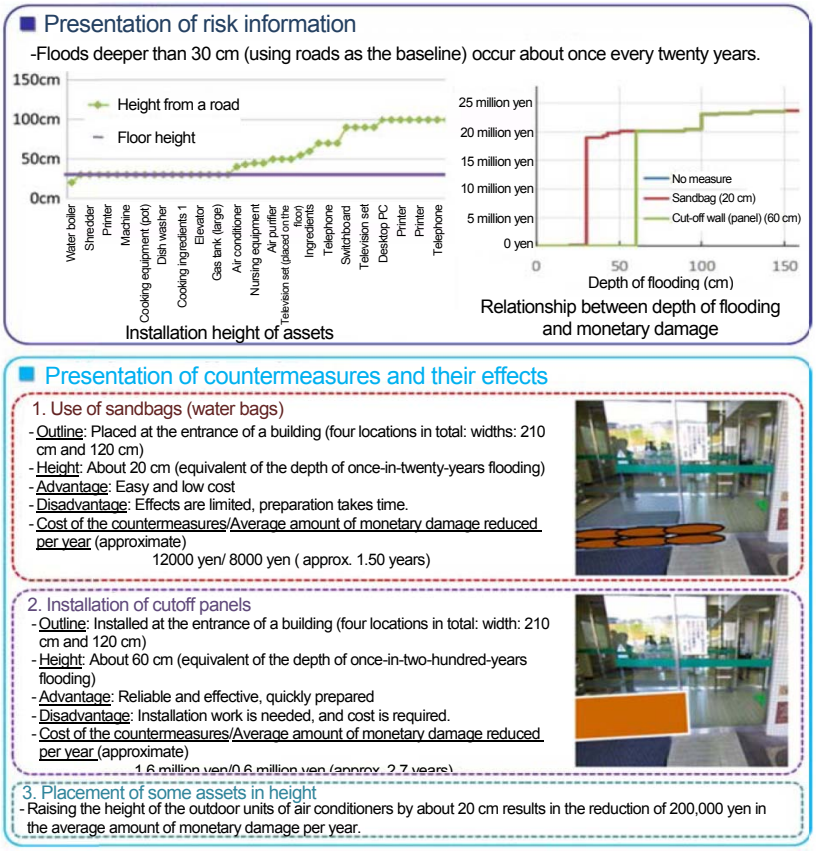

Figure 2: Flooding risks for residents and businesses and the presentation of countermeasures and their effects (example)

Development of real-time information collection, investigation, and sharing technology for infrastructure damage. in SIP disaster prevention research

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Disaster Prevention and Reduction Research Committee

Keywords: Disaster prevention and reduction, initial response, information needs

1. introduction

When a large-scale earthquake occurs, it is necessary to grasp the status of the affected areas immediately from limited information in order to respond appropriately. NILIM is developing technologies to grasp damage immediately by effectively using existing CCTV cameras and satellites. In order to develop and implement these technologies properly, we conducted an information needs survey at the site of the disaster response for the 2016 Kumamoto earthquake, one of the major disasters in recent years, and tried to clarify the information needs and the expected role for each disaster grasping technology.

In this report, based on the results of an information needs survey and technology evaluation, we introduce technological development and social implementation progress as a part of an SIP disaster prevention study.

2. Information needs investigation and technical evaluation for disaster response

Based on research into the 2016 Kumamoto earthquake response, the information needs and expected role for each disaster grasping technology are being clarified. Based on the research results, we arranged the facts as to when and what kind of information was collected on the time axis. From the arrangements, the information blank period and the issues of collecting information that changed with time were organized. With reference to these results, we are developing technology for efficiently using CCTV cameras and satellites during a disaster.

3. Efficient detection of disaster form the image of CCTV cameras

CCTV cameras are installed nationwide for the purpose of monitoring infrastructure. These cameras are also used for grasping damage. However, it requires labor and time to manually turn the cameras one by one and select images that show the status of the disaster from a huge number of cameras in the situation where the number of personnel is limited immediately after a disaster. Therefore, we are developing these two functions: (1) turn the camera automatically and create a panoramic image for grasping the surrounding situation, and (2) detect the disaster from enormous image information (Figure 1).

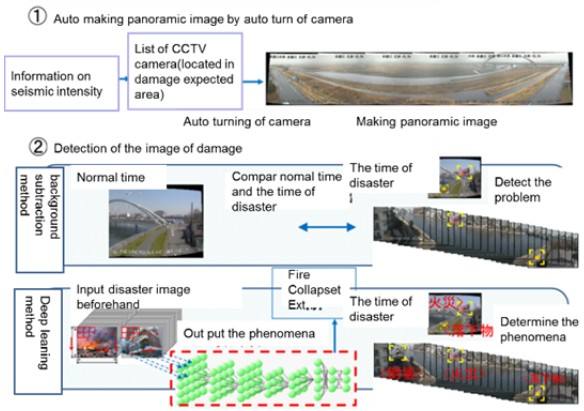


Figure 1 Panoramic image and detection of damage

(1) Auto creation of panoramic image

When earthquakes occur, a list of CCTV cameras in the damage expected area (CCTV camera list) is automatically created based on the information on seismic intensity provided by the Meteorological Agency. Cameras on the list automatically turn and create panoramic images. In 2017, we conducted trial experiments of making panoramic images in an actual environment using the Regional Development Bureau's CCTV cameras.

(2) Auto detection of damage image

We are developing technologies by using two types of

methods: the background subtraction method and the deep learning method in order to efficiently detect damage from images. In the background subtraction method, an abnormality is detected by taking the differences in the images between normal time and the time of the disaster, then judging the possibility of a disaster occurring. In the deep learning method, we let the AI system learn the types of damage by using pictures from past disasters provided by Regional Development Bureaus (RDBs).

For more efficient utilization, (1) panoramic images and (2) detected disaster images are planned to be reflected in the DiMAPS (Integrated Disaster Information Map ping System) managed by the Ministry of Land, Infrastructure, Transport and Tourism.

4. Technology for effectively use of satellite

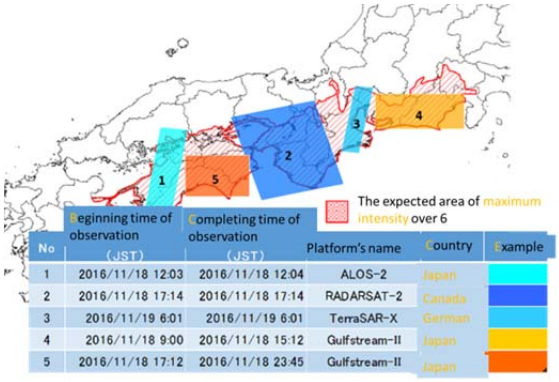
Synthetic Aperture Radar (SAR) loaded on an artificial satellite can observe a wide area even at night or in bad weather. However, there is a case where the disaster area cannot be monitored since the observable range depends on the orbit of the artificial satellite. In addition, SAR images require more skills to read compared to optical images.

(1) Observation planning by combining artificial satellites and airplanes

For observing the affected area quickly, we are developing a technology to support observation planning that efficiently combines platforms, such as satellites, airplanes, and disaster prevention helicopters (Figure 2). The observation plan includes operational conditions and environmental conditions (time weather, available airports, and so on). We have been developing a Web system that supports observation planning followed by system improvement on the basis of trial results at the RDBs.

(2) Support for interpretation of SAR image

In order to support the personnel responsible for responding to disasters, we have developed image processing technology that can improve the readability of SAR images for shortening the



No	Beginning time of observation (JST)	Completing time of observation (JST)	Platform's name	Country	Example
1	2016/11/18 12:03	2016/11/18 12:04	ALOS-2	Japan	
2	2016/11/18 17:14	2016/11/18 17:14	RADARSAT-2	Canada	
3	2016/11/19 6:01	2016/11/19 6:01	TerraSAR-X	German	
4	2016/11/18 9:00	2016/11/18 15:12	Gulfstream-II	Japan	
5	2016/11/18 17:12	2016/11/18 23:45	Gulfstream-II	Japan	

Figure 2 Example for observation planning assuming the Nankai Megathrust Earthquake

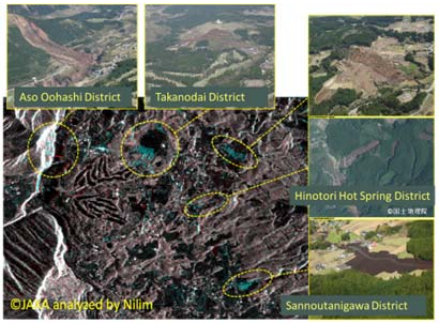


Figure 3 SAR image interpretation in case of the 2016 Kumamoto earthquake

work time. In addition to improving visibility, semiautomatic extraction of the priority part of the visual judgment supports interpretation. The readability was verified by actual disasters such as the Kumamoto earthquake in 2016 (Figure 3) the torrential rain in northern Kyushu in 2017. We employed the technology for training interpretation methods for the personnel responsible for responding to a disaster.

5. Auto distribution of seismic information system

We have developed technologies to provide information within 15 minutes after an earthquake. One is spectrum analysis information that makes it possible to estimate the scale of damage to the infrastructures and the other is the CCTV camera list mentioned in 3. (1). These two sets of information are automatically created when an earthquake with a certain seismic intensity occurs and automatically distributed to the address registered in advance. From April 2017, we started automatic distribution for disaster prevention personnel of the RDBs. It is utilized in disaster prevention drills in the Regional Development Bureau.

6. Conclusion

We are planning to continue social implementation and to upgrade the system based on the information needs toward the final year of the SIP disaster prevention study. In the future, we will consider technical development targets by comparing the information needs and characteristics of various technologies and clarifying the roles required for each technology.

☞more information

1) Research Center for Infrastructure Management's website
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn000.htm

2) Sabo Risk-Management Division's web site
http://www.nilim.go.jp/lab/scg/index.htm

3) Earthquake Disaster Management Division's website
http://www.nilim.go.jp/lab/rdg/division/division.htm

Empirical study on B-DASH Project (ICT-applied equipment deterioration diagnosis technology) (Study period: from FY2015)

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Keywords: sewerage, ICT, maintenance, 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 MLIT has been implementing the Breakthrough by Dynamic Approach in Sewage High Technology Project (B-DASH Project) since fiscal 2011 and NILIM has been serving as an implementing agency of this empirical study.
This paper introduces the outline of two technologies used to diagnose sewerage equipment deterioration using ICT.

2. Technologies to diagnose sewerage deterioration using ICT

(1) Empirical study on the deterioration diagnosis technology and the equipment inspection technology by sensor continuous monitoring and cloud server concentration
(Joint Research Organization of Swing Corporation and Sendai City)
These technologies are used for condition-based maintenance comprising deterioration diagnosis technology and equipment inspection technology that use the sensor monitoring data obtained by constantly monitoring the condition of equipment by the vibration method and the direct entry data obtained by daily inspection with a tablet terminal, both of which are efficiently concentrated on the cloud server (see Figure 1). In sensor monitoring, vibration and other sensors are installed on rotating equipment for continuous monitoring and obtained data is accumulated in the cloud server using wireless communication function. In tablet inspection, data is efficiently accumulated in the cloud server while reducing operation time by replacing the conventional method of recording in paper forms in daily inspection. For the data concentrated in the cloud server, data effective for equipment deterioration diagnosis is identified and visualized in order to raise the efficiency of condition-based maintenance by upgrading the deterioration diagnosis technology. Demonstration and introduction of these technologies are expected to contribute to reduction of maintenance cost and work load / time or appropriate equipment repair planning by upgrading deterioration diagnosis.

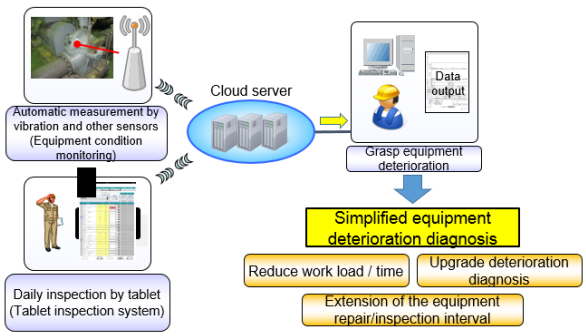

Figure 1: Continuous sensor monitoring and cloud server concentration technology

(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 big data analysis using continuous monitoring (sensing technology) data of rotating equipment and a large amount of operation data (big data) in the facilities, using vibration sensors. Condition-based maintenance of these technologies is expected to demonstrate the effective detection of abnormalities and the effect of reducing maintenance cost.

3. Future development

NILIM continues to lead the B-DASH project and promotes dissemination of the innovative technologies. This empirical study is going to continue data acquisition. We aim to contribute to reduction of maintenance cost and productivity improvement in sewerage service with these technologies developed from the results of the empirical study.

☞See the following for details.
[Reference] Website introducing B-DASH
http://www.nilim.go.jp/lab/ecg/bdash/bdash.htm

Development of Dam Displacement Monitoring Technology Using Satellite SAR

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Masafumi KONDO, Head
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Keywords: dam, maintenance, satellite SAR, displacement monitoring

1. Introduction

In dam safety management, measurement of displacement of dam or foundation rock is one of the important monitoring items, and such measurement is conducted using plumb line (pendulum) for concrete dams and electro-optical survey or GPS for embankment dams. Because conventional geodetic survey for embankment dams is relatively time-consuming, it is difficult to conduct quick geodetic survey after large earthquakes. Further, if displacement distribution with high spatial resolution is needed, the cost will increase accordingly by conventional geodetic survey. Therefore, NILIM has focused on satellite SAR (Synthetic Aperture Radar), which data has been increasingly used in the disaster prevention field and has been developing technology to use for displacement monitoring of large structures including dams. [1)]

2. Findings obtained and ongoing study

Displacement measurement using satellite SAR data has been conducted for 19 rockfill dams across the country which are operated by the MLIT and Japan Water Agency. [2)] As an example, Figure 1 shows displacement of the dam by the earthquake. The dam is located relatively near the epicenter of the Kumamoto Earthquake (Apr. 2016). For this dam, slight settlement was found by the electro-optical survey conducted after the earthquake by the dam management office, and the satellite SAR data provides spatial distribution of settlement of the dam. Note that the results of comparison of existing measurement data (including GPS measurement results) with displacement data of the satellite SAR in 19 rockfill dams show that the average difference was 5 mm in more than half of the dams and 10 mm in more than 80% of the dams, which suggests good accuracy of satellite SAR data displacement monitoring. For the cases of relatively large difference between SAR and existing survey, some error factors have been found, including relationship between the incident direction of radio waves from the satellite and the direction of slope gradient of the dam body surface, condition of the dam body surface that affects the scattering of radio waves, and vegetation of dam body surface. Based on the error factors we have found, we have been conducting technical development to improve the accuracy of displacement using satellite SAR data.

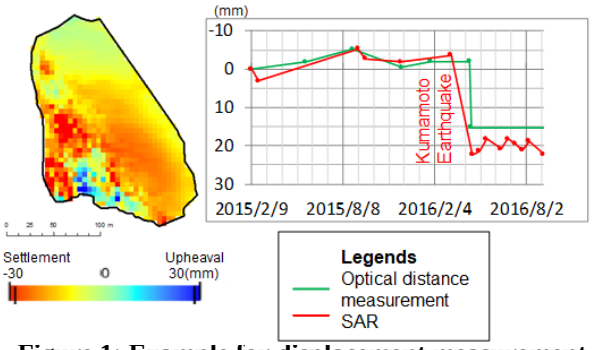

Figure 1: Example for displacement measurement in a rockfill dam by satellite SAR (Left: Displacement distribution on the dam; Right: time series data on displacement at representative points (comparison of satellite SAR and electro-optical survey))

3. Future activity

It has been found that the SAR-based displacement monitoring is highly expected to be applicable particularly to rockfill dams. For this reason, we plan to develop a manual that can be widely used by dam engineers as a manual in order to promote the utilization for monitoring displacement in rockfill dams. We also intend to conduct displacement monitoring of slopes around reservoirs, which is relatively difficult to monitor by other method, and establish a system for supporting utilization of satellite SAR data by dam administrators.

☞See the following for details.

1) Cross-ministerial Strategic Innovation Promotion Program ("SIP") infrastructure maintenance / renewal / management technology: "Development of a displacement monitoring methodology that detects deterioration in the ground and structures widely at an early stage using satellite SAR," http://www.jst.go.jp/sip/k07_kadai_dl.html

2) SATO Hiroyuki, KONDO Masafumi, KOBORI Toshihide, ONODERA Aoi: "External Deformation Monitoring of Nineteen Rockfill Dams Using Satellite SAR Data," Civil Engineering Journal, Sep. 2017, pp. 36-41

Prospect for Utilization of Three-dimensional Topographic Data in the River Field (Study period: from FY2017)

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River Division, River Department

keywords: laser survey, Nature-oriented River Management, CIM, VR, AR

1. Progress of survey technology

During the last decade, Airborne Laser Bathymetry (ALB), enabling measurement of river topography including underwater topography, and Mobile Mapping System (MMB), vehicle-mounted type laser survey technology enabling levee shape measurement with high density, were developed. In addition, drone-mountable laser survey devices have been developed during the last two years, enabling the acquisition of survey results of river topography as high-density point group data for not only levees but flood plain or land area of low water channel. Further, since laser survey devices mountable on large weeders or hay collectors were developed, it is possible to obtain data on the shape of levee slopes as high-density point group data with little effect of vegetation.

Utilization of three-dimensional topographic data thus obtained for desktop analysis of deformation in channels and levees is expected to improve efficiency in inspection work. In addition, channel design has been conventionally conducted using the results of cross-sectional survey with a 200 m interval, and use of river morphology data areally obtained as fundamental information is expected to change river development. This paper introduces effects expected from use of three-dimensional topographic data with an example of Nature-oriented River Management and prospects future utilization.

2. CIM and Nature-oriented River Management

Introduction of CIM (Construction Information Modeling/Management) is going on in order to facilitate information sharing between stakeholders across the project and improve efficiency of / upgrade a series of construction production system through utilization of the models of topography and structures prepared in the planning, research and design phases using three-dimensional topographic data etc. ("topography and other models") for construction and maintenance (Fig. 1). Application of such CIM has also begun to be considered in the river field.

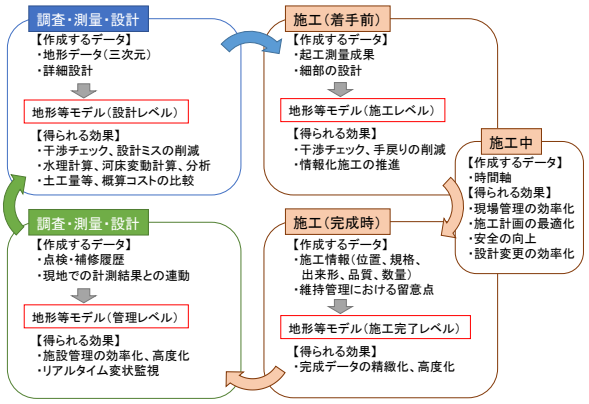


Fig. 1 Concept of the introduction of topography / structure models in research, design, construction, and maintenance [1)]

On the other hand, the concept of planning / design may not be fully reflected in construction work for river improvement or disaster restoration. In particular, in practice of Nature-oriented River Management, discussion is made from the viewpoints of a landscape, use, and organism habitat about river shape, arrangement of ramp, etc., installation area / color tone of revetment, channel excavation method, etc. Sharing an image of the river after renovation only with a sectional view and a plan view interpolated from it is difficult, and transfer of the shared image to the persons in charge in each phase is further difficult. River Division is therefore developing "river version" CIM using three-dimensional topographic data and aerial photographs taken at the same time as basic data of CIM so that an image of completion is shared among stakeholders and the concept in planning and design stages is accurately reflected in construction (Fig. 2). Further, River Department is proceeding the study on utilization method of three-dimensional topographic data and structure of models of topography, etc. particularly for channel models in cooperation with Advanced Construction Technology Division and Information Platform Division.

3. Prospect for future utilization

To make contents of movies and games more enjoyable, some technologies have been developed to create virtual

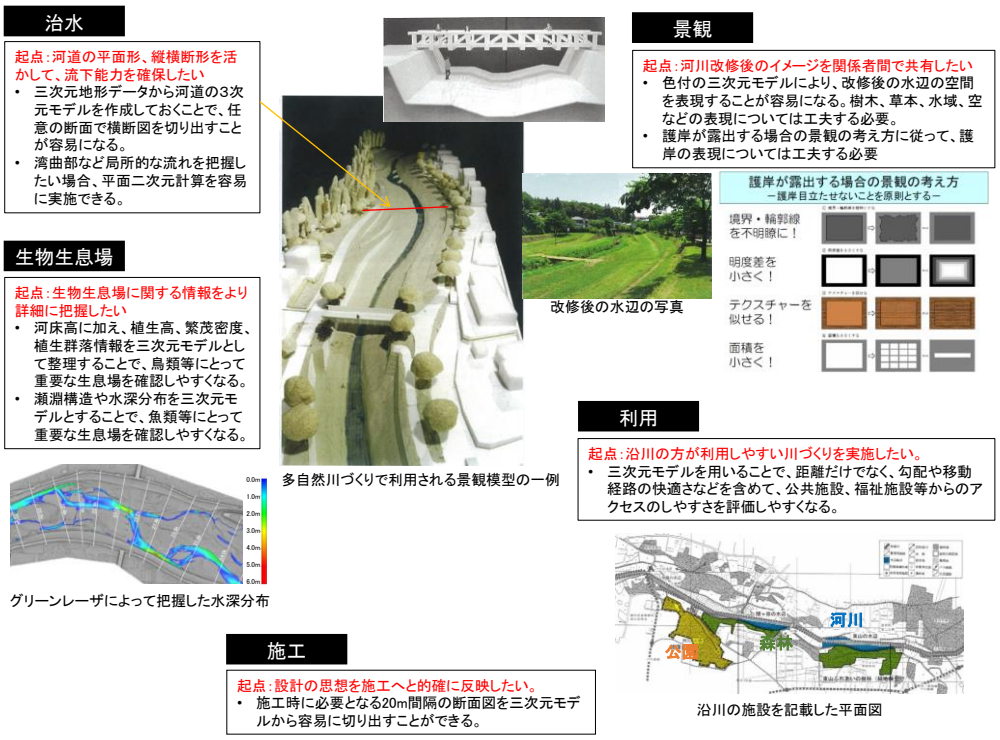
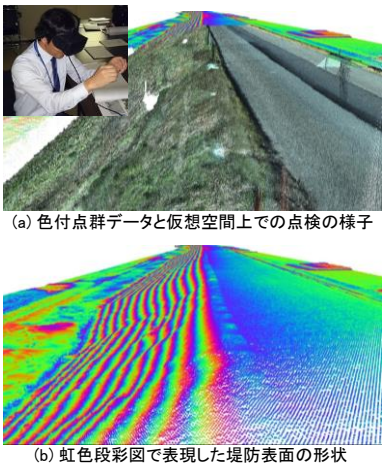


Fig. 2 Image of utilization of topography / structure models in Nature-oriented River Management (river version CIM)

space or add additional information to real space, such as VR (Virtual Reality), AR (Augmented Reality), and MR (Mixed Reality). Three-dimensional topographic data has high affinity with such technologies.

Figure 3 expresses models of topography etc. as colored point group and gradient tints diagram using the photos of levee surface taken by large weeder and results of laser survey. Rainbow color gradient tints diagram is a mode of expression that makes easier to check concavo-convex on the levee surface by repeating the colors of contour lines. If deformation is checked on virtual space using a VR head set in advance of levee inspection, on-site inspection will be efficient and failure to detect deformation is expected to decrease.

Models of topography etc. are expected to be used in many scenes, such as consensus building, evaluation of organism habitat, and study of waste soil disposal. When outline of a river project is explained to community people, it will be possible for each resident to see topography (landscape) after renovation, spatial relationship with their homes, etc. In evaluation of organism habitats, it will be possible to easily recognize the positions and shapes of riffle pools, wands, former flow channels, etc. from topographical information with high space resolution, which is expected to lead to meticulous development of rivers, such as consideration for important organism habitats. In addition, for treatment a large amount of sediment generated in channel excavation, which is sometimes difficult, it will be possible to estimate the amount of surplus soil provisionally in the design phase to consider treatment thereof in early stage, which is expected to lead to planning of construction projects with high effectiveness. We intend to extend the possibility of utilization of three-dimensional topographic data to contribute to better river development in cooperation with Regional Development Bureaus, etc.


(a) 色付点群データと仮想空間上での点検の様子

(b) 虹色段彩図で表現した堤防表面の形状

Fig. 3 Levee inspection on virtual space

☞See the following for details.

1) MLIT CIM Introduction Promotion Committee: CIM Introduction Guidelines (draft), Part I, Common Part, p.4, March 2017

Systematization of Methods for Considering Water Quality Improvement in Dam Reservoirs

(Study period: Fiscal 2015 and 2017)

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Water Cycle Division, River Department

Keywords: *dam reservoir, water quality improvement, PDCA cycle, eutrophication, long-term persistence of turbid water, cold/hot water phenomenon*

1. Introduction

In dam reservoirs, a phenomenon of water quality change may cause a problem. According to a survey in fiscal 2015, about 30% of the dam sites do not satisfy the environmental standards and eutrophication phenomena, such as microcystis, were confirmed in about 40% of the dam reservoirs.

In order to advance water quality improvement measures more accurately and efficiently in the severe financial status, it is required to organize the findings and know-how accumulated on water quality improvement measures, points of attention in introduction, etc. and systematize them for utilization.

Photo 1: Example of water quality change phenomena in the dam reservoir (Left: Eutrophication, Right: Long-term persistence of turbid water)

2. Systematization of water quality improvement method for dam reservoir

This study identified and systematized the common study process to the water quality improvement measures for dam reservoirs and organized basic concepts of the measures under the conditions where hydraulic / hydrologic and inflow load characteristics, social environmental characteristics of the basin, water quality improvement levels required, urgency of response to water quality problems, etc. are different according to dams.

The basic frame of water quality improvement measures is shown in Figure 1 System chart (proposal). The measures are roughly classified into three processes: "Emergency response process", "Countermeasure study / implementation process", and "Maintenance process."

2.1. Emergency response process

"Emergency response process" shows the flow of emergency response in the event of water quality change phenomena. This process determines the necessity for emergency response based on recognition of the situation and whether to shift to "Countermeasure study / implementation process."

2.2. Countermeasure study / implementation process

"Countermeasure study / implementation process" shows the flow for implementing water quality improvement measures and verifying the effect after implementation. After estimation of the factors causing water quality change phenomena, necessity for countermeasure implementation is determined, method and operation rules for water quality improvement measures are considered, and monitoring survey plans are formulated.

2.3. Maintenance process

Maintenance process shows a flow for confirming whether continuous effect is produced from the water quality improvement measures implemented in the countermeasure study / implementation process and for implementing efficient operation and monitoring survey. This process periodically verifies the effect of water quality improvement measures and considers, as needed, operation of countermeasures, efficiency increase of countermeasure facilities, etc.

Additionally, in each process, "Utilization of cooperation / advice", "Hearing of opinions from dam management follow-up, etc.", and "Provision of information" on dam management status etc. to citizens and basin stakeholders are positioned, including cooperation with basin stakeholders and guidance / advice from academic experts, etc. Further, PDCA cycle is adopted in each process to look back on the consideration by returning to the step as needed according to situations if the effectiveness of water quality improvement measures was not confirmed or if a different water quality change phenomenon occurred.

3. Future activities

We plan to prepare and publish a guide based on this system chart in cooperation with the MLIT.

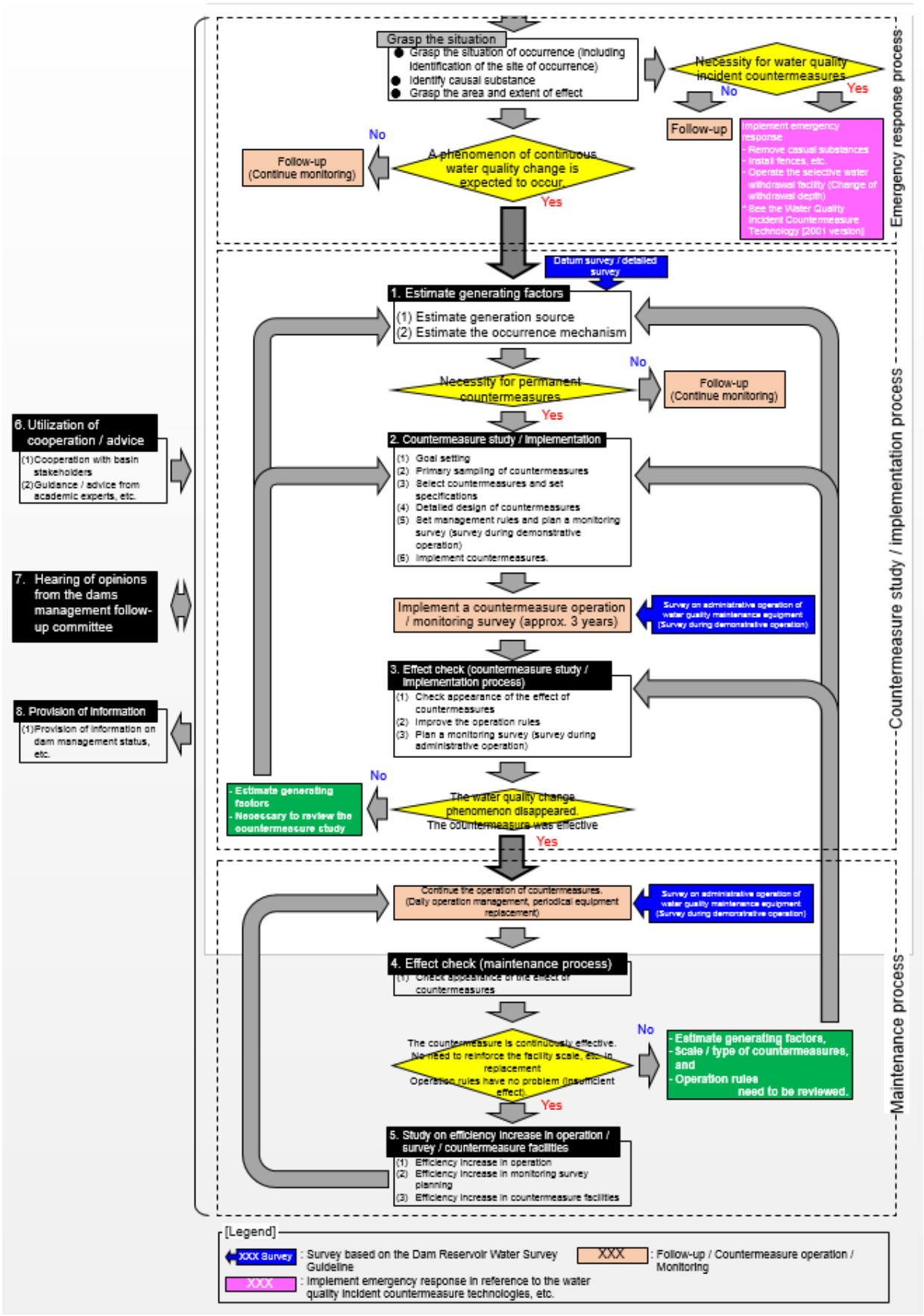


Figure 1: System chart for considering water quality improvement in dam reservoirs (proposal)

Analysis of inspection outcomes of civil engineering structures (large culvert and jets)

Toshiaki MABUCHI, Head Kazuo FUJIYAMA, Senior Researcher Kazuhiro MORIMOTO, Senior Researcher Takashi KIMURA, Researcher Yuki UEHARA, Researcher
Foundation, Tunnel and Substructures Division, Road Structures Department

Keywords: Civil engineering structure, robustness, regular inspection

1. Introduction

Among civil engineering structures on roads, the regular inspection procedures for large culverts and sheds were reported in 2014, and these structures are being inspected based on the procedures.

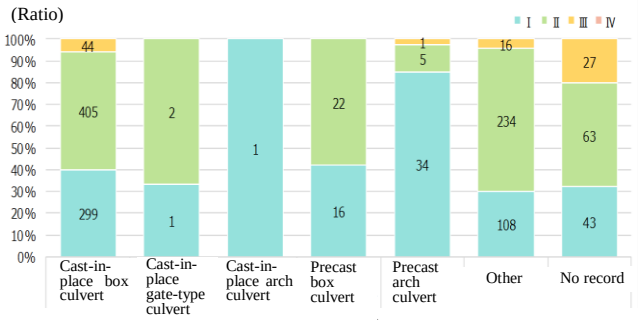
NILIM is analyzing the outcomes of the regular inspections to identify the tendency for damage on already constructed structures to improve the reliability and efficiency of regular inspections.

2. Characteristics of damage on already constructed civil engineering structures on roads

The authors organized the outcomes of regular inspections conducted in 2014 and 2015 at 646 large culverts and 289 sheds on national roads managed by the national government.

Among the large culverts, about 40% were categorized as robustness I (robust), about 50% robustness II (preventive maintenance phase), and about 10% robustness III (early implementation of measures phase). No facility was categorized as robustness IV (urgent measures phase). The relationship between structural styles and robustness was organized to improve the efficiency of inspections based on structural styles (figure 1). Some structural styles were not categorized in robustness III, but such structures were available in small numbers, and the ratio of robustness may vary depending on the outcomes of future inspection outcomes. Thus, the accumulation of more inspection outcomes is needed.

Meanwhile, about 10% of the sheds were evaluated as robustness I, about 40% as robustness II, and about 50% as robustness III. No shed facility was evaluated as robustness IV. The relationship between structural styles and the diagnosis of the robustness of materials, including RC, PC, and steel (figure 2), shows that the ratio of robustness III is not high with RC in any of the structural styles, while the ratio of robustness III is high in the upper structure and valley-side structure of simple bridges made with PC. Among structures made with steel, the ratio of robustness III is high in the upper structure and bearing



Note) Other: Facilities with no indication of cast-in-place or precast)
No record: Facilities with no indication of structural style in inspection reports

Figure 1. Robustness by structural styles (large culvert)

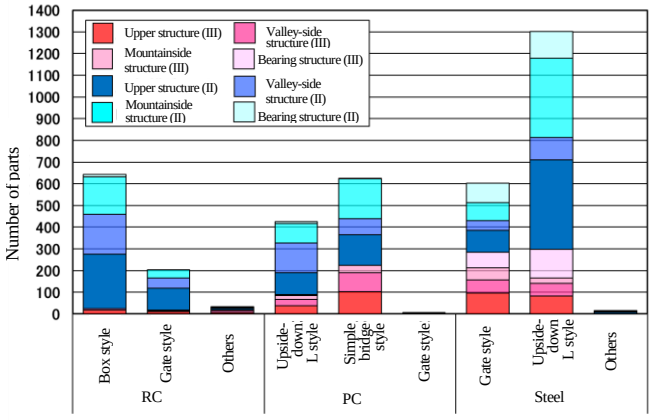


Figure 2. Robustness by structural styles (shed)

structure of gate-type structures and upside-down L-shaped structures. The ratio of robustness III tends to increase in relatively older facilities indicating that parts with damage differ depending on structural styles. Additional analysis of the tendency is needed.

