PWRI

National Research and Development Agency

Public Works Research Institute

IV

2016-2021

Medium to Long-term Plan

Message from the President

Kazuhiro Nishikawa

President

National Research and Development Agency
Public Works Research Institute (PWRI)

The Public Works Research Institute (PWRI) is a national research and development agency that can trace its history back to the Road Materials Testing Department in the Ministry of Internal Affairs, established in 1921, and the Testing Laboratory of the Civil Engineering Department, Hokkaido Agency, Ministry of Internal Affairs, established in 1937. Throughout the intervening years, PWRI has been continually engaged in the resolution of various civil engineering technological issues, offering technical support after disasters, providing technical advice for national and local government, and engaging in research related to public works, such as rivers and roads.

The Public Works Research Institute started its six-year Fourth Medium to Long-term Plan on April 1, 2016. The primary aim of a national research and development agency like PWRI is to maximize research and development achievements; in other words, to maximize, for the nation as a whole, research and development that will contribute to further progress of the Japanese society in the people's livelihood, economy and culture. Based on this primary aim, in our six-year plan, our mission is indicated by the Minister of Land, Infrastructure, Transport and Tourism and the Minister of Agriculture, Forestry and Fisheries. This mission is to return the benefits of research to society, and by doing so i) to contribute to the effective provision of high-quality social infrastructure and to the development of Hokkaido; and ii) to properly perform tasks related to the Land, Infrastructure, Transport and Tourism Ministry's strategy and to the promotion of agriculture, forestry, and fisheries by the Hokkaido development authorities. In addition, PWRI aims to engage, in a focused and intensive manner, in research and development activities that will contribute to:

1. Realization of a safe and secure society
2. Strategic maintenance, management, and renewal of public infrastructure
3. Realization of a sustainable and vibrant society

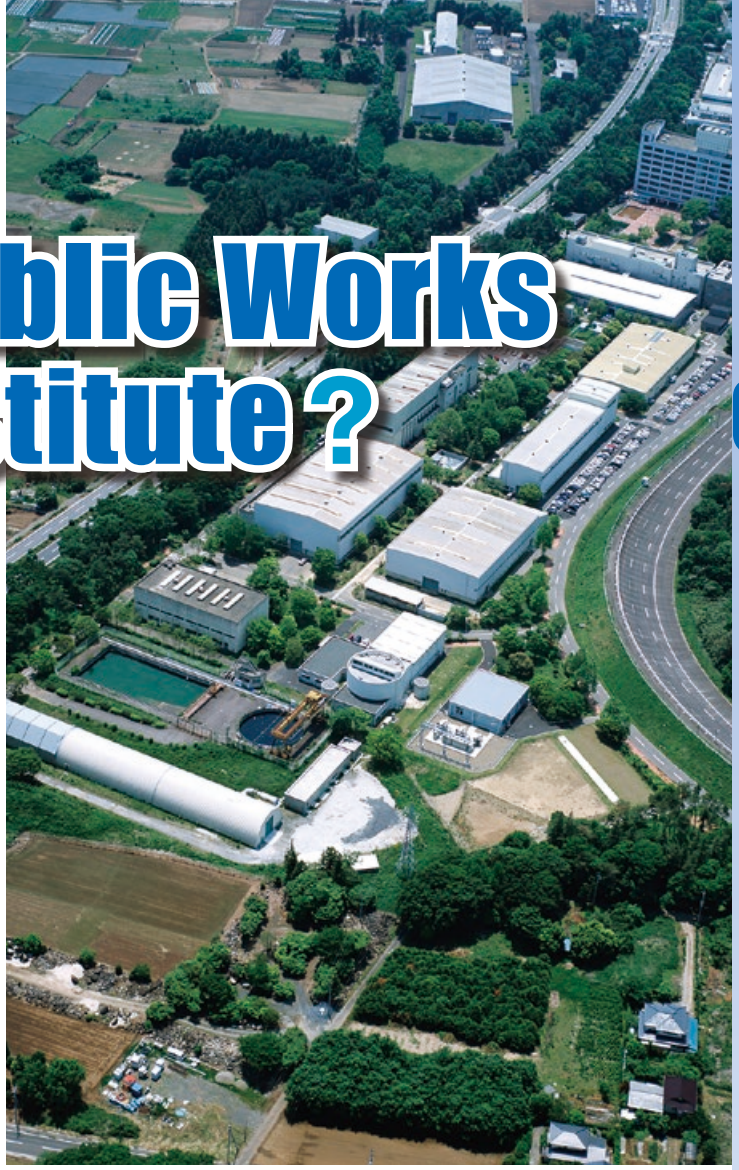
Based on the abovementioned goals, our fourth six-year plan contains 17 intended research and development programs that will allow us to respond in a focused and intensive manner to issues that will affect society in the future. These programs involve exploratory research and development initiatives that take into account the current situation (a declining trend in the working age population, a reduction in workers with construction skills, and an increase in the number of people retiring from work). We aim to pursue these programs in an effective and efficient manner by incorporating procedures such as offering technical advice, disseminating research and development results, utilizing civil engineering skills to make international contributions, and cooperating with other research institutes.

PWRI has long been involved in civil engineering technology research and development activities that will contribute to the efficient provision of high-quality social infrastructure. In the future, we intend to work diligently on research and development projects that meet both the short- and long-term needs of Japanese society. Alongside this, we intend to make an international contribution as a global center of civil engineering research and development. We would appreciate your continued support and cooperation in these regards.

April 1, 2019

Contents

What is the Public Works Research Institute?



The National Research and Development Agency Public Works Research Institute (PWRI) conducts high-quality studies as a core institution of civil engineering research in Japan. PWRI was founded to improve civil engineering technology by conducting research and development on civil engineering techniques, providing technical support, disseminating research results, etc., and to contribute to society by improving infrastructure and promoting development of Hokkaido.

PWRI began anew in April 2006, when the Civil Engineering Research Institute of Hokkaido, which had been established in 1937 as the Testing Laboratory of the Civil Engineering Department of Hokkaido Agency, was integrated into PWRI, which itself had been established in 1920 as the Road Materials Testing Department of the Ministry of Internal Affairs, and was transformed into a "national research and development agency" in April 2015.

The PWRI has been working towards the major objective of the National Research and Development Agency, which is to maximizing the effectiveness of the outcome of R&D, committing to the R&D to;

1. Realization of a safe and secure society
2. Strategic maintenance and renewal of public infrastructure
3. Realization of a sustainable and vibrant society

History of the Public Works Research Institute

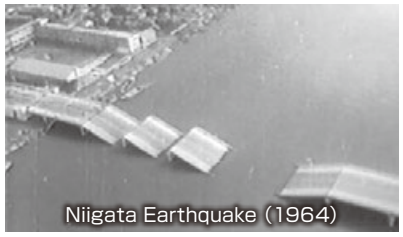
May 1921	Established as the Road Materials Testing Department in the Ministry of Internal Affairs
Sep. 1922	Reorganized as the Civil Engineering Laboratory in the Ministry of Internal Affairs (Hon-Komagome, Bunkyo-ku)
Aug. 1937	Founded as the Testing Laboratory of the Civil Engineering Department, Hokkaido Agency, Ministry of Internal Affairs
July 1948	Renamed as the Public Works Research Institute, Ministry of Construction
July 1951	Renamed as the Civil Engineering Research Institute, Hokkaido Development Bureau
Aug. 1960	Established the Chiba Branch
Apr. 1961	Established the Kashima Hydraulics Laboratory
Mar. 1979	Relocated and integrated in the Tsukuba Science City
Apr. 1988	Renamed as the Civil Engineering Research Institute
Jan. 2001	Reorganized as the Public Works Research Institute, Ministry of Land, Infrastructure and Transport
Apr. 2001	Reorganized as the Independent Administrative Agency Public Works Research Institute, and the Civil Engineering Research Institute of Hokkaido, as part of reform of government, central ministries and agencies
Mar. 2006	Established the International Centre for Water Hazard and Risk Management
Apr. 2006	Integrated the Public Works Research Institute with the Civil Engineering Research Institute of Hokkaido
Apr. 2008	Established the Center for Advanced Engineering Structural Assessment and Research.
Apr. 2015	Reorganized as the National Research and Development Agency, Public Works Research Institute that aims to maximize the achievements of research and development, and established the Innovative Materials and Resources Research Center

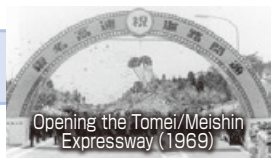

Establishment of the Road Materials Testing Department in the Ministry of Internal Affairs(1922)

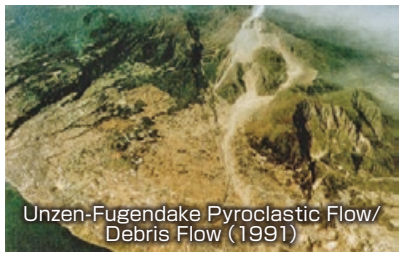

Great Kanto Earthquake (1923)


Opening the Kanmon Tunnel (1958)


Ise Bay Typhoon (1959)


Niigata Earthquake (1964)


Opening the Tomei/Meishin Expressway (1969)


Unzen-Fugendake Pyroclastic Flow/ Debris Flow (1991)


Great Hanshin Earthquake (1995)


Great East Japan Earthquake (2011)


Present Public Works Research Institute (2015)

Organization

As of April 1, 2019

Executives

- President
- Vice President (2)
- Auditor
- Auditor (part-time)
- Councilor
- Auditing Director
- Executive Director for Research Coordination (2)
- Executive Director for Geology
- Executive Director for Earthquake Engineering

Management

- Audit Office
- Compliance Management Office
- General Affairs Department
  - General Affairs Division
  - Welfare Division
  - Budget and Accounting Division
- Planning and Research Administration Department
  - Planning and Management Division
    - Research Evaluation and International Section
  - Facilities Management and Research Information Division
- Administration Department
  - Administration Division
  - Accounting and Contract Division
- (Executive Director for Research Coordination)
  - Deputy Director for Research Coordination
  - Planning Division

Research

Tsukuba Central Research Institute

- Construction Technology Research Department
  - Deputy Director of Construction Technology Research Department
  - Promotion Coordinator for Cold-Region Construction Technology
  - Advanced Technology Research Team
  - Technology Applications Research Team
- Geology and Geotechnical Engineering Research Group
  - Geology Research Team
  - Soil Mechanics and Dynamics Research Team
  - Construction Technology Research Team
- Water Environment Research Group
  - River Restoration Research Team
  - Water Quality Research Team
  - Aqua Restoration Research Center
- Hydraulic Engineering Research Group
  - River and Dam Hydraulic Engineering Research Team
  - Hydrologic Engineering Research Team
- Erosion and Sediment Control Research Group
  - Volcano and Debris Flow Research Team
  - Landslide Research Team
  - Snow Avalanche and Landslide Research Center
- Road Technology Research Group
  - Pavement Research Team
  - Tunnel Research Team
- Director for Geological Research

Civil Engineering Research Institute for Cold Region

- Director for Cold-Region Technology Development Coordination
  - Cold-Region Technology Promotion Division (Northern Hokkaido and Eastern Hokkaido Branch Office)
  - Machinery Technology Research Team
- Cold-Region Construction Engineering Research Group
  - Structures Research Team
  - Geotechnical Research Team
  - Geological Hazards Research Team
- Cold-Region Maintenance Engineering Research Group
  - Materials Research Team
  - Road Maintenance Research Team
- Cold-Region Hydraulic and Aquatic Environment Engineering Research Group
  - River Engineering Research Team
  - Watershed Environmental Engineering Research Team
  - Port and Coast Research Team
  - Fisheries Engineering Research Team
- Cold-Region Road Engineering Research Group
  - Traffic Engineering Research Team
  - Snow and Ice Research Team
- Cold-Region Agricultural Development Research Group
  - Rural Resources Conservation Research Team
  - Irrigation and Drainage Facilities Research Team
- Director for Special Research
  - Scenic Landscape Research Team
- Director for Geological Research

International Centre for Water Hazard and Risk Management

- Water-related Hazard Research Group
  - Chief Researcher (Communications and Training)
  - Chief Researcher (Risk Management)
  - Chief Researcher (Water Hazard)
- Director for Special Research

Center for Advanced Engineering Structural Assessment and Research

- Bridge and Structural Engineering Research Group
  - Chief Researcher (Management System and Substructures)
  - Chief Researcher (Rehabilitation and Earthquake Engineering)
  - Chief Researcher (Structural Assessment and Superstructures)
  - Chief Researcher (Inspection Technology and Concrete Structures)
- Research Coordinator for Earthquake Engineering

Innovative Materials and Resources Research Center

- Materials and Resources Research Group
  - Chief Researcher (Advanced materials and improvement)
  - Chief Researcher (Recycling)
  - Chief Researcher (Concrete and metallic materials)

Medium to Long-term Objectives / Plan

Medium to Long-term Objectives

Medium to long-term objectives are the objectives national research and development agency must achieve during a period of not less than five years and not more than seven years, decided by the competent minister and instructed to relevant national research and development agency. The Minister of MLIT and the Minister of MAFF announced the PWRI the 4th medium-and long term objectives on February 29, 2016.

Medium to Long-term Plan

The Medium to Long-term Plan was planned to achieve the medium to long-term objectives, and created by a national research and development agency for a purpose of obtaining the authorization for such a plan from the competent minister. In PWRI we created the Medium to Long-term Plan based on the 4th medium to long-term objectives and received the approvals from the Minister of MLIT and the Minister of MAFF on March 31, 2016.

The 4th medium to long-term objectives of PWRI

■ Period for the medium to long-term objectives

For 6 years from April 1, 2016 to March 31, 2022

■ Role of PWRI (mission)

"Maximization of research and development achievements" is the mission of the Public Works Research Institute. In other words, we, as the entire nation, “maximize” creation of research and development achievements that contribute to people's lives, economy, healthy development of culture and other public interest. Based on the primary purpose of the national research and development agency, as a core research base for civil engineering in Japan, we will contribute to the promotion of efficient maintenance and the development of Hokkaido for quality public infrastructure through giving research results back to society and disseminating results. We execute our mission following the national policy for the land, infrastructure and transportation as well as for the promotion of agricultural and fishery industries.

We will conduct research and development to gain the technological knowledge that could be used for establishing the relevant policies and technical standards, thus we will maximize results of research and development. These are the examples: the risk management technology for water-related disasters occurring more frequently and severely, damage mitigation technology for snow and ice disaster due to climate change, effective implementation method of maintenance responding to aging of the stock of infrastructure, approach to river channel planning technology for the conservation of the river environment. These will contribute to building sustainable national land against disasters and also maintain, organize and use the foundation of the national land. They also contribute to formation of sustainable national land with safety and security by appropriate management.

We will strive to understand the needs of infrastructure particularly in order to fulfill its mission to support the national and local governments, which are responsible organizations of public infrastructure for road/rivers. We work closely with the business of the Regional Development Bureau of MLIT and the Hokkaido Regional Development Bureau. We also maximize the research and development efforts of the entire Japan, including research results of universities and private sectors. Therefore, we will make even more efforts to promote cooperation with people-to-people exchanges and joint research.

Taking into account of PWRI's strong points, during this medium to long-term plan period, we will focus on our R&D efforts on:

1. Realization of a safe and secure society
2. Strategic maintenance and renewal of public infrastructure
3. Realization of a sustainable and vibrant society

We also promote R&D on civil engineering technologies adjusting to effective improvement of caliber social infrastructure in snowy and cold regions, covering approximately 60% of Japanese areas.

R&D Program

PWRI will work on the following issues revealed at the medium to long-term objectives to focus on socially demanding issues while looking at the future.

1. Contribution to realization of a safe and secure society
2. Contribution to strategic maintenance and renewal of public infrastructure
3. Contribution to realization of a sustainable and vibrant society

For achieving these issues effectively and efficiently, PWRI categorizes these issues as "R&D programs" by the subjects to be solved, or the method of such as technical instruction and technological dissemination. By these units of methods, we establish 17 research and development programs and proceed efficiently.

R&D Program

1. Contribution to realization of a safe and secure society	(1) Development of design technique for disaster prevention facilities against recently more frequent and intense water hazards
	(2) Development of technology to support risk management for water-related disasters occurring more frequently and severely in Japan and overseas
	(3) Development of technology to prevent or mitigate damages from sediment-related disasters caused by sudden natural phenomena
	(4) Development of seismic technology for strengthening earthquake resilience of infrastructure facilities
	(5) Development of technology for the mitigation of snow and ice disasters caused by extreme weather
2. Contribution to strategic maintenance and renewal of public infrastructure	(6) Development on the efficiency and reliability of the maintenance cycle
	(7) Research on renewal and new construction technology aiming at longer-life and efficiency of maintenance for public infrastructure
	(8) Research on the maintenance and reconstruction of the infrastructure subject to frost damage and combined effect of deterioration
3. Contribution to realization of a sustainable and vibrant society	(9) Development of technology for public infrastructure construction to achieve sustainable construction recycling
	(10) Research on effective use of resources/energy focusing on sewer facilities
	(11) Development of river channel management technology that satisfies both flood control and environmental sustainability
	(12) Development of sustainable sediment management technology in sediment transport system
	(13) Development of water quality management and control techniques for regional water use and aquatic ecosystem conservation
	(14) Research on ensuring the safety and reliable road transport services in winter
	(15) Study on improving landscapes and the efficient use of infrastructure for attractive local development
	(16) Research on maintenance and management of agricultural infrastructure in the snowy cold regions contributing to improving food supply
	(17) Study on the development and conservation of fishery infrastructure of cold waters that contribute to strengthening food supply capacity

Contribution to realization of a safe and secure society

(1) Development of design technique for disaster prevention facilities against recently more frequent and intense water hazards

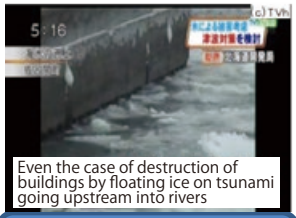
Research Summary

Research period: FY 2016 - FY 2021
Program leader: Director of Cold-Region Hydraulic and Aquatic Environment Engineering Research Group

Research background

Levee breach by overflow beyond the designed level

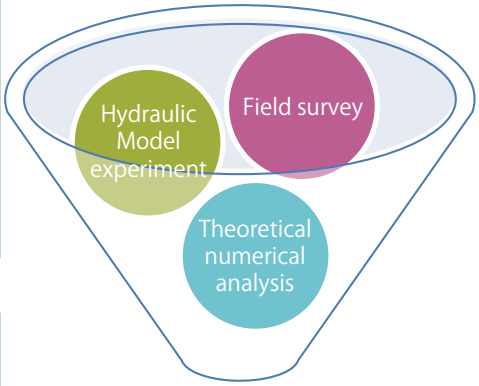
Levee breach by piping

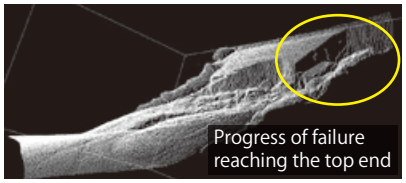


Collision by tsunami debris

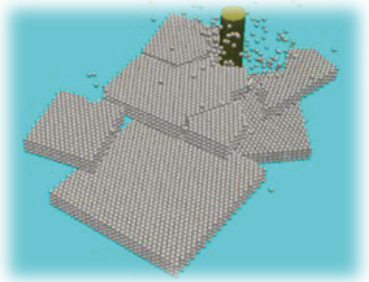
Future risk for extream waves and storm surge

Technical evaluation using full-scale experiment





Progress of failure verified by the permeation model experiment



Development of numerical calculation method for collision/fracture of tsunami debris such as sea ice floes

Development of technology for non-structural measures to mitigate damages for the new stage of water-related disasters and massive earthquakes/tsunami

Understanding the effect on structures by experiment of tsunami running up a river

In recent years, intensive and heavy rainfalls in local areas cause frequent floods that is beyond the capacity of facilities. Levees are destroyed by overflow and seepage, and river structures are damaged by high-speed flow. In addition, due to the 2011 Great East Japan Earthquake, working on tsunami disasters has become an urgent issue.

Furthermore, the technology capable of responding to hydrographic changes such as massive waves caused by the low-pressure is required, because frequent low-pressure system developing into a powerful level equal to typhoon due to climate change is expected to approach the coastal area facilities.

However, the research has not been fully conducted to establish technologies to make higher resilience against devastating destruction. For this reason, in this research, we develop technology for structural measures to mitigate damages against the new stage of water-related disasters and massive earthquake/tsunami caused by climate change in consideration of the external force of disaster at the level of reaching maximum and causing shocking destruction. In order to achieve these goals we will work on the following research topics.

(1) Development of technology for evaluation/strengthening river levees against overflow and erosion
(2) Development of technology for evaluation/investigation of safety of river levees against water permeation.
(3) Development of technology for evaluation of impact of tsunami on structures and design method
(4) Development of technologies appropriate for hydrographic changes due to climate change

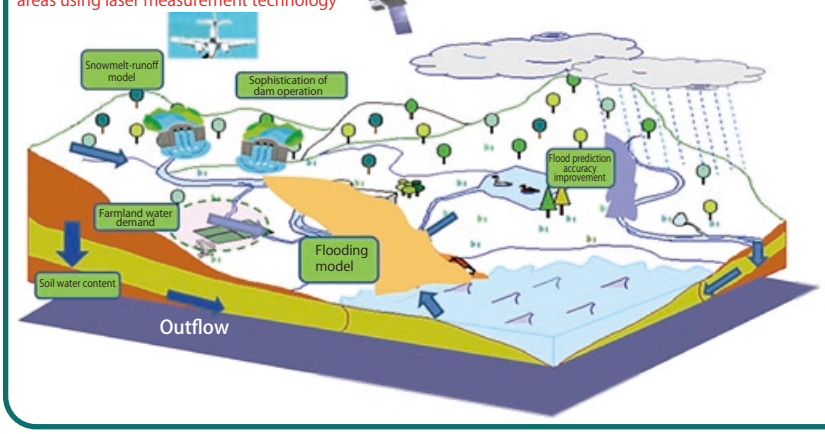
(2) Development of technology to support risk management for water-related disasters occurring more frequently and severely in Japan and overseas

Research Summary

Research period: FY 2016 - 2021
Program leader: Director of Water-related Hazard Research Group

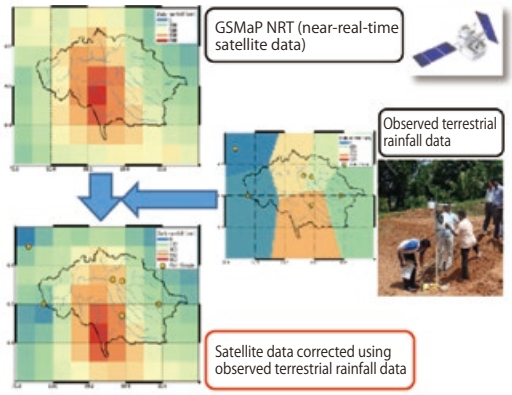
Development of hazard analysis technologies and models that improve the accuracy of flood forecasting and of long-term water balance analysis

Understanding of characteristics of snow accumulation distribution at high altitude areas using laser measurement technology



Understanding of rainfall and terrain information using satellite observation information

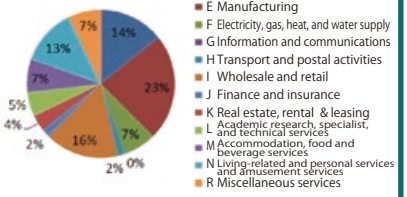
Example of satellite data correction using observed terrestrial rainfall in the Kalu River region in Sri Lanka



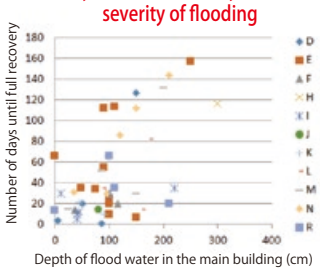
Study of the impact of water damage on businesses

In order to regionally evaluate the level of water damage and resilience, in cooperation with the Joso City Society of Commerce and Industry, 60 randomly chosen companies were interviewed for information on their response at the time of the flood, damage, recovery, and flood damage measures before and after flooding.

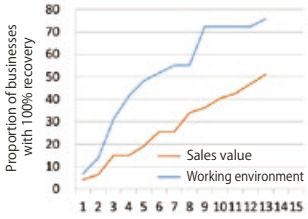
Industries surveyed



Analysis of business days lost and severity of flooding



Recovery of sales value and working environment



Development of a versatile information sharing system for local governments

Prototype of the Aga town Risk Information System (ARIS)

Risk map showing anticipated inundation maps, sediment disaster risk map, and homes for those who need help in emergency

In recent years, rainfall events have become more localized, intensive, and extreme; for example, more events with an hourly rainfall of over 50 mm have been observed throughout Japan. In the future, due to the impact of global warming, more regions of the country will suffer from extreme rainfall that may be even more intensified and frequent. In contrast, snowy cold regions are projected to have a shorter snowfall period and, as a result, less snowpack.