3. Conclusion

Researchers are going to continue accumulating the outcomes of regular inspections and conduct analyses with higher precision to pursue the improvement of the reliability and efficiency of regular inspections for civil engineering structures.

Establishment of inspection procedure for road civil engineering structures

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Keywords: Civil engineering structure, maintenance and management, inspection

1. Introduction

The Shed and Large Culvert Regular Inspection Procedure was announced in June 2014 for the inspection of civil engineering structures on roads. In August 2017, the Road Bureau of the Ministry of Land, Infrastructure, Transport and Tourism established the Inspection Procedure for Road Civil Engineering Structures (hereinafter the "Procedure") targeting other civil engineering structures on roads. With the Procedure, inspection procedures for all civil engineering structures on roads have been announced (figure 1).

The Public Works Research Center and the National Institute for Land and Infrastructure Management were involved with the establishment of the Procedure in examinations for drafts, such as the organization of the viewpoints of inspections and ideas concerning the diagnosis of robustness based on findings through past research.

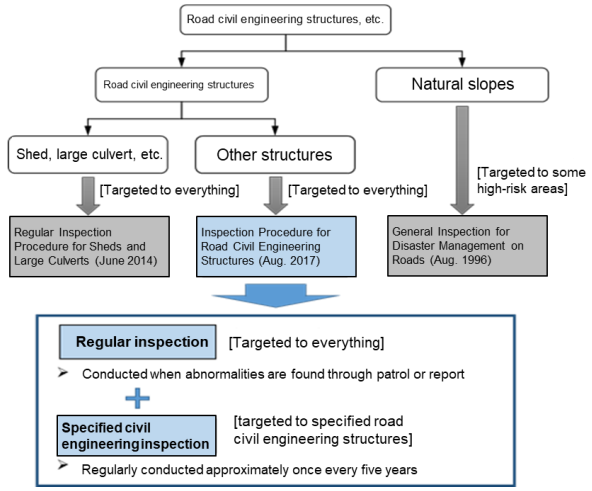

Figure 1. Position of the Inspection Procedures for Road Civil Engineering Structures

2. Outline of the inspection of road civil engineering structures

The objective of this inspection is to determine the necessity of maintenance or repairs by checking for any abnormal conditions to improve the safety of civil engineering structures on roads and to efficiently conduct maintenance and repairs.

The inspection includes a regular inspection targeting all structures and a specified civil engineering inspection targeting structures, such as long and large cutout and tall embankments that have great social effects if a large-scale collapse occurs (specified road civil engineering structures).

The specified civil engineering inspections are regularly conducted at set intervals to assess the robustness of structures. It is also important that inspectors are familiar with the forms of damage that can occur to road civil engineering structures and disasters that occur from ground conditions.

The diagnosis of robustness within the specified civil engineering inspection is conducted based on categories I to IV as shown in table 1.

Table 1. Robustness diagnosis

Diagnosis category	Detail of assessment
I. Robust	No abnormality is found. Even when an abnormality is found, it does not require repairs. (A condition in which road functions are not affected.)
II. Observation stage	Abnormality is found, and the observation of the progress of the abnormality is necessary for a certain period. (A condition in which road functions are not affected, but more detailed investigations, regular observation, or other measures are required.)
III. Early repairs stage	Abnormality is found and should be repaired as soon as possible because the abnormality is expected to exacerbate until the next inspection and may trigger a structural collapse. (A condition in which road functions are not affected, but some impediment may occur until the next inspection, and the condition should be repaired as soon as possible.)
IV. Urgent repairs stage	A significant abnormality is found and expected to cause a major collapse requiring immediate repairs. (A condition in which road functions are being affected or highly likely to be affected, and immediate repairing is required.)

The Procedure also stipulates that the proper method and time for conducting the necessary repairs shall be determined on the basis of the outcome of the robustness diagnosis and that the outcomes of inspection, diagnosis, and measures shall be recorded and kept for the duration in which the applicable road civil engineering structures are in service.

3. Summary

The authors expect that road civil engineering structures that are under the strong influence of natural conditions and disasters, such as rain and earthquakes, are properly maintained and repaired at the proper times from the viewpoint of preventing disasters and providing efficient maintenance and repairs using the inspection diagnosis of the Procedure.

☞For detailed information

1) Inspection Procedure for Road Civil Engineering Structures
http://www.mlit.go.jp/road/sisaku/yobohozen/tenken/ty_h2908.pdf

Result of the regular inspection of road tunnels

(Research period: FY 2015–2019)

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Keywords: Tunnel, regular inspection, category of abnormality

1. Objective of this study

The National Institute for Land and Infrastructure Management is examining ways to improve the efficiency of the inspection of road tunnels and rational designs, construction, and the methods of maintenance and management of tunnels based on the outcomes of inspections. This paper describes the analysis of the conditions of deterioration and damage and their tendencies based on the results of regular inspections conducted on road tunnels of national roads in FY 2014 and 2015 focusing on tunnels constructed with the sheet piling method (mainstream up to the 1980s) and NATM (upstream after the 1980s), which account for the majority of road tunnels in Japan.

2. Details of the study

This study focused on records of abnormalities (a general term for deterioration) in the concrete lining (walls and ceiling inside tunnels) among the results of regular inspections of road tunnels.

Abnormalities are categorized into three types, including external force, deterioration of materials, and water leaks. They are also categorized into five levels of countermeasures, including I, IIb, IIa, III, and IV (IV being the worst condition).

To identify the number of years since the construction of a tunnel and conditions of abnormalities, the authors divided the number of years by decade and organized the conditions of recorded abnormalities by individual categories of abnormalities (figure 1). Since abnormalities in category I indicate conditions that do not require any repair, category I was removed from the data processing. The study targeted abnormalities in IIb or worse conditions. Since the number of abnormalities varied depending on the number of tunnels and number of years since construction, the numbers were processed as the number of abnormalities per 100 meters of tunnels.

Figure 1 indicates that the number of abnormalities per 100 meters increase with the number of years since construction for both the sheet piling method and NATM. In particular, the numbers of abnormalities have significantly increased in the group of sheet piling aged 31 to 40 years and the group of NATM aged 21 to 30 years compared to younger age groups in each construction type.

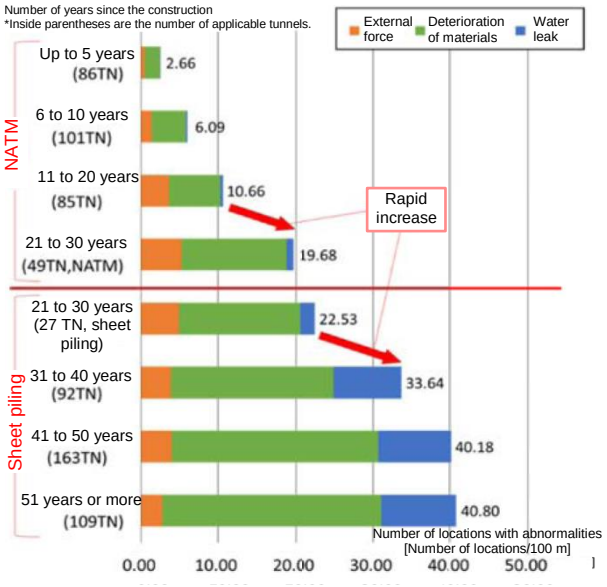

Figure 1: Conditions of abnormalities in category IIb or worse conditions

Possible causes of this phenomenon include technological development and the effect of changes in social situations.

Material deterioration (green) accounts for the majority in the category of abnormalities in both the sheet piling method and NATM. Abnormalities of water leaks (blue) occurred significantly in tunnels constructed with the sheet piling method. In particular, tunnels older than 31 years accounted for about a quarter of all abnormalities. One of the causes is that the sheet piling method does not provide waterproofing.

4. In the end

The authors are going to continue inspections and studies to improve the efficiency of regular inspections of tunnels based on analyses using the results of regular inspections of road tunnels.

☞For detailed information

1) Road Tunnel Regular Inspection Procedures (June 2014, National Highway and Risk Management Division, Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism)
http://www.mlit.go.jp/road/ir/ir-council/pdf/yobo3_1_9.pdf

Promotion of research on the maintenance of social capital

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Maintenance Research Promotion Headquarters

Keywords: Social capital, maintenance, continuity, management

1. Introduction

As social capital is becoming older, plans to elongate service lives are being established based on the concept of preventive maintenance in individual fields of social capital. In addition, studies are rigorously being conducted on inspections, diagnoses, countermeasures, and databases to properly implement maintenance. With the progress of these activities, the importance of common issues in individual fields, such as ensuring the continuity of the PDCA cycle of maintenance, is likely to increase.

Under such recognition, the National Institute for Land and Infrastructure Management (NILIM) is promoting technological development on maintenance in individual fields. At the same time, the NILIM is also solving common problems of maintenance in general, including the direction of studies on maintenance and the setup of issues with high priorities.

2. Improvement of management in maintenance

In regards to the framework to continue management in maintenance, the authors organized the framework consisting of three levels (figure 1) and improved it by creating evaluation categories in individual levels for the roads, rivers, and sewage as self-inspection check sheets as a trial.

In FY 2017, the authors reflected outcomes of these activities in the management of pavement based on pavement inspection procedures.

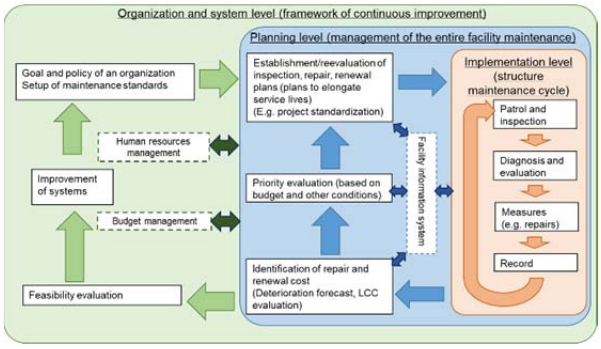

Figure 1: The framework of maintenance and management

3. Use of information in maintenance

The authors evaluated the development of technologies to accumulate and use information to improve the efficiency of and advance the maintenance of social capital that was conducted from FY 2013 to 2016.

Also, studies are being conducted to improve the efficiency of and advance maintenance using CIM based on on-site needs and scenes of uses (figure 2).

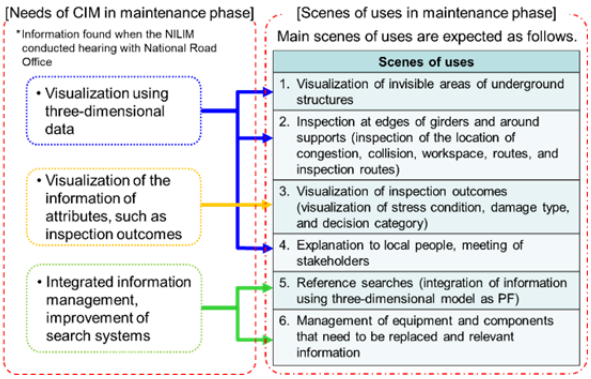

Figure 2: Use of CIM in maintenance phase

4. Future outlook

As five years have passed since 2013 that was positioned as the first year of the maintenance policy, the Ministry of Land, Infrastructure, Transport and Tourism started the Social Capital Maintenance Strategy Subcommittee (third period) installed under the Technology Group, Technology Committee, Social Capital Development Council/Transportation Policy Council in December 2017. The subcommittee has been reviewing the progress of policies and past activities and planning the directions of future activities.

The NILIM also continues to identify on-site challenges, needs, and the latest technological trends and review past studies to conduct research and development and provide technical instructions in the field of maintenance. The NILIM is going to transmit the information of outcomes and the progress of these activities to the outside of the NILIM.

Promotion of Global Warming Countermeasures in Sewerage (Study period: FY2017 to FY2019)

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Keywords: sewerage, global warming, nitrous oxide

1. Introduction

As global warming countermeasures in sewerage, NILIM has been studying on how to grasp and reduce emissions of nitrous oxide ("N_2O"), one of the greenhouse gases.

2. Field survey on N_2O emissions in sewage treatment facilities

It is known that N_2O is generated as by-product or intermediate material when household effluent is biologically treated in sewage treatment facilities. There are a number of sewage treatment methods available and the amount of N_2O emitted in treatment process differs according to methods as known from the results of field surveys. Particularly in the advanced treatment method and MBR method, which both have a high nitrogen removal rate, the level of N_2O emissions is low and stable, while in the conventional activated sludge process (the "conventional process"), emissions differ according to treatment facilities and are higher than other treatment methods. Hence, with focus on the conventional process, in which emissions are relatively large, it is necessary to examine the relationship between operating conditions and N_2O emissions and take countermeasures. For this fiscal year, we are conducting a field survey for sewage treatment facilities that have adopted the staged advanced treatment operation, which is one of the operation control measures for improving water quality while using conventional process facilities. The result of this survey shows that N_2O emission factor and N_2O conversion factor in the staged advanced treatment operation are lower than those of the conventional process in the existing knowledge, which suggests a possibility of reduced N_2O generation. It is expected from this result that the staged advanced treatment operation has an effect on the control of N_2O emissions in the conventional process.

3. Study on operation with reduced N_2O emissions in the conventional process

In order to examine operation with reduced N_2O emissions for the conventional process, which accompanies particularly high emissions, we are investigating the relationship between operating conditions and N_2O emissions with a test using an experimental device (bench reactor) imitating the conventional process. As a result of considering the pre-aeration limitation operation (RUNA) and the nitrification-suppressed operation (RUND) as an operating condition, reduction of N_2O emissions was confirmed (Figure). In the pre-aeration limitation operation, insufficient nitrification in the aeration tank leading to post-aeration was suppressed since nitrous acid generated through nitrification was consumed promptly due to the proceeding denitrification in the pre-aeration limitation tank and organic matter was consumed through denitrification. It is consequently considered that nitrous acid accumulation in the system was reduced and N_2O generation on the whole was controlled. Hence, operation incorporating denitrification process in the conventional process is considered effective for reducing N_2O emissions.

4. Future issues

It was found how to prevent accumulation of nitrous acid in operation is important to reduce N_2O emissions in the conventional process. For establishment of appropriate operating methods according to various environmental conditions, it is necessary to organize microorganisms related to metabolism and operation control factors and clarify the control mechanism and we are going to work for clarification.

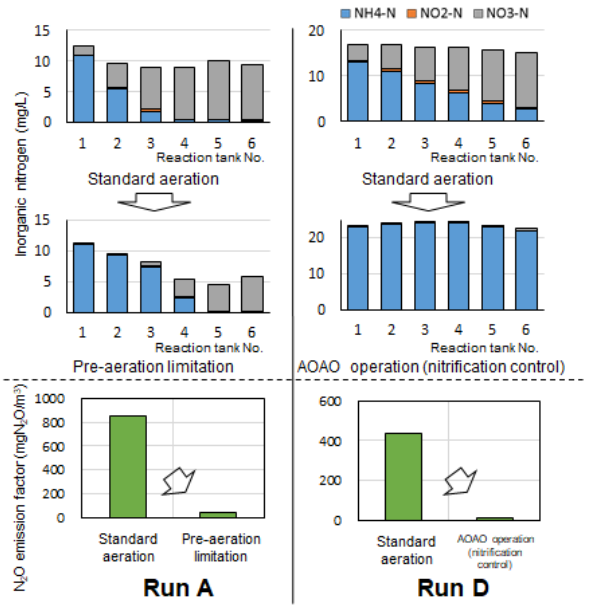

Figure: N_2O emission factors and behavior of inorganic nitrogen during different operation using the bench scale reactor

Formulation of Guidelines for B-DASH Project (CO_2 separation / recovery / utilization, use of recycled water) (Study period: Fiscal 2015 and 2016)

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Keywords: effective use of sewage resources, CO_2 utilization, use of recycled water, innovative technology

1. Introduction

Sewerage is 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 sought as well as measures for greenhouse gas reduction. For the effective use of sewage resources, 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 Systems Engineering Vision Acceleration Strategy" (August 2017, Sewerage and Wastewater Management Department, Ministry of Land, Infrastructure, Transport and Tourism ("MLIT") also considers important efficient utilization of sewage resources (carbon dioxide, recycled water, etc.) and "improvement of added value by utilization of sewerage" based on such efficient use.

New technologies responding to such social and administration needs have begun to be developed but are less used in practice since many sewerage service providers are cautious about introduction. For this reason, the Sewerage and Wastewater Management Department of 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 verify excellent innovative technologies and formulate guidelines for introducing them and then disseminate this technology in order to realize cost reduction in sewerage service, creation of renewable energy, etc.

2. 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 guidelines (proposal) are composed as follows (**Table 1**). Next section hereof introduces a part of the content of the guidelines, including the outline of demonstration projects.

Table 1: Composition of Guidelines (proposal)

Chapter 1. General Provisions	Objective, scope of application, definitions of terms
Chapter 2. Outline of the Technology	Characteristics of the technologies, conditions of application, evaluation results
Chapter 3. Consideration of Introduction	Introduction examination method, examples for examination of introduction effect
Chapter 4. Planning and Design	Introduction plan, design
Chapter 5. Maintenance	Check items, frequency, etc.
Reference Data	Verification results, case study, etc.

3. Outline of the demonstrated technologies, etc.

(1) Empirical study on the technology for separation / recovery of CO_2 in biogas and application to microalgae culture (Joint Research Organization of Toshiba Corp., Euglena Co., Ltd., Nikkan Tokushu Co., Ltd., Nihon Suido Consultants Co., Ltd., Japan Sewage Works Agency, and Saga City)

This study demonstrated the performance of CO_2 separation / recovery, performance of producing microalgae, performance of removing nitrogen and phosphorus in dehydrated separated liquid, business potential of the entire system, etc. by separating / recovering CO_2 from biogas and culturing microalgae (euglena) using the recovered CO_2 and dehydrated separated liquid, etc. (Figure 1)

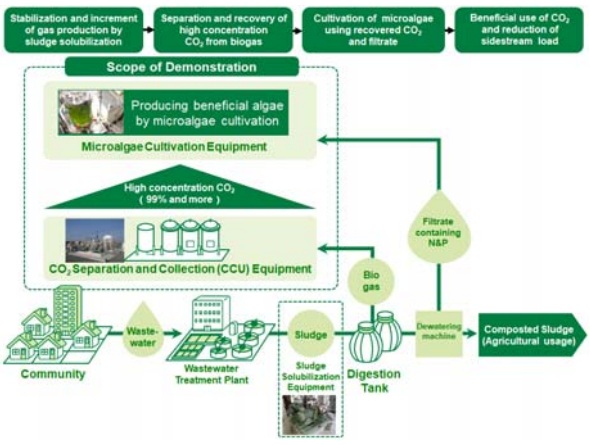

Figure 1: Technologies for CO_2 separation / recovery and application to culture of microalgae

Note that euglena is expected to be used as foodstuff, coloring matter, biofuel, etc. Considering such usability, we used euglena as microalgae in this empirical study.
In the "CO_2 separation / recovery technology," we verified that high concentration CO_2 (99% or more) is recoverable from biogas. With regard to "microalgae culture facilities," we also verified that culture of microalgae (euglena) is possible using CO_2 there and nitrogen / phosphorus in dehydrated separated liquid. We further verified that generation of biogas will increase by annexing "sludge solubilization facility." It is estimated from the trial calculation that when this technology is applied to a treatment facility capable to process 50,000 m^3/day, about 130 tons/year will be used effectively and about 75 tons of microalgae are producible.
This technology is expected to lead to shift in thinking from "Reduce CO_2" to "Utilize CO_2," and further contribution of future sewerage service to recycling society is expected from this technology.

(2) Empirical study on the regeneration system for sewage treatment water (Joint Research Organization of Nishihara Environment Co., Ltd., Tokyo Engineering Consultants Co., Ltd., Kyoto University, and Itoman City).
As a technology for supplying safe, stable and highly reliable sewage treatment water at low cost with energy saving by reducing pathogen risk on humans by virus etc. through combination of filtration with UF membrane (filtration membrane with pore size of 0.01 μm) and ultraviolet disinfection, we verified virus removal performance, life cycle cost, greenhouse gas emissions, etc. (**Figure 2**)
This technology is based on the combination of filtration with UF membrane (ultra-filtration) and ultraviolet disinfection. We set target assessment values for virus infection risk assuming the use of treatment water in urban areas where people may contact with the water and the use as agricultural

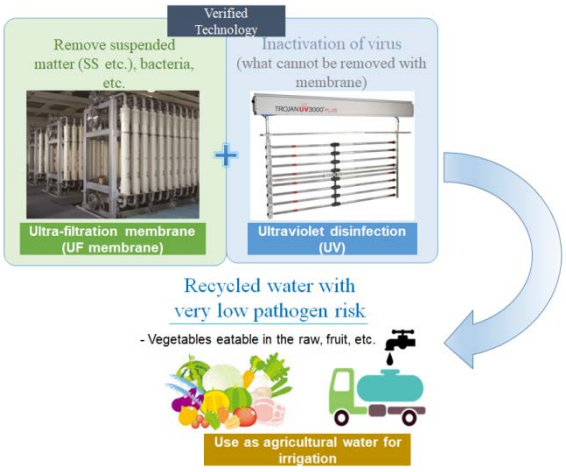

Figure 2: Flow of the recycling system

water for irrigation, and verified that target values can be achieved. It was also verified that life cycle cost and greenhouse gas emissions can be reduced 13.0% and 20.6% respectively more than the reduction by conventional technology (flocculant-added sand filtration + ultraviolet disinfection). In addition, we verified the operation management method to secure the reliability of the entire system.
This technology effectively uses the water potential of sewerage in areas where the supply and demand of water resources are tight, and is expected to contribute to establishment of a society that creates abundant water environment and new values through cooperation with various fields.

4. Utilization of results and future development

NILIM established guidelines based on the results of verification and, in order to introduce these guidelines to local governments and sewerage-related enterprises, etc., held the Guidelines Presentation at Tokyo Big Sight in August 2017, attended by about 80 people. Through the holding of such presentation etc., we intend to actively introduce the guidelines to disseminate the technology.

Photo: Guidelines presentation

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

Empirical Study on B-DASH Project (Technology for utilization of local production for local consumption type energy by high efficiency digestion system, Global warming countermeasure type sludge combustion technology, Technology for improving sewage treatment capacity at low cost)

(Study period: from FY2017)
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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 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. We also started to study further six technologies in fiscal 2017.

Of these six technologies newly studied, this paper introduces the outlines of three empirical studies --- "Empirical study on practical use of the technology for utilization of local production for local consumption type energy by high efficiency digestion system," "Empirical study on the generation type sludge combustion technology considering greenhouse gas reduction," and "Empirical study on the technology for improving the treatment capacity of final settling tank."

2. Outline of the empirical study on practical use of the technology for utilization of local production for local consumption type energy by high efficiency digestion system (Joint Research Organization of Mitsubishi Kakoki Kaisha, Ltd., Kyushu University, Japan Sewage Works Agency, and Karatsu City)

In the sewerage service, concentration of resource energy and formation of energy supply center are required, as well as utilization of unused biomass and establishment of a local production for local consumption type energy system.

For this reason, this empirical study demonstrates the effect of improvement in processing performance, energy recovery rate, etc. with regard to utilization of unused biomass such as garbage, non-powered digester stirring device, solubilization equipment that increases biogas generation, and high-efficiency digestion system in combination of fuel cells with high generation efficiency.

Specifically, demonstration facilities are prepared to study the effect of improving the maintenability of non-powered stirring type digester and of reducing running cost, effect of improving digestibility and increasing biogas with high-efficiency heating equipment (solubilization equipment), effect of enhancing the generation efficiency with solid oxide fuel cell (SOFC) not requiring precious metal as an electrode catalyst, etc.

Demonstration and introduction of this technology is expected to lead to LCC reduction due to decrease in sludge emissions and stirring power, increase in biogas by concentration of local biomass and sludge, reduction of sludge disposal cost, improvement of energy self-sufficiency rate, etc.

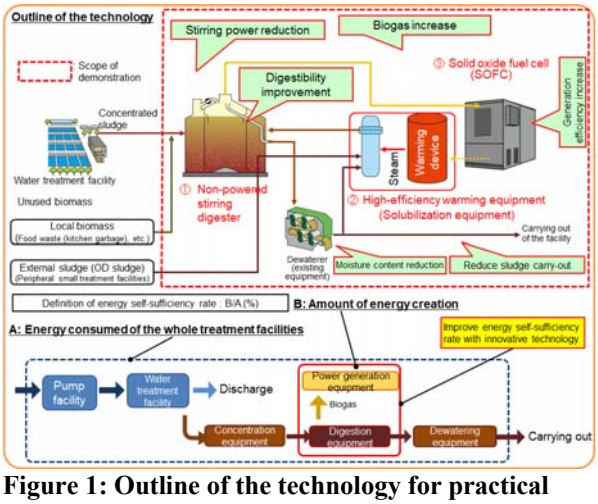

Figure 1: Outline of the technology for practical use of the technology for utilization of local production for local consumption type energy by

high efficiency digestion system

3. Outline of the empirical study on the generation type sludge combustion technology considering greenhouse gas reduction (Joint Research Organization of JFE Engineering Corporation, Japan Sewage Works Agency, and Kawasaki City)

As the Act concerning the Promotion of the Measures to Cope with Global Warming (Global Warming Prevention Act) was enforced, reduction of greenhouse gas emissions is becoming required. For the sewerage service, reduction of CO_2 emissions deriving from power consumption and N_2O (global warming potential is about 300 times) emissions from sludge incinerators is required.

Accordingly, this empirical study aims to demonstrate the effect of improvement in power self-sufficiency rate and substantial reduction of greenhouse gas emissions is produced from combination of the high efficiency power generation technology utilizing unused waste heat from the sludge incinerator and the local stirring air blowing technology applicable to existing sludge incinerators (fluidized bed).

Specifically, demonstration facilities are prepared to study the effect of improvement in generation efficiency by adopting a high-efficiency small condensation type turbine and a condenser that uses sewage treatment water as cooling water, the effect of reducing N_2O emissions with the local stirring air blowing technology enabling space-saving installation and not requiring complicated management of piping, etc.

Demonstration and introduction of this technology is expected to lead to reduction of energy consumption and greenhouse gas emissions, etc.

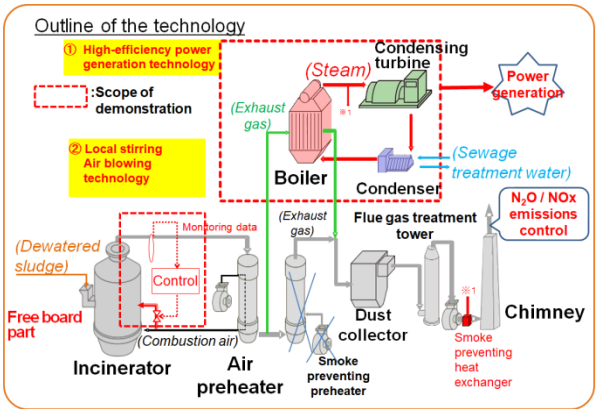

Figure 2: Outline of the generation type sludge combustion technology considering greenhouse gas reduction

4. Outline of the 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)

Time to renew sewage treatment facilities is approaching for many local governments, which are faced with the issues of depopulation, financial deterioration, etc. and technology for renewal to sewage treatment facilities that can handle changes in the amount of treatment water at low cost.

This empirical study therefore aims to demonstrate a technology for improving treatment capacity quantitatively or qualitatively at low cost by installing a filtration component and using the existing final settling tank body without adding a final settling tank, and to establish a new sludge management method available for considering applicability of the technology, etc.

Specifically, demonstration facilities are prepared by installing easily maintainable filtration equipment in the existing final settling tank in order to study (i) the effect of improving quantitative performance to double treatment capacity without degrading the quality of treated water, (ii) the effect of improving qualitative performance to realize the quality of treated water similar to that of rapid filtration in the designed volume of treatment water, (iii) derivation of an expression to predict the height of final settling tank sludge interface using a new sludge settlement volume index (SSVI) for examination of applicability of this technology, (iv) applicability to operation management, etc.

Demonstration and introduction of this technology is expected to lead to prevention of water quality deterioration by increase in treatment capacity, improvement in sewage treatment capacity using existing facilities, etc.

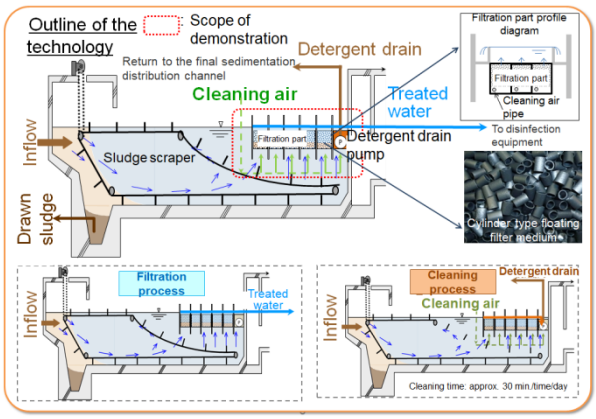

Figure 3: Outline of the technology for improving the processing capacity of final settling tanks

5. Future development

NILIM is going to continue to lead the empirical studies and 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

A Study on B-DASH Project (hydrogen production without digestive, sewage sludge intra-regional circulation system, energy-saving advanced sewage treatment, volume reduction of excess sludge)

(Study period: from FY2016)

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

1. Introduction

Sewerage is social capital essential to public life and measures for reducing greenhouse gases are also sought as response to the issue 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 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 verification and dissemination of excellent innovative technologies and to support the overseas development of the water business by Japanese enterprises.

B-DASH Project 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 consider the possibility of dissemination including an introductory effect and verify technical performance.

This paper introduces the outlines of "Hydrogen production technology without digestive", adopted for FS survey in fiscal 2016, and "Technology for sewage sludge intra-regional circulation system," "Energy-saving advanced sewage treatment technology," and "Technology for excess sludge volume reduction," which were all adopted for FS survey in fiscal 2017.

2. Outline of FS survey adopted in fiscal 2016

(1) Hydrogen production technology without digestive

(i) Outline of the study on the technology of producing hydrogen directly from sewage sludge (Joint Research Organization of Tohoku University, Carbon Freenet Work, Yamato Sanko Mfg. Co., Ltd., and Hirosaki-shi)

Improvement of hydrogen production, reduction of life cycle cost, etc. are under verification for the technology of producing hydrogen successively from sewage sludge using nickel hydroxide and calcium hydroxide.

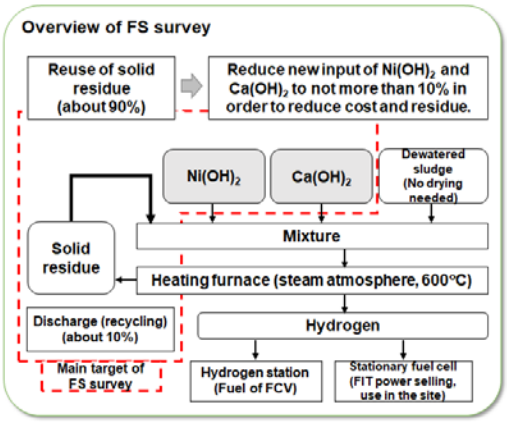


Figure 1: Flow of the hydrogen production technology using nickel hydroxide and calcium hydroxide

(ii) Outline of the study on the hydrogen production system technology using the salinity difference between sewage treatment water and sea water (Joint Research Organization of Yamaguchi University, Seiko Electric Co., Ltd., Japan Sewage Works Agency)

Improvement of hydrogen production and purity, reduction of life cycle cost, etc. are under verification for the new hydrogen production technology using the salinity difference between sewage treatment water and sea water, site conditions of sewage treatment facilities, and potential of sewage treatment water.

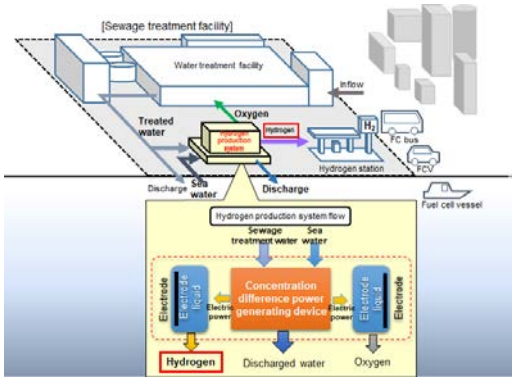


Figure 2: Flow of the hydrogen producton technology using salinity difference

3. Outline of 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 (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.

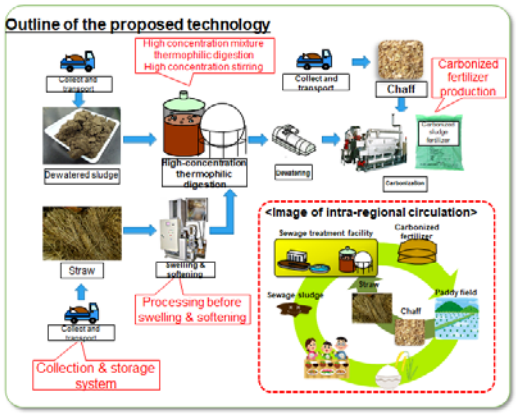


Figure 3: Flow of the intra-regional circulation system technology

(2) Energy-saving advanced sewage treatment technology

Outline of the research and study on the energy-saving advanced sewage treatment technology using anammox bacteria (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 energy usage by removing nitrogen efficiently by treatment using anammox bacteria to reduce energy consumption and recovering energy from organic matter contained in sewage sludge more efficiently.

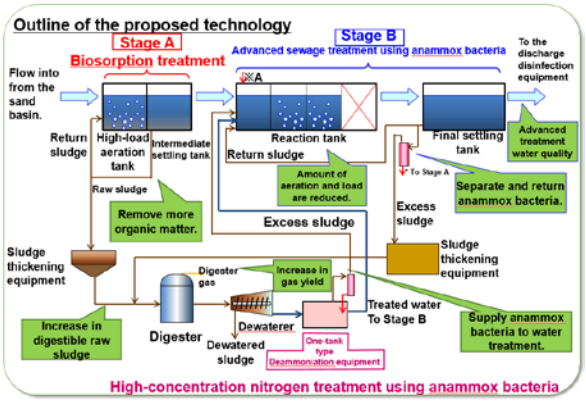


Figure 4: Flow of the energy-saving advanced sewage treatment technology

(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 (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 oxyecoia supply is under verification and business profitability is under evaluation by introducing high-pressure jet equipment that reduces excess sludge at low cost and high speed into the flocculant addition / nitrified liquid circulation activated sludge system

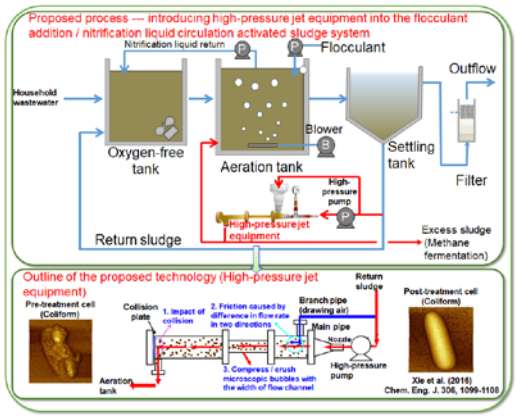


Figure 5: Flow of the excess sludge volume reduction technology

4. Future development

NILIM is going to continue to lead the FS survey and idenitfy 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

A Study on B-DASH Project (gas collection, sludge dewatering / drying, water treatment for downsizing)

(Study period: from FY2015)

YAMASHITA Hiromasa, Head OTA Taichi, Senior Researcher YAMOTO Takatoshi, Researcher
MICHINAKA Atsuko, Researcher (Dr. Env.) FUJII Tsuyako, Researcher
ISHIKAWA Takeshi, Researcher WATANABE Kosuke, Guest Research Engineer
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 social capital essential to public life and measures for reducing greenhouse gases are also sought as response to the issue of global warming. There are also high needs for technologies that can be introduced to small-to-medium sized treatment facilities and technologies for downsizing treatment facilities according to depopulation.