In this research project, we aim to develop technologies to characterize water-related disasters in terms of meteorology, hydrology and resulting damage. We will also develop technologies for various organizations to cope better with disasters using technologies for collecting and providing information. The following are the main research goals:

(1) Development of technologies and models for improving accuracy of flood forecasting and long-term water balance analysis

(2) Development of technologies for analyzing water disaster hazards in various natural and local conditions, methods for water-related disaster risk assessment using highly accurate, advanced estimation approaches, and indicators for evaluating the effectiveness of disaster prevention measures

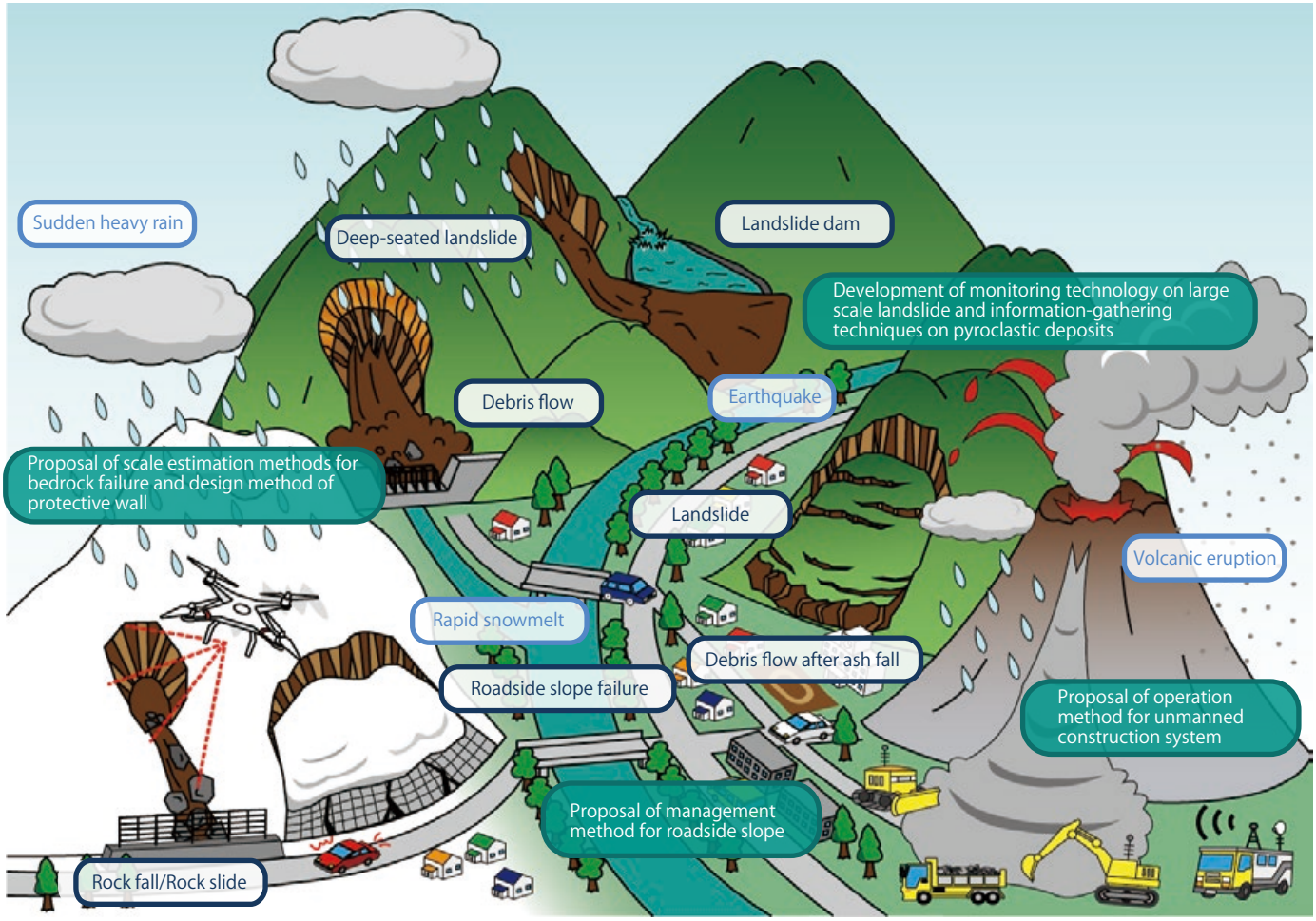
(3) Development of methods for producing, utilizing and communicating useful information on disaster prevention and disaster status to assist efforts in disaster prevention and mitigation

These technologies and methods will be used to establish systems to estimate damage and risk using real-time observation information. Such systems will make reliable disaster information readily available for municipal disaster management personnel, who will thus be able to make well-informed decisions for effectively fighting floods and leading safe evacuation in time of disaster.

(3) Development of technology to prevent or mitigate damages from sediment-related disasters caused by sudden natural phenomena

Research Summary

Research period: FY 2016- 2021
Program leader: Director of Erosion and Sediment Control Research Group



In recent years, the impact of climate change has caused more adverse events than statistically expected, and the risk of sediment-related disasters has increased. Moreover, sediment-related disasters have required emergency response after unexpected natural phenomena, such as volcanic eruptions, large-scale earthquakes, sudden heavy rain, or rapid snowmelt. Technological countermeasures are therefore required to minimize damage, speed up the initial disaster response, and make responses more effective.

This study lists the following three targets needed to speed up and make more effective the initial response aimed at preventing or mitigating the damage or impact from such a sediment-related disaster:

(1) Development of technology for monitoring sediment-related events and for inspecting and maintaining roadside slope
(2) Development of technology to estimate the range of sediment movement and technology to assure safety of road traffic.
(3) Development of the design technology and the robot technology to prevent/reduce sediment-related disasters.

(1) We conduct research on technology that is able to identify, at an early stage, locations at risk of a sediment-related disaster, methods of inspecting roadside slope with regard to sudden heavy rain and snowmelt, and relevant monitoring and management technology. (2) Our research relates to improvement in the accuracy of technology that estimates the likely area of debris-flow damage, methods of evaluating the safety of roadside slope during sudden heavy rain or snowmelt, and evaluation of the risk of soil movement. (3) We conduct research on unmanned construction technology for use at dangerous disaster sites, including near volcanic eruptions, and on technological measures for dealing with sediment-related disasters.

We aim to develop countermeasures against sudden sediment-related disasters by reflecting the results of this research in technical standards.

(4) Development of seismic technology for strengthening earthquake resilience of infrastructure facilities

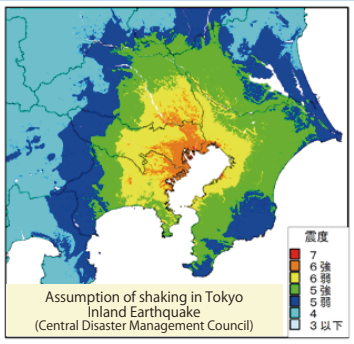
Research Summary

Research period: FY 2016 - 2021
Program leader: Executive Director for Earthquake Engineering

Research background・Needs

◆There is a high probability of the imminent occurrence of large-scale earthquakes (massive earthquake in the Nankai Trough, Tokyo Inland Earthquake)
◆Recent large-scale earthquakes caused various types of damage, severely affecting society (e.g., Great East Japan Earthquake of 2011, Kumamoto Earthquake of 2016, Hokkaido Eastern Iburi Earthquake of 2018).
◆It is necessary to develop technologies that will contribute to protecting human lives, maintaining important infrastructure functions, minimizing disaster damage, and facilitating quick recovery, based on lessons learned from past earthquake disasters.

Imminent earthquakes



Assumption of shaking in Tokyo Inland Earthquake
(Central Disaster Management Council)

Various kinds of damage and impacts


Damage caused by collapsed slopes and ground deformations, affecting traffic for a long time


Enormous impacts on traffic due to collapse of embankments


Emergency responses to large-scale damage of river embankments and floods



Severe liquefaction damage and wide area liquefaction severely impact on travel

Research contents

◆The following technologies will be developed for road and river structures (e.g., bridges, embankments, levees) and soft grounds.
●Technology for minimizing damage of structures against earthquakes and recovering the damage quickly
●Seismic design technology consistently applicable for ground, underground, and aboveground structures.
●Liquefaction evaluation method for soil layers considering the effect on structural responses

Aim is to help realize a resilient society through applying research findings to society (proposals to reflect them in standards and projects)

It is pointed out that there is a high probability of the imminent occurrence of large-scale earthquakes, such as Nankai Trough Earthquake and Tokyo Inland Earthquake, all over in Japan. In the Great East Japan Earthquake of 2011, the wide areas of Pacific Ocean coast from Hokkaido to Kanto suffered the extensive damage by the strong shaking and huge tsunami. Moreover, strong vibrations and large-scale ground deformation had serious impacts on public infrastructure struck by the 2016 Kumamoto earthquake. And unprecedented large-scale slope collapses, liquefaction etc. caused severe damage during the 2018 Hokkaido Eastern Iburi Earthquake.

For such earthquakes, pressing issues are to prevent and minimize the earthquake damage, and to improve the earthquake resilience (strong and resilient against earthquakes) of infrastructure facilities including; road facilities which play a key role for emergency/life-saving activities and transportation of emergency goods; river facilities to prepare for the tsunami or flood occurred in a complex way after earthquakes.

This research consists of the following three segments for the purpose of development of the countermeasure technology to prepare for large-scale earthquakes and complex disasters after the earthquake that exceeds the past experience.

(1) Development of technology for minimizing damage of structures against earthquakes and recovering the damage quickly
(2) Development of seismic design technology consistently applicable for ground, underground, and aboveground structures.
(3) Development of liquefaction evaluation method for soil layers considering the effect on structural responses

We develop and improve the evaluation method of seismic performance and seismic measures for road bridges, road soil structures, soft ground, and river structures.

With proposing practical application of developing technology and the reflection to the technical standards and manuals, we aim to contribute to the realization of earthquake resilient society by minimizing damage of infrastructures and recovering functions quickly at the time of disasters for future large-scale earthquakes.

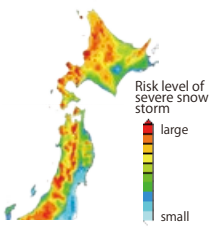
(5) Development of technology for the mitigation of snow and ice disasters caused by extreme weather

Research Summary

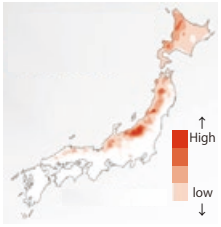
Research period: FY2016 - 2021
Program leader: Director of Cold-Region Road Engineering Research Group

Identification of the actual condition of snow and ice disasters caused by extreme weather and development of risk assessment technology

- Proposal of indicators offering appropriate evaluation of the severity of single-event snowstorms or heavy snow.
- Proposal of development of hazard maps for snow storm and heavy snow, risk evaluation method of the avalanche caused by large amount of snowfall in short period of time.



Distribution map of snow storm (image)



Frequency distribution of the avalanche risk (image)

Development of technology for prediction of poor visibility occurred on various winter roads

- Development of technology for forecasting visibility in blizzards under different climatic environments.

Blizzard prediction
(left: Goshogawara; right: Teshikaga)

PC version

Smartphone version

Snowstorm Visibility Information System

Development of technology to improve performance of snow-storm countermeasure facilities and snow removal vehicles

- Proposal of management approach towards stable performance of snow protection for the snowbreak woods.
- Proposal of methods for countermeasure selection at the end of and at gaps in snow fences, where visibility changes suddenly.
- Proposal of technology to support snow removal work by preventing collisions and lane-departure at the time of poor visibility.

Proposal of countermeasures for the lower dead branches in the snowbreak woods.

Support operation of snow removal vehicle (image)

Examples of countermea-sures for the end of the snow fences

Mitigation by snow and ice disaster posed by extreme weather

In recent years, a large number of vehicles stranded on the roads, traffic closure for long hours and isolation of communities have caused by unusual snow storm, snow falls, and avalanches due to effect of climate change.
Therefore, in this research program, we are committed to realizes the three goals below based on "technology development in order to reduce the damage caused by snow and ice disasters that extreme weather will bring".

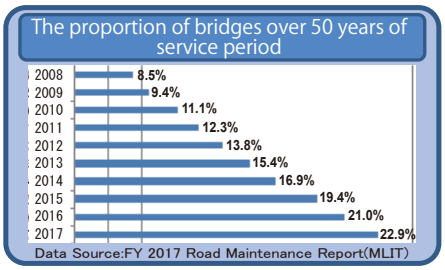
(1) Identification of the actual condition of snow and ice disasters caused by extreme weather and development of risk assessment technology
(2) Development of technology for prediction of poor visibility occurred on various winter roads
(3) Development of technology to improve performance of snowstorm countermeasure facilities and snow removal vehicles

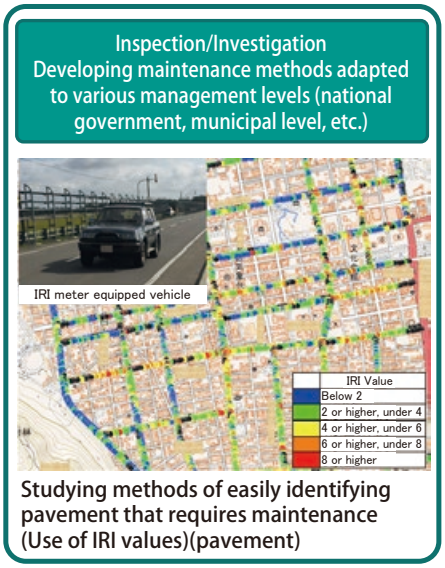
We will give research result of above goals back to society and continue to support reduction of traffic interruption or damages to communities caused by snow and ice disaster which have occurred more frequent and complex.

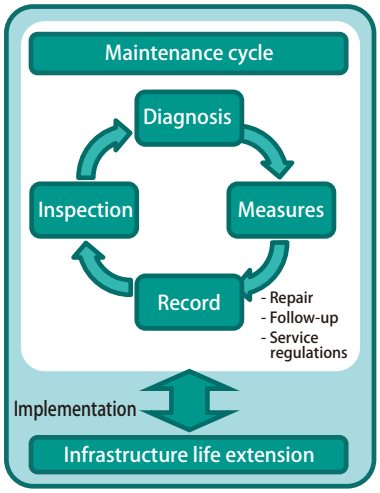
(6) Development on the efficiency and reliability of the maintenance cycle

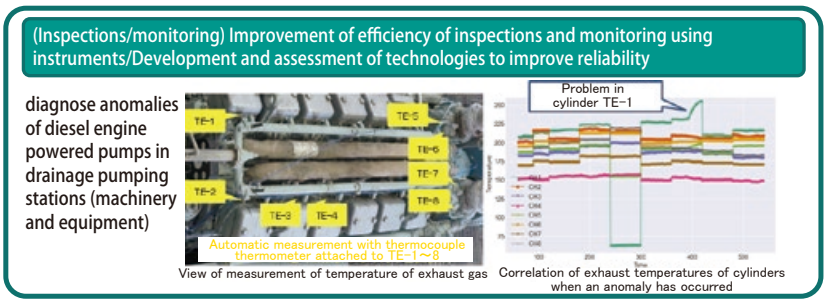
Research Summary

Research period: FY2016-2021
Program leader: Director of Bridge and Structural Engineering Research Group









Currently, aging of public infrastructure has been progressing rapidly. The serious damage due to deterioration occurred in Sasago tunnel and it caused the accidents. Aging of social capital has become major social problem.

In order to respond to these challenges, we need to implement maintenance cycle without fail and ensure to keep the health of social capital.

In this research we work to solve the following technical problems that we face at each phase of maintenance cycle (inspection, investigation, diagnosis, measures (repair and reinforcement)).

(1) Inspection/Investigation: technology to improve efficiency and reliability of monitoring and investigation contributing to improvement of the reliability at time of diagnosis

(2) Diagnosis: determining methods to identify area/parts where countermeasures are needed and the degree of urgency (priority)

(3) Measures: Establishing repair and strengthening methods, developing new materials and structures including their evaluation optimal to the on-site conditions

We also work on the development of maintenance technology appropriate for the various management levels, such as consideration for the service level of properties that the municipality managements control.

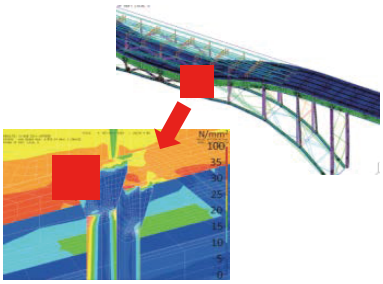
Thus, we will continue to contribute to the health of the social capital in order to achieve a spiral up in the technical aspects of the maintenance cycle.

(7) Research on renewal and new construction technology aiming at longer-life and efficiency of maintenance for public infrastructure

Research Summary

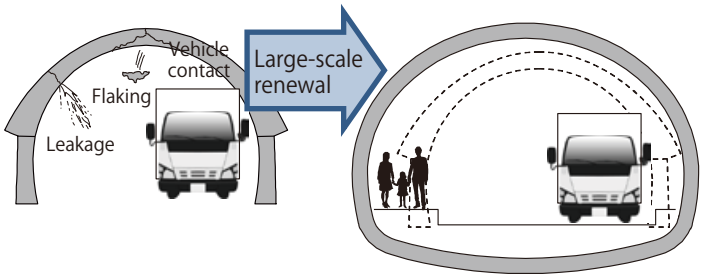
Research period: FY2016-2021
Program leader: Director of Road Technology Research Group

Development and evaluation of structural design methods and advanced materials for the structures that exhibit high durability



Review on close examination method of fatigue cracks in steel bridges

Development and evaluation of structural design methods and advanced materials that achieve renewal of existing infrastructures without interrupting the services



Study of large-scale renewal method for tunnels

Development and evaluation of structural design methods and advanced materials that suggests the optimum timing and part of the structures for strengthening and repair with simplified inspection methods

Example of outflow of reinforced-back-surface soil (a simple maintenance method is required)

Development of effective utilization of precast concrete products for both high productivity of construction work and long term durability of concrete structures

Consideration of a reasonable selection method of pre-cast materials

Japan's stocks of public infrastructure were intensively improved during the period of rapid economic growth and now the increasing aging infrastructures are concerned. It is important to renew or enlarge the service life for these existing infrastructures without interrupting their service. Under the severe fiscal situation, in order to ensure renewal or repair of infrastructure and, it is essential to conduct strategic maintenance work with consideration of priority and consequences of the infrastructures. For structures which have high priority, we need to achieve high durability to reduce their lifecycle costs. On the other hand, management level is not really high but for a huge number of simple structures, it will be advantageous to achieve structures that can clearly show you timing of renewal and locations needed for renewal using simple inspection methods.

In addition, decline of working-age population has affect the construction sector. Even if workers engaged in the construction industry is declined, we need to realize an improvement of productivity in order to efficiently renew public infrastructure. For example, we will need engineering development to build high quality structures efficiently using the precast concrete products.

This research program aims to establish evaluation methods necessary for development of material and construction in order to commercialize the new technology that can adapt to society's needs. We will also propose such research results reflected in the standards of various design guidelines.

(8) Research on the maintenance and reconstruction of the infrastructure subject to frost damage and combined effect of deterioration

Research Summary

Research Period: FY2016-2021
Program leader: Director of Cold-Region Maintenance Engineering Research Group

For the aging of public infrastructure, we need to understand the conditions of deterioration according to various effects such as environmental conditions and make a plan of maintenance and renewal based on the importance of facilities. We also need to establish a series of systematic engineering. Particularly for the public infrastructure in the snowy and cold regions, frost damages and deterioration by combined effect such as low temperature, snow, frost, frost heave, freeze-thaw, snowmelt water, salt occur due to harsh environments. However, countermeasures for these deterioration caused by combined effect has not fully developed yet.

For bridges, rivers and coast of concrete structures, paving, heave cut slope, in this research we develop structure-specific technology and common technology targeted at frost damage and its deterioration by combined effect/damage mechanism with related to the following 4 items;

(1) Establishment of efficient inspection, diagnosis and evaluation methods of frost damage/deterioration by combined effect
(2) Establishment of a reliable repair/reinforcement technology for frost damage/deterioration by combined effect
(3) Establishment of technology of durable reconstruction and new construction for frost damage/deterioration by combined effect
(4) Systematization of inspection, diagnosis, assessment, repair/reinforcement, reconstruction/new construction related to infrastructures due to frost damage/deterioration by combined effect.

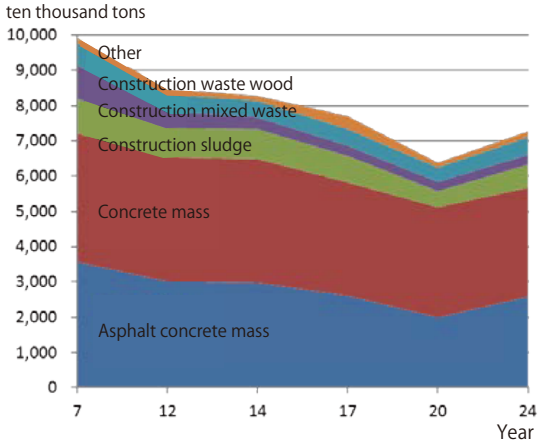
We support to help maximize and extend the life of infrastructures in the snowy and cold environment by applying these technologies to the infrastructure, which will contribute to maintenance, development and utilization of the land structure to support the safety and security and economic growth.

(9) Development of technology for public infrastructure construction to achieve sustainable construction recycling

Research Summary

Research period: FY2016-2021
Program leader: Director of Materials and Resources Research Group

Changes in emissions of construction waste



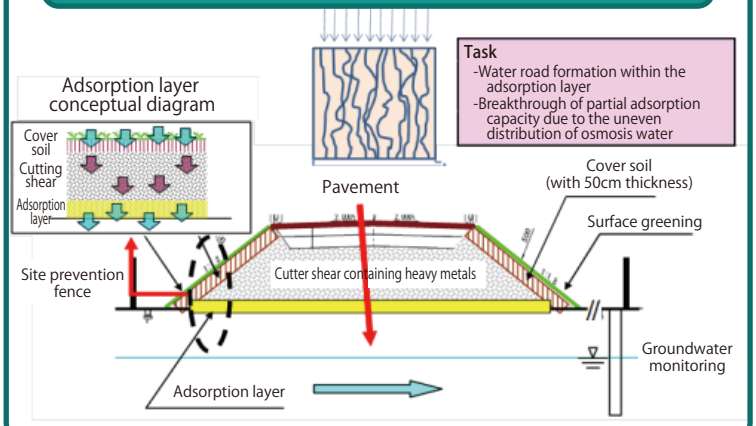
Source: construction product survey results by Ministry of Land, Infrastructure and Transport (2012)

Example of utilization of recycled aggregate

L-shaped retaining wall using recycled aggregate (provided by Prof. M. Kitatsuji, Miyagi University)

Clarification of applicable conditions of recycled asphalt admixture containing a large amount of recycled aggregate

Development of inexpensive and efficient countermeasures for surplus soil including natural heavy metals



Conceptual diagram of the adsorption layer construction method

Establishment of a sustainable society has become an important proposition that we are responsible on a global scale. Among other things, our nation with poor natural resources needs to effectively use the wastes and strive to build a recycle-oriented society.