For this reason, the Sewerage and Waste Water Management Department of 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 verification and dissemination of excellent innovative technologies and to support the overseas development of the water business by Japanese enterprises.

This paper introduces the outlines of "Technology for efficient collection / utilization of biogas from multiple sewage treatment facilities," adopted in fiscal 2015 as real scale demonstration, and "Technology for effective use of sewage sludge for small-and-medium-sized treatment facilities" and "Water treatment technology that enables downsizing," both adopted in 2016 as real scale demonstration.

2. Outline of the real-scale demonstration technologies adopted in fiscal 2015

(1) Technology for efficient collection / utilization of biogas from multiple sewage treatment facilities

Empirical study on the technology on practical collection using a methane refiner and an 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 Town, Mashiki Town and Yamaga City)

This study aims to demonstrate the effects of promotion of effective use of sewage resources, energy production at low cost, etc. from power generation using surplus biogas in small-scale sewage treatment facilities at three locations, which are refined and kept in occlusion containers and conveyed by vehicle to one location. This study continued through the Kumamoto Earthquake and the recovery of treatment facilities from the earthquake disaster.

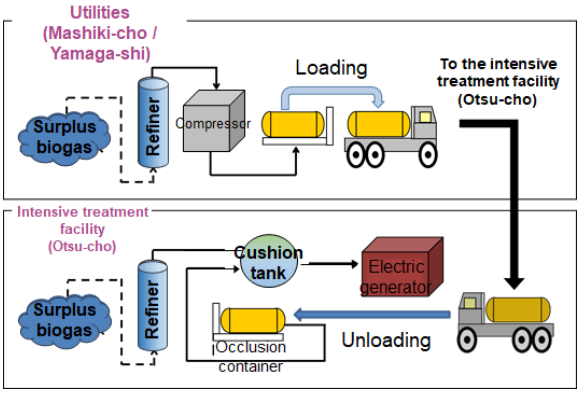


Figure 1: Flow of the technology for efficient collection / utilization of biogas from multiple sewage treatment facilities

3. Outline of the real-scale demonstration technologies adopted in fiscal 2016

(1) Technologies for effective use of sewage sludge for small-and-medium-sized treatment facilities

(i) Outline of empirical study on the highly efficient sewage sludge drying technology with self-heat recuperative heat pump (Joint Research Organization of Okawara Mfg. Co., Ltd., Hadano City and Kansai Electric Power Co., Inc.)

This study is demonstrating the reduction of the amount of sludge treatment, diversification of effective use including use as fertilizers/fuels (plant damage test, grasp of fuel needs, etc.), reduction of running cost, etc. with the aim to save energy and cost in sludge drying by recovering and utilizing thevapor latent heat in the sludge drying exhaust gas.

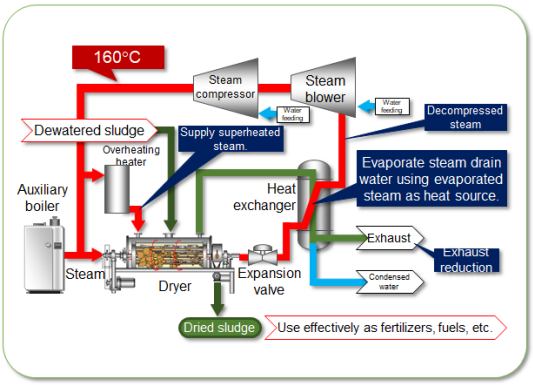


Figure 2: Flow of the highly efficient sewage sludge drying technology with self-heat recuperative heat pump

(ii) Outline of the empirical study on the technology to convert sewage sludge to fertilizers / fuels with the dewatering drying system (Joint Research Organization of Tsukishima Kikai Co., Ltd., Sun Eco Thermal Co., Ltd., Japan Sewage Works Agency, a Kanuma City, and Kanuma Agriculture Public Corporation)

This study is demonstrating adaptability to various effective uses including fertilizers and fuels by manufacturing dried sludge using the dewatering drying system (internal two-liquid thermal refining spin dryer + annular flash dryer) (fertilizer response test in a soybean field, fuel quality, etc.), as well as performance of equipment, life cycle cost reduction, etc.

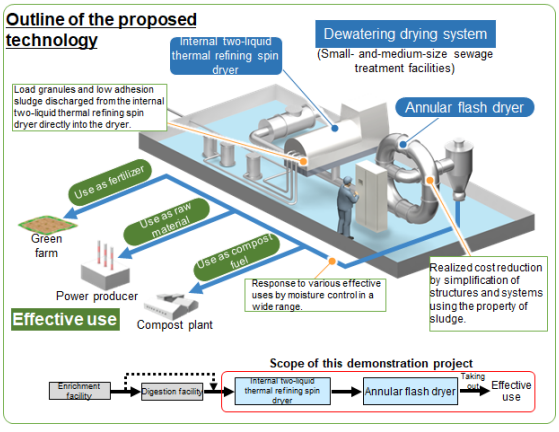


Figure 3: Flow of the technology to convert sewage sludge to fertilizers / fuels with the dewatering drying system

(2) Water treatment technology that enables downsizing

(i) Outline of the empirical study on the water treatment technology with excess sludge reduction using special fiber carrier (Joint Research Organization of IHI Environmental Engineering, Teijin Frontier Co., Ltd., Japan Sewage Works Agency, and Tatsuno-machi)

This study is demonstrating the low water temperature period, effect of sludge reduction, effect of life cycle cost reduction, etc. for the water treatment technology that enables the downsizing of sludge treatment equipment by reducing the generation of waste sludge substantially using the the multi-stage reaction tank and special fiber carrier.

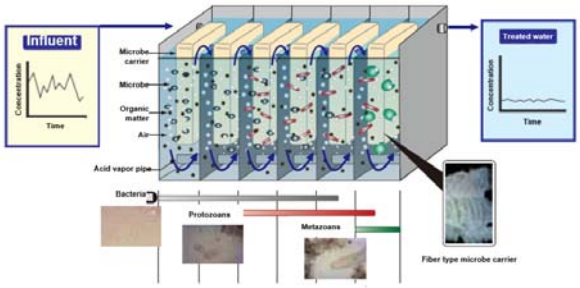


Figure 4: Flow of the water treatment technology with excess sludge reduction using special fiber carrier

(ii) Outline of the empirical study on the water treatment technology with following water amount variation using DHS system (Joint Research Organization of Sanki Engineering Co., Ltd., Tohoku University, National Institution of Technology - Kagawa College, National College of Technology - Kochi College, Japan Sewage Works Agency, and Susaki City)

This study is demonstrating the effect of reducing life cycle cost, nature of treatment cost that follows decrease in the amount of influent, ease of maintenance, and stability of processing performance for the technology that enables downsizing efficiently by combining "filter bed filled with spongy carrier (DHS filter bed)" and "biological membrane filtering tank" in order to adapt to depopulating society.

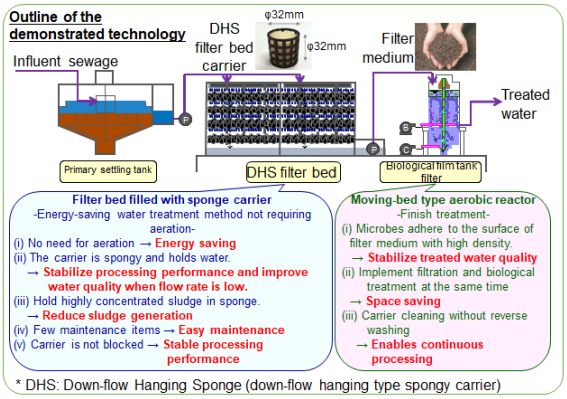


Figure 5: Flow of the water treatment technology with following water amount variation using DHS system

4. Future development

NILIM is going to continue the real-scale empirical studies and formulate successively guidelines for considering introduction based on study results and promote dissemination.

☞See the following for details.

[Reference] Website introducing B-DASH

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

Promotion of Water Treatment Technology Considering Energy / Resource Optimization and Risk Control

(Study period: from fiscal 2016)

YAMASHITA Hiromasa, Head FUJII Tsuyako, Researcher
MATSUHASHI Manabu, Researcher YAMOTO Takatoshi, Researcher
Wastewater and Sludge Management Division, Water Quality Control Department

Keywords: energy optimization, coliform, recycled water, effective use of ammonia

1. Introduction

Sewerage greatly contributes to conservation of good water environment by treating / removing organic matter, nutrients, pathogenic microorganisms, etc. in sewage, while it is urgently required to reduce a large consumption of electricity used for sewerage. Since discussion on the revision of the items in the effluent water quality standards is going on, it is also required to study the risk assessment of sewage treatment water.

2. Energy optimization in treatment process

~~Since~~ specific and actual power consumption in each treatment process in sewage treatment facilities has not been sufficiently grasped. And we organized the specifications, operational condition, etc. of individual equipment and provisionally calculated per-unit power consumption of individual equipment and power consumption of the entire treatment facilities in several cases where treatment processes, plant scales, and combination of equipment are different. Figure 1 provides the result of provisional calculation of per-unit power consumption for each equipment assuming a sewage treatment facility where average daily flow is 40,000 m^3 and conventional activated sludge process is adopted. The result showed about 30% reduction of per-unit power consumption by shifting from the basic type (case of setting a model with the maximum number of operating units for each equipment) to the energy-saving type (case of using the basic type principally and assuming the installation of an energy-saving type for reaction tank diffuser). Based on this result, we examined energy balance, etc. further considering sludge utilization for energy etc.

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 standards from the coliform group to coliform , it is necessary to change the coliform group-, one of the items of the effluent quality standards for sewage treatment facilities. In addition, since an international standards for water reuse of treated wateris under consideration, it is necessary to check domestic applicability of the standards. Accordingly, we examined the microorganism removal rate, etc. that could be indicators for hygienic risk control in sewage treatment facilities and the behavior of

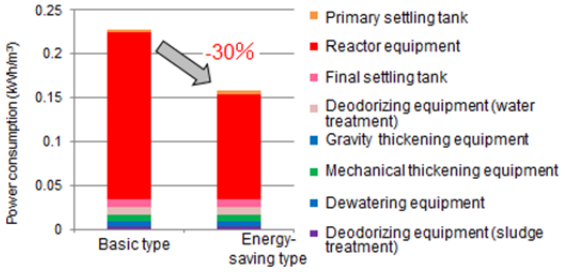


Figure 1: Result of provisional calculation of the reduction of power consumption by introducing energy-saving equipment (conventional activated sludge process)

coliform by disinfection has a similar trend to the coliform group and have been examining the behavior throughout the year.

4. Effective use of ammonia

In recent years, ammonia is attracting attention as a hydrogen career. In sewage treatment facilities, high concentration ammonia is included in the liquid separated by dewatering anaerobically digested sludge but is not generally used as a resource. For this reason, basic examination was conducted in this study focusing on ammonia stripping, which recovers evaporated ammonia. It was confirmed in the laboratory scale experiment (Figure 2) that the ammonia recovery rate is the highest (approx. 94%) under the operating conditions of high temperature and high pH (70°C, pH: 12). We examined the method of effective use considering as well the needs and seeds of producers and consumers, including the use as denitration agent, and recognized feasibility.

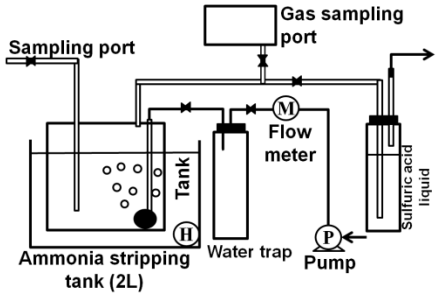


Figure 2: Outline of ammonia stripping equipment

Efficiency Increase of Sewage Treatment System in the Trend of Depopulation (Study period: from Fiscal 2015 to 2017)

YAMASHITA Hiromasa, Head FUJII Tsuyako, Researcher ISHIKAWA Takeshi, Researcher
Wastewater and Sludge Management Division, Water Quality Control Department

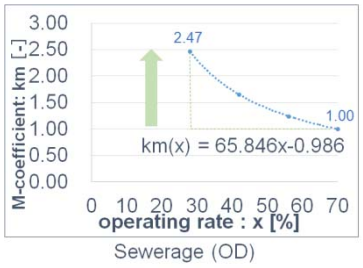
Keywords: sewage treatment system, depopulation

1. Introduction

Sewage treatment systems include sewerage, agricultural community effluent, human waste treatment facilities, etc. Due to a decrease in the service population and subsequently its sewage inflow, the sustainability of the service is now in jeopardy since the operating efficiency of the facilities with lower inflow volume than the designed capacity could decline significantly and the revenue from user-fees would also be decreased, while still investments in the reconstruction / renewal of aged facilities would be required in the near future. Hence, NILIM has been conducting research on efficient (sustainable) wastewater treatment systems in a population declining society.

2. Maintenance cost prediction considering operating rate

The trends in the unit of maintenance costs due to the differences in the operating rate were arranged as the coefficient (M-coefficient), based on the published operation records and questionnaire surveys of each system. Consequently, the maintenance coefficient increased as the operating rate declined in each facility (see Figure 1).



* M-coefficient [-] = (Unit of maintenance cost at a certain operating rate x) (JPY/m3) ／(Unit of maintenance cost at the maximum operating rate(70%)) (JPY/m3)

Figure 1: Relationship between the operating rate and the maintenance coefficient (Sewerage: OD method)

3. Optimization method for sustainable wastewater treatment systems

We developed a method for selecting sustainable wastewater treatment systems based on comprehensive viewpoints including the economical, technological and environmental factors. (Figures 2 and 3 and Table show study cases.) We conducted validation by studying model cases in actual cities and summarized results of validation as evaluation method.

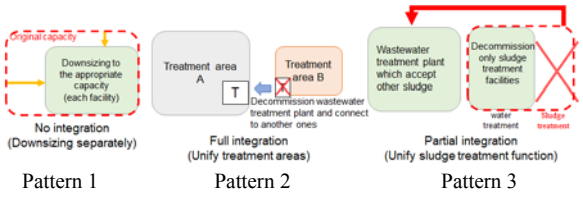


Figure 2: Representative integration scenarios

Table: Example of trial optimization result (in virtual city)

Factors		scenario 1	scenario 2	scenario 3
Overview		Downsizing A and B separately (no integration)	Unify treatment area B to A (full integration)	Unify sludge treatment function only (partial integration)
Costs (25years)	Total cost	5,879 million (JPY)	4,368 million (JPY)	5,016 million (JPY)
	Cost per year	235 million (JPY)	175 million (JPY)	201 million (JPY)
Technological		-	the capacity of the pipe etc	the capacity of the treatment plant etc
Environmental (25years)	Energy consumption	120 million(MJ)	109 million(MJ)	116 million(MJ)
	GHG emissions	16,732 (t-CO2)	15,116 (t-CO2)	16,144 (t-CO2)
Evaluation results		△	◎	○

4. Utilization of study findings

The findings are to be published as technical data (Technical Note of NILIM). We hope that local governments use the findings of this study to promote efficiency increase in sewage treatment systems.

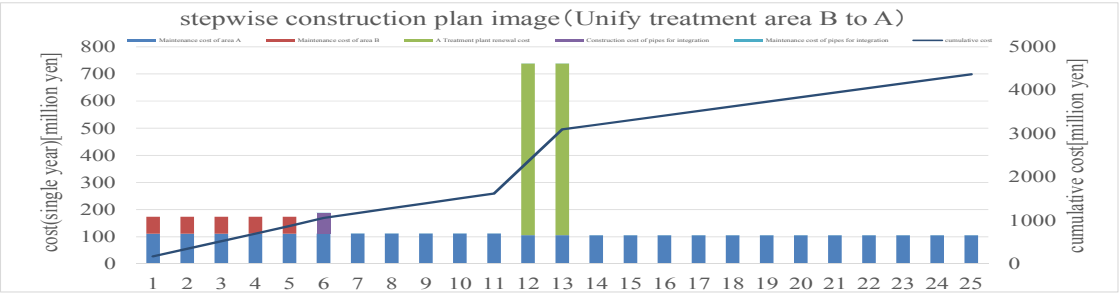


Figure 3: Example of stepwise construction plan (in virtual city)

Examination concerning structures for the use of 2+1 car lanes (Research period: FY 2016–2017)

Hiroki Onishi, Guest Research Engineer Daiya Morita, Guest Research Engineer
Yusuke Kono, Researcher Yoshihiro Tanaka, Senior Researcher Shinsuke Setoshita, Head
Road Division, Road Traffic Department

Keywords: 2+1 car lane, installation interval and lane length, density of following vehicles

1. Introduction

The interim report of the Land and Arterial Road Group, Road Division, Council for Social Infrastructure titled *Efforts To Use Roads Wisely Mainly on Highways* (July 2015) discussed the installation of effective passing lanes and three-lane roads as wise ways to reinforce the functions of temporary two-lane zones. In European countries in recent years, the so-called 2+1 car lane road, in which a passing lane is alternately installed in both directions, is being installed on two-lane roads with the expectation to improve service levels.

Therefore, the Road Division is now examining the installation of 2+1 car lanes in Japan.

2. Outline of analysis based on traffic flow simulation

On two-lane roads, passing behavior becomes limited when the car driving in front is slow, and cars behind the slow car are forced to follow the slow car. The road service level may be lowered in such cases.

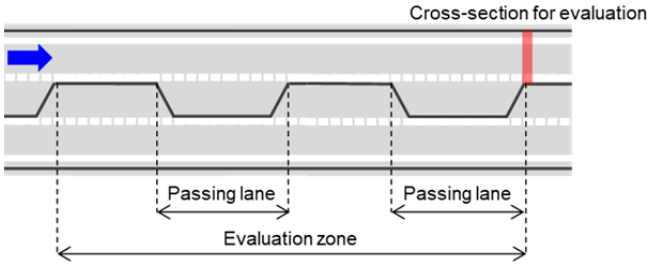


Figure 1. 2+1 lane road model

Table 1. Setup conditions for traffic flow simulation

Category	Setup conditions
Passing lane installation interval and length (km)	1.0, 1.5, 2.0, 2.5
Traffic volume (number of vehicles per hour)	300, 500, 700, 900, 1,000, 1,100, 1,200, 1,300, 1,400, 1,500
Expected speed distribution	Distribution from past studies[1)] is used.
Longitudinal gradient (%)	0

In this study, the density of following cars (number of vehicles where the time headway is within three seconds within a one-kilometer zone) is used as the index to assess the service level to simulate effective structures (installation interval and length of passing lanes) of 2+1 lane roads through traffic flow simulations.

As shown in figure 1, the traffic flow simulation used a road model of three lanes each way where the installation interval and length of passing lanes were equal. The conditions were set as shown in table 1.

3. Outcome of analysis

Table 2 shows the density of the following cars estimated by passing lane installation interval, length, and traffic volume. The gray section in the table indicates cases of installation interval and length with which the density of the following vehicles was at the minimum from the perspective of traffic volume. The analysis found that the density of following vehicles was at the minimum most often in cases of 1.5 km and 2.0 km. Based on the above, effective application of 2+1 lane roads that reduce the formation of the group of vehicles becomes possible when the installation interval and length of passing lanes are 1.5 km or 2.0 km.

4. Conclusion

This paper examined the effective structure of 2+1 lane roads using traffic flow simulations. The authors are going to continue examinations to enable the effective application of 2+1 lane roads.

Table 2. Estimated density of following vehicles

Traffic volume (number of vehicles per hour)	Passing lane installation interval and length (km)			
	1.0	1.5	2.0	2.5
300	**1.0**	1.1	1.2	1.3
500	2.8	**2.7**	2.8	3.1
700	5.3	**4.8**	**4.8**	5.1
900	8.2	**7.4**	**7.4**	7.8
1,000	10.1	9.3	**8.9**	**8.9**
1,100	12.6	**11.0**	**11.0**	11.1
1,200	14.8	13.1	13.1	**12.9**
1,300	17.9	15.4	**14.4**	14.8
1,400	18.5	17.3	**17.2**	18.5
1,500	23.1	20.2	**19.8**	20.0

[Reference]
1) *Traffic Engineering* Vol. 45 No. 1 pp. 58-67, 2010.

Proposal for method to identify high-risk areas in community roads using ETC 2.0 probe information

(Research period: FY 2016–2018)

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Road Safety Division, Road Traffic Department

(Keywords) ETC 2.0, traffic safety measures, community road

1. Introduction

An important factor in the effective and efficient implementation of traffic safety measures is to find areas with frequent accidents or high-risk traffic accident areas and implement focused measures in such areas.

The NILIM is exploring methods to extract high-risk traffic accident areas on community roads based on the actual onset of accidents and data on sudden braking and through-traffic obtained as ETC 2.0 probe information.

2. Method to aggregate data to extract high-risk areas

Accidents on arterial roads tend to occur in specific areas. On the other hand, the locations of traffic accidents on community roads tend to be widespread. Also, it is effective to implement focused traffic safety measures on community roads in areas surrounded by arterial roads. Based on the above, an accident risk evaluation to extract target areas needs to be conducted by taking into account the spread of high-risk areas. In addition, big data, such as ETC 2.0 probe information, should be handled using simple methods.

One way is a method to aggregate and evaluate 500-meter mesh data. Yet, it is associated with the disadvantage that the result changes depending on the methods to divide the mesh.

Therefore, this study examines a method to evaluate the risks of accidents by taking into consideration their spatial distribution using a kernel density estimation, which is one of the methods to estimate the spatial distribution of density across all data using limited volumes of data. Kernel density estimations estimate the density of data at individual spots by setting the same function (kernel function) for each data set and using the function that combines all the functions (Fig. 1).

Figure 2 shows the distribution of sudden braking obtained as ETC 2.0 probe information and the result of the kernel density estimation of sudden braking data. The use of this method is expected allow the visual observation of the spread of the density of sudden braking and enable the risk evaluation of accidents by taking into account their distribution.

3. Future studies

Future studies will aim to establish methods to identify high-risk areas on community roads by combining the results of examining data aggregation methods introduced in this paper with the result of examining indexes to evaluate the risk of accidents.

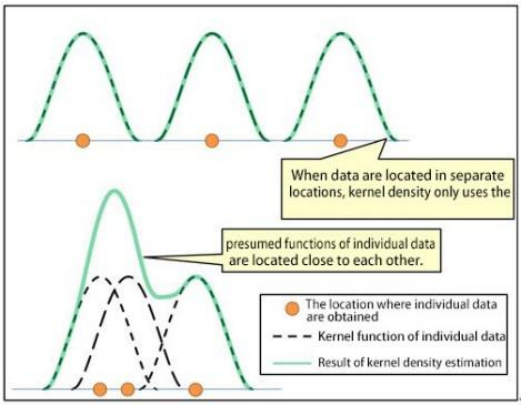

Figure 1 Kernel density estimation

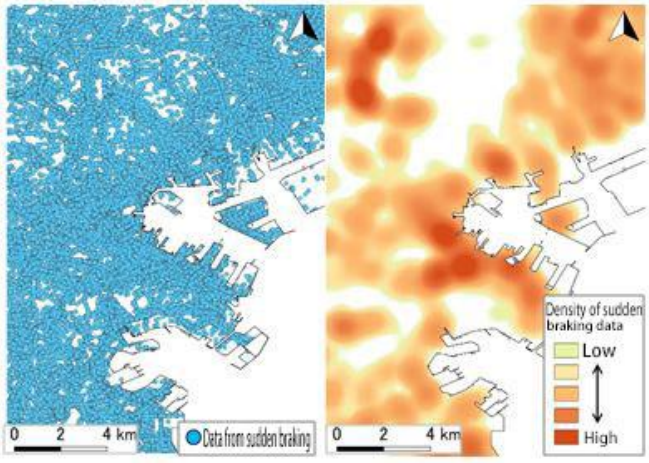

Figure 2 Result of a kernel density estimation of sudden braking data density estimation

Social experiment of ETC 2.0 vehicle operation management assistance service

(Research period: FY 2015–2017)

Kazunori Oshima, Senior Researcher　Hidenori Yoshida, Head　Gaku Ohtake, Researcher

Tatsuyuki Negishi, Guest Research Engineer

Intelligent Transport Systems Division, Road Traffic Department

Keywords: ETC 2.0, vehicle operation management assistance service, distribution

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is aiming to realize productive and wise operation management in an effort to use roads wisely. MLIT is thus planning to start the ETC 2.0 vehicle operation management assistance service that supports distribution companies managing the operation of vehicles to improve the efficiency of operation management and the effort to ensure the safety of drivers by providing various information, such as driving locations and braking.

2. Outline of social experiment

The National Institute for Land and Infrastructure Management has been conducting a social experiment by publicly recruiting distribution companies managing vehicle operations to analyze and evaluate the improvement in the efficiency of operation management, effectiveness of services to ensure driver safety, feasibility, and social effects of the ETC 2.0 vehicle operation management assistance service to use the findings for efficient and effective application of the service since February 2016. This experiment uses the specified probe data extracted by specifying vehicles using the ID of on-board ETC 2.0 based on the application from the participating companies.

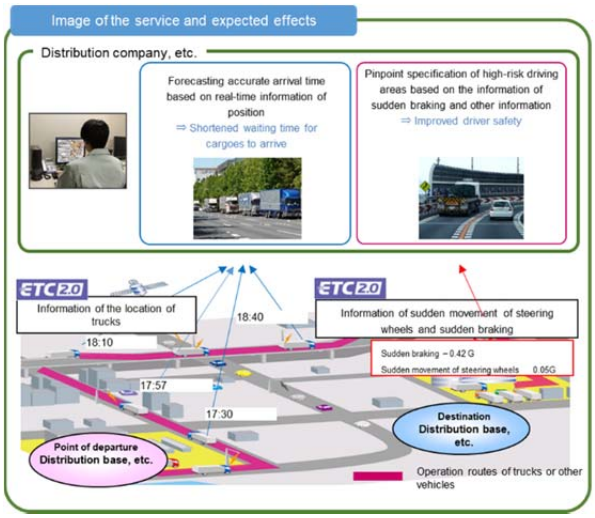

Figure 1. Image of the vehicle operation management assistance service

3. Evaluation of the effect of the service

The ETC 2.0 vehicle operation management assistance service includes a service that uses the information of the location of vehicles and a service that uses the information on sudden braking.

The service that uses the information on the location of vehicles includes the function to check the location of a driving vehicle and forecast the arrival time at the destination. Seventeen out of nineteen companies that used this service found that the service was useful in providing quick responses to inquiries by checking the location of vehicles and shortening cargo waiting time for drivers and unloading staff by notifying them of arrival times. Meanwhile, the acquisition of information may be delayed in areas without roadside equipment, which needs to be dealt with in the future. In addition, 12 companies responded that they would like to continue using this service.

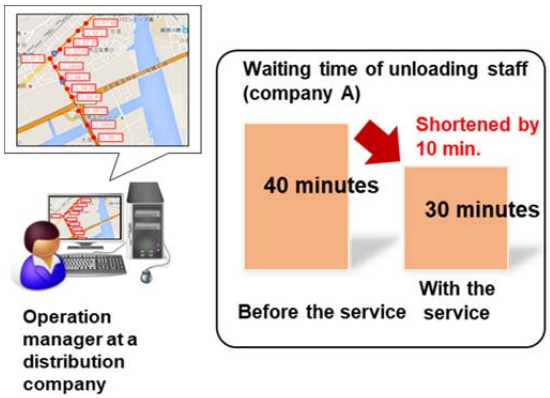

Figure 2. Image of vehicle location display service and example of its effects

4. Future activities

The ETC 2.0 vehicle operation management assistance service is going to start from FY 2018. NILIM is going to keep improving the convenience of this service.

☞For detailed information

1) The 14th Distribution Subcommittee, ETC 2.0 vehicle operation management assistance service
http://www.mlit.go.jp/policy/shingikai/road01_sg_000376.html

Automatic driving experiments using roadside stations as bases in hilly and mountaneous areas (Research period: FY 2017–2018)

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Keywords: Roadside stations, automatic driving, road-vehicle coordination

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is conducting experiments on automatic driving services using roadside stations as bases using automatic driving vehicles in hilly and mountainous areas where the population is becoming very old to lead the outcomes of the experiments to secure human and material flows and support rural areas.

Regional Development Bureaus launched Regional Experience Councils consisting of intellectuals and local governments in 13 locations around Japan in FY 2017. The councils established experiment plans and ran experiments.

2. Details of technical examinations

The National Institute for Land and Infrastructure Management (NILIM) is participating in Regional Experiment Councils as a committee member. The NILIM is providing technical support to run the experiments and analyzing technical examination categories to lead the experiments to social application (figure 1) including [1] road and traffic, [2] regional environment, and [3] social acceptability.

Figure 1: Technical examination category (the red frames indicate categories assigned to the NILIM)

Detailed analyses are now being conducted. This paper introduces some of the knowledge gained through the experiments.

3. The relationship between road management and automatic driving

Automatic driving vehicles detect whether there are any obstacles on their routes using optical cameras and laser sensors. In the example shown in figure 2, an automatic driving vehicle detected a plant hanging over a road as an obstacle and stopped. Similar incidents are occurring in other locations. Many obstacles, such as weeds and litter are expected to be on roads. A high-level road management, such as the early detection of obstacles in cooperation with other regions, needs to be established for the early application of automatic driving.

Figure 2: Detection of plants

4. Analysis of social acceptability

Figure 3 is the outcome of surveys on reliability toward automatic driving gathered from on-board monitors. It indicated that the reliability toward automatic driving improved after being on board an automatic driving vehicle.

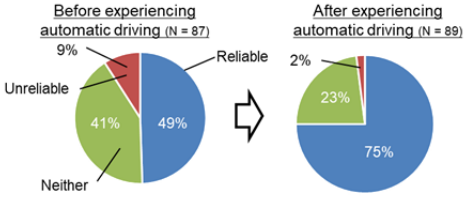

Figure 3: Reliability toward automatic driving (Ashikita Dekopon)

5. Future activities

Providing mobility in hilly and mountainous areas is an urgent task because elderly drivers are expected to voluntarily give up their drivers' licenses, and public transportation in such areas is decreasing. These experiments are expected to result in the social application of automatic driving in hilly and mountainous areas.

☞For detailed information

1) The MLIT website on the experiment of automatic driving using roadside stations as bases
http://www.mlit.go.jp/road/ITS/j-html/automated-driving-FOT/index.html

Joint research concerning next-generation cooperative ITS

(Research period: FY 2017–2019)

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Keywords: Cooperative ITS, wise use, automated driving

1. Introduction

The cooperative ITS system integrates vehicle-vehicle communication, vehicle-infrastructure communication, and infrastructure-infrastructure communication and coordinates communication methods and the data format to enable the mutual exchange of information among vehicles, roadside equipment, center, and individual terminals and then distribute the information through various applications, such as safe driving support, road and traffic management, distribution management, environment, information collection and distribution, and automated driving.

2. Government-private sector joint research

To realize an effective and feasible cooperative ITS service, it is important that stakeholders, such as automobile manufacturers, electric device manufacturers, and road administrators, examine it together. Therefore, the joint research for technological development to realize the practical application of next-generation cooperative ITS is conducted from FY 2018 to FY 2019 for the government and private sectors to jointly examine the service.

Researchers participating in the joint research were publicly recruited from September to November 2017, and the National Institute for Land and Infrastructure Management and 29 private companies (32 organizations) started the joint research in January 2018.

[Private companies and organizations participating in the joint research]
4 automobile manufacturers (4 organizations)
13 electric device manufacturers (16 organizations)
1 map company (1 organization)
5 relevant incorporated foundations (5 organizations)
6 highway companies (6 organizations)

3. Research categories

Among the many cooperative ITS applications, this joint research set three research categories to realize the government goal of realizing automated driving on highways until 2020. Joint researchers are now examining the relevant topics in the working-group style.

1) Examinations of support services for merging

Researchers are examining a service to support smooth flows of merging traffic by identifying congestion in the main lane and providing information to drivers and vehicles that are about to merge.

2) Examination concerning forecasted information distribution service

Researchers are going to explore services to support vehicles in changing lanes or engaging in other actions by providing road information, such as vehicles in accidents ahead on a road (road forecast information) that vehicles alone cannot detect, to drivers and vehicles.

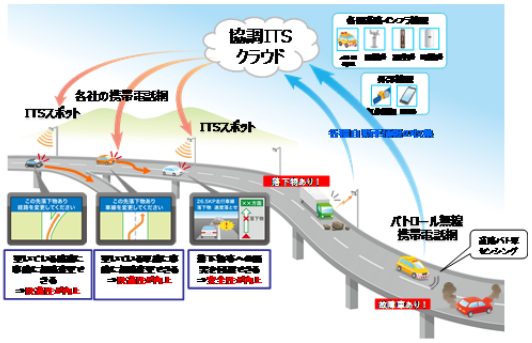

Figure: Example of road forecast information service

3) Examinations concerning the advancement of road management using vehicle information

Researchers are going to explore measures to advance road management, such as the early detection of road abnormalities, including objects on roads and accidents, using information, such as braking behavior and the use of turn signals on individual vehicles, to quickly respond to the abnormalities and provide information to drivers.

4. Conclusion

Researchers are planning to conduct driving tests of the services studied in this joint research using the NILIM test lanes to test technologies for commercial application.

Revision of Technical Standards for Bridges, Overpasses, and other Structures (Specifications for Roads and Bridges)

(Research period: FY 2013–2017)

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Keywords: Specifications for roads and bridges, partial factor design method, limit state design method

1. Background and purpose of revision

The Technical Standards for Bridges, Overpasses, and other Structures (Specifications for Roads and Bridges) are the standards used for the design of bridges on highways and national roads. It is also commonly used for other bridges on roads. It has been revised along with changes in technical knowledge and social situations. A major revision since its establishment was conducted recently, which was announced by the chief of the City Bureau and the chief of the Road Bureau on July 21, 2017.[1]

This revision included changes in the design methods to improve productivity and realize high-quality road bridges with longer service lives. The changes include the adoption of the partial factor design method that enables a more accurate evaluation of the performance of road bridges compared to the conventional design method while continuously using performance standards adopted in the revision of 2001.

2. Switch to partial factor design method

In the conventional design method, various types of safety measures have been secured using the combination of loads based on experience and one safety factor.

On the contrary, in this revision, the conventional safety factor is divided into five partial coefficients, which are then individually defined. Specific partial coefficients include the partial coefficient multiplied by the load depending on the scattering of the load and the difference in the frequency of the load combination, the partial coefficient that takes into account the scattering of material strengths and construction, the partial coefficient to take into account the precision of design formulas and the quality and quantity of fundamental data, the partial coefficient that takes into account the quality of the ground investigation and structural analysis, and the partial coefficient depending on the differences in the state of damage (figure 1).

The Bridge and Structures Division has been conducting research to shift to the partial factor design method that is now the international technical standard founded on the concept of reliable design. Many outcomes of these research studies, including coefficients to multiply to the loads, are being reflected in this revision.

The development of new technologies and the acceleration of their application are expected as a method to evaluate performance without relying on how materials are being combined, and the necessary quality and quantity of data for an evaluation become clearer than the conventional method in this revision. The use of such a design method also enables a rational performance evaluation of already constructed structures as well in the future.

3. Other revisions

The revision also increased regulations concerning durability and reevaluated earthquake resistant designs by reflecting the lessons learned from the damage sustained in the Kumamoto earthquake in 2016 to construct bridges that would be more resistant to damage and recover more quickly from damage.

The revision of the Specifications for Roads and Bridges is expected to accelerate the use of various structures and new materials. The new Specifications for Roads and Bridges are being applied to new designs after January 1, 2018.

☞For more detail

1) The revision of the Technical Standards for Bridges, Overpasses, and other Structures (Specifications for Roads and Bridges) on the website of the Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism
http://www.mlit.go.jp/report/press/road01_hh_000862.html

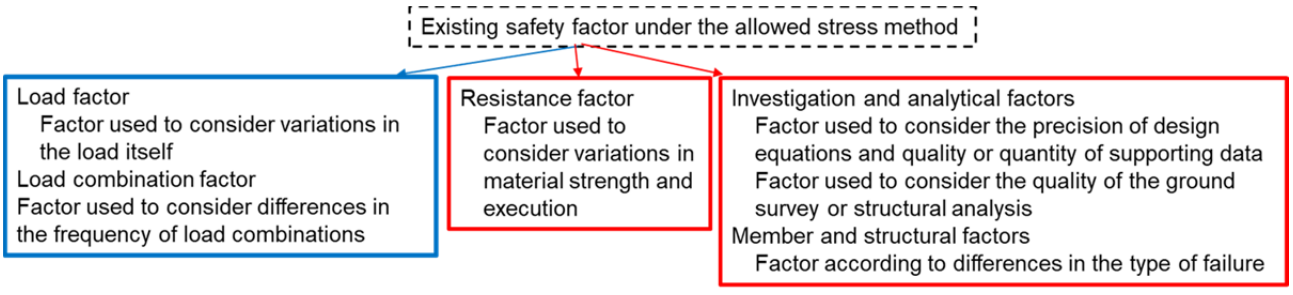

Figure 1. System of practical coefficients

Development of design and construction technologies for mixed-structure buildings using new wood materials (Research period: FY 2017–2021)

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Evaluation System Division
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Keywords: Midrise mixed-structure wooden building, common technology, exposed structure, joint section, mega-structure, durability evaluation

1. Introduction

The use of wood resources is called for in the field of construction, which accounts for a large ratio of demand for lumber. An effective way to increase the use of lumber is to use lumber as the structural material for relatively large construction projects. To increase the use of lumber, there is a demand for the structure design method, fireproof design method, durable design method, and other relevant methods that use common technologies to be applied to midrise mixed-structure wooden buildings with wooden structures constructed with large wood panels, such as CLT and other types of structures. Researchers are thus developing technologies to establish these methods. This report introduces the outline of the technological development.

2. Outline of technological development

Neither construction experience nor technical references are scarce for midrise mixed-structure wooden buildings. Thus, researchers set the main expected variations and are examining them together while checking the main technological development categories as follows, which become necessary to realize wooden buildings while checking their designs whenever necessary.

(1) Examinations concerning structural performance

Technological development is conducted for structural design methods and structural performance evaluation methods for joint sections of prototype mixed-type structures that allow the use of lumber as exposed structures or with simple fireproof coating for fireproof sections in the horizontal and vertical directions, which is one of the variations.

Figure 1. Image of a prototype (RC rigid frame + wood)

(2) Examinations concerning fireproof performance

Technological development is conducted for fireproof design methods by taking into account the effects that the fireproof performance of the wooden structure section has on the entire building while maintaining a good balance between the structural performance stated in (1) and fireproof performance, as well as a mega-structure with high fireproof performance that would contain a fire within a certain section.

Figure 2. Examination of fire within a mega-structure

(3) Examinations concerning durability

Technological development is conducted for the establishment of design and construction methods, durability evaluation technologies, and maintenance and management methods intended to improve the durability of midrise wooden structures focusing on moisture from the infiltration of rainwater and condensation, which become the cause of decay in wooden structures.

3. Future plans

Technological development is going to be continued in cooperation with the relevant bureaus of the Ministry of Land, Infrastructure, Transport and Tourism, Building Research Institute, intellectuals, and relevant organizations (e.g. industry organizations in the field of wooden structures).

Technological development for the rationalization of fire control and evacuation regulations

(Research period: FY 2016–2020)

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Urban Disaster Mitigation Division, Urban Planning Department

(Keywords) Evacuation safety, large wooden structure, urban building, main structural part

1. Introduction

Local governments and private businesses engaging in regional development are demanding the effective use of available buildings by changing their uses or renovating them to make them more useful in promoting regional economies and international tourism. The NILIM is engaging in the necessary technological developments to rationalize fire management and evacuation regulations and streamline the use of the regulations to effectively promote activities to utilize the available buildings. This paper introduces an outline of such technological developments.

2. Rationalization of standards concerning the evacuation safety of people in buildings

To ensure the evacuation safety of people in a building, the main structural parts of a building, such as columns and walls, are required to be fireproof structures, except for cases when evacuation can be relatively quickly completed. The maximum size for which such structures are not required is two-story buildings with 300 m^2 of floor area on the second floor, which becomes applicable when people sleep in the building. The rationalization of building regulations may be possible if the same or higher level of evacuation safety is secured for three-story buildings. The researchers are calculating the evacuation time targeting welfare facilities in which special care becomes especially important during evacuation to specify the areas to regulate (Fig. 1).

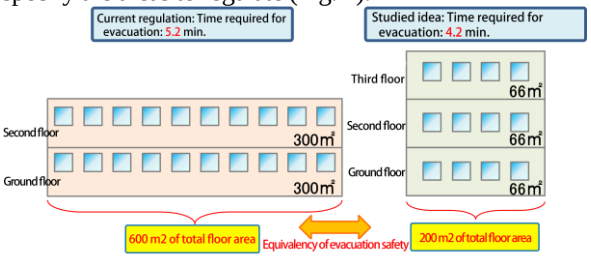


Figure 1 Example of examining sizes with which evacuation safety is secured

All rooms in buildings of certain sizes used for certain purposes are restricted in terms of interior materials and required to be equipped with smoke extraction facilities. In terms of the evacuation from individual rooms into the corridors, the installation of sprinklers and smoke leakage prevention doors and walls is expected to prevent the smoke from spreading within each room and from leaking from the rooms into the corridors. The researchers are exploring rational methods to replace current regulations that are applicable to all rooms, including interior materials and smoke extraction, while ensuring safety with new methods (Fig. 2).

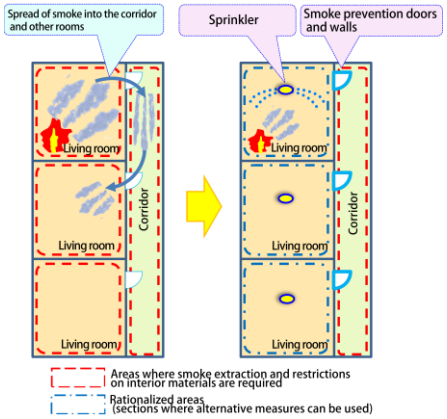


Figure 2 The rationalization of regulations on smoke extraction and interior materials

3. Rationalization of standards for wooden buildings

Regulations applicable to sizes (height and area) of buildings mainly constructed with wooden materials would become major restrictions when renovating available buildings and changing their uses.

Specific restrictions in the flexibility of design include the following: 1) the provision in the Article 21-1 of the Building Standards Act (hereinafter “the Act”) regulating the height of large wooden structures (13 m or higher or 9 m or higher for the eaves height) and fireproof functions of the main structural parts, and 2) the provision in Article 26 of the Act regulating the structural method of fireproof walls to divide areas in wooden structures (vertical walls every 1000 m^2).

The restrictions on the height of wooden buildings are based on regulations from the Urban Buildings Act, the law preceding the Building Standards Act. They practically prohibit the use of wooden materials for the main structural parts. Although some regulations have been relaxed, these regulations are one of the factors that prevent the use of wooden materials. The researchers are

conducting technological developments to organize objectives and functional requirements realized through these standards-based regulations and to modify the applicable regulations to govern performance. Specifically, the prevention of the collapse of a wooden building of a certain height from damaging nearby buildings is organized as the objective of this regulation. Instead, a framework is constructed to evaluate the rationally required duration of fire resistance and fire resistance performance by assuming the use of fire extinguishing measures (e.g. fire control using sprinklers and firefighting activities by firefighters), which are not evaluated under the current regulations (Table 1). These developments are expected to enable optimal wooden buildings based on the effect of fire control measures.

Table 1 The duration of fire based on fire control measures

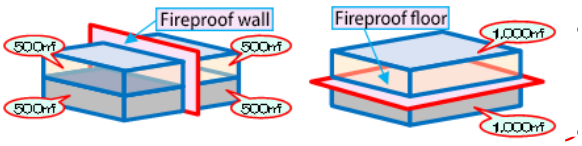
Duration of fire (time when water spray is started + duration of firefighting activities)	
(1) Main factors that affect the time when water spray is started	(2) Main factors that affect the duration of firefighting activities
・ Time required for firefighting teams to arrive at the scene of fire ・ Time required for preparation ・ Time required to move to the source of fire	・ Area of combustion ・ Fire control using sprinklers ・ The amount of water spray

The installation of fireproof walls every 1,000 m^2 is required in wooden buildings. The division of areas using fireproof walls is only applicable to a structure that vertically divides areas inside a wooden building. It does not include the effect of dividing sections using horizontal members such as floors (called fireproof floors) (Fig. 3). The establishment of methods to evaluate the fire spread prevention performance and independency of fireproof floors will enable designs that rationally use wooden materials while reducing the spread of a fire with dividing members. A fireproof floor is expected to increase the possibility of realizing buildings with a mixed structure in which the ground floor is based on a RC structure and the second floor is a wooden structure.

a) Fireproof wall (vertical) b) fireproof floor (horizontal)

Figure 3 Fireproof walls and fireproof floors

4. Rationalization of standards related to the prevention of urban fire



When fire safety zones and semi-fire safety zones are designated, buildings within such areas must be fireproof buildings or semi-fireproof buildings depending on their floor areas and the number of floors. In addition, gates and walls within the premises of the buildings must be made with nonflammable materials when they are more than two meters in height. The current situation is that the use of wooden materials is largely restricted while urban fire prevention measures are being strengthened. The researchers are currently constructing methods to evaluate whether urban buildings have fire spread prevention functions or not. For example, flexible designs that abundantly use wooden materials within a building are enabled if the same level or better fireproof performance can be realized by improving the performance of the outer walls and openings.

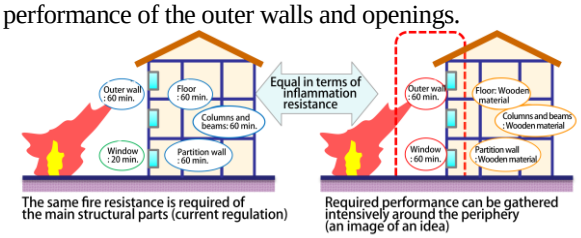
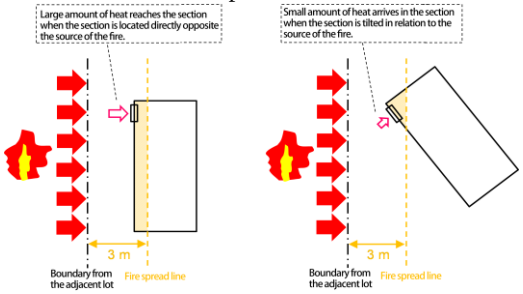


Figure 4 The reevaluation of fire control regulations within fire safety zones

The design of the facade is often regarded as an important factor when preserving and utilizing the historic townscape. Current regulations regard the section of the ground level of a building and the second level or higher section of a building within three meters and five meters, respectively, from the center line of a road or the boundary of an adjacent lot as sections to which the fire may spread. Fire control measures are required for such sections, such as the installation of fireproof windows. Depending on the position (e.g. distance, angle, and height) in relation to the building located at or near the boundary of an adjacent lot that may become the source of a fire, however, some sections are known to be less affected by heat (Fig. 5). The researchers are thus conducting empirical examinations to remove such sections from the sections to which the fire may spread. The rationalized standards are expected to increase the sections where the use of metal window sashes or wired glasses is exempted, which would make it easier to preserve historic townscapes.



A) oppositely located b) located in angle

Figure 5 The effect of heat depending on the relationship of the location of the source of the fire and building

5. Future perspectives

The researchers are going to maintain the cooperative relationship with the relevant bureaus of the Ministry of Land, Infrastructure and Transport, local government organizations, Building Research Institute, and intellectuals to continue technological development for the establishment of a draft of the technological standards and guidelines.

Research for the improvement of efficiency and advancement of urban traffic investigation, analysis, and planning method using new technologies

(Research period: FY 2015–2018)

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Keywords: Big data, mobile phone base station, demographic statistics, urban traffic, investigation, analysis, and planning method

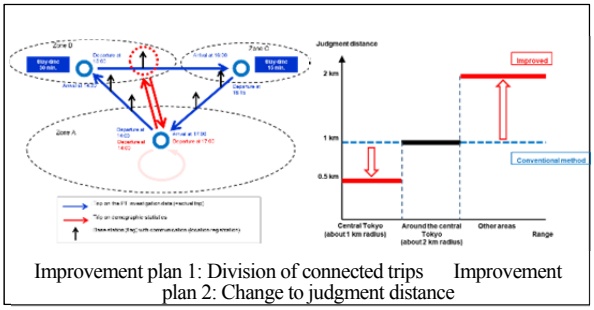
1. Background and purpose of study

Studies for using the various types of big data and its application in the field of urban traffic have been rapidly advancing in recent years. This study is intended to refine and improve the efficiency of urban traffic investigations, analyses, and planning methods by improving demographic statistics,[1,2] which is generated from the data of the use of mobile phone networks that provide a large volume of samples meaning high representability (see relevant study on page ○).

2. Main research and findings

Trips in demographic statistics are usually generated by determining travel and congestion depending on the distance between base stations that identify mobile phones at certain intervals. In the current method, the movement is identified every hour, and the judgment time is one kilometer. Therefore, the current method is known to generate statistical errors caused by missing data or excessive data generation, such as judgment of excessive travel that occurs because of the connection of multiple trips with short stays in-between and with a slight deviation in the mobile phones when the distance between base stations is one kilometer or more.[1]

Thus, researchers tried two improvement proposals (figure 1) including [1] the division of connected trips by checking details of identification information and [2] changing the judgment distance depending on regional characteristics, such as population density. The comparison with the result of the PT investigation for individual trip distance ranges found that the results were nearly matched (figure 2).[1]



Improvement plan 1: Division of connected trips Improvement plan 2: Change to judgment distance

Figure 1: Improvement plan of demographic statistics (image)

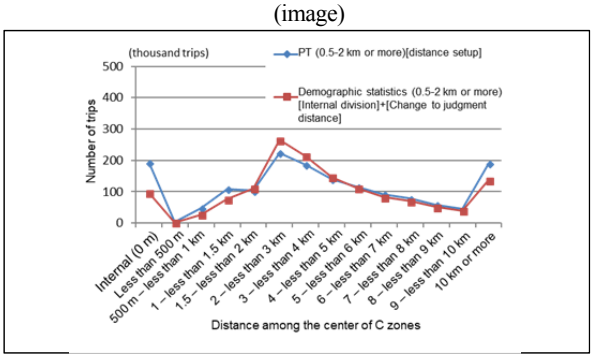
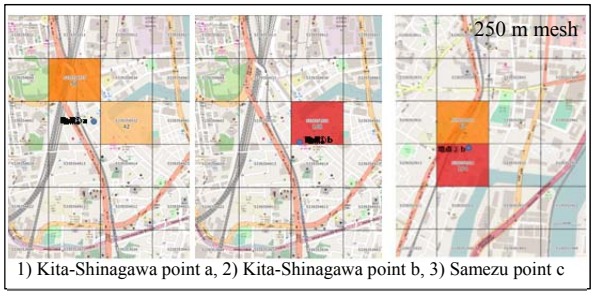


Figure 2: Comparison of OD load by distance ranges (after improvement)



1) Kita-Shinagawa point a, 2) Kita-Shinagawa point b, 3) Samezu point c

Figure 3: Spatial resolution of demographic statistics (when devices are not moving)

Then, to clarify spatial resolution, about 80 mobile phones were actually moved around and remained still in multiple urban areas in Tokyo, and statistical data were obtained. As a result, the radio wave travel range of one base station, that is, the minimum resolution when a mobile phone is not moving, was approximately 300 meters (figure 3).[1]

In addition, as a presumption to identify activities that are repeated daily, researchers calculated the structure of objectives by departure and arrival zones by creating an algorithm that would sort trips into going home or going to work. The obtained result was about the same as the result of the PT investigation.[2]

3. Future perspective

To further advance and improve the efficiency of the current investigation, analysis, and planning method, researchers are going to improve the practicability of data uses by comprehensively and inclusively comparing and examining the data acquisition precision and reliability of traffic-related bid data, which are advancing in various ways without being limited to demographic statistics.

☞For detailed investigation

1) Research concerning the trip data acquisition precision from the perspective of the spatial resolution of demographic statistics based on the mobile phone network operation data. Compilation of civil engineering planning and research and lectures. Vol. 56, Committee of Infrastructure Planning and Management Nov. 2017

2) Research concerning methods to estimate purposes of trips in demographic statistics based on mobile phone network operation data. Compilation of civil engineering planning and research and lectures. Vol. 55, Committee of Infrastructure Planning and Management Jun. 2017

Challenges to fire management regulations when preserving and using historical townscapes

(Research period: FY 2016–2020)

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Keywords: Historical building, historic townscape, alternative measures

1. Introduction

There is demand for promoting the development of tourism-oriented town development using historical buildings and townscapes. Old and traditional houses remaining in many regions are now being renovated as the core of tourism-oriented town development (photo 1). Major renovations sometimes face difficulty in complying with the current Building Standards Act, however, and renovations or uses of old and traditional buildings are often abandoned. Thus, systems need to be streamlined for the preservation and use of historical buildings.

Therefore, the National Institute for Land and Infrastructure Management is examining how fire management and evacuation regulations and other relevant regulations can be streamlined. Among them, this report introduces the current status of the examination of challenges that fire management regulations are facing in regard to the preservation and uses of historical buildings and townscapes.

Photo 1. An example that a townhouse is renovated as a tourist information building

2. Challenges to the preservation of historical townscapes

The authors examined the restrictions under the Building Standards Act applied to 20 municipalities with historic townscapes, such as traditional building preservation zones. The examination found the following challenges.

-Difficulty in renovating buildings while maintaining historical and traditional styles (photo 2) and the difficulty in finding engineers and procuring materials
-Necessity of increasing budget for renovation and maintenance costs and the increased construction cost when buildings are designed to suit landscape restrictions of a given area
-Difficulty in renovating wooden buildings as fireproof buildings when an area is specified as a semi-fire control zone
-Difficulty in renovating a building while preserving the original atmosphere when building confirmation cannot be acquired for a major renovation, which results in the necessity of renovating the building within a range that would not require a building confirmation

Photo 2. An example that a house is renovated using metal fittings

3. Example of streamlining the application of fire control regulations

Some municipalities are streamlining the application of fire control regulations to solve problems.

Examples include the cancellation of fire control zones or semi-fire control zones or the requirement of alternative measures to ensure safety while exempting some of the application of the Building Standards Act in traditional building preservation zones.

For example, the city of Hakodate applied Article 85-3 of the Building Standards Act to relax some of the fire control regulations for historical buildings within semi fire control zone. Meanwhile, the city required alternative measures, such as using wood materials with a thickness of 12 mm or more as the finishing material of outer walls and the back of the eaves, using aluminum or steel fittings on the inside of an opening, and using wire glasses on the inside of an opening (photo 3). Similar alternative measures are also being implemented in other cities.

4. Future plans to use outcomes

The authors are going to further examine the procedures to ensure a minimum level of safety and evaluation methods when fire control regulations are relaxed and release the outcomes as guidelines.

Photo 3. An example in which wire glass is used on the inside of an opening

Establishment of bidding and contracting method for construction as disaster recovery under the direct management of the Ministry of Land, Infrastructure, Transport and Tourism

(Research period: FY 2016–2017)

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Keywords: Bidding and contracting, disaster recovery, Guideline

1. Introduction

Construction projects that the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) orders are based on the general public bidding method, which is a basic rule for accounting laws and regulations as a rule to ensure competitiveness and fairness. In the case of natural disasters, which have frequently occurred in recent years; however, MLIT is using special bidding and contracting methods, such as private contracts and selective bidding, which differ from regular methods to ensure quick recovery.

The Construction and Maintenance Management Division of the National Institute for Land and Infrastructure Management investigated the status of using special bidding and contracting methods adopted in recent major natural disasters and organized the basic concept of applying bidding and contracting methods to help ordering officials of Regional Development Bureaus to efficiently and properly select bidding methods for disaster recovery works.

2. Detail of the research

As shown in table 1, the research targeted five examples of significant damage to facilities under direct management of MLIT among the specified catastrophic natural disasters that have occurred over the past five years (2011–2016). The researchers gathered order-related documents for recovery construction in these natural disasters and organized and analyzed the ordering period of individual construction, details of notifications, adopted bidding and contracting methods, methods to select contractors, processing method, bidding procedures, and other relevant aspects.

The research found that private contracting was often adopted for emergency quick recovery work for about four months after the onset of a natural disaster. Among the full recovery projects, selective bidding was often adopted for one to twelve months after the onset of a natural disaster for construction with great time restrictions and not enough time for general public bidding, such as the necessity to complete construction before the flood season, for example. Meanwhile, after three months from the onset of a natural disaster, general public bidding was used for main recovery work, which would allow a certain length of time for the bidding and contracting method. Based on these findings, table 2 summarizes the basic ideas of the bidding and contracting methods adopted during a natural disaster.

Table 1. Targeted natural disasters

Natural disaster	Damaged areas	Date and time
Great East Japan Earthquake	East Japan areas	March 11, 2011
Flooding in Kii Peninsula	Nara Prefecture and nearby areas	September 4, 2011
Heavy rain and landslide in Hiroshima	Hiroshima Prefecture and	August 19, 2014
Heavy rain and Kinugawa River flooding in Kanto and Tohoku	Ibaraki Prefecture and nearby areas	September 9, 2015
2016 Kumamoto earthquakes	Kumamoto Prefecture and	April 16, 2016

Table 2. Basic idea of selecting bidding and contracting methods

Type of construction	Urgency	Bidding and contracting method	Method of selecting contractors
Emergency recovery Full recovery (Onset to the first four months)	Extremely high	Private contract	The most appropriate contractors are selected based on the following perspectives [1] Past experience in maintenance and restoration work in disaster-hit areas [2] Status of disaster restoration work agreement [3] Probability of completing construction work (location of head office, status of damage that a contractor is suffering from, status of ongoing construction in nearby areas, past experience, etc.)
Full recovery (first 1-12 months)		Selective bidding	From competent candidates, contractors are selected based on the following perspectives to fairly distribute contracts among different contractors based on contracting and ordering status. [1] Locations of head office (headquarters), branch offices, and sales offices [2] Past experiences of the same or similar types of construction [3] Status of ongoing constructions
Full recovery (after the first 3 months)	When regular methods allow quick responses	Regular method (general public bidding, general evaluation bidding method as a rule)	

3. Conclusion

The findings of this research were reflected in the Guidelines for Applying Bidding and Contracting Methods for Disaster Recovery established in July 2017. The authors expect that the Guidelines will be useful for those who order construction at the regional development bureaus and municipalities when they have to quickly and properly select bidding and contracting methods for disaster recovery, which would improve the efficiency of recovering from major natural disasters that have occurred at high frequencies in recent years.

☞For detailed information

1) The website of Construction and Maintenance Management Division, Research Center for Infrastructure Management, National Institute for Land and Infrastructure Management
http://www.nilim.go.jp/lab/peg/gijutsujouhou.htm

Method to estimate means of transportation using the operation data of mobile phone base stations

(Research period: FY 2014–2017)

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Daiki Kitagawa, Guest Research Engineer
Information Platform Division, Research Center for Infrastructure Management
Hiroyasu Shingai, Head Urban Facilities Division, Urban Planning Department

Keywords: Big data, traffic planning, mobile phone base station, demographic statistics

1. Introduction

The demographic statistics of mobile spatial statistics generated from the operation data of mobile phone base stations are the origin-to-destination (OD) data in which the 24-hour, 365-day location information of 75 million mobile phones (except for the data of corporate accounts) is expanded by adding information, such as the Docomo mobile phone penetration ratio and areas covered by base stations. Unlike a conventional urban traffic survey, however, the demographic statistics cannot directly identify the means of transportation. If the means of transportation can be identified, it would complement and reinforce person-trip surveys, complement other statistical surveys, and be used for measuring the effect of new developments in areas with new services. In this research, the authors came up with methods to estimate whether a certain long-distance trip in the demographic statistics of mobile spatial statistics was a trip by an airplane or Shinkansen and analyzed the precision of the estimates.

2. Proposal of estimation method

The authors proposed a method to estimate whether a trip is an airplane trip or not by combining three ways to judge it, including judgment based on power off status, judgment based on travel speed, and judgment based on base stations around airports. The authors also proposed a method of estimating whether a trip is a Shinkansen trip by combining two judgments, including judgment based on the highest speed and judgment based on whether the trip passes near Shinkansen routes.

3. Comparison of the outcomes of estimation

The authors compared the O-D quantity data of airplanes and the Shinkansen prepared by setting departure and arrival areas in five prefectures (Tokyo, Osaka, Fukuoka, Kumamoto, and Kagoshima), spatial resolution in prefectures, and chronological resolution in one day and the traffic facility data obtained from the 2010 national arterial passenger flow survey as the O-D pair of individual departure and arrival areas. The authors then analyzed the characteristics of individual cases in the airplane and Shinkansen estimation method for individual departure and arrival areas. These comparisons and analyses indicated that the method exhibited a high correlation with the national arterial passenger flow survey and that the number of trips erroneously judged between airplanes and the Shinkansen could be reduced when judgments were combined.

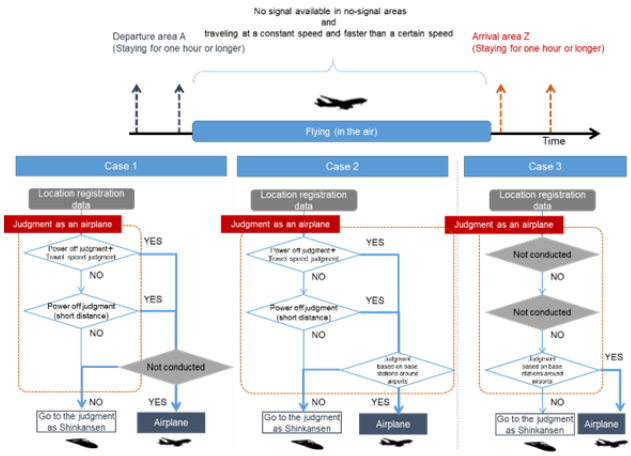

Figure. Image of judging power off status and the judgment chart of the method to estimate airplane trips

4. Future outlook

A report session will be held to spread the outcomes of research on the operational data of mobile phone base stations, including this research. In addition, challenges and problems in using the operational data will be clarified by letting actual operators use the operational data of mobile phone base stations.

☞For more detail

1) Daiki Kitagawa, Hirotaka Sekiya, Toshiro Itouji, Daizo Ikeda, Tomohiro Nagata, Aya Fukute, Hiroyasu Shingai, Ryuichi Imai: 携帯電話網の運用データを用いた新幹線トリップの推計手法に関する一考察 (An observation of a method to estimate Shinkansen trips using the operational data of mobile phone networks), *Journal of Japan Society of Civil Engineers* Vol. 56, Japan Society of Civil Engineers, 2017

2) Takayoshi Saito, Daiki Kitagawa, Ryuichi Imai, Daizo Ikeda, Tomohiro Nagata, Hirotaka Sekiya, Hiroyasu Shingai, Hiroyoshi Hashimoto, Aya Fukute, Tsutomu Yabe, Kazuki Hirokawa: 携帯電話網の運用データに基づく人口流動統計を用いた交通手段の推計手法に関する一考察 (An observation of a method to estimate means of transportation using demographic statistics based on the operational data of mobile phone networks), *Journal of Japan Society of Civil Engineers* Vol. 55, Japan Society of Civil Engineers, 2017

Method of calculating construction quantity using three-dimensional models (Research period: FY 2017)

Information Platform Division, Research Center for Infrastructure Management
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Keywords: Quantity calculation, three-dimensional model, CIM

1. Introduction

The April FY 2017 Civil Engineering Work Quantity Calculation Procedure (draft) that the Ministry of Land, Infrastructure, Transport and Tourism revised in April 2017[1] (hereinafter the Quantity Calculation Procedure) permits three-dimensional quantity calculations using CAD software. Yet, the Procedure does not provide specific methods of construction quantity calculation using three-dimensional models. Therefore, the National Institute for Land and Infrastructure Management is studying methods to calculate the quantity using three-dimensional models based on the current categories provided in the Quantity Calculation Procedure.

For this fiscal year, the authors examined the quantity calculation methods using three-dimensional models of soil structures, concrete structures, and steel structures. This paper reports a proposal for a method to prepare a three-dimensional model to be used for quantity calculations targeting soil structures using the model shown in figure 1 as an example.

2. Quantity calculation method for soil structures using a three-dimensional model

The three-dimensional model used for the quantity calculation of soil structures is expressed using a three-dimensional ground model that depicts the ground surface and the surface of the soil layers and an earthwork model that expresses the formation level (subgrade surface) and slope surface. Details of the methods to create individual models are discussed below.

For the ground surface (figure 2 (a) [1]), a surface model is prepared based on survey data obtained through three-dimensional survey technologies. For the soil layer surface (figure 2 (a)[2][3]), a surface model is prepared using geological profiles based on boring data by mathematically complementing (estimating) spatial characteristics between two cross sections. Geological information in the space vertically below is registered for the surface models of individual soil layers.

The construction width and cut width of an earthwork model (figure 2 (b)) is expressed using a surface model.

These models are layered, and the quantity of the soil structure is calculated using the mensuration method based on the TIN division using the difference in volumes among the different models, a height method that uses the differences in heights, and the prismoidal method.

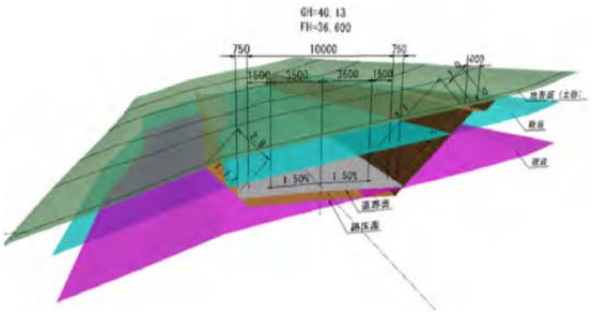
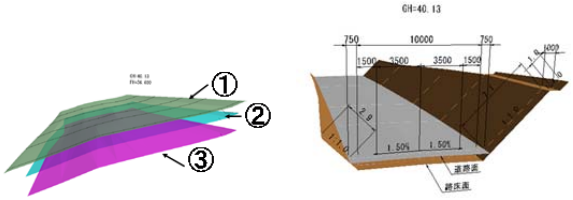


Figure 1. An example of expressing a three-dimensional model of a soil structure



(a) Three-dimensional ground model (b) An earthwork model

Figure 2. An example of expressing three-dimensional ground model and an earthwork model

3. Summary

In FY 2017, the authors prepared a revision proposal concerning the river and erosion management edition and the road edition of the Civil Engineering Work Quantity Calculation Procedure (draft) based on knowledge acquired through the research. In FY 2018, the authors are going to extract the challenges of quantity calculation using a three-dimensional model and find ways to overcome the challenges, as well as to expand the targeted types of construction through the implementation of operations and construction based on the revision proposal.

References

1) Ministry of Land, Infrastructure, Transport and Tourism: FY 2017 (April edition) Quantity Calculation Procedure (draft), Apr. 2017. <URL: http://www.nilim.go.jp/lab/pbg/theme/theme2/sr/yoryo2904.htm> (browsed in January 2018)

Examination of the effect of repairs using ICT monitoring for bridges damaged in the Kumamoto earthquakes

(Research period: FY 2017–2021)

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Kumamoto Earthquake Recovery Division, Research Center for Infrastructure Management

Keywords: Kumamoto earthquakes, road bridges, ICT monitoring, examination of the effect of repairs

1. Introduction

The recovery work of some of the bridges damaged in the Kumamoto earthquakes requires special and advanced technologies. Upon the implementation of recovery work, the effects of the repairs are being checked using ICT monitoring in cooperation with the Kumamoto Restoration Office, which is in charge of the projects. This paper introduces the case of the Aso Choyoo Bridge in which ICT monitoring was conducted at individual restoration steps, and changes in the condition of the bridge during the progress of the repairs and the effects of the repairs were checked.

2. Monitoring at Aso Choyoo Bridge

As shown in the photograph, the Aso Choyoo Bridge suffered significant damage to its members in the Kumamoto earthquakes. Among them, the P3 bridge pier had a crack that penetrated the cross-section at mid-height where the inside was hollow. Therefore, fluid concrete was injected into the hollow section to restore the shear resistance that had been lost due to the crack. The effect of this repair was checked by measuring the frequency of oscillation on the bridge and the oscillation mode of the bridge pier using the characteristic that the filling of the concrete would cause changes in the oscillation of the bridge pier.

For the monitoring, an accelerometer that could accurately measure slight oscillations was installed on the bridge pier to measure oscillations on the bridge before and after the repairs.