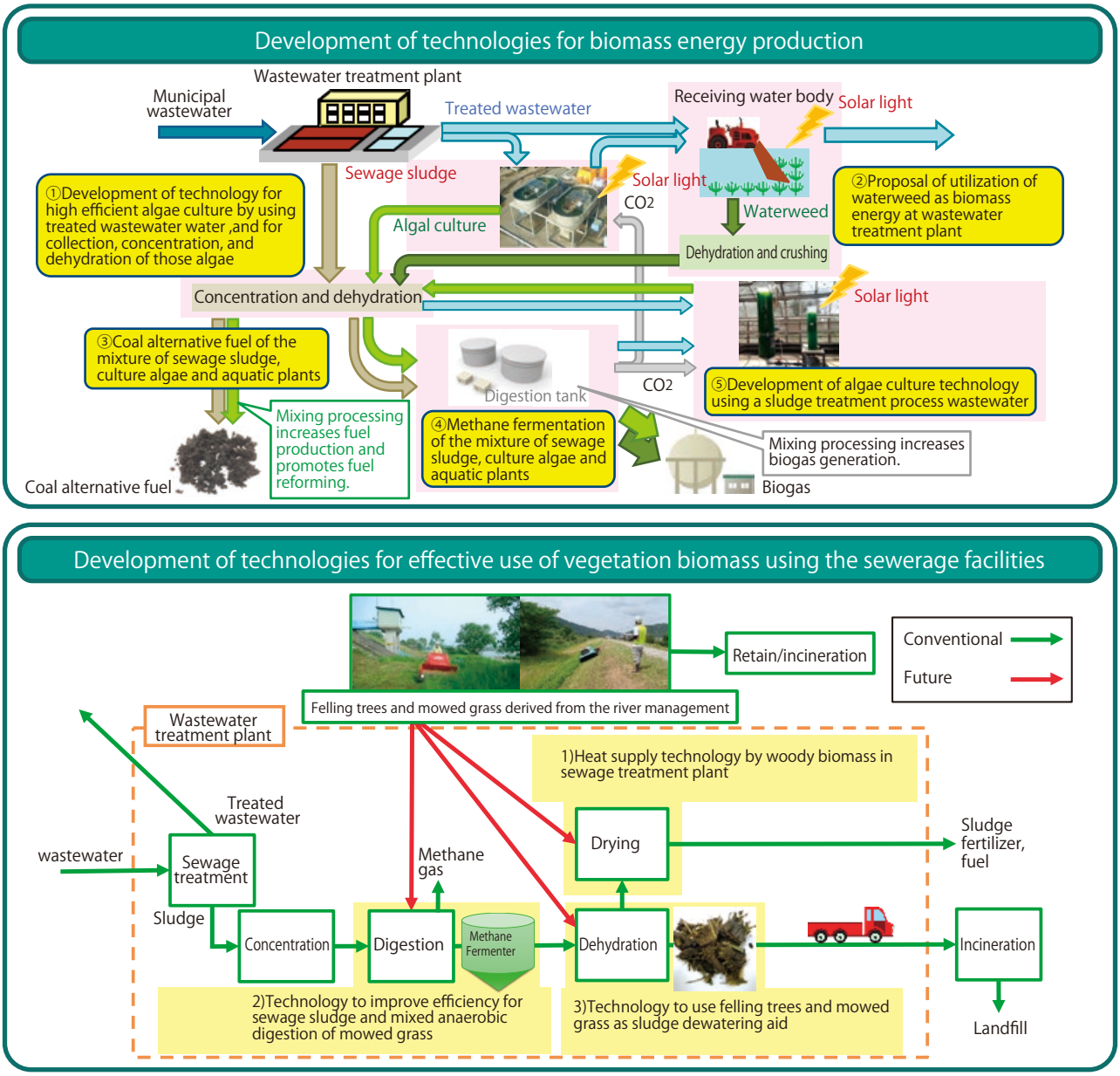
The construction sector generates construction by-products due to update of the structures, such as concrete blocks, asphalt blocks, and surplus soil. Efficient use of these construction by-products without disposal reduces burden of the disposal sites and also helps conservation of natural resources. So far, such construction by-products have been utilized and we have obtained certain results, however, the amount of construction by-products will continue to increase in the future along with the full-scale constructions of the 2020 Summer Olympics and Paralympics in Tokyo and full-fledged maintenance and renewal work for existing structures. Further expansion of utilization is expected in order to properly maintain the resource circulation including the construction by-products. Specifically, we conduct research on further expansion of utilization of concrete recycled aggregate, clarification of applicable conditions in case of using a lot of recycled aggregate, and expansion of utilization of warm mix asphalt pavement technology for recycled asphalt pavement.

On the other hand, due to the large-scale tunnel construction, surplus soil occurrence from construction is expected. It is necessary to enhance environmental safety assessment and countermeasures for surplus soil. We conduct research on development of regulations for surplus soil including natural heavy metals, evaluation for sources in accordance with the environmental characteristics of the element type, and practical use of efficient countermeasure at low costs.

(10) Research on effective use of resources/energy focusing on sewage facilities

Research Summary

Research period: FY2016-2021
Program leader: Director of Materials and Resources Research Group



There is a growing expectation for renewable energy towards building of a recycle-oriented society. "Basic Energy Plan" that was approved by the Cabinet in 2014, shows the promotion policy of effective use of the sewage sludge as one of the renewable energy. The Ministry of Land, Infrastructure, Transport and Tourisum has set "New sewage works vision" and it shows resource-intensive, energy supply base and self-reliance sewage treatment plants as a medium-term goal. It includes facilitation of new technological development such as mixing process of sewage sludge and other biomass and extraction methods of useful algae using nutrients in the sewage. On the other hand, for example, biomass such as mowed grass and logging produced in rivers are required to be used without simply disposing.

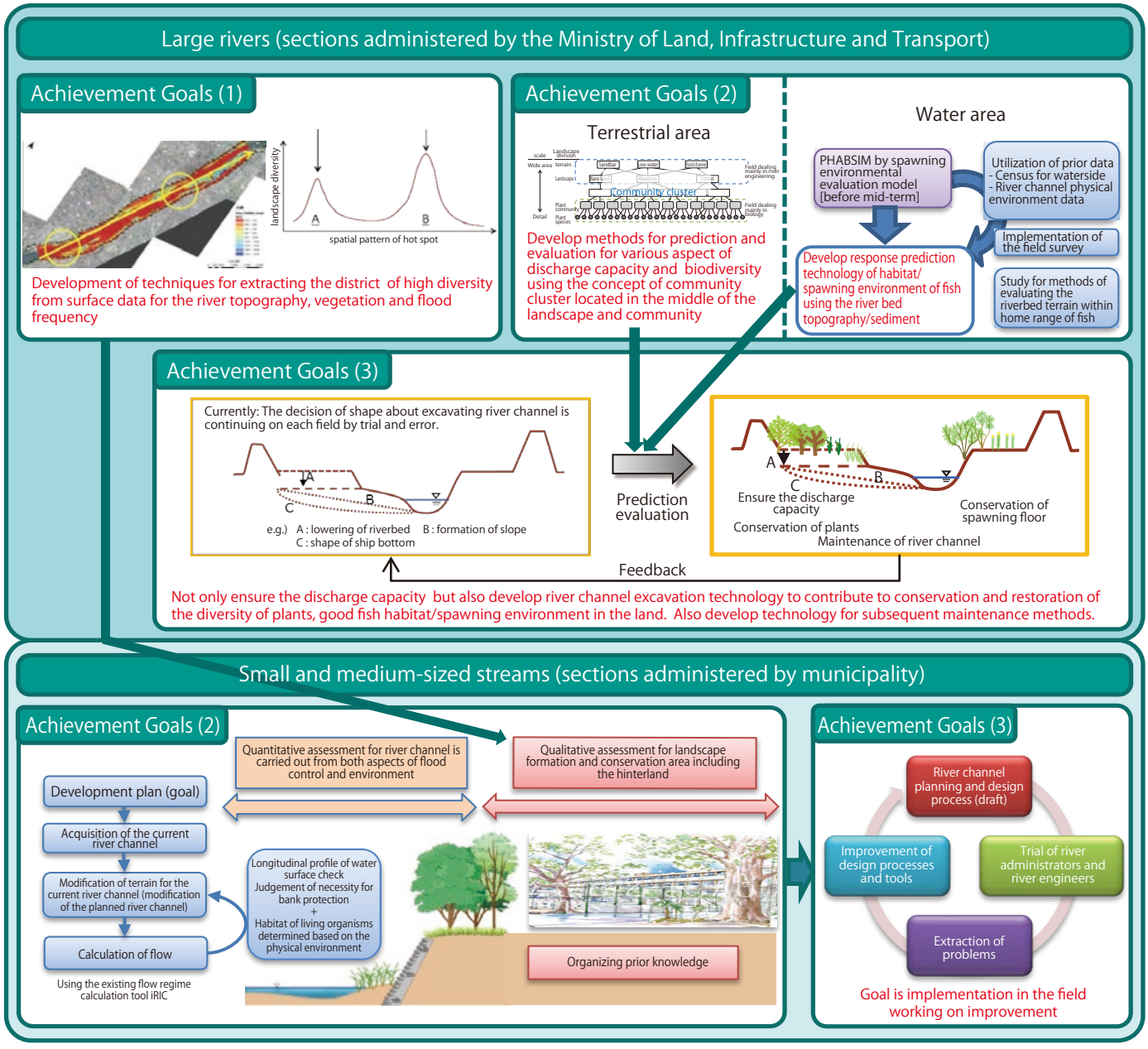
In particular the sewage treatment facilities are expected to accept biomass and use as energy required for sewage treatment.

In this program, in light of these circumstances, we develop production methods for biomass energy and aim to achieve highly efficient alga culture using the treated wastewater and embark on the studies in advanced technologies for collection, concentration and dehydration for algae culture. We also examine the applicability of mixture of algae culture/water plants and sewage sludge to the coal alternative solid fuel. Technology for utilization of wood chips and pellets as dehydration agent for sewage sludge is also a part of our research.

(11) Development of river channel management technology that satisfies both flood control and environmental sustainability

Research Summary

Research period: FY2016-2021
Program leader: Director of Water Environment Research Group



Water system such as rivers and lakes is an important foundation of biodiversity and its loss has continued. In the future we need to set the management objectives of the specific river environment. The urgent tasks are recovery of biodiversity from the losses and maintenance of good conditions. On the other hand, a huge increase of risks resulting from water disasters are also expected. So, it is necessary to promote the river management by taking disaster prevention/mitigation and the natural environment as an integral part while clarifying management objectives.

This research consists of the following three segments for the purpose of development of planning, design, maintenance technology for river channels based on a set of conservation/ formation area of the river environment.

(1) Development of space management technology with a focus on the river landscape, biological growth and habitat.

(2) Development of response/prediction techniques for vegetation and fish towards for human alteration such as a river channel excavation

(3) Development of river channel excavation technology that satisfies flood control and environment as well as maintenance technology

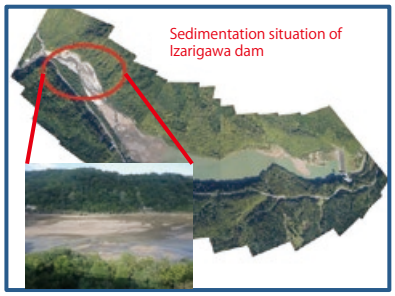
Through these, we aim to satisfy both flood control and environment and propose river channel planning/design for easy maintenance and maintenance/management techniques to maintain the river environment in good condition. Research results will be reflected in basic guidelines and technical standards to disseminated to the sites.

(12) Development of sustainable sediment management technology in sediment transport system

Research Summary

Research period: FY2016-2021
Program leader: Director of Hydraulic Engineering Research Group

Example of cases required resolutions through comprehensive sediment management



Dam sedimentation

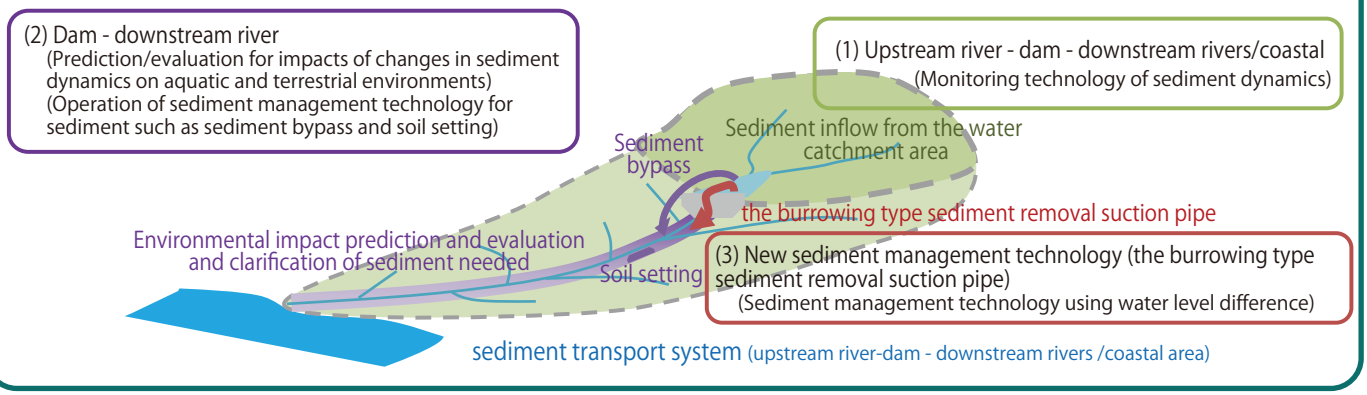

Armor of the riverbed (coarse-grained)


Lowering the riverbed/exposed bedrock

Local scour around bridge piers

Loss of coastal sand

For a sustainable sediment management



Consistent comprehensive sediment management from the mountains to the coast is required to solve the safety and operation issues caused by the flow of sediment, and preserve the natural environment and landscape formed by sediment.

The development of technology that contribute to the realization of the development and effective sediment management of technology to contribute to the collection and analysis of data related to sediment transport can be found in the still developing stage. For promotion of comprehensive sediment management, we are still in the process of developments of technology for data collection/analysis about sediment movement and technology for realization of efficient sediment management.

(1) Development of technology for monitoring sediment dynamics

(2) Development of technology for prediction and evaluation for impacts of changes in sediment dynamics on aquatic and terrestrial environments and development of the sediment management technology with these prediction and evaluation

(3) Development of technology for sediment management technology using water level difference

With the development of technology, we aim to contribute sediment dynamics monitor, survey and prediction of sediment production source, prediction and evaluation for impacts of changes in sediment dynamics on river environment, sustainable sediment management by sediment supply.

(13) Development of water quality management and control techniques for regional water use and aquatic ecosystem conservation

Research Summary

Research period: FY2016-2021
Program leader: Director of Water Environment Research Group

(1) Develop a quick and accurate assessment strategies for basin water environments

Develop assessment and monitoring techniques for water usage, the living environment and aquatic ecosystems

Locating sources of pollutant emissions in the water environment

Next-generation high-speed sequencer

Algal bloom occurrence

Investigate current impact mitigation strategies for water environments
- Inflow from urban areas and agricultural land
  → Countermeasures against non-point source pollution
- Inflow from wastewater treatment plants
  → Controlled by improving the treatment performances

Develop a simple algae surveillance using DNA sequencing
- In present conditions, specialized skills are required to identify musty odor-producing planktons
- Implement surveillance using new DNA sequencing technology

With developed techniques, monitoring and evaluation methods, we aim to preserve water usage in basins, living environments and aquatic ecosystems

Proposing management plans to improve the water environmental quality

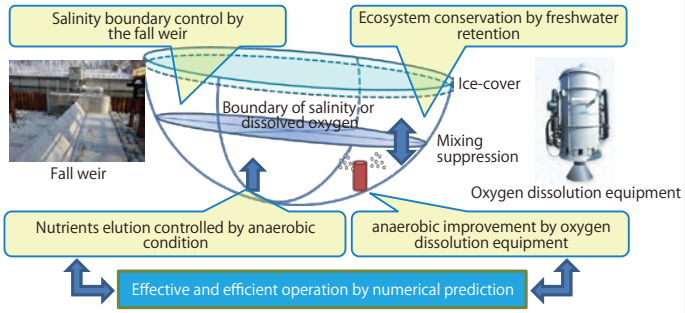
(2) Develop adequate water treatment techniques to mitigation water quality risks

Efficient chemical contaminant removal and pathogenic microbe disinfection

- Develop technology to remove micro pollutants (e.g. pharmaceuticals, surfactant) in treated wastewater through microbial carrier processes. In particular use of low cost and energy conservation technologies to optimize the process conditions
- Aim to improve the inactivation and removal of pathogenic microorganisms in chlorine treated water through applications such as complex disinfection technology

(3) Develop more efficient and effective water quality control strategies

Investigate measures focusing on the changes in bottom layer environments and inflow load



- Develop a prediction method and measures to improve anaerobic conditions such as freezing brackish lakes and dam reservoirs
- Propose measures to adapt to the impact of climate change on water environment quality

Although various improvement measures for water quality have been implemented, serious issues are still found in water environments, such as infectious diseases that influence social activities, ecological effect of chemical substances derived from products for daily use, and occurrence of algal bloom and musty odor in reservoirs. Therefore, new strategies for evaluation, monitoring and management are required to respond to these issues. In addition, it is important to apply these techniques to the basins in an integrated manner to improve environmental quality.

In this R&D program, in order to respond to these challenges we will promote researches towards achieving the following 3 goals:

(1) Development of assessment and monitoring methods to understand the water environments of basins with accuracy and speed.

(2) Development of adequate water treatment technology for the mitigation of water quality risks.

(3) Development of water quality management focused on the bottom layer environment and the inflow change in stagnant water areas.

We aim to reflect these developments to the planning of the administrative measures and technical standards by the national government towards the improvement of water environmental quality, conservation of regional water use in basins, living environment and the aquatic ecosystem.

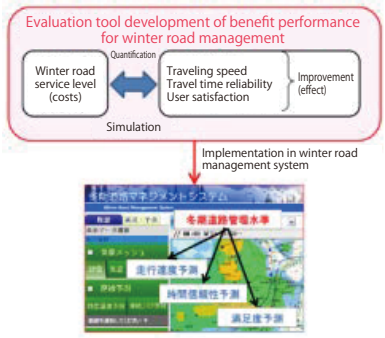
(14) Research on ensuring the safety and reliable road transport services in winter

Research Summary

Research period: FY2016-2021
Program leader: Director of Cold-Region Road Engineering Research Group

Development and establishment for the reasonable level of the winter road service based on the cost-benefit performance evaluation

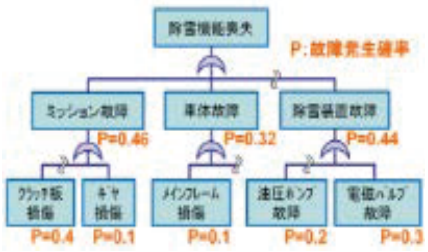
- Establishment of the quantitatively assessment method for cost-benefit performance of the winter road management
- Development of supporting technology of work plan for snow disposal



Evaluation tool for cost-benefit performance for the winter road management

Development of labor-saving operation technique using ICT and efficient maintenance technology for winter maintenance equipment

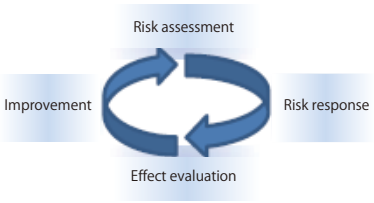
- Development of supporting technology for spraying anti-freezing agent using ICT
- Establishment of effective and efficient maintenance methods based on quantitative assessment of deterioration of snow removal machines



Analysis of probable failure of snow removal machines using FTA

Development of effective and efficient countermeasures for winter traffic accidents using risk management

- Using the traffic big data, establishment of risk management method for winter traffic accident analysis, systematizing accident factor analysis methods, accident risk assessment methods, and accident responding menu.



＊Evaluate winter traffic accident risk and quantify the risk response measures from the countermeasure method (loss and the calculation of the cost-benefit) and maximize the effect of the measures

Risk management approach of winter traffic accident

Improvement of safety and reliability for winter road traffic service

Japan is facing the nationwide problems such as population decline, aging population, large-scale disasters, and financial shortage. In the snowy and cold regions, it has been more difficult for the government to continue to provide the same winter road services due to the financial deterioration. Therefore, the Ministry of Land, Infrastructure and Transport, has launched a compact + network of the national land structure (National Spatial Planning approved by the Cabinet, August 2015).

We must have the inter-regional cooperation and sharing functions by strengthening of the transportation network in order to realize this national land structure in the cold and snowy region. We also need to ensure the safe and reliable winter road traffic service.

In this research program, we have 3 achievement goals and set the "development of management technology techniques contributing to the safety and reliability of the winter road traffic services" as a program goal.

(1) Development and establishment for the reasonable level of the winter road management based on the cost-benefit performance evaluation
(2) Development of labor-saving operation using ICT and efficient maintenance technology for winter road management
(3) Development of countermeasure technology for effective and efficient winter traffic accident by risk management

By giving these research result back to society we will support safe and reliable winter load traffic services in the snowy and cold regions.

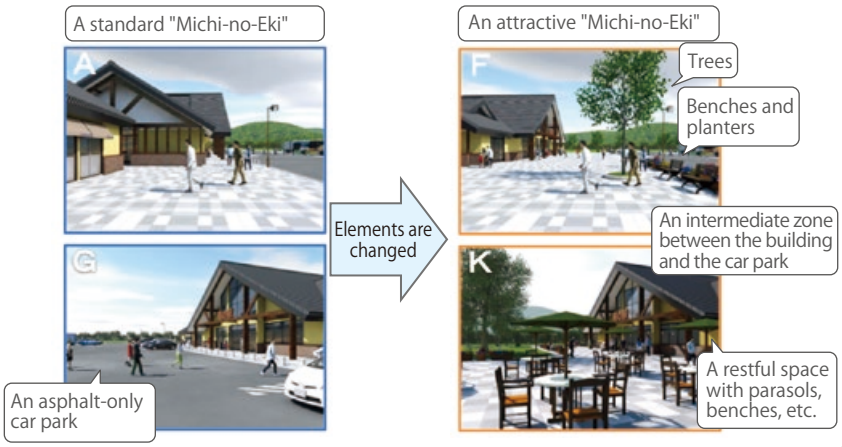
(15) Study on improving landscapes and the efficient use of infrastructure for attractive local development

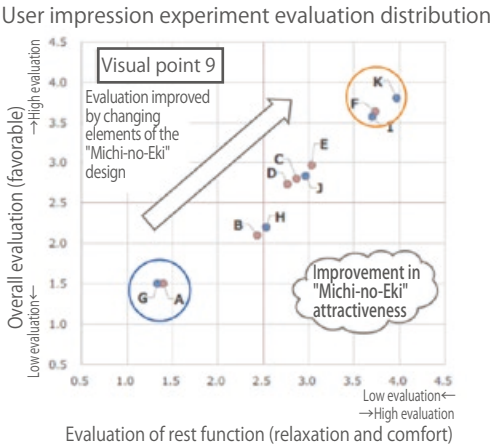
Research Summary

Research period: FY 2016 - FY 2021
Program leader: Director of Special Research.

Public infrastructure, such as "Michi-no-Eki", can contribute greatly to regional regeneration

Planning and design technology that improves attractiveness and functions of "Michi-no-Eki" is important





▲Visitor experience experiment using CG images of "Michi-no-Eki" whose elements have been changed using the relevant design process

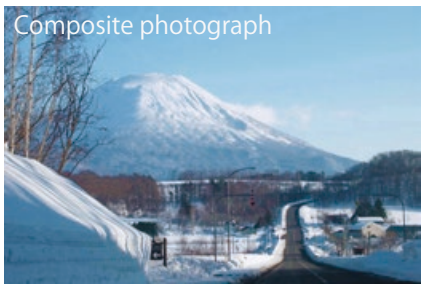
Results

▲Design elements, such as an intermediate zone between the building and the car park and how benches and trees are placed, have a significant impact on users' impressions

The development of suitable landscapes for globally competitive tourist areas

The necessity of creating attractive public spaces to make globally competitive tourist sites.

▲ Utility cables and poles obstruct the view of the scenic Mount Yotei, in the Niseko area visited by many foreigners.



▲ Removing the utility cables and poles has the scenery much better in natural or rural areas

Scenic landscape is an essential element in rich living environment and also plays a significant role in making regions more attractive and in promoting tourism and interaction among them. Regeneration to a characteristic region requires the creation, protection, maintenance, and utilization of good public spaces. The following are three goals of this project.

(1) The development of a landscape evaluation technique for infrastructure in public works
(2) The development of planning, design and management techniques to promote the landscape improvement of outdoor public spaces which enhance regional attractiveness
(3) The development of technical support for the application and use of utility infrastructure in light of regional revitalization

We will contribute to enhancement of Japan's image and conduct a community support to create a rich living environment by maximizing the result of our studies.

(16) Research on maintenance and management of agricultural infrastructure in the snowy cold regions contributing to improving food supply

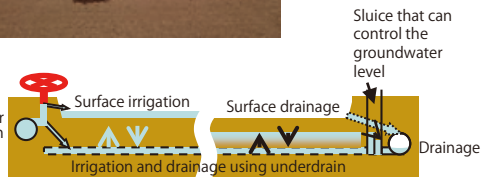
Research Summary

Research period: FY 2016-2021
Program leader: Director of Cold-Region Agricultural Development Research Group

(1) Development of technology for maintenance and management of large-sized paddy fields

Example of large-sized paddy field after improvement: the size of 1 paddy field is about 8 times that of the traditional field.