Photo: Conditions of major damage on Aso Choyoo Bridge

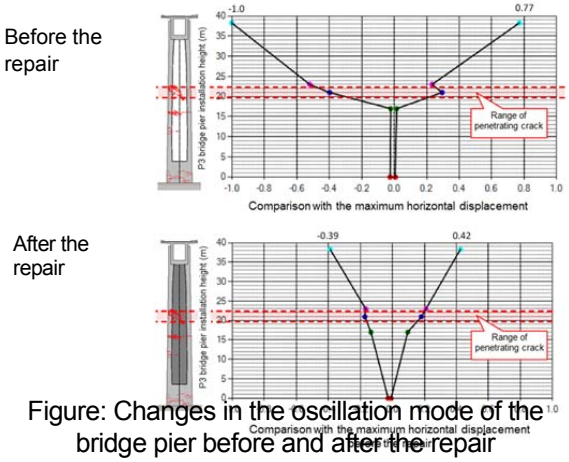

Figure: Changes in the oscillation mode of the bridge pier before and after the repair

The figure shows the comparison of the distributions of horizontal displacement in the direction of the height that occurred to the P3 bridge pier when oscillation was applied to the bridge by dropping a vehicle from a step before and after the concrete filling as an example of the outcome of the measurement. The x-axis in this figure indicates the value of horizontal displacement at the bridge pier which occurs when the maximum horizontal displacement found at the surface of a bridge during a vibration test conducted before a repair is 1.0. Before filling the concrete, the oscillation mode originated near the cross-section area where the crack penetrated. On the other hand, after filling, the oscillation mode changed to originate at the base of the bridge pier. This indicated that the concrete filling was resisting the shearing force that works on the damaged cross-section.

3. Use of monitoring data after recovery

The measured data of the oscillation characteristics of the repaired bridge can be used for maintenance and management, such as future diagnosis of the robustness of the bridge and measures to prevent deterioration. The authors are going to explore methods to use the data in the maintenance phase and the format of recording and saving the data.

☞For detailed information

Website of Kumamoto Earthquake Recovery Division

http://www.nilim.go.jp/lab/pgg/news.html

Promotion of i-Construction

Masahiko Sasaki, Research Coordinator for Construction Management
Takashi Sasaki, Research Coordinator for River Structures Masashi Fukushima, Research Coordinator for Road Structures i-Construction Promotion Headquarters

Keywords: i-Construction, productivity improvement, ICT, CIM, overall optimization

1. Introduction

Labor shortages have been a concern over a mid-to-long-term perspective in construction sites due to the aging of workers and the decreased young population in the industry. i-Construction is a part of the productivity reform that the Ministry of Land, Infrastructure, Transport and Tourism has been promoting. It aims to create attractive construction sites by improving the productivity of construction sites by optimizing the entire process from investigation and design to construction, inspection, and maintenance and management. In the Growth Strategy Council – Investing for the Future in September 2016, Prime Minister Abe, the chairperson, issued instructions to improve the productivity of construction sites by 20% by 2025.

The National Institute for Land and Infrastructure Management launched the i-Construction Promotion Headquarters in March 2016 to promote the research and development of the use of ICT and three-dimensional data and the improvement of the productivity of construction using concrete to promote their uses.

2. ICT construction

ICT construction can improve productivity through the integrated use of three-dimensional data in the investigation, survey, design, construction, and inspection processes. ICT earthwork was first introduced as one of top-runner projects of i-Construction in FY 2016, followed by the additional use of ICT pavement work in FY 2017. The National Institute for Land and Infrastructure Management is examining ways to expand applicable construction types and methods to use new survey technologies while investigating the implementation status at construction sites. It prepared a draft of work-done management using ICT in river dredging work in FY 2017. Based on the outcomes of these activities, the Ministry of Land, Infrastructure, Transport and Tourism released new standards for construction using ICT in March 2018 [planned].

3. Promotion of the use of CIM

CIM is the abbreviation of Construction Information Modeling/Management. It aims to improve the efficiency of the individual processes of design, construction, and maintenance and management and advance the coordination of information among these processes based on a three-dimensional model to which attribution information is added (figure). The National Institute for Land and Infrastructure Management is conducting research related to the use of the procedures and standards to promote the use of CIM. In FY 2017, it conducted research concerning the standards and specifications to be used for the contracts of CIM models, standards for quantitative calculations using CIM models, and the use of CIM in the maintenance and management phase.

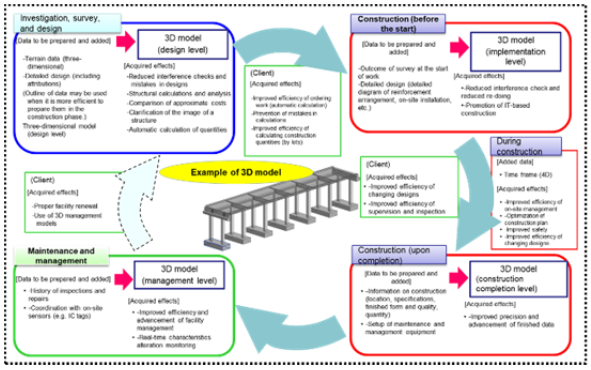

Figure: Use of three-dimensional models

4. Productivity improvement for concrete constructions (introduction of overall optimization)

Research is being conducted to realize overall optimization in the entire country rather than being limited to individual construction projects by improving the productivity of all concrete construction projects through the spread of technologies to improve construction depending on the individual characteristics of on-site concrete casting and pre-casting. Overall optimization focusing on design methods was examined in FY 2017.

5. Future outlook

In FY 2018, too, the NILIM is going to conduct research to improve productivity through the use of i-Construction, such as research to establish the necessary procedures and standards to spread ICT construction and start the use of CIM and research related to the use of the latest technologies, including AI, IoT, and robots, while following up on the implementation status at actual construction sites.

A proposal for ways to deal with vehicles parked or stopping on roads for safe and comfortable bicycle traffic (Research period: FY 2017–2019)

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Road Safety Division Hiroshi Kobayashi, Head(Dr.Eng.) Yuta Ozaki, Senior Researcher
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Road Division Hiroki Onishi, Guest Research Engineer

Keywords: Bicycle traffic space, ways to deal with vehicles parked and stopping on roads, bicycle lanes

1. Introduction

Today, bicycle traffic spaces, such as bicycle lanes, visually separated from car lanes are being installed on roads. Many bicycle lanes are being installed in urban areas, whereas many vehicles are parked on roads in urban areas. Vehicles parked in bicycle traffic spaces are impeding the traffic of bicycles in some cases. Coming up with ways to deal with vehicles parked or stopped on roads has therefore become an important issue along with the installation of bicycle traffic spaces (photo 1).

Photo 1: Examples of vehicles parked on bicycle traffic spaces

Conventional ways to deal with vehicles parking or stopping on roads include providing parking spaces based on parking demand. Meanwhile, such measures are often difficult on roads with limited widths.

Therefore, the National Institute for Land and Infrastructure Management (NILIM) is seeking methods to reduce the parking or stopping of vehicles in bicycle traffic spaces. This paper introduces these activities.

2. Vehicles parking or stopping on bicycle traffic spaces

Vehicles can easily enter bicycle traffic spaces when bicycle and vehicle traffic spaces are not physically separated. Thus, ways to prevent vehicles from parking or stopping in bicycle spaces may be necessary in some cases.

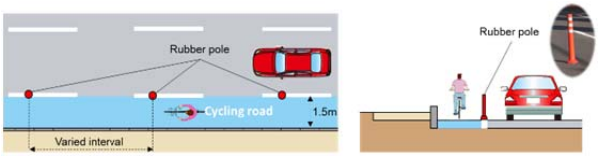

Figure 1: A way to prevent vehicles from parking or stopping using rubber poles

Thus, the authors focused on methods to prevent vehicles from parking or stopping in bicycle spaces by installing rubber poles with a certain height at the boundary between bicycle and vehicle traffic spaces (Figure 1).

3. Examination of a measure to prevent parking and stopping of vehicles using rubber poles

The expected effects of installing rubber poles include the reduction of parking or the stopping of vehicles and increased sense of safety among bicycle users. On the other hand, when rubber poles are installed at short intervals, they would affect the passing of bicycles (sense of being confined). Thus, the authors conducted an experiment to find the proper installation interval of rubber poles focusing on the sense of safety for bicycle riders and the effects on the passing of bicycles. In the experiment, twenty bicycle riders and vehicle drivers rode bikes and drove cars on a road mimicking a bicycle lane with a width of 1.5 meters in six cases, including 3, 6, 8, 10, and 12-meter intervals among the rubber poles. The participants answered a survey on the sense of being confined with the rubber poles and the effects to prevent vehicles from parking or stopping in the bicycle space after the experiment.

The experiment found that shorter intervals meant more preventive effects for vehicles from parking in the bicycle space and stronger sense of being confined for bicycle riders (Figure 2).

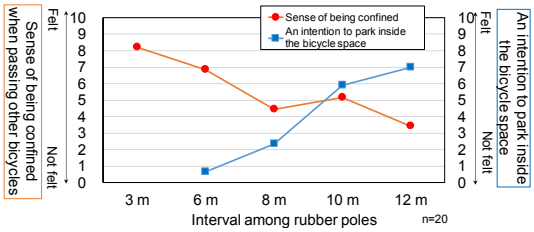

Figure 2: Result of the survey after the experiment

4. In the end

In addition to ways to reduce parking or the stopping of vehicles as discussed above, the authors are going to continue exploring effective ways to reduce vehicles parking or stopping on roads, including ways to install parking spaces based on parking demand.

For the promotion of the use of road spaces by streamlining the consensus building process

Hitomi Oguri, Senior Researcher Ryuji Inoue,Head
Road Environment Division, Road Traffic Department

(Research period: FY 2016–2017)

Keywords: Use of road spaces, open cafe, consensus building, process analysis

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism is working to promote regional activities using road spaces in response to the increasing need to use road spaces.[1] Consensus building among various stakeholders is one of the challenges in realizing the use of road spaces. Thus, the National Institute for Land and Infrastructure Management is clarifying the effects on traffic, especially during exclusive uses and the effects of using the road spaces, which are often discussed, and examining ways to effectively and efficiently build consensus for further promotion.

2. Analysis of consensus building process in examples of road space uses

The authors investigated the conditions of ongoing examples of road uses and identified challenges in consensus building and points to overcome the challenges through the analysis of the consensus building processes in individual cases (figure 1).[2] The authors examined the appropriateness of the outcomes of these analyses focusing on cases in which there were the intentions to use road spaces but actual uses were yet to be realized. The following section summarizes the flow of introducing a road use project and consensus building processes by project types and points to streamline the consensus building processes in negotiations and other necessary procedures.

3. Effects on traffic functions and the organization of methods to identify the effects

The authors focused on ongoing cases of road use projects and organized valid road widths, occupied ranges, and the relationship with pedestrian spaces. They also conducted on-site measurement surveys of open cafes and analyzed their effects on traffic. Specific methods to identify traffic conditions were also organized so that those who use road spaces could efficiently conduct investigations.

4. Systematization of the effects of road use projects and the organization of identification methods

The authors focused on the correlation with direct changes in the movement of people and systematically organized the category of effects from the perspective of the continuity of road uses. Specific methods to identify the effects of investigation methods and procedures were also examined to ensure efficient investigations and the reliability of investigation outcomes.

5. Future plans

The outcome of this research is going to be summarized in the Guidelines for Effective and Efficient Consensus Building to Promote the Use of Road Spaces and will be used as a reference to smoothly build consensus among stakeholders.

☞For detailed information

1) Ministry of Land, Infrastructure, Transport and Tourism: the website of exclusive use of road
http://www.mlit.go.jp/road/sisaku/senyo/senyo.html

2) Hitomi Oguri, Takashi Inoue, Mari Takimoto: Consensus building process for the use of road spaces and the analysis of points to streamlining consensus building process. Papers of Research Meeting on Civil Engineering Planning. Vol. 56, No. 213, 2017

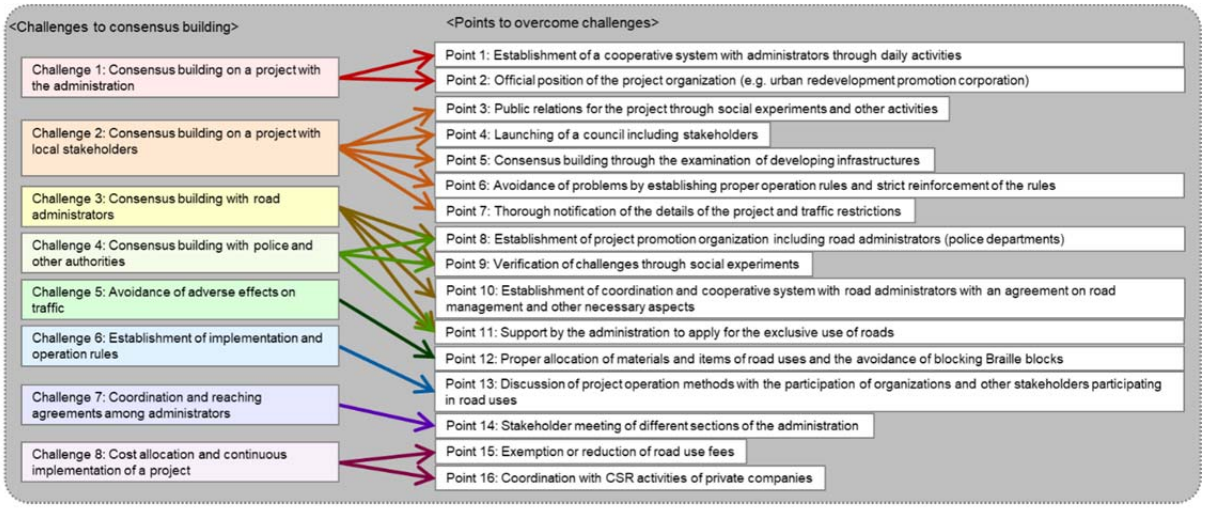

Figure 1. Challenges to consensus building and points to overcome them

Investigation to lower the cost of eliminating utility poles

Ryuji Inoue, Head Nodoka Oshiro, Senior Researcher Hitomi Oguri, Senior Researcher
Yuki Mitsutani, Researcher Road Environment Division, Road Traffic Department

Keywords: Elimination of utility poles, cost reduction

1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism has been eliminating utility poles to improve the disaster management capability of roads, secure safe and comfortable traffic spaces, and to build favorable landscapes and promote tourism. While the elimination of utility poles is a common practice in large cities in Europe and the United States, the ratio of zero-utility pole areas is still low in Japan. The Act on Promoting the Elimination of Utility Poles was issued and enacted in December 2016,[1] and the expectation for eliminating utility poles has been increasing since then. The common cable ducts that have been used in Japan are associated with the high construction cost of about 530 million yen per kilometer (including the cost of electric and communication facilities).[2] Thus, the cost needs to be lowered to promote the elimination of utility poles.

The National Institute for Land and Infrastructure Management has been conducting investigations to extract, organize, and examine technological challenges to lower the cost of utility pole elimination projects and to identify policies and technological trends in other countries to further accelerate the elimination of utility poles.

2. Identification of technical challenges to lower the cost

Challenges to reduce the cost of facilities (special parts, ducts, cables, ground devices, etc.) of utility pole elimination projects (common cable ducts, small boxes, direct burying, etc.) and construction methods are extracted and organized based on the characteristics of a location where utility poles will be eliminated (conditions along roads and road structures) and processes (probing of buried materials, relocation of obstacles, burying of ducts and cables, installation of special parts, supply conducts, installation of ground devices, etc.).

When organizing challenges associated with the characteristics of specific locations, the investigation is conducted assuming roads in residential areas where the electricity demand density is low, and utility poles will be removed using small boxes, commercial areas where the electricity demand density is high, and scenic areas in the suburbs where the electricity demand density is low, and the electricity demand remains relatively constant.

Figure 1. An image of residential areas

Figure 2. An image of scenic areas in the suburbs

3. Investigation concerning technologies and policies to lower costs

Based on the challenges extracted in 2, the authors are gathering information on the relevant technologies concerning methods that might contribute to a reduction in the cost of eliminating utility poles.

In other countries, utility poles are being quickly excavated and backfilled using special equipment and backfilling with concrete among other measures. The authors are investigating measures and technologies to reduce the cost in overseas cities, such as setting burying standards for electric wires and cables (e.g. direct burying, burying depth) and burying technologies (excavation, installation, backfilling, etc.).

Figure 3. Backfilling using low-strength concrete (Taiwan)

4. Future plans

The authors are going to continue efforts to establish technologies to reduce the cost to accelerate the elimination of utility poles.

☞For detailed information
1) Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism
http://www.mlit.go.jp/road/road/traffic/chicyuka/chi_20_01.html
2) The First Utility Pole Elimination Promotion Committee, Reference 3
http://www.mlit.go.jp/road/ir/ircouncil/chicyuka/pdf01/5.pdf

Handling of soil contamination with naturally occurring heavy metals (Research period: FY 2015–2017)

Ryuji Inoue, Head Nodoka Oshiro, Senior Researcher Yuki Mitsutani, Researcher
Road Environment Division, Road Traffic Department

Keywords: Road construction, soil contamination, naturally occurring

1. Introduction

Road construction sometimes discovers soil and rocks contaminated with naturally occurring heavy metals. These contaminations occur in soil up to a diameter of 2 mm, which is regulated under the Soil Contamination Countermeasures Act, rocks larger than 2 mm that are not regulated under the Act, and soil mixed with waste. Effective ways to deal with soil mixed with waste are now in demand.

The objective of this study is to share effective and efficient ways to deal with soil contamination in current road construction projects.

2. Investigation of conditions to deal with soil contamination

Conditions to deal with soil contamination found in national road construction projects were investigated from FY 2015 to FY 2017, and hearings were conducted when needed.

3. Scale of soil contamination and trends of disposal cost

The analysis of 57 cases of soil contamination in which the disposal cost per cubic meter was available (figure 1) found that the cost of common ways to dispose of contaminated soil was approximately from 1 to 100,000 yen per cubic meter. Based on the relationship between the amount of contaminated soil and the disposal cost, high-cost cases, such as 100,000 yen per cubic meter (road A and road B in figure 1) are ones with the disposal of soil mixed with waste. The cost per cubic meter probably increased because the soil must be separated from waste, which then must be sorted before disposal. Meanwhile, very low-cost cases, such as 150 yen per cubic meter, included ones in which enough space was provided as a temporary soil storage area for soil excavated from a tunnel, and most of the soil was reused near the construction site (road C in figure 1)

4. Method to dispose of rocks and risk communication

Contaminated rocks larger than 2 mm that are not categorized as soil under the Soil Contamination Countermeasures Act are large, and the elution of heavy metals from them is relatively slow. Therefore, effective measures, such as the example shown in figure 2, can be conducted after assessing the effect of heavy metals leaching out of the rock on groundwater.

Meanwhile, it is important to properly notify local residents of the risk of contamination to gain their understanding on the disposal of contaminated soil before actual disposal. Thus, the authors selected good examples of risk communication and analyzed factors for successfully gaining the understanding of local residents.

5. Application of findings

The authors are going to organize the findings of these investigations, prepare guidelines on the disposal of soil contamination in road construction projects, and apply the knowledge to various activities.

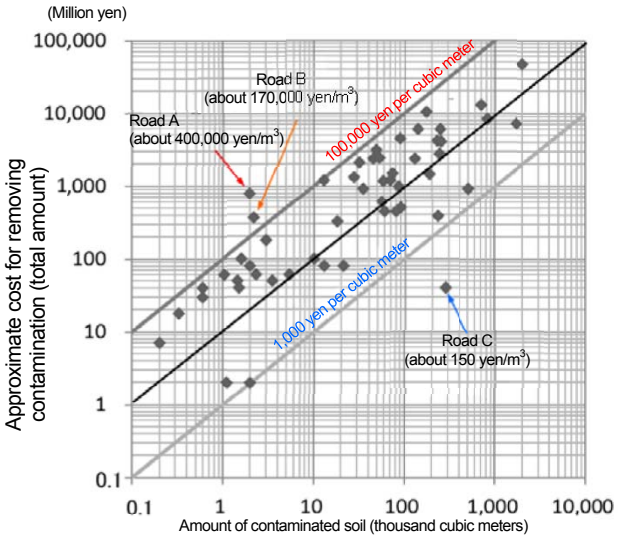

Figure 1: The relationship between the amount of contaminated soil and disposal cost

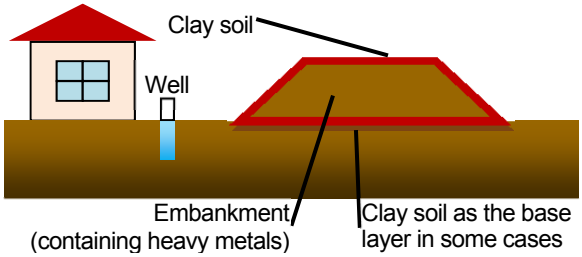

Figure 2: The concept of a way to use clay soil as water blocking material

☞For detailed information

1) Nodoka Oshiro, Yuki Mitsutani, Ryuji Inoue. Soil contamination encountered in road construction projects and the investigation of current measures to deal with the contamination. *Civil Engineering Technology Reference*. Pp. 8-11, November 2017

Maintenance and management of wooden public housing

(Research period: FY 2017–2018)

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Hideyuki Kobayashi, Researcher(Dr.Eng.) Koya Utsumi , Researcher(Dr.Eng.)
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Keywords: Wooden public housing, longer service life, repair of outer walls

1. The stock of wooden public housing units and the difficulty of maintaining them

There are more than two million public housing units in total in Japan. Among them, however, there are only about 83,000 wooden public housing units (3.8%). Yet, the ratio of wooden public housing units is more than half of all public housing units at 236 local public organizations, and some areas are operating many wooden public housing units.

A general technological development project titled the Development of Strategic Stock Management Technology of Regional Safe Residential Functions (FY 2015–2017) examined methods to elongate the service life of public housing units made with reinforced concrete for fireproof structures. Yet, not enough reference is available for the stock of wooden public housing units. Wooden public housings are often built with unique materials and structural methods, and the level of deterioration varies depending on management and utilization methods. Thus, it is difficult to present the standard style of maintenance and management.

2. How the uniqueness of wooden public housing units should be perceived

Wooden public housing units are unique. How the uniqueness should be perceived is important when exploring ways to elongate their service lives. The following is an approach focusing on the specification of the outer walls and construction methods (figure 1). For the specification of the outer walls, the main material of the outer wall is categorized into three types, including wood, non-wood (dry), and non-wood (wet), and the component pattern is assumed to be one type on the entire surface and a mixture of two types. For the construction method, many wooden public housing units are the two-in-one type (two dwellings in one building), which is distinguished from a townhouse-style housing unit consisting of three or more dwellings in one building. In addition, some housing complexes are mid-to-large-scale wooden housing complexes, such as three-story wooden housing complexes built with unique frameworks and joint technologies.

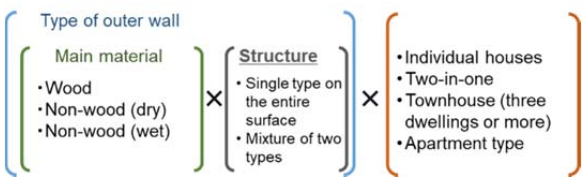

Figure 1. Category focusing on types of outer walls and construction type

3. Method to repair outer walls to elongate service life

The following section introduces methods to elongate the service life using the repair of the outer walls as an example.

3.1 Regular application of protective coating on wooden parts

The cycle of the application of protective coatings on wooden parts is usually five to ten years. The bases of columns start to decay before the tenth year after construction, and costly repairs become necessary in some cases. Thus, the regular application of protective coatings is preferred. The cost of re-application is about 300,000 to 600,000 yen per unit as the direct cost. Actually, however, not many local public organizations regularly re-applied coatings.

3.2 The renewal of outer walls with covering method

The regular application of the outer layer seems difficult as the budget is tight in many local public organizations. Under such circumstances, the renewal of the outer walls using a covering method is useful in public housing. The base material is applied on top of the deteriorated outer walls, and the base material is covered with new siding materials. The cost per unit exceeds one million yen, but this method does not require maintenance afterward and is advantageous in reducing the long-term management cost. The construction period is shorter than the replacement of the outer wall materials, and the work can be done while residents are in the house. Meanwhile, there are many uncertainties in regard to the compatibility with the original outer walls, and many issues need to be examined later.

Figure 2. Re-application of protective coating (left) and covering method (right)

4. To plan methods to elongate service lives

This paper introduced methods to elongate the service lives of wooden public housing focusing on the repair of the outer walls. Today, local public organizations are independently managing and repairing wooden public housing. A future plan is to prepare references to systematically elongate the service lives of wooden public housing units based on the knowledge gained through experience.

Planning of housing safety net using private rental houses

(Research period: FY 2015–2017)

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Housing Department

Keywords: People in need of special considerations in housing, private rental house, vacant house, supply plans, living support

1. Introduction

As the birth rate declines and the population ages, an important policy issue is to reinforce the housing safety net to enable the supply of houses for people, such as the single elderly and low-income people who require special consideration in housing (hereinafter "people in need of special considerations in housing"). Public housing used to play the central role as a housing safety net. Yet, as the national government and municipalities face tighter financial situations, it has become difficult to increase the amount of public housing. Meanwhile, the number of vacant private rental houses has been consistently increasing, and effective use of vacant houses has become a social challenge.

Thus, the Act to Partially Revise the Act on the Promotion of the Supply of Rental Houses for People in Need of Special Considerations in Housing was enacted on October 25, 2017. This revision stipulates the establishment of plans of municipalities to increase the supply of rental houses for people in need of special consideration in housing. In addition, a new registration system was established so that private rental houses would not decline for people in need of special consideration in housing as tenants.

Based on such changes in policies, the General Technological Development Project of the Ministry of Land, Infrastructure, Transport and Tourism, a development project for strategic management technologies for regional and reliable living functions (FY 2015–2017) examined methods to plan housing safety nets using private rental houses in FY 2017. It organized ideas concerning the establishment of plans to promote the supply of rental houses for people in need of special consideration in housing targeting municipalities.

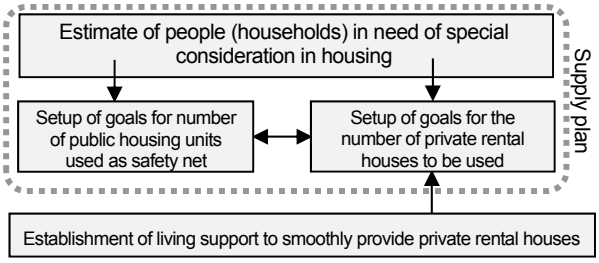

Figure 1: Framework of examining housing safety net planning methods

2. Housing safety net planning methods

Case studies were conducted targeting city A in a large city (population: 1.5 million) and city B, the capital city of a prefecture (population: 0.27 million), and the concept of the plan was organized.

(1) Estimate of households in need of special consideration in housing

The household in need of special consideration in housing is defined as households eligible for using public housing where the household income is too low to afford the average rental cost of a house that satisfies the minimum standard for living in a given region based on the range of the proper ratio of rent to income (approximately 14% to 21% depending on the number of people in a household and income).

The number of households in need of special consideration in housing was estimated for every five years from 2015 to 2045 based on the national census and housing and land statistics. The number of households continues to increase in city A from about 42,000 households in 2015 to 50,000 households in 2040 (Figure 2). The increase in the number of elderly household residents aged 60 or older becomes especially significant. Meanwhile, in city B (Figure 3), the number of households gradually decreases from 11,000 households in 2015 to 8,400 households in 2045.

(2) Number of public housing units under management and the goal for the number of private rental houses to be used

The red lines [1] in figures 2 and 3 indicate the number of public housing units in each city in 2015, and the blue line [2] the sum of [1] and the number

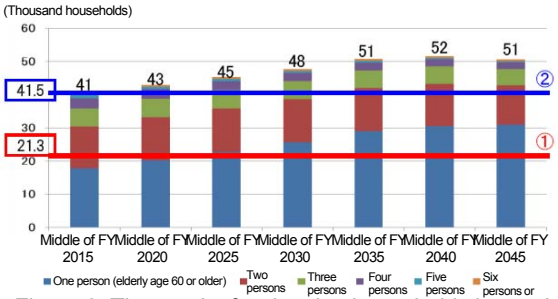

Figure 2: The result of estimating households in need of special consideration in housing in City A

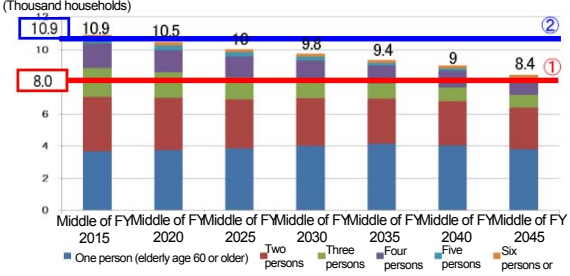

Figure 3: Result of estimating households needing special consideration in housing in City B

households receiving housing support as public assistance for living in private rental housing besides public housing (hereinafter "the number of public housing and housing assistance").

The result of estimating the number of households in need of special consideration in housing in 2015 and the number of public housing units and housing assistance were nearly the same in both city A and city B. City A, where the number of households in need of special consideration in housing is increasing, is expected to maintain the number of public housing units in stock while increasing the number of private rental houses to be used as safety net housing (hereinafter "SN housing") to up to 30,000 houses in 2040. Meanwhile, city B, where the number of households in need of special consideration in housing, can reduce the number of public housing units by about 20% to about 6,200 houses in 2045 by schematically terminating the use of and renewing public housing units that exceed their service lives (Table 1). About 2,000 private rental houses are going to be used as SN housings.

(3) Necessity of responding to regional demand and improving living support to effectively use private rental houses

Figure 4 shows the difference between the demand for people in need of special consideration in housing and the number of public housing units in city B in individual junior high school districts. The supply and demand balance greatly varies among regions. Table 2 shows the policy of using public housing in central urban areas where the demand is high and the estimated number of available private rental houses. The number of public housing units is in short supply compared to demand. In addition, city and prefectural plans are going to reduce the number of housing units by terminating the use of houses that exceed their service lives.

Table 1: Decrease in the number of public housing and the number of private rental houses used (City B)

(Year)	2015	2020	2025	2030	2035	2040	2045
Number of people in need of special considerations	10.9	10.5	10.0	9.8	9.4	9.0	8.4
Number of public housing *1	8.1	8.0	7.9	7.9	7.8	6.9	6.2
Number of private rentals *2	2.8	2.5	2.1	1.9	1.6	2.1	2.0

(Unit is thousand households and thousand units)

*1: Legally set service life is 70 years for fireproof structures, 45 years for semi fireproof structures, and 30 years for wooden structures

*2: Abbreviation of private rental housing, hereinafter

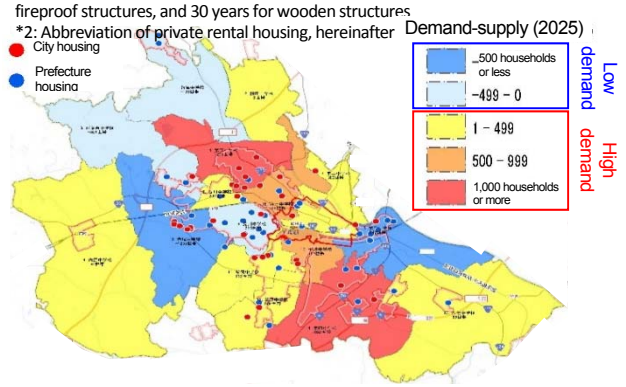

Figure 4: Demand and supply balance of public housing (City B, estimate for 2025)

Table 2: Necessary number of private rental houses and available number of units

(year)	2015	2020	2025	2030	2035	2040	2045
Number of people in need of special considerations	644	604	569	552	521	488	439
Number of public housing *1	186	186	150	150	102	102	102
Number of rented units *2	0	60	60	60	60	60	0
Necessary number of private rental housing	458	358	349	342	359	326	337
Available number of rental houses*3	Max: 376		Tenant non-declining rate: about 30%: 113 units Tenant non-declining rate: about 93%: 350 units				

*1: Based on action policies positioned as the public housing service life elongation plan in city B and applicable prefecture

*2: The city purchases properties with higher rent than the upper limit of the rent of SN houses and uses them as public housing for 20 years.

*3: The number of houses that satisfy the following conditions are estimated based on the data of construction plan outlines and housing and land statistics

[1] Constructed after 1981 (under new earthquake resistance standards)

[2] Housing area is 25 m^2 or more (larger than the minimum standard

Table 3: Main concerns of moving into private rental houses and ways to eliminate them

	Factors of concern	Living support service
Upon contracting	・Difficulty finding cosigners	・Cosigner agent service
	・Inability to understand contracts, inability to communicate	・Contract procedure support service (a person accompanying contract signing, dispatching of interpreters, etc.)
	・Risk of delayed rent payment	・Ret debt warranty service ・Rent support, payment of living support as an agent of the recipient of living support
While occupying a unit	・Anxiety toward causing neighborhood problems	・Living support service (watching, safety confirmation, living consultation, etc.) ・Furniture, asset, and property organization and disposal service, funeral agent service
	・Risk of sudden changes in health conditions	
	・Risk of dying alone	
When moving out	・Anxiety toward problems concerning reinstatement	・Reinstatement rules, inspection and appraisal upon moving out by third parties

Private rental houses need to be actively used to respond to housing demand within a region. The estimated number of available private rental housing units was up to 376 units. This means that there are enough vacant private rental houses to accept people in need of special consideration in housing who cannot be accommodated in public housing after 2020. Yet, landlords are sometimes worried about accepting single elderly people in need of special consideration in housing and reject renting houses to them (Table 3). According to a survey conducted by the national government, only about 30% of landlords do not feel the sense of rejection toward accepting single elderly people. The number of actually available units estimated based on this number is 113 units, which is far too few to respond to the demand. The ratio of landlords who would not reject single elderly people needs to be increased to more than 90% to respond to the demand. Ideas to overcome such a situation include the spread of subleasing systems through living support organizations and the improvement of living support services through cooperation between public and private services (such as examples shown in the right column of table 3).

3. Future plans

This paper summarized the concept of setting utilization targets for private housing and private rental houses and the supply of living support services to use private rental houses given the increasing demand among people in need of special consideration in housing. The author is going to summarize and release the outcomes of this study as a guideline.

Development of technologies to evaluate the energy consumption performance of advanced buildings

(Research period: FY 2016–2018)

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Building Environment Division, Housing Department

Keywords: Building, energy conservation, automatic control, evaluation technology

(Ph.D. (Engineering))

1. Expansion of energy consumption performance calculation programs

In April 2017, non-residential buildings with 2000 m^2 or more of floor area became required to comply with energy conservation standards. To support the evaluation to see the compliance status relative to the standard, the National Institute for Land and Infrastructure Management released the energy consumption performance calculation program (for non-residential buildings).[1] In addition to the evaluation to see compliance with the energy conservation standards, people started to use the program as an evaluation tool for the labeling system (BELS), which is linked to the application for subsidies. The program was mainly used to see whether a building satisfied the minimum level of energy conservation standards. Yet, the program is now in demand to properly evaluate advanced buildings equipped with advanced technologies. Therefore, the authors developed evaluation methods based on the analysis of on-site investigations and simulations of advanced technologies (especially automatic control technology and the technology to use unused energies), which are not sufficiently evaluated with the current program due to the shortage of technical examinations. The function of the program was thus expanded.

2. Brightness detection and control in lighting devices (automatic control technology)

Brightness detection and control in energy conservation standards is defined as the function to detect the brightness inside a room using a sensor (sensors) installed on the ceilings or other areas and to control the output of lighting devices depending on the detected values. The analysis using a simulation (radiance) was conducted to determine the energy reduction rate per opening ratio (area of window per floor area) (table 1). The requirements of lighting devices to ensure control to function effectively are also organized along with the requirements for the function of automatically controlled blinds that are used along with lighting control. References are thereby prepared to allow inspection organizations to properly evaluate energy conservation performance.

Table 1. Options of brightness detection control in lighting control

Option	Condition of application	Reduction rate
Dimming type W15	Opening ratio: 15% or more	0.85
Dimming type W15BL	Opening ratio: 15% or more with automatically controlled blinds	0.78
Dimming type W20	Opening ratio: 20% or more	0.80
Dimming type W20BL	Opening ratio: 20% or more with automatically controlled blinds	0.70
Dimming type W25	Opening ratio: 25% or more	0.75
Dimming type W25BL	Opening ratio: 25% or more with automatically controlled blinds	0.63

3. Air-conditioning systems using geothermal heat (unused energy)

The authors analyzed geothermal heat pump air-conditioning systems with large piles that could not be evaluated with the current program based on four on-site investigations at four sites and simulations (Ground Club). Geothermal heat exchangers were then categorized, and the conditions of their applications were organized (figure 1). The formula for estimating the heat exchange rate with the ground was then developed.

4. Reflection in the program

The evaluation methods for the brightness detection control of lighting devices and geothermal air-conditioning systems developed in this research were reflected in the program, which was released to the public in October 2017.

☞ For detailed information

1) NILIM reference No. 973: 2016 Energy Conservation Standards (issued in January 2016) Description of Relevant Technical Reference, Energy Consumption Performance Calculation Program (for non-residential buildings)
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn973.htm

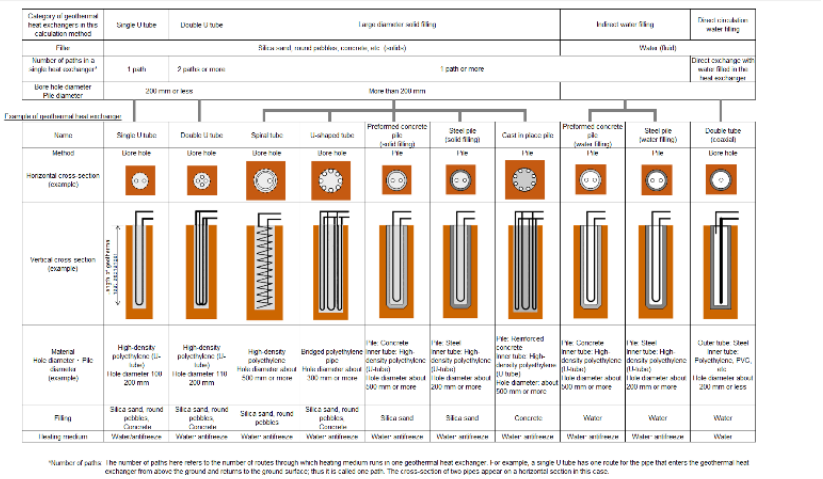


Figure 1. Category of geothermal heat exchanger and conditions of application in the energy conservation standard evaluation method

Study of facade design method to improve the energy consumption performance of buildings

(Research period: FY 2017–2019)

Building Environment Division, Housing Department

Head (Dr. Eng.) Yasuhiro Miki Senior Researcher (Dr. Eng.) Yoshihiko Akamine Senior Researcher (Dr. Eng.) Masato Miyata

Housing Department Research Coordinator for Housing Information System (Dr. Eng.) Yasuo Kuwasawa

Keywords: Energy conservation, facade, heat environment, light and visual environment

1. Background and objective

An important point in improving the energy conservation of a building is to reduce the load on devices, such as the air-conditioning load and lighting load, using arrangement plans and façade designs (plans for outer shells such as outer walls, windows, and roofs) that are in the upstream side of an architectural design process.

Also, façade designs have large effects on the heat environment and the light and visual environment, such as that low insulation performance creates an uncomfortable environment, such as cold temperatures near the floor and high temperatures near people' heads while using heaters. Meanwhile, the evaluation of the energy consumption performance of a building requires the forecasting of energy consumption that keeps changing with weather conditions and how devices are used. Thus, the presumptions of the indoor environment are now being limited, such as assuming that the indoor temperature remains homogeneous and constant while using air conditioning.

Based on the above, this study aims to develop methods to evaluate how façades affect building energy consumption performance and methods to design buildings (design guidelines) to increase the number of energy efficient buildings that realize high energy efficiency and a comfortable indoor environment at the same time.

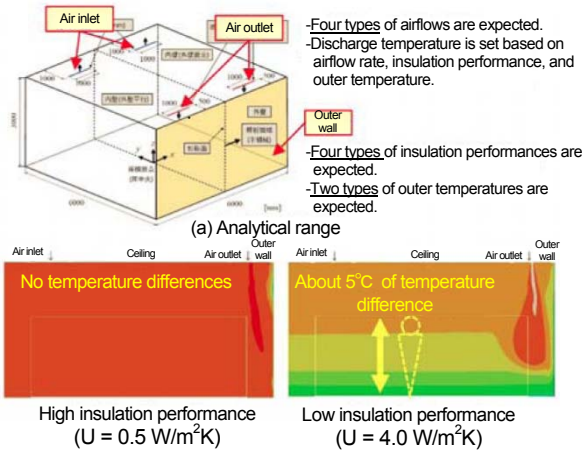
2. Details of the study

In FY 2017, the authors examined regulations and past studies inside and outside of Japan in regard to the aspect stated in 1 in table 1 and organized methods to calculate individual performances based on the types of façade (insulation and sunlight blocking performances, lighting and light guiding performances), as well as indexes and standards of the indoor environment (heat environment and light and visual environment).

The authors also simulated the indoor environment based on different types of façades. Figure 1 is the example of the computational fluid dynamics (CFD) of the heat environment while using heaters based on insulation performance. In addition to insulation performance, it examines the rate of airflow from an air-conditioning unit and its temperature. This examination found that improved insulation performance reduces vertical temperature differences (improved heat environment) even when the temperature setup is lowered with the same airflow rate or when the airflow rate is reduced with the same setup temperature (energy efficiency is improved in either case). The result was expressed in a figure so that designers could instinctively understand it.

Table 1: Main aspects of the study

1.	Development of methods to calculate individual performances of façades (redevelopment) and indexes and standards of indoor environments
2.	Development of methods to evaluate the energy consumption performance of buildings that takes into account the combined effects of arrangement plans and facades on air conditioning and lighting
3.	Development of facade design methods to improve energy consumption performance and the maintenance of proper indoor environments



(a) Analytical range

(b) Temperature distribution in indoor vertical cross-section (outlet rate 5 times/h, outer temperature 0°C)

Figure 1: The CFD of the heat environment based on insulation performance

3. Future plans

The authors are going to mainly examine table 1-2 in the next fiscal year, and test the developed evaluation methods in the final fiscal year to prepare a façade design method (design guideline) reflecting the outcomes of the study.

Development of method to evaluate annual lighting energy saving effect using daylight in offices

(Research period: FY 2015)

Building Environment Division, Housing Department

Head (Dr. Eng.) Yasuhiro Miki Senior Researcher (Dr. Eng.) Masato Miyata

Equipment Standards Division, Building Department Senior Researcher (Dr. Eng.) Hideki Yamaguchi

Keywords: Use of daylight in offices, annual lighting energy saving effect, evaluation method, energy conservation standard

1. Introduction

Non-residential buildings are expected to further improve their energy conservation performances, such as through the gradual requirement for new buildings to comply with energy conservation standards by 2020. Non-residential buildings are expected to improve the lighting energy saving effect using daylight as natural energy to realize net zero energy buildings (ZEB) while the use of high-efficient LED lights is now a common practice. Still, the reduction of lighting energy using daylight fundamentally requires annual simulations that take into account the weather conditions, the shape of openings and indoors, and specifications and setups of lighting devices. It is difficult to require designers to run such simulations and reflect them in the energy conservation standards. Therefore, the authors developed a method to simply and precisely evaluate the annual lighting energy saving effect in offices by running a systematic annual daylight simulation and calculating the energy saving effect based on indexes, such as the ratio of openings and the availability of automatically controlled blinds. The developed method was then reflected in the energy conservation standards.

2. The outline of the use of daylight in offices and outcomes of examinations

The use of daylight is a method to reduce lighting energy consumption while maintaining the necessary brightness within the entire office space by detecting brightness on a desktop using brightness sensors placed on the ceiling and controlling lighting devices based on the level of daylight entering through windows. Blind control is a system to automatically control the angle of blind slats. Its lighting energy saving effect was higher than non-controlled blinds (figure 1). This case was examined using Radiance, high-precision daylight simulation software, using standard setups to be reflected in energy conservation standards (no adjacent building on the outside, ratio of opening: 10%, setup illuminance: 750 lx, lower limit of the lighting control of a lighting device: 25%, fixed blind angle: 45°, no blind on the north side), and by systematically combining the directions of windows, number of surfaces, surface areas, and shapes of rooms. As a result, the standard office where blinds were installed had about 10% of an annual lighting energy saving effect with the use of daylight when the ratio of opening

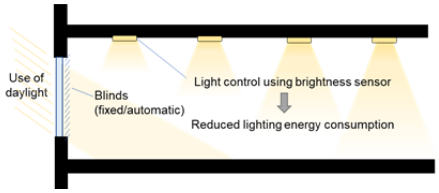


Figure 1: Method to reduce lighting energy using daylight

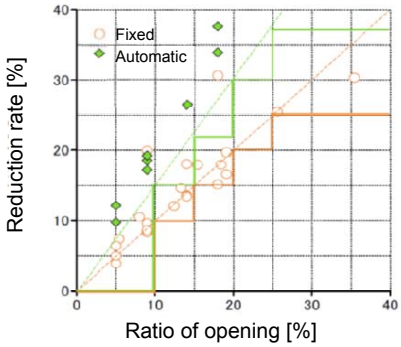


Figure 2: Relationship between the ratio of opening (open area/floor area of a room) and annual lighting energy saving rate

was 10%. The energy saving effect was greater when the blinds were being controlled compared to fixed-angle blinds. The angle of the regression line of the lighting energy saving rate for the ratio of opening was two times greater with controlled blinds. The study indicated that the energy saving effect could be easily identified with high precision (figure 2).

3. Reflection to energy conservation standards

The effects of reducing lighting energy using daylight based on the ratio of opening and the availability of automatically controlled blinds were reflected in the online program for the standard input method in the non-residential energy conservation standards in October 2017.

☞For more detailed information

1) National Institute for Land and Infrastructure Management Reference No. 973 2016 Energy Conservation Standards Technical References: Energy Consumption Performance Calculation Program (non-residential version) Ver. 2.4 (October 2017)

Investigation of the behavior of executors to optimize the evaluation of energy and indoor environment in buildings

(Research period: FY 2017–2018)

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Keywords: Utilization behavior, OA devices, internal heating, energy evaluation, evaluation of the indoor environment, ZEB

1. Background and objectives

Basic aspects to realize Zero Energy Buildings (ZEB: a building in which the net annual primary energy consumption is zero or approximately zero) include the elemental technologies, such as the improvement of the performance of outer shells and the use of facilities with advanced functions in addition to the reduction of internal heating (including the energy conservation of OA devices). Internal heating is given in the design of regular air-conditioning systems as the intensity per floor area. The conventional intensity is simply set with one meaning depending on the purpose of a given room; thus, it is not suitable for designs that take into account the energy conservation of OA devices. Hence, the design of air-conditioning systems to achieve ZEB requires a method to flexibly and reasonably set the amount of heat generated from OA devices.

The amount of heat generated from OA devices is affected by the maintenance status and how the devices are used; thus, it is likely to differ depending on business types even when devices are used for similar purposes. References about the actual uses of these devices are scarce, however, and the examination of methods to set the amount of heat generation requires the gathering and organization of fundamental information.

Therefore, this study investigates how OA devices are maintained and used in offices and prepares fundamental references to come up with a method to set the amount of heat generated from OA devices by taking into account the differences in the utilization behavior of users in different business types for the purpose of applying outcomes to air-conditioning systems aiming to achieve ZEB.

2. Outline of the investigation

In FY 2017, the author studied the literature and references to organize information concerning the maintenance status and utilization of OA devices. The author also conducted a survey about the maintenance status and categorized office spaces into three types ([1] clerical work, [2] research, professional, engineers, and [3] retail and sales) depending on business types where OA devices were used. The author then investigated the number of OA devices used, number of seats (desks) by business types, total floor area, and seat (desk) occupancy rate by hours (table 1). Twenty-six businesses responded to this study, and the author is now organizing the responses (figure 1).

3. Future perspective

The author is planning to analyze the correlation between the number of devices and individual elements (number of seats (desks), total floor area, and the component of business types which use office spaces) and organize the findings as a fundamental reference for examining methods to set the amount of heat generation.

Table 1. Outline of the investigation

Method of investigation	Distribution of survey forms by mail	
Number of surveys distributed (number of responses returned)	45 cases (26 cases)	
Investigated room	Office space ([1] clerical work, [2] research, professional, engineer, [3] retail and sales)	
Investigation category	Basic information	Name of company/organization, attribution of respondent, business type
	Information of the room	Number of seat (desks) by business types, total floor area, seat (desk) occupancy rate by hour
	Number of OA devices in the room	Multipurpose device, copy machine, scanner, fax, printer, shredder, telephone, desktop PC, laptop PC, PC monitor, desk lamp, projector, server, router, charger for tablets, charger for mobile phones, vending machine, coffee machine, tea server, water server, refrigerator, electric pot, electric kettle, microwave, television set, humidifier, air purifier, fan, electric heater

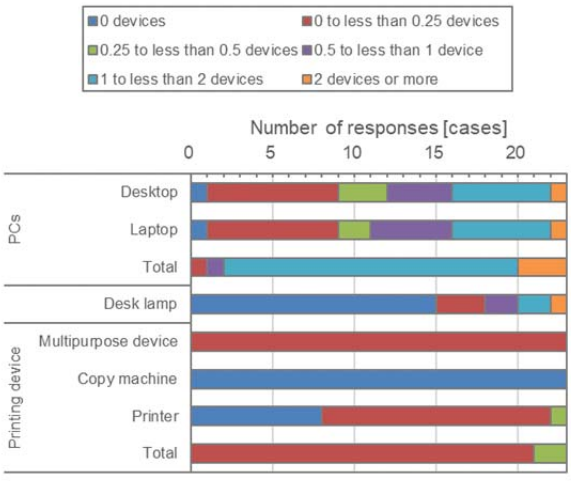

Figure 1. Number of OA devices per seat (desk) ([2] research, professional, engineering [23 cases])

Research on the investigation of urban greenery using aerial laser surveys

(Research period: FY 2015–2017)

Masamiki Ohashi, Senior Researcher Urban Planning Division, Urban Planning Department

Keywords: Aerial laser surveying, remote sensing, greenery

1. Introduction

Green plants are an important element for developing a favorable urban environment. A quantitative evaluation of the effects of greenery is needed to effectively introduce the various functions of urban green areas. Making it visible to see how nearby greenery is positively affecting the surrounding environment leads to a deepening of the understanding of landowners and an increase in the awareness of local residents when expanding green areas on privately owned land that occupies the major part of urban areas. It also becomes the ground data for presenting the effects of greening policies.

Today, local public organizations are investigating green coverage rates using aerial photographs when they investigate the conditions of green areas. The investigation of the green coverage rate enabled the identification of the total amount of urban greenery. This therefore clarified the fact that green areas have been decreasing. A quantitative evaluation method to measure the effects of greenery and the advancement of methods to measure green areas are necessary to maximize the effects of remaining greens and to increase green areas again.

This study examined the advancement of methods to measure green areas using aerial laser surveys to quantitatively evaluate the effect of green areas in the urban environment.

2. Investigation of green areas using aerial laser surveys

Laser surveying (LiDAR) is a technology to measure the distance from a target using a laser. Aerial laser surveys enable the three-dimensional identification of trees and buildings on the ground and terrain as the data of point groups (figure 1). Figure 2 shows an example of creating tree-height models (DCHM) that express the three-dimensional quantity of greenery by processing data obtained through aerial laser surveys. The surveys enable the three-dimensional capture of the conditions of green areas, which used to be limited to the identification of the plane surface distribution of greenery in investigations based on conventional aerial photographs. Among the green areas, the effect of reducing the thermal environment differs between turf and trees. The three-dimensional survey of the amount of greenery enables the evaluation of these differences.

The distribution of laser points surveyed from the air with the background of black-and-white photograph which is expressed with colored point groups

(Legend)
Reflection intensity
Red: Strong
Blue: Weak

Figure 1. An example of point group data of aerial laser surveying

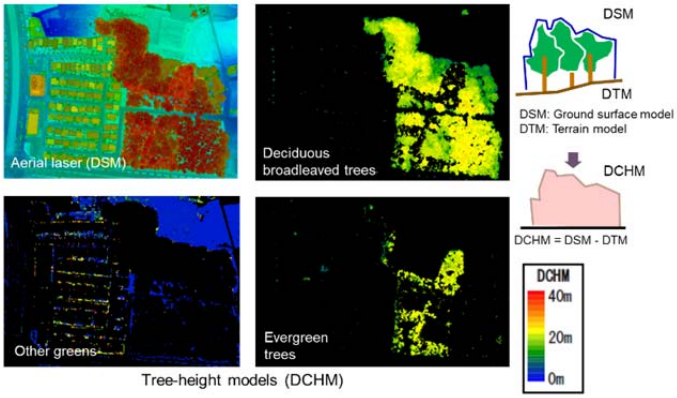

Figure 2. Three-dimensional green surveying

3. Conclusion

A more detailed analysis requires the categorization of the types of greenery identified as values based on functions. This study developed a method to estimate the necessary parameter of trees to run numerical simulations of the urban environment based on the effects of trees using aerial laser survey data and examined simple methods to evaluate the thermal environment improvement effects of urban green areas and the indirect effects of reducing carbon.

Survey methods that enable the quantitative evaluation of other functions of green areas are going to be developed in the future.

☞For more detailed information

1) Website of Urban Planning Division (Identification and evaluation of urban greens)
http://www.nilim.go.jp/lab/jbg/green/green.html

Development of method to analyze and evaluate urban structures based on diversifying living support functions (Research period: FY 2017–2019)

Urban Facilities Division, Urban Planning Department

Head Hiroyasu Shingai Senior Researcher Jundo Yoshida

Urban Planning Division Head (Dr. Eng.) Nozomu Kiuchi

Urban Development Division Head (Dr Eng.) Wataru Katsumata

Keywords: Compact, urban structure, living support functions

1. Background and objective of the study

An important issue of individual cities is how they would realize compact urban structures as a function to deal with population changes as the overall population in Japan rapidly decreases and ages while the need for the development of sustainable cities increases.

Meanwhile, methods to supply living support services (living support functions) have rapidly been developed in recent years. Such developments are not limited to demand response services linked to ICT and the field of transportation, such as automatic driving and drone technologies, they also include increased functions of convenience stores for use as social infrastructures. In addition, there are also rapid developments in the field of land use. The National Institute for Land and Infrastructure Management (NILIM) has been focusing on ways to combine modes of transportation systems based on new technologies, such as the automatic driving mentioned above, and clarified how transportation networks and component technologies should be developed to realize compact cities and the feasibility of the entire transportation systems.[1] This study expands its perspectives and determines various possibilities of urban structures associated with the advancement and uses of living support functions in the fields of transportation and land uses. This study then aims to develop technologies to analyze and evaluate the effects of improving compactness and the quality of life as a function of cities based on urban structures.

2. Main contents of the study

In this fiscal year, the first year of the study, the authors first gathered and organized information concerning the new technological development of living support functions, as well as the trend and outlook of the spread of such technologies (figure 1).

Figure 1: Example of diversifying living support functions

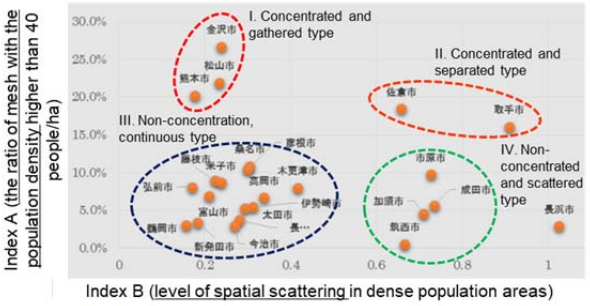

Figure 2: Characteristics of cities seen based on the level of population density and how they are scattered

The authors also analyzed the current urban structures using the level of population densities in the main cities in Japan and the scattering of dense population areas as the scale of evaluation and successfully categorized them into groups with certain characteristics (figure 2).

The authors are further categorizing and organizing options of possibly sustainable urban structures while linking them to living support functions. They are also organizing fundamental structures of indexes for the effects of using living support functions and methods to analyze their effects on urban structures.

3. Future perspectives

The authors are going to set analytical indexes to measure the effects of using the diversifying and advancing living support functions and their effects on urban structures and perform case studies using actual cities as subjects. At the same time, the authors are going to construct methods to analyze and evaluate what types of urban structures would realize compact cities based on regional characteristics and develop methods to analyze and evaluate what kind of living support functions would become factors for realizing compact cities.

☞For more detailed information

1) Study of methods to plan urban transportations using new technologies. Urban Infrastructure Technology Promotion Council, the 29th Technical Research Presentation, B01, UIT, Nov. 2017

Study of new technology to survey pedestrian spaces

(Research period: FY 2017–2018)

Urban Planning Division, Urban Planning Department
Jundo Yoshida, Senior Researcher Hiroyasu Shingai, Head

Keywords: Image analysis, pedestrian traffic volume, survey conditions

1. Introduction

The flow of pedestrians is becoming significantly complicated in pedestrian spaces in recent years because of the mixture of various types of pedestrians (e.g. commuters, shoppers, and tourists) as the functions of nearby facilities are becoming combined, in addition to the increased size and diversity of the belongings of pedestrians (e.g. suitcases and baby carts). Under such circumstances, administrations are often required to improve the pedestrian environment in central parts of cities and tourist spots as the number of non-Japanese tourists increases.

The improvement of the pedestrian environment requires the identification of complicated pedestrian flows. The required data include the types of pedestrians at many fixed points within the target areas, walking speed, and walking routes within the target areas. A mainstream method to obtain these data used to be the allocation of survey staff in observation ranges to visually check pedestrians. Yet, the data acquisition method using image analysis has been established in recent years. This paper introduces the effectiveness of the current image analysis technologies.

2. Comparison between visual surveying and image analysis

The figure below shows the comparison between pedestrian traffic volumes measured through visual counting surveys and volumes estimated using image analysis technologies at Shinjuku Dori near Shinjuku Station during the daytime of a cloudy day.

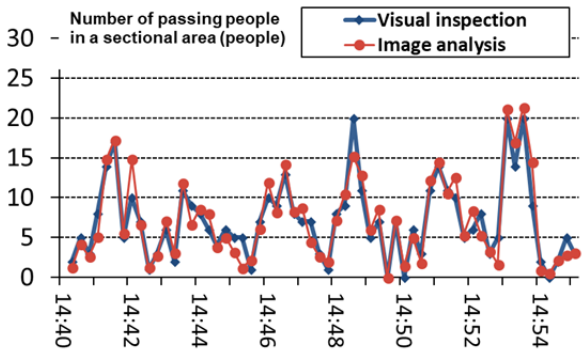

Figure: Comparison between visual survey and image analysis

The ratio of the sum of the volume estimated by the image analysis during the survey period was 101% of the volume measured through visual inspections indicating that the volumes were about the same in both methods.

3. Precautions for using the image analysis technology

The environments around pedestrian spaces where actual surveys are conducted are diverse. The result of the comparison discussed in the last chapter is an example under the environment that is relatively suitable for surveying with image analysis. It must be noted that the precision may decrease under certain survey conditions. The table below summarizes the characteristics of visual surveys and image analyses, including the effects of survey conditions on the outcomes of surveys.

The selection of suitable survey methods and complementation among different survey methods are required based on these characteristics.

Table: Characteristics of image analysis and visual survey

		Investigation method	
		Visual inspection	Image analysis
Effects of survey conditions	Pedestrian density	- Errors tend to increase when many pedestrians overlap with each other depending on the angle of image capture. G6	- Errors tend to increase when many pedestrians overlap with each other depending on the angle of image capture.
	Belongings and clothes of pedestrians	- No serious effect	- The precision tends to lower when many pedestrians put up their umbrellas. - Failure to recognize pedestrians may occur when they are wearing masks or hats.
	Optical environment	- No serious effect	- The precision tends to lower in the morning and late afternoon when the sun angle is low.
	Road conditions	- No serious effect	- The precision may lower when pedestrians and vehicles are not clearly separated.
Other characteristics	Privacy	- No major problem because no personal information is used.	- Notification about the survey is required. - Images need to be immediately deleted after acquiring traffic volume data (after the analysis).
	Continuity of data acquisition	- Data can be acquired only while survey staff are present.	- Data can be acquired for a long time.

☞For more detailed information
1) The 37th Presentations of the Japan Society of Traffic Engineers No. 72, pp. 459-465

Research concerning tourism-oriented town development

(Research period: FY 2016–2018)

Jundo Yoshida, Senior Researcher Hiroyasu Shingai, Head
Urban Facilities Division, Urban Planning Department

Keywords: Tourism-oriented town development, pedestrian space, possible duration of sunshine, morning type

1. Introduction

The national government of Japan has set a goal of nearly doubling the number of non-Japanese travelers visiting Japan to about 40 million people by 2020. Presently, the balance between demand and supply of the service of tourism infrastructures (e.g. traffic facilities, accommodations, and cultural facilities) are in tight balance in some regions and seasons. Given such circumstances, this study examined morning-type tourism to reduce the peak load on traffic infrastructures and other facilities that support the tourism industry.

2. Characteristics of standard time in Japan

Since the introduction of the fixed time method in 1872 in Japan, many social activities, including tourism activities, have basically been conducted based on the time indicated by clocks rather than the position of the sun. Since the national land is located toward the east of the Japan Standard Time Meridian, however, the time between sunrise to the start of social activities is long. When longitude momentum is defined as follows, and the condition of Japan is compared with conditions of other countries, the peculiarity of Japan becomes clarified (see the table).

$$\overline{M} = \frac{\iint_A R\,(\cos\phi)\lambda \cdot R\,d\phi \cdot R\cos\phi d\lambda}{\iint_A R^2\cos\phi\,d\lambda d\phi} = \frac{\iint_A R\cos^2\phi\,d\lambda d\phi}{\iint_A \cos\phi\,d\lambda d\phi}$$

Here;

$\overline{M}$: Longitude momentum φ: Latitude

R: Radius of Earth A: Target area (national land)

λ: Difference in longitude from Japan Standard Time Meridian

Table: Longitude momentums of many countries

Country	Longitude momentum [km]	[Reference] Number of international travelers accepted [10,000 people](2014)*based on Tourism White Paper
Spain	1543.4	6,500
China	1488.6	5,562
France	949.1	8,370
South Korea	663.7	1,420
United States	363.0	7,476
Italy	268.2	4,858
Japan	**-230.1**	**1,341**

3. Business hours of tourist facilities and possible duration of sunshine

Given that many tourism activities are conducted within the possible duration of sunshine, the setup of standard time with which sunrise and sunset become earlier may be lowering the international competitiveness of the tourism industry in Japan. As shown in the figure, possible durations of sunshine in different countries and business hours of tourism facilities indicate the possibility that the time from sunrise to the start of business hours is longer in Japan compared to other countries; thus, tourist activities may be restricted. In addition, in especially crowded tourist spots, it is important to guide tourism demand to the time zone immediately after sunrise to reduce peak demand. To realize this, all stakeholders, such as the administrators of traffic and tourism facilities and those in the accommodation industry, need to cooperate with morning-type tourism.

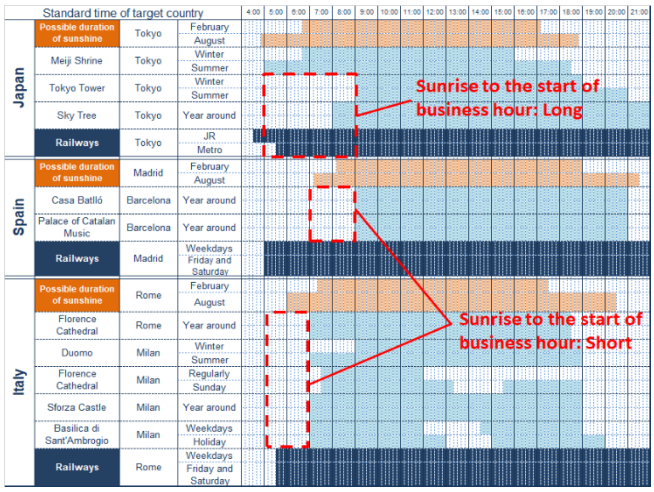

Figure: Possible duration of sunshine and business hours of tourism facilities

4. Future plans

This study is going to analyze the economic effects of morning-type tourism and examine measures to vitalize towns by guiding tourists to pedestrian routes.

☞For detailed information

1) The 55th Research and Lectures of the Japan Society of Civil Engineers vol. 55, No. 06-08 "An observation concerning the leveling of tourism demand by dispersing activity hours of tourism."

Challenges to the use of open spaces in winter

(Research period: FY 2016–2017)

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Urban Disaster Mitigation Division, Urban Planning Department

Keywords: Snowfall, open space, tourism, disaster management

1. Introduction

While deep-snow areas are expected to actively attract non-Japanese tourists to their regions, open spaces, such as parks, are playing various roles, including for relaxing and as tourism resources. Open spaces also function as evacuation sites and bases of rescue and recovery activities in case of natural disasters. However, deep-snow areas in winter do not have enough plans to use open spaces for disaster management based on an expectation that snow would restrict the use of open spaces. It is necessary to prepare open spaces so that they can smoothly function as disaster management sites in case of a natural disaster while actively using them during regular periods.

Based on the above, the National Institute for Land and Infrastructure Management (NILIM) is examining challenges to maintain the disaster management functions of open spaces in winter while using them during regular periods.

2. The status of the use of open spaces in winter

The authors organized how open spaces were actually being used in snowy areas and found the following uses.

- Using open spaces as snow-dumping sites to improve the efficiency of snow removal work and regional safety
- Having winter events, such as snow festivals, by seeing snow and cold temperatures as regional resources (Photo 1)
- Winter sports, such as cross-country skiing, and uses as observation sites for swans
- Snow removal as a part of the activities for local people and using open spaces as sites where local people can meet each other and build relationships
- Using open spaces as movie film locations to promote uses during winter

3. Challenges when a natural disaster occurs in winter

Some challenges are found in terms of the use of open spaces when a natural disaster occurs in winter.

- Shortage of budget and labor: It is difficult to gain the understanding of finance departments to increase the function of open spaces to prepare for years with heavy snow.
- Limited use of open spaces during the period of snowfall: Emergency manhole toilets cannot be used during the period of snowfall. It is difficult to designate outdoor spaces as evacuation sites (photo 2). People cannot reach there in heavy snow.
- Restrictions as event sites: It is difficult to provide spaces as evacuation sites in case of a natural disaster when events are being held in the open spaces.

4. Plans to use findings in the future

The authors are going to additionally investigate challenges and countermeasures in regard to disaster management so that open spaces can be used during regular periods and in case of natural disasters in winter. Information found through these investigations is going to be provided to administrators of open spaces and disaster management organizations through the website of the NILIM.

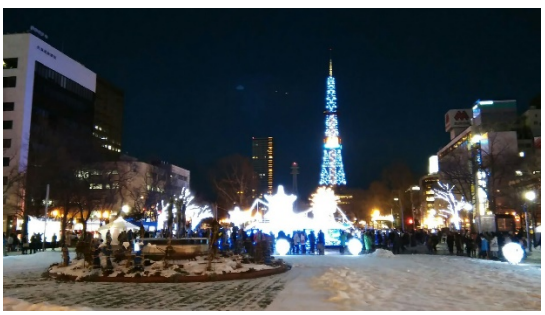

Photo 1: An example of using open spaces in winter

Photo 2: An example of difficulty in using open spaces due to snow

Method to estimate the cost effectiveness of developing medical and welfare facilities which support lives in regions

(Research period: FY 2015–2017)

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Urban Facilities Division, Urban Planning Department　Hiroyasu Shingai, Head

Keywords: Consolidated urban structure, regional base, future population, medical and welfare facility, proper arrangement, cost effectiveness

1. Introduction

The development of a consolidated urban structure where child-raising households to elderly households can safely live within walking distance requires the proper arrangement of facilities and services, including medical facilities and welfare facilities, which support the lives of a region (hereinafter "regional lives support functions") by shifting them to the central area of a region, such as by constructing them adjacent to public tenant housing when they are rebuilt.

The National Institute for Land and Infrastructure Management is developing planning and evaluation technologies to chronologically and spatially forecast the demand and shortage of regional lives support functions based on forecasts of the future population and household structures on a regional level to accelerate proper arrangement of these facilities.

The following discusses the method to estimate the cost effectiveness of developing regional lives support functions proposed through the development of this technology.

2. Method to estimate cost effectiveness concerning the development of regional lives support functions

Upon the development of regional lives support functions, the authors examined categories to evaluate the costs and effectiveness of individual stakeholders (local residents, facility administrators, regional public organizations) in monetary amounts (table 1).

The cost effectiveness is evaluated by blocks for local residents, individually for facility administrators, and by administrative zones for regional public organizations.

Figures 1 to 2 show examples of estimating the future shortage of facilities through the construction of new facilities using a kindergarten as an example and changes in the cost effectiveness for local residents. In figure 1, the mesh distribution of the forecasted number of children in 2040 is overlapped with the available zone (walking distance) of current facilities. When a new kindergarten is constructed in 2020 in an area with many children who face difficulty in using a kindergarten because they are outside of the available zone or because current kindergartens are full even when they are in available zones, the number of children facing difficulty in using a kindergarten significantly decreases. Figure 2 indicates that the cost effectiveness for applicable local residents remains around 0.5 with the current facilities, but it exceeds 1.6 when a new kindergarten is constructed in 2020, indicating the high effect of constructing the facility.

Table 1: Categories to evaluate cost and effects of constructing facilities for individual stakeholders

Stakeholder	Cost (C)	Effect (B)
Local residents	User fees, time and cost to go to hospitals and drop off/pick up, time and cost needed to childcare and nursery when a facility cannot be used, etc.	Value of time to use childcare and nursery services, value of the time for dropping off/picking up by facilities, etc.
Facility administrator	Cost of administration, cost of dropping off/picking up, lease charges and renovation cost, cost of trips for visiting nursery services, etc.	Business revenue, subsidy, etc.
Regional public organizations	Subsidies given to administrators	Residents tax with increased employment for parents and caretakers, corporate tax revenue from facilities, increased residents tax due to the employment of staff at facilities, etc.