Water is brought up to topsoil from underdrain.



Mechanism of groundwater level control system


Construction of large-sized paddy field: Decision on selection of machinery and construction timeframe based on the soil diagnosis is required.

(2) Development of maintenance and renewal technology for irrigation facilities


Example of deterioration of irrigation facilities: pier of the headworks with wear and frost damage, and gate with wear and corrosion


Example of waterway repair

(3) Development of irrigation and drainage technology balanced with surrounding environment


Storage facilities of adjusted dairy cattle manure slurry


Scattering dairy cattle manure slurry on pasture


Large-scale dairyland: appropriate circulation of organic resources and preservation of water environment are required.

The target of the self-sufficient rate was set a 45% with the calorie-base in the "Food, Agriculture and rural basic plan (March 2015)" of Japan while the relationship between food supply and demand has become tight.
The importance of the agriculture in Hokkaido, with the large food supply capacity, is increasing to achieving this. The urgent need of the development of food production infrastructure using the new technology is required. For this reason, we develop technology for the following topic related to implementation and maintenance of the agricultural infrastructure.

(1) Development of technology for maintenance and management techniques for large-sized paddy field
Accommodating with decline of workforce/aging population and expansion of the farming scale, we propose the following technologies; improvement of large-sized paddy field in accordance with the soil properties, advanced utilization technology of groundwater level control system in large-sized paddy field, irrigation and drainage technology harmonized with the surrounding hydrological environment in the maintenance section of large-sized paddy field.

(2) Development of maintenance and renewal technology of irrigation facilities
Deterioration of irrigation facilities have been progressing and now appropriate maintenance for these facilities are required. We develop methods of diagnosis and evaluation for deterioration by combined effect of freezing damages and wear occurred in the irrigation facilities in the snowy and cold regions. We also develop methods of repair and reinforcement appropriate for these problems, and planning technology for disaster response to risks needed for large-scale disasters.

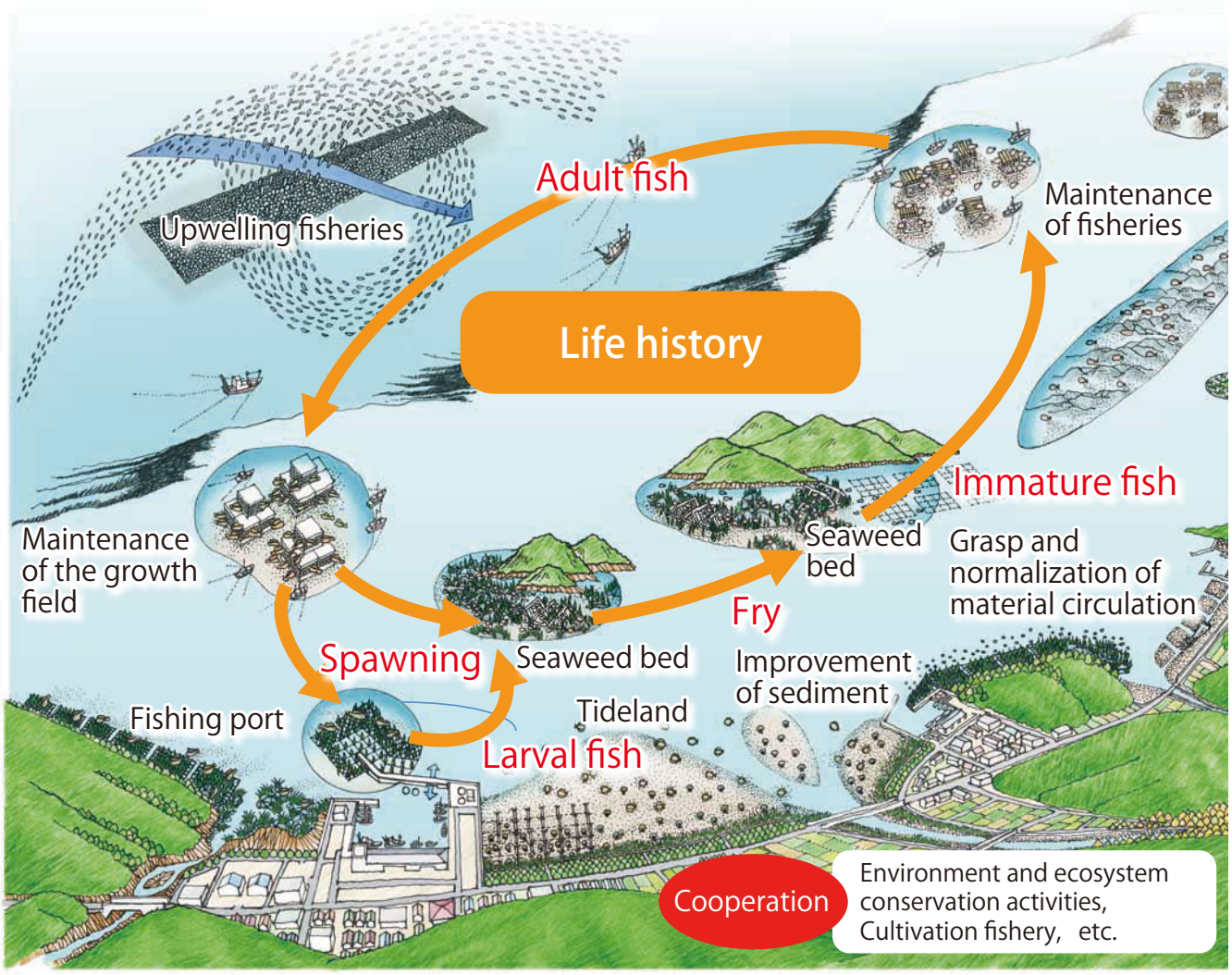
(3) Development of technology for irrigation considering harmony with the environment
With requirement of agriculture in harmony with the environment, we propose the energy-saving type of treatment technique for dairy cattle manure slurry in slurry irrigation facilities, and evaluation technology and measures of water quality environment in dairy farming area.

(17) Study on the development and conservation of fishery infrastructure of cold waters that contribute to strengthening food supply capacity

Research Summary

Research period: FY2016– 2021
Program leader: Director of Cold-Region Hydraulic and Aquatic Environment Engineering Research Group

The creation of favorable habitat space by promoting fishery environmental improvement (long-term plan for maintenance of fishing port and fishing ground)



Reference from the Fisheries Agency website

With increase of the world population, dietary changes and the frequent occurrence of abnormal weather, there is a possibility that the relationship of food supply and demand in the world is tightening. In the future, the role of the fishery industry in Hokkaido, which has the country's largest food supply capacity, increases even more than ever before. It is essential to improve resource productivity of Hokkaido in surrounding waters and strengthen fishery products.

For this reason, in rivers, coastal areas and surrounding ocean of Hokkaido, we will improve the protection/nurturing function of coastal structures and develop the technology to support the sustainable use of fishery resources. We also promote cultivating fisheries by aquaculture that takes advantage of the quiet fishing port harbor waters, and maintain and improve productivity of the fisheries by large-scale fisheries development. This makes it possible to raise the productivity of the entire ecosystem and promote the fishing area by support of cultivating fisheries.

We work in the following research topics to achieve these objectives.

(1) Develop and maintain assessment technology for the protection/nurturing function of fishery living organisms in coastal facilities.
(2) Create comprehensive assessment methods concerning the development effectiveness of large-scale fisheries
(3) Develop effective use and maintenance technology of the fishing harbor to strengthen support of the firming fishery
(4) Create impact assessment and improvement methods concerning the river structures and costal structures by understanding of swimming behavior of high-valued fish.

Introduction of institutions

Tsukuba Central Research Institute

Tsukuba Central Research Institute aims at improving civil engineering technology by conducting studies on civil engineering techniques, experiments, research and development, as well as giving technical instruction and disseminating research achievements.
It also aims at contributing to society by efficiently improving infrastructure and appropriately accomplishing the duties in land, infrastructure, transport and tourism policy.

Introduction of institutions

Civil Engineering Research Institute for Cold Region

Civil Engineering Research Institute for Cold Region, as only one laboratory core of civil engineering technology for cold regions, actively disseminates research results and development technologies to cold regions both in Japan and other countries.
It also takes leading role as an organization to offer information about the civil engineering technology for cold regions in Japan.

Tsukuba Central Research Institute

Construction Technology Research Department

PWRI is responsible for high-quality research and development showing leadership in the innovation of civil engineering technology, turning research results into "technologies utilized", and widely disseminating them. Based on these underlying aims, our Construction Technology Research Department engages in advanced interdisciplinary research and development that goes beyond civil engineering technology. As well as supporting their progress, we actively disseminate the results of our projects both in Japan and overseas.

ICT-assisted construction machine

Remotely operated excavator

Pump diagnostic method

The Advanced Technology Research Team is engaged in research and development aimed at improving productivity in construction projects, conserving the global environment, and raising the level of national resilience. We undertake, in cooperation with partners such as central and local government, i) research and development relating to the application of ICT to construction machinery, robotics for disaster response, and other kinds of leading technology (including robotics, artificial intelligence, and measurement techniques); and ii) advanced research and development contributing to the management of relevant machines and equipment, such as dams and river pumping system.
The Technology Applications Research Team i) undertakes research and development projects aimed at the practical use of civil engineering techniques on construction sites; ii) provides technical information via various publications and events; iii) offers support via technical evaluation, discussion, and guidance; iv) effectively manages intellectual property rights; and v) collects information on international standards to facilitate internationalization. The activities of the Technology Applications Research Team are outlined on pages 35-41.

▶ **Advanced Technology Research Team** http://www.pwri.go.jp/team/advanced/index_en.html

Tsukuba Central Research Institute

Geology and Geotechnical Research Group

The Geology and Geotechnical Research Group is conducting extensive research targeted survey, design, construction and management that including disaster prevention and environmental protection measures in ground and rock, slopes, earth structures, soil environments, and other areas.
The Geology and Geotechnical Research Group is comprised of the Geology Research Team, Soil Mechanics and Dynamics Research Team, and Construction Technology Research Team.
The Geology Research Team develops objective criteria and methods to find out properties of foundation ground.
The Soil Mechanics and Dynamics Research Team conducts research using model test and numerical analysis for the development of design methods including seismic design and reinforcement methods for earth structure.
The Construction Technology Research Team conducts research for the development of construction and maintenance/ management technologies used in earth structures.

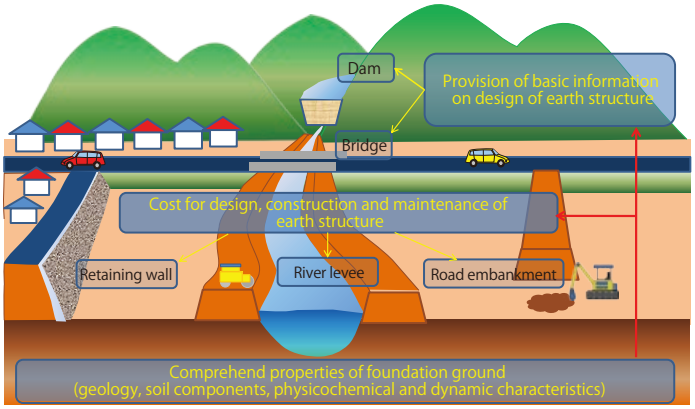


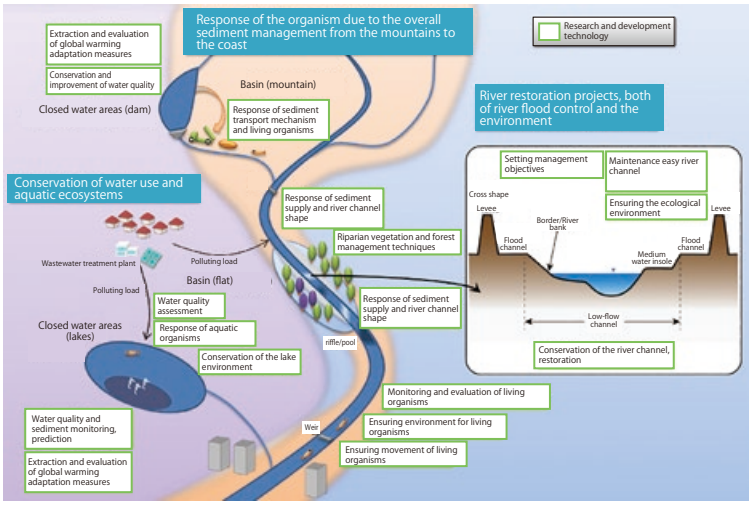
Image of research field of the Geology and Geotechnical Research Group

We also develop and promote innovative techniques to investigate and evaluate soil pollution and integrated geophysical exploration technologies, which are combined solutions to survey and analyze the internal structure of ground and earthworks.