3. Summary

The method proposed above enabled the estimation of the cost effectiveness of constructing regional support functions for individual stakeholders that can be used to determine the appropriateness of constructing applicable facilities. The authors are going to improve the precision of the cost effectiveness estimation method by verifying it based on case studies in various cities and regions.

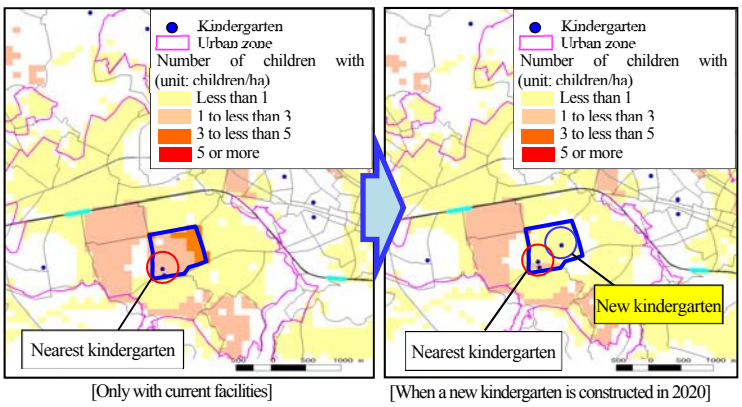

Figure 1: An example of estimating changes in future shortage of facilities when a new kindergarten is constructed

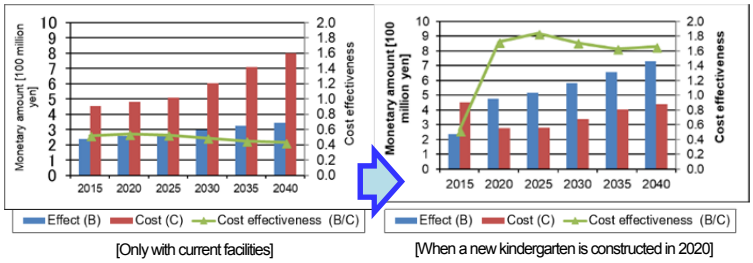

Figure 2: An example of estimating changes in cost effectiveness for local residents when a new kindergarten is constructed

Investigation of the emergency interpretation of landslides using SAR satellites

Joko Kamiyama, Senior Researcher Tomoyuki Noro, Head Yamato Suzuki, Research Engineer Kumiko Yamashita, Guest Research Engineer Hikaru Todate, Guest Research Engineer Sabo Risk-Management Division, Sabo Department

Keywords: Large-scale landslide, synthetic-aperture radar, interpretation study

1. Introduction

The method to interpret and examine large-scale landslides using images from synthetic-aperture radar (SAR) is proposed to identify the onset of landslides regardless of day, night, or weather.[1] The constant observation by high-resolution SAR satellites has accumulated data in recent years, which increased the opportunity to gain images before and after a natural disaster observed under the same conditions. The comparison of radio wave reflection intensity before and after a natural disaster makes it easier to find areas with changes in the ground surface covering two periods of time. While images captured after a natural disaster alone were mainly targeted for the interpretation of the large-scale movement of sediment, such as deep-seated landslides, SAR images may be able to target the interpretation of small-scale phenomena by comparing two periods of time.

This paper reports how the National Institute for Land and Infrastructure Management (NILIM) interpreted landslides that occurred in the heavy rain in northern Kyushu in July 2017 using images captured before and after the natural disaster and the outcomes of the interpretation.

2. Responses with interpretation and outcomes of the interpretation

For the heavy rain that occurred mainly in the city of Asakura, Fukuoka, on July 5, 2017, ALOS-2 was observed around 12:50, July 7 when images were captured before and after the heavy rain for the purpose of interpreting the locations of landslides. NILIM received the observation data around 14:20 and reported the interpretation outcome to the Kyushu Regional Development Bureau via the Ministry of Land, Infrastructure, Transport and Tourism around 20:00. The interpretation was based on RGB color composite images of data captured before the disaster (April 29, 2016) and after the disaster (July 7, 2017) (figure 1) and optical images captured before the disaster to identify conditions before the damage.

The interpretation found no major landslides or blockages of rivers like the ones in the Ono District, city of Hita, Oita. Yet, it found many areas with possible outflows of landslides along the valleys on slopes. The result of the interpretation was used to select focused areas of helicopter investigations near Toho Village, Fukuoka, where no helicopter investigation could be conducted after the onset of the disaster due to the effect of bad weather.

Some of the identified areas indicated changes in the ground surface covering, which was probably artificially modified through deforestation, although the interpretation was correct as to finding areas with changes in radio wave reflection intensity. Yet, it still has a problem in determining its certainty when it is used to find areas with the onset of new sediment movement. Although it successfully identified small-scale sediment movements of a few thousand square meters, it missed collapses larger than 10,000 square meters because of ambiguous changes in the SAR images compared to surrounding areas due to the relationship among ground covering conditions, slopes, and the direction of radio wave irradiation (figure 2).

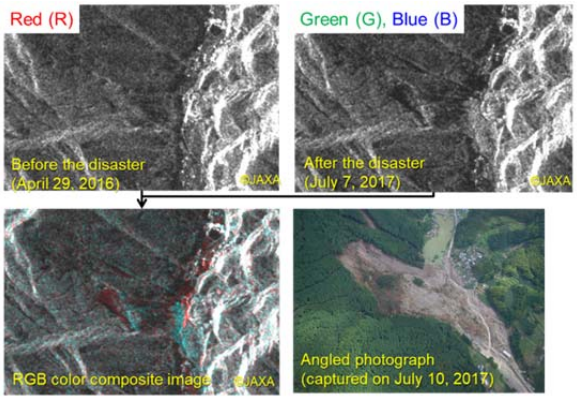

Figure 1: Examples of color composite images (Ono District, city of Hita: about 60,000 m^2 of area)

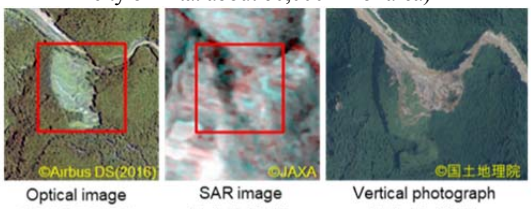

Figure 2: Examples of overlooked collapses (about 15,000 m^2 of area)

3. Summary

The authors are examining the ranges of application and investigation methods in regard to the interpretation of sediment movement using images captured in two periods of time before and after a natural disaster. The authors are going to continue this study to effectively use SAR images as the technology to investigate damage from natural disasters.

☞For detailed information

1) NILIM reference No. 791

http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0791.htm

Concept of Setting Volume of Sediment Supply in Considering Channel Restoration in the Akatani River

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River Division, River Department

keywords: channel clogging, volume of sediment supply, channel design

1. Introduction

The 2017 Northern Kyushu Heavy Rain caused slope failures simultaneously in different places along the Akatani River, a branch river of the Chikugo River system, leading to clogging of the channel and flood, as well as damage to people and many houses (see Photo 1). In the Akatani River basin, there still remains a lot of unstable sediment on the slopes and in the streams, and even in the event of a relatively small flood, sediment discharge that could cause riverbed elevation may occur. We therefore organized the concepts of how to determine the volume of sediment supply in order to consider river channel restoration based on the sediment deposition in the Akatani River.

Photo 1 Sediment deposition in the Akatani River

2. Grain size of sediment clogging the channel of the Akatani River

Figure 1 shows the riverbed height profile and grain size composition of sediment clogging the channel before and after the disaster in the Akatani River and Otoishi River, a branch river in the upstream of which a large scale collapse occurred. It is known from the grain size composition of the lower layer, which is considered free from the effect of sediment movement / fine classification by normal flow after the flood, that main components of sediment clogging the channel are coarse sand (0.5-1 mm), which constitutes sand of weathered granite soil, very coarse sand (1-2 mm), and fine gravel (2-4 mm). In the upstream, coarse grains are found more in the grain size composition of the surface layer than that of the lower layer since the ratio of medium gravel (4-64 mm) and large gravel (64-256 mm) is higher than the lower layer. In the downstream, refined grains are found more since the ratio of coarse sand increased than the lower layer. It can be conjectured from that the re-migration and classification of sediment due to the small flow rate

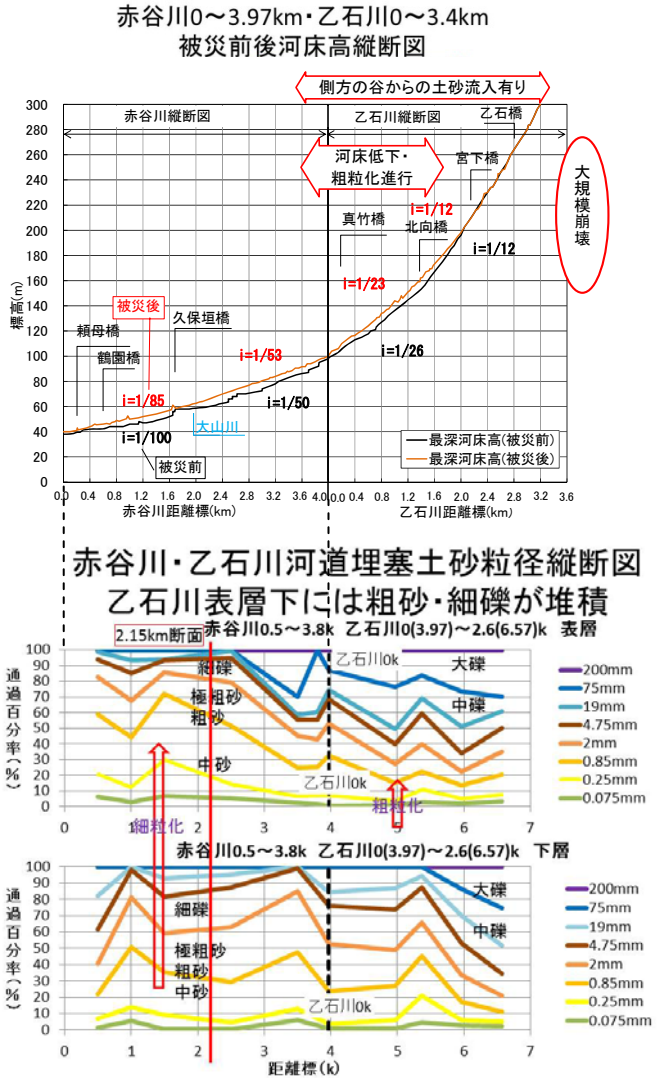

Fig. 1 Bed height profile (above) and grain size composition profile (below) before and after the disaster in the Akatani and Otoishi Rivers

after flood have begun to proceed.

Figure 2 shows the plotting of the grain sizes of riverbed material after disaster in the Akaishi and Otoishi Rivers on the map where relationship between the riverbed materials and grain sizes in Japan's Class A rivers is organized. In the Figure, dots representing

the relationship between the grain size of riverbed materials and gradient in Japan's alluvial rivers gather near the line drawn from upper right to lower right on the graph. Riverbed materials are rather hard to move and stable when away upward from this line and rather easy to move and active when away downward.

Dots showing the riverbed materials of the Akatani River, etc. after disaster are away downward from the standard relationship in Japan's alluvial rivers, which shows that riverbed materials are in a condition where unstable sediment that is easy to migrate is deposited.

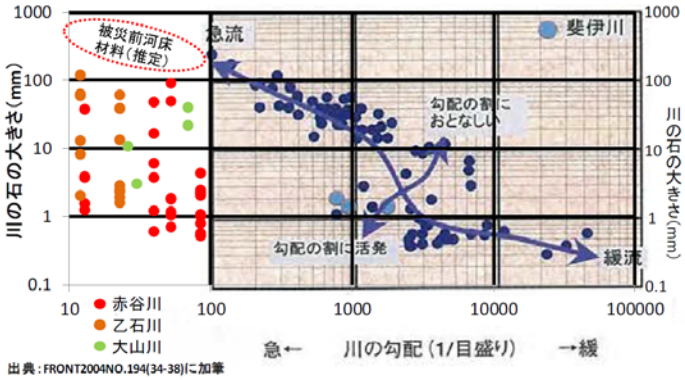

Fig. 2 Relationship between river gradient and river stone size

3. Setting the volume of sediment in design of channel restoration

In channel design, designed section is determined after verifying / forecasting riverbed elevation / degradation in the channel with riverbed variation calculation and confirming changes in the channel. In riverbed variation calculation, volume of sediment supply (relationship of sediment discharge Qs according to flow rate Q ("Q-Qs relationship")) is determined, and setting the volume of sediment supply based on actual status is important since the volume of sediment supply has a great effect on river-bed variation. Since volume of sediment supply varies according to deposition in the upstream and branch river, we studied channel design considering changes in the volume of sediment supply due to secular changes causing run-off / stabilization of unstable sediment in the upstream and branch river.

Figure 3 is a conceptual diagram assuming the Q-Qs relationship for each phase. Phase 1 is the volume of sediment supply before the disaster, Phase 2 is the volume of sediment supply when unstable sediment remaining after the disaster is moving actively, and Phase 4 is the volume of sediment supply when residual unstable sediment generated from the disaster is stable and is assumed to return to the same level in Phase 1. Note that Phase 3 is the volume of sediment supply in a transitional condition of returning from Phase 2 to Phase 4.

When setting the volume of sediment supply in design of channel restoration, Phase 2, where volume of sediment supply is large, was assumed as upper limit, and Phase 1 and 4, where volume of sediment supply is small, were assumed as lower limit. This is to ensure design for preventing revetments, dams, and groundsills from suffering damage due to riverbed degradation in Phases 1 and 4, where unstable sediment in torrents becomes stable. With setting of both upper and lower limits, river channels are designed to prevent rapid riverbed change and local riverbed elevation / degradation in either condition, and riverbed variation calculation is used for verification. Note that the Q-Qs relationship in the event of large-scale sediment generation is also important when considering disaster reduction measures, such as evacuation or land use.

4. Conclusion

Since deposition of run-off sediment is expected according to progress in development of erosion control dams and other facilities for restoration, it is considered important to continue to grasp the volume of unstable sediment in the upstream and scour / deposition in riverbed through sediment discharge observation and survey of riverbed materials and riverbed variation after flood season and to continue monitoring to secure discharge capacity

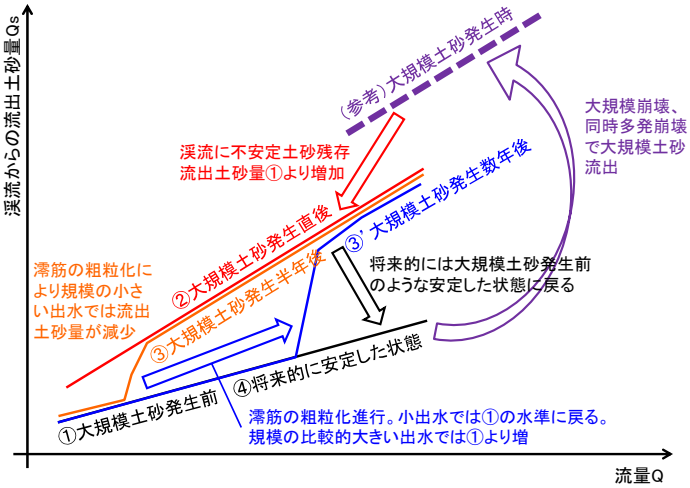

Fig. 3 Conceptual diagram for setting Q-Qs relationship in considering channel restoration

[References]

Chikugo River Right Bank Basin River / Erosion Control Restoration Technology Review Committee Report, Nov. 22, 2017
http://www.qsr.mlit.go.jp/bousai_joho/H29hokubugouu/taisaku.html

Technological support for damage to the National Route 186 Noboritani Snow Shelter

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Keywords: Disasters caused by heavy rain, road embankment, valley fills, technological support

1. Introduction

In the prefecture of Shimane, record-breaking heavy rain that had started on July 4, 2017, triggered many landslides in the western part of the prefecture. Among them, the collapse of the foundation of the National Route 186 Noboritani Snow Shelter (town of Kanagi, city of Hamada) was found before the dawn of July 5. All road traffic was then stopped. At the request of the prefecture of Shimane, researchers inspected the site on July 7 and provided advice on technical precautions before restoration.

2. Causes of the damage inferred based on on-site investigation

At the snow shelter, the valley side of the embankment collapsed for about 20 meters in height, approx. 20 meters in width, and about 2 meters in depth. Some of the discharge pipes installed inside the embankment were damaged and exposed.

The embankment was valley fills into which water easily penetrated. The inspection of the intake part of the discharge pipes found the accumulation of sediment and driftwood and a trace of a raised water level on the upstream side. Although there was no major change to the pavement surface inside the snow shelter, the inspection found a gap between the asphalt surface and the roadbed.

A possible cause of the damage was that a large volume of water entered the embankment from the discharge pipe joints, which accelerated the outflow of sediment from the embankment or erosion of the top of the slope and triggered the slipping and collapse of the embankment.

Photo 1: The entire view of Noboritani Snow Shelter and damaged section

Photo 2: On-site inspection at Noboritani Snow Shelter

3. Contents of technological support

Additional rain may cause the collapse of the entire foundation. Thus, the researchers advised that the slope and collapsed sections should be covered with blue sheets to prevent them from being directly exposed to rain and to stop the outflow of sediment from the discharge pipes as emergency measures.

The researchers also advised that the reopening of the road needed to be determined after checking the robustness of the road along its entire width, range of loosened embankment, and conditions of the foundation at the snow shelter.

They also advised checking the condition of support structures, such as the depth of H-shaped steel pipes and foundation subgrade of the shelter, to examine conditions of water discharges, such as the soundness of currently installed water discharge functions based on the relationship between precipitation and water basins, and to prevent the inflow of blocking materials to prepare for the possibility that sediment and driftwood would destroy pipe functions.

4. In the end

Based on above advice, the foundation of the shelter was confirmed to be free of deformation, and the remaining embankment was intact, while protective measures were implemented, such as the reinforcement of the collapsed surface. Two-lane traffic was restarted on December 4, 2017, thanks to the restoration work, such as the repairs of discharge pipes and the restoration of the embankment at the collapsed section.

Contribution to early recovery with the establishment of Kumamoto Earthquake Recovery Division and overall technologies

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Keywords: Kumamoto Earthquake Recovery Division, road bridge, early recovery, advanced technological support

1. Introduction

The Kumamoto earthquakes in 2016 caused significant damage to road facilities. The road network connecting the Kumamoto and Aso areas remained disconnected for a long period of time. This report introduces the technical support that the National Institute for Land and Infrastructure Management (NILIM) provided for an early recovery.

2. The establishment of the Kumamoto Earthquake Recovery Division and its mission

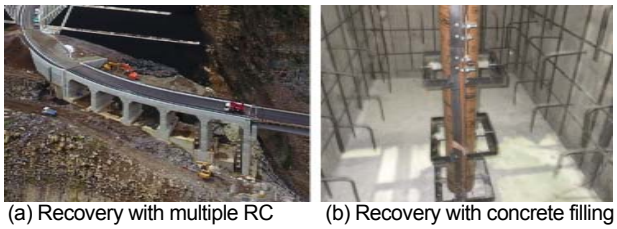
To accelerate the recovery and restoration from the Kumamoto earthquakes, the NILIM installed the Kumamoto Earthquake Recovery Division in April 1, 2017, in the village of Minamiaso, which was close to the disaster recovery sites. It was the first attempt by the NILIM to install an on-site division. The division is working while maintaining close contact with the Kumamoto Restoration Office installed on the same day in the Kyushu Regional Development Bureau in the same building.[1]

The Kumamoto Earthquake Recovery Division has two major missions. The first mission is to promptly solve problems that require advanced and special technologies for the recovery work on site. The second mission is to gather technical knowledge through the recovery work and engage in research for reflection in national technical standards and other references.

3. Technical ideas reflected in the restoration of the Aso Choyoo Bridge

The Aso Choyoo Bridge is a four-continuous PC box girder rigid frame bridge. The slopes around the bridge collapsed, and major subsidence occurred at the A1 abutments of the bridge as shown in photo 1. In this case, the bridge was restored with a multi-RC rigid frame structure as shown in photo 2 so that the bridge would be able to stand by itself while retaining enough support at the back while excavating and removing unstable ground based on the observation of the damage on the ground after the disaster.[2]

Meanwhile, the P3 bridge pier had a crack that penetrated through the mid-height where the inside was hollow. Based on knowledge of the NILIM about the mechanism of damage that can occur during an earthquake on a RC bridge pier with a hollow section, the hollow section where the crack was found was evaluated as losing the shear resistance function of the concrete.



(a) Recovery with multiple RC reinforcement structure (b) Recovery with concrete filling

Photo 2: Aso Choyoo Bridge that reopened after emergency restoration

Thus, the selected recovery method was to restore the shear resistance function by filling the hollow section with fluid concrete based on the comprehensive examination of the feasibility of the repair and its effects on other sections.[2]

4. Conclusion

The Kumamoto Earthquake Recovery Division is also conducting studies by taking advantage of being a research laboratory at the site of a natural disaster. The studies include tests using the cables of a removed cable-stayed bridge and measures to use recovery construction management data for future maintenance and management. The researchers are going to properly identify the needs of actual recovery sites and promote studies that would be useful at the actual sites and distribute the outcomes of such studies.

☞For detailed information

1) Civil engineering reference Vol. 59, No. 6, pp. 44-45, June 2017
2) Civil engineering reference Vol. 59, No. 10, pp. 46-49, October 2017

Improvement of River Technologies through Practice of Channel Management (Study period: from FY2006)

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Keywords: river management, maintenance, human resource development

1. Channel Management Workshop

In channel management, not only the knowledge of river engineering but comprehensive river technologies, such as biology, landscape and maintenance cost, are required. In addition, in order to perform proper channel management, channel design considering changes after development is required.

In order to upgrade the river technology required for such channel management, the channel management workshop has been held about 3 times per year jointly with the Kyushu Regional Development Bureau and the Tohoku Regional Development Bureau. Continuous implementation of this workshop is expected to lead to acquisition of knowledge and sharing of findings among employees who are engaged in channel management and to improvement of young engineers' skills, and thereby to human resource development and transfer of skills.

2. Activities of each Channel Management Workshop

The Kyushu Channel Management Workshop aims to research and develop maintenance technology for preventive maintenance type, which detects signs of changes in channels, such as bed scour, sediment deposition, and overgrowth of trees, to implement countermeasures in appropriate timing and channel excavation technology to control recurrence of deposition and overgrowth. The Kyushu Channel Management Workshop consists of members from academic experts, Kyushu Regional Development Bureau, NILIM, and the seven prefectures of Kyushu, and held a total of 26 meetings to date and conducted on-site inspections during the decade from March 2006 to 2016.

We devised and tried "Channel Management Basic Sheet" jointly with the Kyushu Channel Management Workshop as a management tool for grasping discharge capacity, sediment deposition, overgrowth of trees, and bed scour in channels to ensure inspections and countermeasures. The Sheet has been used practically for channel management. We also organized the patterns and types of channel management practice with focus on data collection, computerization, and judgment and published the collection of cases, organizing findings by pattern obtained from the practice of the channel management in Kyushu and "Guide to Practice of Channel Management," consisting of basic information for analyzing channel characteristics, which are both used on sites.

Photo: On-site inspection of junction of the Sendai River and its branch river, Hatsuki River

We expect improvement in channel management technologies across the country by accumulating and sharing the knowledge of channel management through the aforementioned activities.

Tohoku Regional Development Bureau has been holding "Channel Management and Survey Working" internally since fiscal 2016 in order to strengthen cooperation between Tohoku Regional Development Bureau, river counselor, Tohoku River Management Technology Workshop, and River Division of NILIM.

Since channel excavation is also scheduled in the rivers under control of the Tohoku Regional Development Bureau, this Working is exchanging opinions and making discussions mainly on channel excavation methods and monitoring methods after excavation while confirming changes etc. that occurred on the sites, in order to control re-deposition, overgrowth of trees, etc. after channel excavation.

3. Future plan

The place where a wide range of employees including young and executive employees get together and exchange opinions is helpful in upgrading skills for executive employees as well as young personnel and NILIM employees participating in the Workshop, where they can share problem consciousness and know countermeasures for problems, and in developing human resources.

At present, Channel Management Workshop has been held in Tohoku and Kyushu, and we are going to continue activities for Channel Management Workshop and intend to implement activities while considering the possibility of application to other regions and sharing the knowledge obtained in each Channel Management Workshop.

Technical Support of NILIM in Comprehensive Inspection of Dams in Long-term Operation

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Keywords: dam, maintenance, life extension, comprehensive inspection, technical support

1. Comprehensive Dam Inspection

Dams support safety as well as civic life and economic activities along the basin and require regular careful maintenance so that they certainly perform their functions. Accordingly, maintenance of dam facilities has been implemented in combination of (i) patrols and inspections in daily management activities (condition check by visual inspection, routine inspection with measurement of various data, extraordinary inspection after an earthquake, etc.), (ii) periodic inspection by experts other than the administrator (in principle every 3 years), and (iii) Comprehensive Dam Inspection.

Comprehensive Dam Inspection [1)] was instituted in 2013 for the dams under the control of the MLIT that have passed more than 30 years from completion due mainly to the increase in dams in long-term service, most of which were constructed in the period of rapid economic growth, and to the difficulty in overall renewal requiring necessarily suspension of the functions of dam facilities.

In Comprehensive Dam Inspection, various information is analyzed including the survey and design materials used for dam construction, records on construction and test filling of reservoir, inspection record and measurement data to date, and various types of analyses and tests with sampling are conducted to examine in detail the condition of the dam and its long-term change, and thereby evaluate the soundness of the dam. The results of Comprehensive Dam Inspection are reflected in future maintenance policy in consideration of the required management level according to the importance of the inspected parts.

Photo 1: Implementation of Comprehensive Dam Inspection

(Check the condition of concrete and structure joints in the inspection gallery inside the dam body)

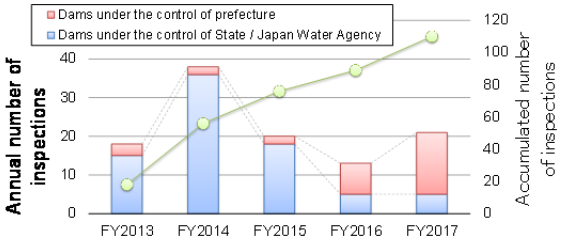

Figure 1: The number of cases of technical support for Comprehensive Dam Inspection

2. Technical support by NILIM

As a part of the technical support for dam projects by NILIM in cooperation with the Public Works Research Institute, NILIM participates in Comprehensive Dam Inspection upon request of the dam administrator (Photo 1) and gives advice from expert / objective position on reasonable inspection planning, evaluation of soundness diagnosis results, establishment of maintenance policy, etc. (Figure 1). Such advice includes (i) detection of long-term changes in the dam structures, which are hard to notice in daily management, from various information including various measurement data and site check results and determination of the causes of changes and impact on the functions / safety of the dam or proposal of additional investigation methods necessary for such determination, and (ii) indication of matters requiring particular focus / attention in future maintenance activities as well as matters to be improved and proposal of methods for specifically reflecting such indication in the site maintenance policy.

Through the participation in the Comprehensive Dam Inspections conducted so far, we have deeply recognized the importance of the viewpoint of future maintenance through exchange of frank opinions based on the sharing with site personnel etc. of various information accumulated to date through design concepts, construction, and test filling of reservoir in individual dams, as well as the present condition of each dam. In the future, we expect that Comprehensive Dam Inspection would be helpful in making an order-made sustaining maintenance policy for further long-term operation of dams.

☞See the following for details.

1) MLIT, Water and Disaster Management Bureau, River Environment Division:
Comprehensive Dam Inspection Manual and Commentary (*in Japanese*)
http://www.mlit.go.jp/river/shishin_guideline/

Support to promote road traffic safety measures in residential roads (Research period: FY 2016–2018)

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Keywords: Target residential road areas, road traffic safety, big data, hump

1. Background

The Road Bureau of Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has been working to improve the safety of roads in residential areas since FY 2015. The MLIT has been registering target residential road areas and promoting proposals for effective road traffic safety measures by providing the outcomes of analyzing ETC 2.0 big data, including vehicle speed and sudden movements, to the registered residential road areas. National Institute for Land and Infrastructure Management (NILIM) is also supporting the promotion of road traffic safety measures for the target residential road areas and other areas in cooperation with the Road Bureau.

2. Support to promote residential road traffic safety measures

An effective way to ensure road traffic safety on residential roads is to keep the vehicle speed to 30 km/h or slower. Effective tools to realize the slow speed include road bumps and road-narrowing poles at certain spots of a road.

The NILIM conducted a social experiment from FY 2013–2015 with the city of Tsukuba to install bumps and road-narrowing poles on roads used by children to go to schools. The experiment confirmed the effects of the measures, such as the slowing down of vehicles and improved awareness among drivers.

In 2016, the Technical Standards on the Installation of bumps, Road-Narrowing Poles, and Curves were prepared based on the research outcomes of the NILIM and released. Road traffic safety measures are now being installed and used according to the standards. At the same time, the NILIM is lending portable bumps to road administrators to experience the effects of the bumps. Today, Regional Development Bureaus are also lending portable bumps to support local governments.

Photo: Loaned bumps
(scene of the social experiment)

In addition, the NILIM is responding to inquiries from local governments while providing information, such as bump driving videos and outcomes of experiments in cooperation with the Portal Site on Road Traffic Safety Measures on the Residential Roads of the Road Bureau.

The NILIM is recently responding to technical consultations concerning measures in hilly residential areas and effective locations to install bumps (e.g. intersections). The NILIM is providing knowledge through Regional Development Bureaus when technical challenges occur to measures implemented in different regions.

Photo: A scene of meeting to explore measures with local governments

3. Future plans

The number of registered target residential road areas has been increasing, and the installation of bumps and road-narrowing poles has been steadily increasing. The NILIM is gathering and analyzing the information concerning the effects of such measures and consensus building processes. The NILIM is going to organize research findings and information from actual examples so that the information becomes available to road administrators around Japan.

☞For more detailed information

1) NILIM Reference No. 952 Technical references concerning Technical Standards on the Installation of Bumps, Road-Narrowing Poles, and Curves
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0952.htm

2) The website of road traffic safety measures for residential roads (inside the website of the Road Safety Division)
http://www.nilim.go.jp/lab/geg/seikatsu.htm

Support for revision of the seismic design criteria for highway bridges in Chile

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Keywords: 2010 Chile earthquake, seismic design criteria, international technical cooperation

1. Introduction

The Chilean Ministry of Public Works had been working on revising the seismic design criteria for highway bridges since the 2010 Chile earthquake (M8.8) caused extensive damage to bridges (photo 1). The Japan International Cooperation Agency (JICA) initiated a technical cooperation project entitled "Seismic Design Criteria for Highway Bridges" on September 2014 in support of the revision work. The National Institute for Land and Infrastructure Management (NILIM) and the Public Works Research Institute (PWRI) have provided technical support[1] in cooperation with industrial and academic experts in earthquake engineering based on a request from the Chilean government through JICA.

Photo 1 Bridge unseating during the 2010 Chile earthquake

Photo 2 Discussion among Chilean and Japanese engineers (Feb. 2017)

Japanese engineers were dispatched to Chile as JICA short-term specialists four times. Teleconferences were held in 2015 and 2016, and Chilean engineers were dispatched to Japan for discussions on the seismic design criteria for more than two days in each 2016 and 2017 (photo 2).

2. Results of the technical cooperation

Japan has experienced many earthquake disasters and developed technical criteria based on cumulative lessons learned from the experience and various research results on seismic technologies. We have discussed how to apply the made-in-Japan seismic technologies to Chilean design criteria and reached the conclusion that it is effective for improving the seismic safety of bridges in Chile to incorporate Japanese seismic technologies, such as the design methods against liquefaction and the unseating prevention system; the seismic design criteria for highway bridges in Chile was revised in consideration of these technologies in June 2017.

Commending the contribution from the technical cooperation, the Chilean Ministry of Public Works complemented the specialists from NILIM and PWRI with diplomas.[2]

3. Ongoing and future actions

During this technical cooperation, technical support for a wide range of seismic technologies was provided, including a revision of the protocol for earthquake ground motion, bridge monitoring guidelines, standard testing methods of anti-seismic bearings, and other protocols. In order to reach these goals, further investigations are necessary in consideration of the differences in available data and instruments in Chile and Japan. We will continue our support for formulating related guidelines and manuals based on the results from this technical cooperation through discussions and by providing information on Japanese cutting-edge seismic technologies.

[Sources]

1) *Civil Engineering Journal*, No. 59-7, pp. 48-49, 2017.7.
2) Press Release, December 1, 2017
http://www.nilim.go.jp/lab/bcg/kisya/journal/kisya20171201_2.pdf

Application of disaster management examination support took kit

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Keywords: Toolkit, disaster and fire drill

1. Introduction

Japan often suffers various natural disasters, such as earthquakes, typhoons, and floods. The onset of significant damage is also expected in an earthquake that directly hits Tokyo and the Nankai trough earthquake, which are expected to occur. The National Institute for Land and Infrastructure Management (NILIM) developed a disaster management examination support toolkit (hereinafter "the toolkit") as a collective tool containing various methods to estimate disaster damage, evaluate risk, and implement management measures in a series of processes. After testing and evaluating the toolkit at regional development bureaus, the toolkit has been used in the training at the College of Land, Infrastructure, Transport and Tourism and disaster drills at local governments since 2016. The following is the report of how the toolkit was used in Ibaraki in FY 2017.

2. Outline of the toolkit

The toolkit is designed to perform the following: [1] to expect natural disasters, such as earthquakes, typhoons, and flooding, and list the expected damage to infrastructures on maps such as duct maps; [2] to establish a natural disaster scenario that organizes the effects of damage to infrastructures to social and economic activities; [3] to perform risk assessment based on the likelihood of the risk of damage to infrastructures and the seriousness of effects on human lives and the economy; and [4] to examine measures to manage individual damage.[1,2]

3. Use of the toolkit

The prefecture of Ibaraki has installed the Civil Engineering Disaster Management Working Team to plan and examine the reinforcement of disaster management systems, and the team has been examining various disaster management measures. In FY 2017, the toolkit was used in disaster response drills at two civil engineering offices in Tsuchiura and Chikusai and the prefectural government building (including staff who were outside of the building). Photo 1 shows the scene of the drill, and figure shows the evaluation outcome as the tool for disaster management drills. More than 90% of the participants responded that the toolkit was effective as a disaster response training tool. Specific effects were as follows: [1] the ability to conduct comprehensive examination based on maps, [2] the ability to identify priorities of recovery work based on damage levels, [3] the ability to examine the damage spreading process and risks of disasters, and [4] the ease of using the toolkit as it is written on pieces of paper. In addition to disaster response drills, the proposed scenes of using the toolkit included [1] when transferring work, [2] to determine the priority of repairing management facilities, [3] when sharing the information of high-risk areas, and [4] when notifying information to residents. A challenge is that risk assessment tends to produce a variety of results depending on the experience and knowledge of those who participate in drills, which means information on specific cases is needed. In addition, some of the tools need to be simplified so that participants can use them within a limited timeframe, such as during a disaster response drill.

4. Summary

The NILIM is going to use the toolkit at various opportunities and facilities to promulgate it while making necessary improvements based on the outcomes of its uses to make it more useful.

Photo: Uses of the toolkit (presentation of outcomes)

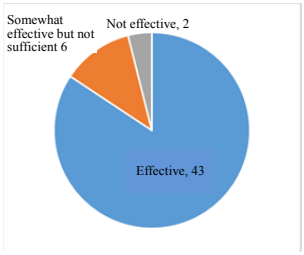

Figure: Outcome of evaluation done by participants

[Reference]

1) Nobuhiro Imanaga, Takakaki Kusakabe, Hiroyuki Ito, Yuko Karasawa, Shojiro Kataoka: Use and evaluation of disaster response examination toolkit –Through the risk management training at College of Land, Infrastructure, Transport and Tourism, Civil Engineering Technology Reference, Vol. 59, No. 3, pp. 20-25, 2017.3.
2) Nobuhiro Imanaga, Ken Kokaki, Toru Kobayashi: Use and evaluation of disaster response examination toolkit, Japan Association for Earthquake Engineering Conference -2017 outlines 4p, 2017.11.

Characteristics of Sewer Pipeline Damage by the Kumamoto Earthquake and Publication of Seismic Damage Database (Study period: Fiscal 2016 and 2017)

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Keywords: sewerage, pipeline, earthquake, database

1. Introduction

Since the occurrence of the Great East Japan Earthquake and the Kumamoto Earthquake, local governments are promoting earthquake countermeasures including formulation of sewerage BCP and earthquake-proofing of facilities. It is, however, important to raise the efficiency of projects for earthquake countermeasures, etc. through selection and concentration based on disaster estimation since the stock of sewerage facilities is enormous and the time and budget that can be spent are limited.

As one of activities to support such local governments etc., Wastewater System Division created and published "Sewer pipeline seismic damage database (the "Database"), organizing information on past earthquake disasters that is available for determination of priorities etc., in implementing earthquake countermeasures in an integrated manner using unified items. We also analyzed the characteristics of disasters and countermeasures based on the data obtained from the field survey conducted after the Kumamoto Earthquake and from the materials collected so that results of the analysis, which are reported herein, may be referred to for more effective earthquake countermeasures and BCP formulation.

2. Outline of the sewer pipeline seismic damage database

The Database organizes the disaster information on sewer pipeline facilities for the earthquakes with seismic intensity of 6 or more that occurred during a period from 1993 to 2016 (13 earthquakes in total). Information registered in the Database consists of earthquake information (seismic intensity, magnitude, SI), ground information (type of soil, type of microtopography), sewerage information (earth covering, pipe type, pipe diameter, manhole type, etc.), and damage information (damage information, extent) and is organized according to each span of sewer pipeline. Total number of data in the Database reached 7,000 as a result of organization and addition of about 2,000 pieces of data (spans) obtained from the recent Kumamoto Earthquake.

The Database is available, e.g. for estimation of hazardous sites in BCP formulation and renewal by local governments etc., preparation of practical drill plans, and determination of priorities in development of earthquake-proofing measures of facilities.

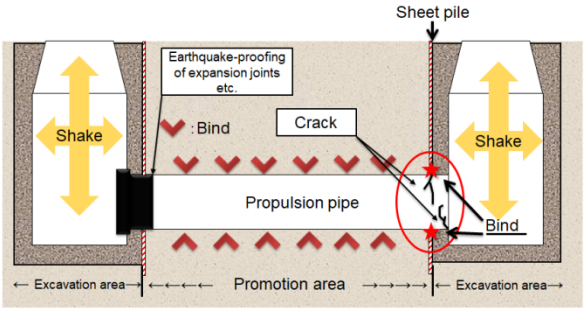

Figure 1: Mechanism of disaster in the jacking method section

3 Trend analysis of sewer pipeline damage in Kumamoto Earthquake

In order to clarify the characteristics of the pipeline damage (about 86 km) in the Kumamoto Earthquake, we analyzed the trend of disaster according to pipe types, pipe diameters, years of laying, earth covering, and damage forms by collecting the MLIT's published material, disaster assessment material, materials showing the sewer attributes of damaged pipelines (sewerage ledgers, drawings, etc.), reports on the telecamera survey of the inside the pipelines conducted after the Earthquake, landform division maps, completion documents, etc.

It was mainly found from this analysis that backfill of crushed stones greatly contributed to the control of liquefaction and that earthquake-proofing of joints such as expansion joints is significant because most cracks occurred around the openings of the pipes laid with the jacking method (Figure 1).

Organization and analysis of disaster information as stated and accumulation of findings are considered important since results are available for disaster estimation in case of an earthquake, selection of more effective earthquake resistant measures, and prompt recovery activities after the earthquake.

☞See the following for details.

1) Wastewater System Division's website: Characteristics of damage to sewer pipeline facilities in the 2016 Kumamoto Earthquake and countermeasures
http://www.nilim.go.jp/lab/ebg/jishin.html

2) Wastewater System Division's website: Sewer pipeline seismic damage database
http://www.nilim.go.jp/lab/ebg/zishin_db.html

Gathering of the information with ETC 2.0 probe and use of the information

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Keywords: ETC 2.0 probe information, data gathering and uses, productivity reform

1. Outline of ETC 2.0 system

In ETC 2.0, the information distribution service to avoid traffic jams and to support safe driving is added to the fee payment service of the conventional ETC. The gathering of ETC 2.0 probe information, such as the history of driving and movement, becomes possible. These services are enabled through mutual communication between ITS spots installed at about 1,700 locations along highways around Japan and route information gathering systems installed at about 1,900 locations along national roads by road administrators (figure 1).

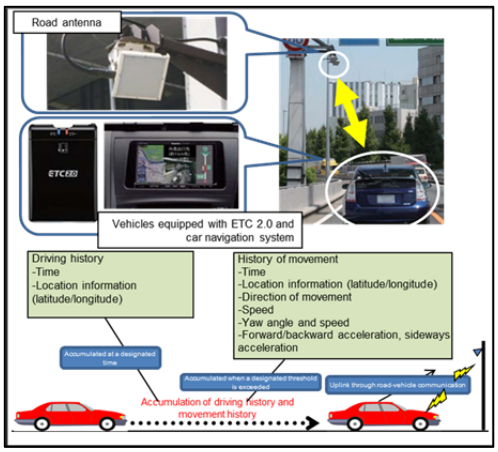

Figure 1: Gathering of ETC 2.0 probe information

2. ETC 2.0 probe information gathering and utilization system

Road administrators, such as the Regional Development Bureau, developed devices to gather and process ETC 2.0 probe information based on specifications prepared by the National Institute for Land and Infrastructure Management (NILIM) and started its uses in April 2011 (Figure 2). The NILIM has been conducting research to advance the gathering, analysis, and utilization of ETC 2.0 probe information. The outcomes are used to analyze traffic conditions and find high-risk areas while contributing to the improvement of the efficiency of road administration and smoothness and safety of road traffic.

The NILIM is reinforcing the information collection system and improving its functions to further promote the use of the system. The current arrangement of roadside devices still has areas with insufficient probe information due to geographical conditions. In addition, the current roadside devices may not be able to collect sufficient information in a natural disaster. Therefore, the NILIM is also developing new roadside devices, such as establishing specifications of portable roadside devices that can gather information with mobility in FY 2017.

Also, the system developed by regional development bureaus has limits to data storage capacity. Thus, the NILIM constructed a data server so that data from the past decade or more can be used online. The NILIM is going to use it for data analyses and the establishment of new data processing and analytical methods (algorithms).

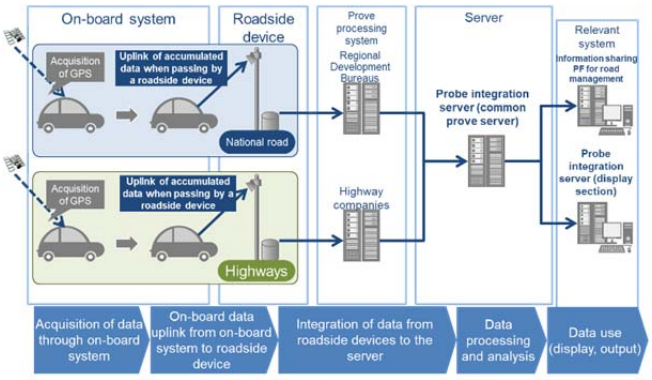

Figure 2: ETC 2.0 probe information gathering and utilization system

Furthermore, the NILIM established a system to collect probe information by specifying a vehicle upon a request from a business as a new attempt. The NILIM is now conducting a social experiment of an operation management support service that can be used to improve the efficiency of operation management and to ensure the safety of drivers by providing the ETC 2.0 data of a vehicle owned by a distribution company. The full use of this system is going to start in FY 2018.

3. Future outlook

The number of vehicles equipped with ETC 2.0 is now increasing; thus, the probe information that will become available is going to increase, and the possibility of using the data is expected to expand. The NILIM is going to conduct research to improve the system and data analysis.

Analysis of deterioration characteristics of road bridges based on regular inspection data

(Research period: FY 2015–2017)

Bridge and Structures Division, Road Structures Department

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Fumi Miyahara, Senior Researcher

Keywords: Road bridge, Regular inspection, deterioration characteristics

1. Objectives and background of the study

Road bridges managed by the national government have been regularly inspected since 2004, and records of objective, detailed conditions have been accumulated. These records are supposed to be organized as the statistical data of age-based deterioration to identify deterioration characteristics to utilize the knowledge for mid-to-long-term maintenance and management.

Therefore, to identify deterioration characteristics, the Bridge and Structures Division has been using the data accumulated from the regular inspections of bridges conducted by the national government to statistically analyze the deterioration characteristics of the different components of bridges under various conditions, such as the installation environment and planar positions of the components.[1]

2. Statistical deterioration characteristics based on inspection data

The national governments have been regularly inspecting bridges and recording the evaluation of the level of damages in up to five categories from a to e for each of 26 types of damage in detailed categories of the elements of bridge components. Thus, changes in the level of damage in the same elements within five years were counted, and the Marcov transition probability matrix was calculated.

Figure 1 is an example of the condition probability distribution for every five years based on the year of design, the onset of water leaks, and the generation of free lime in cracks on the concrete floor of bridges made with steel sheets prepared using the calculated Marcov transition probability matrix. Figure 1 shows the level of damage (a to e) by scoring it from 1.00 to 0.00 in units of 0.25, the deterioration curve in which the mean of the level of damage for every five years is regressed as the cubic function of the number of years passed, and the deterioration curve, which is the regression of the value of the mean ±σ. Differences in the mean deterioration characteristics under different conditions were reflected in the figure as the deterioration curves regressed under various conditions using a large amount of high-quality data. Meanwhile, the scattering around the mean value was still large. The result indicated that precision was expected to improve with the accumulation of data in the future in regard to identifying the mean deterioration characteristics of many bridges. Meanwhile, the scattering was large for the deterioration forecasting of individual bridges and elements.

3. Summary

It is necessary to examine how the outcomes of deterioration forecasting should be used in actual maintenance work while assuming that no correct answer is available for the deterioration forecasting of individual bridges and that the precision would not improve significantly. The analytical results of deterioration characteristics under different conditions and observation concerning precautions for the use of the analytical results have been released for use by road administrators.[2]

☞For detailed information

1) NILIM Report 2017. The Analysis of Road Bridge Deterioration Characteristics based on the Data of the Regular Inspections of Road Bridges
http://www.nilim.go.jp/lab/bcg/siryou/2017report/ar2017hp074.pdf

2) NILIM Reference No. 985. The Analysis of the Deterioration Characteristics of Road Bridges using the Data of Regular Inspections
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0985.htm

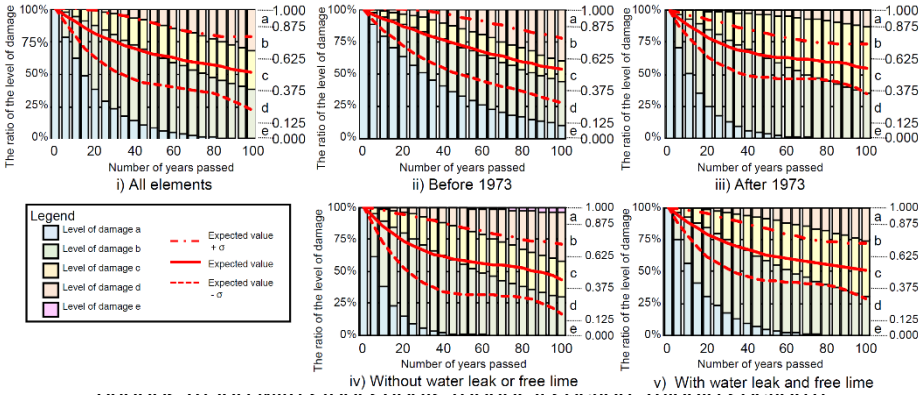

Figure 1: Ex ;rete floor of bridges made with steel sheets (general section, middle section))

The release of the tool to forecast future population and households using small areas (blocks and sections) as the unit (Research period: 2014–2016)

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Keywords: Future population and households, small areas, forecasting tool, compact urban development

1. Introduction

The National Institute for Land and Infrastructure Management (NILIM) created and released the Future Population and Household Forecasting Tool using small areas (blocks and sections) as the unit and released it in January 2017.[1] This paper introduces the objective of creating the tool, its characteristics, and how it is being used.

2. The objective of creating Future Population and Household Forecasting Tool and its characteristics

An important point in proposing a town development policy is to analyze current problems and future perspectives of the town at the town level as well as the regional level. The most fundamental factor in this process is the future outlook of the population and the number of households. The only forecast available for the population in five-year age groups and genders and the number of households is based on individual cities, wards, towns, and villages as the unit, which is prepared by the National Institute of Population and Social Security Research.

The Future Population and Household Forecasting Tool is created based on Microsoft Excel so that future population and household forecasting in five-year age groups and genders can be easily created in the unit of small areas (districts and sections). It allows forecasting in all small areas (districts and sections) within a municipality by selecting options from the menu. Cohort change-rate method or primary factors cohort can be selected as a forecasting method. The tool contains the national population database, which is required for forecasting, and users do not have to provide additional data. The outcome of forecasting can be displayed on the map in Microsoft Excel using the attached simple drawing tool (Figure 1). It can also be output to a geographical information system (GIS).

3. Uses of the tool

This tool is registered at the Geospatial Information Center, the portal website operated by the Association for Promotion of Infrastructure Geospatial Information Distribution.[2] Many users, mainly local governments and town development consultants, have been downloading the tool. The uses of the tool include location optimization planning to shift urban functions, such as medical, welfare, and commercial facilities, and residential functions to a certain area to accelerate compact urban development, urban planning master plans, and the establishment of vacant house utilization plans (figure 2, figure 3). Also, the Guideline for Location Optimization Planning[3] recommends this tool as a way to forecast the future population of an area.

4. In the end

The author is now developing a cost-benefit evaluation tool for district management in suburban cities and a cost effectiveness forecasting tool for the spatial future demand-supply forecasting of medical and welfare facilities, which are going to be linked to this tool. These tools are going to be released when possible.

☞For detailed information

1) NILIM press release. “The development of district-level future population forecasting tool: Forecast the future of a town and promote compact town development” http://www.nilim.go.jp/lab/jeg/kisya20170127_2.pdf

2) Geospatial Information Center. Future Population and Household Forecasting Tool download URL https://www.geospatial.jp/ckan/dataset/cohort

3) City Planning Division, City Bureau, Ministry of Land, Infrastructure, Transport and Tourism. Guideline for Location Optimization Planning. (revised on April 10, 2017) http://www.mlit.go.jp/common/001181578.pdf

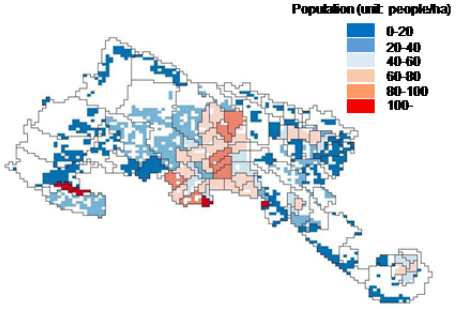

Figure 1: An example of the map of future population forecasting using the attached drawing tool

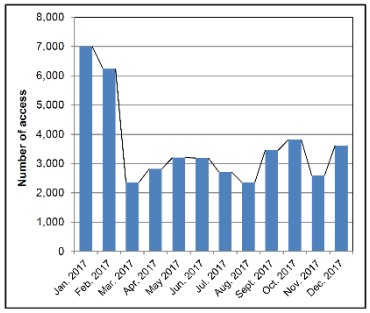

Figure 2: Total number of access (prepared from data provided by the Geospatial Information Center)

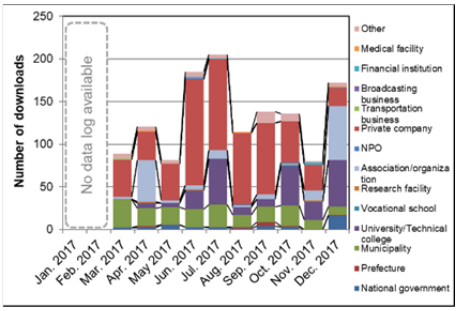

Figure 3: The total number of downloads by user category (Prepared from data provided by the Geospatial Information Center)

Coordination of research

1. Introduction

The basic attitude of the research policy of the National Institute for Land and Infrastructure Management (NILIM) includes to technologically cooperate and unite with a wide range of industries, academia, and the public sector to produce new technologies. The attitude of the research is to recognize one's strengths and weaknesses and build efficient research systems in cooperation with other organizations. One of the important roles of the NILIM is to coordinate the joint research of the industry, academia, and the public sector. Many research projects are being conducted with the coordination and cooperation of government agencies, private companies, and universities. This paper introduces the main systems and research projects.

2. Examples of coordinating and cooperating researches with relevant government organizations

The NILIM is conducting many research projects directly linked to the implementation of policies using project budgets and other budgets in cooperation with the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). General technological development projects (the general project) and the budget for administration costs are examples that support especially large-scale research themes. The general project covers especially urgent research projects that are applicable to a wide range of fields among important research projects on construction technologies. The administration department is in charge of implementing relevant plans, and comprehensive and organized research projects are conducted through the cooperation of industry, academia, and the public sector. The budget for administration costs is the budget

Table 1: General technological development projects conducted in FY 2017

Topic	Research period	Assigned departments and centers
Development of strategic stock management technologies for regional and secure living functions	2015–2017	House, City, Construction
Technological development to improve the use of current buildings by streamlining fire management and evacuation regulations	2016–2020	Construction, City
Research on the improvement of construction productivity through the full use of ICT	2017–2020	Social capital management
Development of technologies to design and construct mixed–structure buildings using new wooden materials	2017–2021	Construction

Table 2: Research conducted using the budget for administrative cost in FY 2017

Topic	Research period	Assigned departments and centers
Research on the improvement of the efficiency of wastewater treatment systems using the performance of current facilities in sewage treatment plants	2015–2017	Sewage system
Development of methods to strategically reduce the risk of disasters in cities under climate change	2015–2017	River
Research on the high–precision method to forecast the onset of landslide or mudflow using real-time observation and monitoring data	2015–2017	Landslide/mudflow
Research on the method to evaluate the safety and recyclability of construction materials damaged in fire triggered by an earthquake	2015–2017	Construction
Development of evaluation standards for evacuation support technologies for the elderly and handicapped in shared housings during natural disasters	2015–2017	House
Development of methods to evaluate low-carbon urban development by improving the thermal environment of cities using plants	2015–2017	City
Development of methods to forecast container sea route network to respond to changes in the structures of marine transportation	2015–2017	Ports and harbors
Development of simple methods to evaluate the performance of wooden houses	2016–2018	Construction
Development of methods to evaluate the energy saving effects of automatic control technologies of construction facilities	2016–2018	House
Research on securing the safety of ports and harbor zones against damages of high tide	2016–2018	Coast, ocean, disaster management
Research on methods to practically evaluate currently operating ports and harbor facilities to elongate their service lives and effectively use them	2016–2018	Ports and harbors
Research on the improvement of on-site productivity in social capital development process	2016–2018	Social capital management
Research on technologies to support water management activities	2017–2019	River
Examination of road-vehicle coordination system to build next-generation ITS including automatic driving	2017–2019	Road traffic
Development of technologies to improve facilities to secure the health and safety of evacuees in evacuation shelters	2017–2019	Construction
Study of facade design method to improve the energy consumption performance of buildings	2017–2019	House
Development of technologies to analyze and evaluate urban structures based on diversifying living support functions	2017–2019	City
Development of technologies to diagnose the possibility of allowing vehicle traffic after an earthquake	2017–2019	City
Research on methods to quickly inspect and restore airport pavements after an earthquake	2017–2019	Airport

allocated to implement general research projects directly assessed by the Ministry of Finance and to create new policies. Table 1 lists topics of the general projects conducted in FY 2017, and table 2 research projects conducted using the budget for administration cost.

3. Examples of joint research projects with private companies and universities

Types of joint research projects include joint research projects of the NILIM and other organizations, outsourced research projects in which research projects are entrusted to other organizations, such as universities that are already conducting research projects, as well as other types of cooperative research projects to maximize outcomes using limited research resources. Joint research projects are roughly categorized as follows.

1. Systematized research projects within the NILIM
[1] Joint research, [2] Contracted research (public offering at research facilities),
[3] Contracted research (public offering in councils),
[4] Budge allocated from other ministries (SIP)

II. Established as a system outside of the NILIM
[5] Technological research cooperative

III. Not a regulated system but established as a system at a certain level
[6] Public offering of new technologies, [7] Social experiment, [8] Study sessions

IV. Studies conducted through various means of operation
[9] Cooperation with the implementation of the policies of the MLIT, [10] Cooperation with local government projects, [11] Study session with the academia and the private sector

Table 3 lists the implementation status of [1] joint research projects in FY 2017. The table below lists the number of research projects conducted as [2] contracted research (public offering at research facilities) and [3] contracted research (public offering at councils). Table 4 shows main joint research projects conducted with private companies and universities including ones listed in the tables below.

Type	Name of councils	Number of research projects
Public offering at research facilities		3
Public offering at the MLIT council		
	New Road Technology Meeting	23
	R&D of River Sediment Control Technologies	10
	Sewer B-DASH	18
	Council for the Development of Next-generation Infrastructure Inspection Systems	1

Table 3: Joint research projects conducted in FY 2017

Themes of joint research	Partners	Research period	Assigned departments and centers
Research on zero-energy houses	Building Research Institute, Japan Sustainable Building Consortium	2009–2017	Houses and construction
Joint research on methods to evaluate energy conservation performance of houses and buildings	Building Research Institute, Institute for Building Environment and Energy Conservation	2012–2017	Houses
Joint research on the evaluation of the permeation resistance of river levees	Public Works Research Institute	2014–2017	Rivers
Joint research on the application of the statistical information of people's behavior based on the operation data of mobile phone base stations on traffic planning	NTT Docomo	2014–2017	Social capital management City
Joint research on the study on earthquake risk management at airports	Shinozuka Research Institute	2014–2017	Airport
Joint research on the development of emergency restoration system for ports and coastal disaster management facilities after the onset of major disasters and the development of marine transportation system for emergency aids	Disaster Prevention Research Institute, Kyoto University	2015–2017	Ports and harbors, coast and ocean, disaster management
Research on technological standards in the field of construction, housing, and cities	Building Research Institute	2016–2021	Construction, Houses, City
Joint research on the advancement of technologies to evaluate the risk of landslide/mudflow	Osaka University, Fujitsu Laboratories, Chuden Engineering Consultants, Eight-Japan Engineering Consultants	2016–2017	Sediment damage
Joint research on methods to evaluate technologies to investigate road structures below the road surface	Public Works Research Institute, prefecture of Kyoto, Kyoto University	2016–2017	Road structures
Joint research on ways to use condition forecasting methods using road bridges inspection data	Kyoto University, prefecture of Kyoto, Public Works Research Institute	2016–2017	Road structures
Research on the early detection of landslide/mudflow using observation and monitoring data in river basins in mountains	National Institute of Advanced Industrial Science and Technology	2016–2018	Sediment damage
Joint research on the development of methods to monitor landslide/mudflow using Daichi 2, the advanced land observing satellite	Japan Aerospace Exploration Agency	2017–2019	Sediment damage
Joint research on the technological development for the practical application of next-generation cooperative ITS	Automobile manufacturers, Electrical manufacturers, relevant foundations, highway companies, and among others in 29 companies and 32 organizations	2017–2019	Road traffic
Joint research on the use of AIS data in the development and use of ports and harbors	Service Center of Port Engineering	2017–2019	Ports and harbors
Joint research on the experiment to verify the earthquake resistance of mixed-structure buildings constructed using new wood materials	National Research Institute for Earth Science and Disaster Resilience	2017–2021	Construction

Table 4: Examples of joint research projects conducted with private companies and universities in FY 2017

Type	Title	Objective and type of cooperation	Participants	Research period	Assigned departments and centers
[3][4]	R&D on infrastructure structures and inspection devices for the advanced inspection of social infrastructures	・Provision of fields using robot technologies developed by the private sector ・Use of specialized organizations based on the adaptability of technologies	Joint research group (Public Works Research Institute, private organizations)	2016–2018	Social capital management
[3]	Sewage system innovative technology experiment project (B-DASH project)	Use of local governments, private companies, and universities for the practical application of innovative technologies which are yet to become common in sewage systems	Joint research group (universities, private companies, other national institutes, local governments, etc.)	2011–	Sewage system
[4]	Reinforcement of resilient disaster management and damage reduction functions "Development and application of technologies to observe, analyze, and forecast water-related disasters"	Use of advanced meteorological observation technologies and special organizations on localized heavy rain forecasting technologies for the social application of technologies to forecast damages caused by localized heavy rain	National Institute of Information and Communications Technology, Osaka University, National Research Institute for Earth Science and Disaster Resilience, Japan Weather Association, Railway Technical Research Institute, etc.	2014–2018	River and sediment damage
[6]	Experiment conducted through public offering to prepare required functions of in-vehicle sensing system	An experiment was conducted through public offering to examine necessary functions for road management concerning being developed in private companies	Private companies (9 parties)	2016–2017	Road traffic
[7]	Social experiment on ETC 2.0 vehicle operation management support service	Service providers and distribution companies were selected through public offering, and experiments were conducted to realize ETC 2.0 vehicle operation management support service	private companies (9 service providers, 20 distribution companies)	2015–2017	Road traffic
[8]	Regional road economy strategy workshop and regional workshop	・Use of administrative needs and knowledge of universities by examining unique themes of individual regions ・Matching with administrative needs to promote innovation in road policies	universities, MLIT, Regional Development Bureaus	2015–	Road traffic
[9]	Cooperation with local governments implementing area management in the research on road traffic safety in residential roads	Technological cooperation for the effective implementation of road traffic safety measures (local government: Implementation of measures, NILIM: Technical consultation, etc.)	Cities of Yokohama, Hamamatsu, and Kurume	2016–	Road traffic
[10]	Cooperation with local governments in studies on the identification of road traffic conditions	・NILIM conducts traffic analysis, and local governments (road administrators) and businesses conduct stakeholders meetings to solve problems under proper allocation of roles.	Prefecture of Ibaraki	2013–	Road traffic

4. In the end

In addition to the above, research projects are being conducted under various types of cooperation and coordination, such as research projects and the revision of technical standards conducted through the cooperation of industry, academia, and the private sector as the committee activities of the academic societies. The NILIM is going to conduct research projects through various types of cooperation among industry, academia, and the private sector to produce better research outcomes and realize their social applications.

International research activities

1. International research activities at the National Institute for Land and Infrastructure Management

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

(1) Improvement of the quality of research outcomes: The NILIM is strengthening the identification of the trends of overseas technological policies concerning [1] disaster management, mitigation of damage during disasters, and risk management; [2] infrastructure maintenance and management; [3] productivity reform; and [4] improvement of the comfort and convenience of life, which are important research themes of the NILIM to produce research outcomes with high value. Therefore, researchers are actively participating in international conferences to gather a wide range of information. The NILIM is acquiring detailed information about especially important fields using frameworks, such as bilateral conferences and multi-nation joint research projects.

(2) Export of infrastructure systems: As a part of the government organization, the NILIM is conducting activities based on the policy to export high quality infrastructures to contribute to bringing profits to Japanese companies and vitalize the industries in Japan. These activities are conducted by participating in projects and transmitting information from the planning phase (upstream), application of software infrastructures, supporting companies exporting infrastructures, and bilateral research cooperation with developing countries. The cooperative activities are conducted specifically with Indonesia as a focused country.

(3) International contribution: The NILIM is dispatching experts to technological cooperation projects that JICA is conducting in developing countries and researchers to restoration support investigations after major natural disasters outside of Japan. The NILIM is also accepting trainees in land development and transport targeting engineers and government officials from developing countries.

2. Main international research activities in FY 2017

Main international research activities conducted in FY 2017 based on the above three perspectives discussed in 1 are introduced below.

(1) Activities related to the improvement of the quality of research outcomes

Researchers of the NILIM participated in the following international conferences to gather the latest information and present information about different research fields.

Photo 1: The 41st IMO/FAL Conference

i. International Maritime Organization (IMO)/Facilitation of International Maritime Traffic (FAL) Committee (UK: April 4–7, 2017)

The Facilitation of International Maritime Traffic Committee of the International Maritime Organization determined to revise the appendix of the Convention on Facilitation of International Maritime Traffic (FAL Convention) in the 40th meeting of IMO/FAL (April 2016) and mandated to digitalize ports and harbors administration procedures to ensure quick processing of administrative procedures concerning the arrival and departure of vessels in ports and harbors. Given this decision, the 41st Conference in April 2017 (photo 1) agreed to revise the entire guidelines for the establishment of ports and harbors administrative procedure processing system and the guidelines for the governments of ratified nations to digitalize the procedures. A communication group (CG) was launched for the entire period of the conference to revise the guidelines. A senior researcher of the Management and Coordination Division of the NILIM was appointed as chairperson of the CG. The CG started discussions in the summer of 2017. As of January 2018, they are discussing how ports and harbors administration procedures should be linked to customs procedures and how inter-system communication should be perceived.

ii. Inter-Jurisdictional Regulatory Collaboration Committee (U.S.: May 7–14, 2017, Singapore: November 11–16, 2017)

Inter-Jurisdictional Regulatory Collaboration Committee (IRCC) was established by building standards establishment organizations of the United States, Canada, Australia, and Japan in 1997. It is examining the development, implementation, and promulgation of building standards to specify building performance (13-member nations today). It is holding regular conferences twice a year. The Housing Bureau of the Ministry of Land, Infrastructure, Transport and Tourism and the NILIM are the Japanese members of the IRCC. In FY 2017, the 42nd conference was held in the United States and the 43rd conference in Singapore. The NILIM reported a major fire in Itoigawa (December 2016) and the fire from a warehouse in Miyoshi-cho (February 2017) and gave a presentation about the promotion of constructing and using wooden buildings (photo

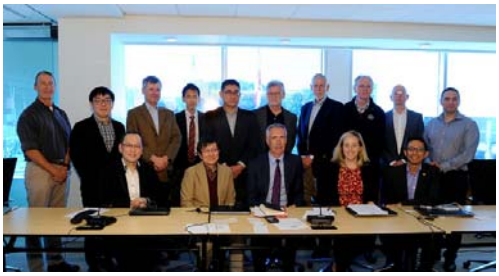

Photo 2: IRCC participating members (the 42nd conference)

2).

iii. International Commission on Large Dam (Czech Republic: July 1–9, 2017)

The International Commission on Large Dams (ICOLD) was established in 1928. It has installed various committees on the design, construction, maintenance and management, and operation of dams to conduct investigations and research. In the 85th Annual Meeting in 2017, the NILIM gave an oral presentation about some of the outcomes obtained through the development of methods to monitor displacements for wide areas and quick detection of changes in ground and structural characteristics using SAR satellites in the symposium. In addition, in the technical committee, the Committee on Earthquake Problems in Dam Designs, the NILIM researchers reported the outcomes of the analysis of recent earthquake data based on the outcomes of the activities of working groups in the Japan Commission on Large Dams that the NILIM has been participating in.

iv. Memorial Symposium concerning the Conclusion of Research Cooperation Agreement with Sri Lanka NBRO (Sri Lanka: January 21–27, 2018)

Upon the conclusion of a research cooperation agreement in the field of landslide disasters between the NILIM and Sri Lanka National Building Research Organization (NBRO), a memorial symposium was held at NBRO. The director of the NILIM gave a keynote lecture at the symposium. In addition, the NILIM and NBRO conducted a joint investigation at the site of a disastrous landslide that killed about 200 people in May 2017 and gathered information concerning the challenges and possibilities of methods of investigation, monitoring, and observation in regions with many undeveloped zones. He also talked about measures to mitigate landslide damage in Japan and research activities at the NILIM and discussed technical challenges to propose methods to forecast the onset of landslides in areas with many undeveloped areas such as in Sri Lanka.

v. ITS World Congress, bilateral meeting and PIARC Technical Committee TCB.1 Meeting (Canada: October 28 to November 6, 2017)

The ITS World Congress is the largest annual international conference in the field of ITS. The 24th conference was held in Montreal, Canada, in 2017. The theme of the conference was Integrated Mobility Driving Smart City. More than 8,000 people from 65 countries and regions around the world participated in the Congress and engaged in presentations and discussions in more than 250 sessions and demonstrations and exhibits by about 300 participating groups. The NILIM participated in presentations and Q&A discussions in multiple technical sessions. The NILIM researchers held bilateral meetings with the United States, the Amsterdam group, China, and South Korea during the event and exchanged information and opinions concerning ITS technologies. They also participated in the technical committee TCB.1 (committee on road network management and ITS) in PIARC (World Road Association) that was held along with the ITS World Congress.

(2) Activities related to the export of infrastructure systems

The NILIM held an interim presentation concerning research cooperation in Indonesia, the focused country of the cooperative activities.

Interim Report on Indonesia IRE-NILIM Research Cooperation (Japan: October 3–5, 2017)

An interim report session to present the outcomes of joint research was held in the city of Tsukuba based on the research cooperation agreement signed between the NILIM and the Institute of Road Engineering (IRE), Indonesia, in November 2009. Both the NILIM and the IRE gave keynote lectures and presented research in five research cooperation fields at the meeting (photo 3). They also participated in technical tours before and after the meeting to observe experimental facilities of the NILIM and the Shuto Expressway Road Bridge Junction among other facilities.

Photo 3: A scene from the interim report session

(3) Activities related to international contribution

In addition to the dispatching of staff to JICA projects (dispatched three staff to the Chile and South America Disaster Management Human Resources Base Support Program) as well as the acceptance of researchers and the dispatch of lectures throughout the fiscal year, the NILIM started to release English versions of technical references on the English website of the NILIM this fiscal year.

The release of the website for English references

The English version of technical references that the NILIM has presented at international conferences and academic societies is being released on the English website of the NILIM to provide knowledge of the NILIM to international society and further accelerate the international exchange of information and opinions (photo 4).

Photo 4: Website of English references (http://www.nilim.go.jp/english/hottopics/index.htm)