▶ **Geology Team** http://www.pwri.go.jp/team/tishitsu/index_e.htm
▶ **Soil Mechanics and Dynamics Research Team** http://www.pwri.go.jp/team/smd/index.htm
▶ **Construction Technology Research Team** http://www.pwri.go.jp/team/sekou/eng_index_33.html
▶ **Geophysical Exploration** http://www.pwri.go.jp/team/geosearch/english.html

Tsukuba Central Research Institute

Water Environment Research Group



Water environment research group, targeting the rivers and lakes that receive a variety of impact due to human activities, conducts research to understand the mechanism of ecosystem and its anthropogenic impact/ and mechanism of water pollution. It also conducts research on the river management techniques which are for both flood control and the environment, monitoring of pollutants and measures/ approach.

Concerning biological, ecological and environmental conservation and restoration of rivers/lakes, the River Restoration Research Team uncovers the relationship of the terrain, the physical environment and material dynamics and ecosystems and conduct research on impact assessment method and approach to ecosystem. The Water Quality Research Team is engaged in the development of methods for analyzing and monitoring chemical substances in rivers, lakes, reservoirs, dam reservoirs, and sewage effluent in order to reduce regional water quality risk. It also develops methods for understanding the behavior of contaminants and for evaluating and mitigating the impact on aquatic ecosystems. The Aqua Restoration Research Center (ARRC) located in Kagamihara, Gifu Prefecture has full-scale model rivers and ponds for experiments and using these facilities the center carries out research on multi-natural river development and flow and sediment management such as river flow, sediment supply, and response of ecosystems to the structural modifications of the river.

- **River Restoration Research Team** http://www.pwri.go.jp/team/rrt/eindex.html
- **Water Quality Research Team** http://www.pwri.go.jp/team/suisitsu/index_e.htm
- **Aqua Restoration Research Center** http://www.pwri.go.jp/team/kyousei/eng/index.htm

Tsukuba Central Research Institute

Hydraulic Engineering Research Group

Hydraulic Engineering Research Group engages in the following developments; (1) Development of accurate sediment supply technology ,which can supply necessary quantity and quality sediment to downstream from dam reservoir, which is the technical issues to carry out the comprehensive sediment management, (2) high-performance sediment supply technology to overcome the shortcomings of the existing sediment supply from structural point of view, (3) Research on influence and adaptation measures of water quality in dam reservoirs due to climate change (4) development of advanced technology using the sensor, which has been significantly improving in recent years, to observe the river flow rate at the time of the flood, that becomes the basis of the flood defense plan, (5) technology to monitor riverbed fluctuations such as the river bed waves that occur at the time of the flood in real time. River and Dam Hydraulic Engineering Research Team is responsible for (1) ～ (3), and (4) and (5) are for Hydrologic Engineering Research Team

Sediment simulation technology for dams

Sediment bypass tunnel (Outlet of Miwa Dam facility)

Flow rate observation technology using the ADCP

- **River and Dam Hydraulic Engineering Research Team** http://www.pwri.go.jp/team/dam_hydraulic/english.htm
- **Hydrologic Engineering Research Team** http://www.pwri.go.jp/team/hydro_eng/index_e.htm

Tsukuba Central Research Institute

Erosion and Sediment Control Research Group

The Japanese archipelago is vulnerable in terms of the nature of its terrain, with around 70% of its area being mountainous or hilly and containing many fast-flowing rivers. Each year, there are debris flow, drift wood, and landslides after sudden heavy rainfall, earthquakes, volcanic eruptions, and sediment-related disasters, such as slope failures. Furthermore, as well as snow avalanches after heavy snowfall, landslide disasters could be occurred when snow melts.
Such sediment-related disasters have a significant impact on communities, not least in terms of harm to human life, houses, and social infrastructure. In recent years, there have been many serious disasters caused by unprecedented sudden heavy rainfall and large-scale earthquakes.
The Erosion and Sediment Control Research Group conducts research and development related to the mechanisms of sediment-related disasters, risk evaluation, and countermeasure methods. This is with the aim of effectively implementing advance countermeasures, emergency response measures immediately after the event, and permanent countermeasures. In addition, immediately after a disaster has occurred, the group is active at the scene; for example, technical support related to subsequent investigations and countermeasures.


Investigating ash distribution from the 2014 Mount Ontake eruption


Investigating drift wood from the 2017 northern Kyushu heavy rain disaster


Investigating the 2017 landslide in Watada district, Bungo-Ono city, Oita Prefecture


Avalanche survey in Maki district, Otari village, Nagano Prefecture in 2019

- **Volcano and Debris Flow Research Team** http://www.pwri.go.jp/team/volcano/eindex.html
- **Landslide Research Team** http://www.pwri.go.jp/team/landslide/english%20pages/index.htm
- **Snow Avalanche and Landslide Research Center** http://www.pwri.go.jp/team/niigata/english.html

Tsukuba Central Research Institute

Road Technology Research Group

The Road Technology Research Group conduct research to resolve the ways of efficient construction and maximum utilization of roads with the objective of providing safe and comfortable road space. The Pavement Research Team conducts research on the pavement technologies by investigating performance evaluations of pavement and design methods, analyzing the economical management of pavement, improving the roadside environment and promoting energy conservation and recycling.
The Tunnel Research Team carries out field-based research through experiments, numerical analyses, and on-site measurements to establish rational and economical methods for investigations, design, construction, maintenance and management of tunnel structure and attached facilities such as ventilation and emergency facilities.


Accelerated load test and non-destructive test for pavement


Example of field test to establish rational inspection and diagnosis

- **Pavement Research Team**
  http://www.pwri.go.jp/team/pavement/eindex.html
- **Tunnel Research Team**
  http://www.pwri.go.jp/team/tunnel/index-e.htm

Civil Engineering Research Institute for Cold Region

Cold-Region Construction Engineering Research Group

As aging of the public infrastructure is progressing, efficient and effective maintenance, update and maintenance of the public infrastructure with consideration of specific environmental conditions which is unique to the cold and snowy regions is required. In addition, there is a growing demand for responses to landslides and earthquake disasters which frequently occur and public infrastructure to protect safety for lives of people.

Cold-Region Construction Engineering Research Group conducts research in order to address these challenges. Structures Research Team develop design and construction technology for road structure to prevent disasters caused by falling rocks and earthquakes. It also develops maintenance technology of road structure in the snowy cold environment. Geotechnical Research Team conducts research on improving technology for safety and durability of civil engineering facility built on peaty soft ground which is widely distributed in the cold climates, and development of technology related to strong soil structure which is durable to frost heave and freeze-thaw. Geological Hazards Research Team conducts research on development of technology to avoid landslides and rock slope disaster of the snowmelt season and development of assessment and countermeasures of natural origin of the heavy metals.

Deterioration of the road bridge deck due to frost damage

Liquefaction damage in a residential area

Massive rockfall disaster

Landslide disasters occurred in snowmelt season

- **Structures Research Team** http://kouzou.ceri.go.jp/ev/index_en.html
- **Geotechnical Research Team** http://jiban.ceri.go.jp/index.html
- **Geological Hazards Research Team** http://chishitsu.ceri.go.jp/

Civil Engineering Research Institute for Cold Region

Cold-Region Maintenance Engineering Research Group

Civil engineering structures in cold snowy regions are subject to the actions of freezing and thawing caused by low temperatures, and chloride ions from seawater and antifreezing agent. So they are deteriorated by frost or combined frost and chloride attack etc., and their functions are reduced by frost heaving or insufficient bearing capacity.

In order to improve durability and to appropriately maintain the functions of civil engineering structures for a longer period of time, in the Cold-Region Maintenance Engineering Research Group, Materials Research Team (mainly concrete structures) and Road Maintenance Research Team (mainly pavement structures) are conducting research to develop technologies to preserve structures such as quality control and maintenance, repair, reconstruction and other technologies to improve durability in the cold snowy environment.

Investigation of concrete structures deteriorated by combined effect

Measures against deterioration/ damage unique to cold region

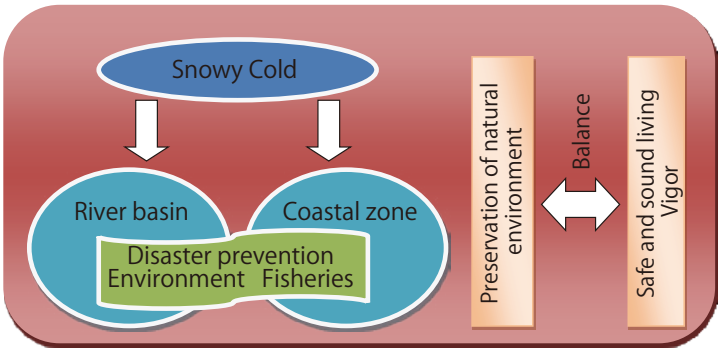
When concrete structures are subjected to combined deterioration of the frost and salt damages cracking and scaling will occur. It accelerates quality deterioration of concrete and reinforcing steel. So we conduct research to predict its degradation progress and selection of appropriate repair method to perform efficient maintenance and reconstruction. In addition, pavement in snowy, cold regions has been deteriorated and damaged uniquely by frost heaving and low-temperature cracking in midwinter, decreased subgrade bearing capacity and freeze-thawing in snowmelt season as well as snow removal and spraying of anti-freezing agents in winter, we also conduct research on countermeasure for deterioration in these cold environment.

- **Material Research Team** http://zairyo.ceri.go.jp/research/research_eng.htm
- **Road Maintenance Research Team** http://www2.ceri.go.jp/eng/iji.htm

Civil Engineering Research Institute for Cold Region

Cold-Region Hydraulic and Aquatic Environment Engineering Research Group

Cold-Region Hydraulic and Aquatic Environment Engineering Research Group conducts research and technology development necessary to strike a balance among securing a safe and sound living, maintaining vigorous socio-economic activities and preserving the rich natural environment in the river basin and coastal zone of the cold, snowy regions.
Cold-Region Hydraulic and Aquatic Environment Engineering Research Group consists of four teams and has collaboration among teams to conduct basin-based research on disaster prevention, environment and fisheries from headwater area to coastal zone. River Engineering Research Team conducts engineering development for flood mitigation and river management by the hydraulic experiments and numerical analyses. Watershed Environmental Engineering Research Team develops technologies associated with the conservation of aquatic ecosystems and monitoring and management of water resources and sediment dynamics at the watershed scale. Port and Coast Research Team develops assessment of storm surge and high waves by tsunami and climate change with a large amount of flotsam like ice and damage mitigation. Fisheries Engineering Research Team conducts research on development of fisheries infrastructure engineering to improve productivity and promote fisheries in the cold coastal water.



Research images of Cold-Region Hydraulic and Aquatic Environment Engineering Research Group

- **River Engineering Research Team** http://river.ceri.go.jp/
- **Watershed Environmental Engineering Research Team** http://kankyou.ceri.go.jp/
- **Port and Coast Research Team** http://cecore.ceri.go.jp/
- **Fisheries Engineering Research Team** http://suisan.ceri.go.jp/

Civil Engineering Research Institute for Cold Region

Cold-Region Road Engineering Research Group

In cold, snowy regions, it is essential to secure and effective snow and ice disaster measures of winter road traffic function to support rich and quality of life and bring out the vitality of the regions. For this reason, Cold-Region Road Engineering Research Group conducts research on winter road management, snow and ice protection, traffic safety and road geometric structure in order to solve these problems due to the cold, snowy natural environment and unique traffic environment in Hokkaido.
The Cold-Region Road Engineering Research Group consists of the Traffic Engineering Research Team and the Snow and Ice Research Team. The Traffic Engineering Research Team is involved in research programs that aim to ensure safe and reliable wintertime road traffic services, even under the current social circumstances of a declining population, aging society, lack of financial resources. Meanwhile, the Snow and Ice Research Team is involved in research programs that contribute to mitigation of transport disruption because of snow and ice events, which have become more frequent and complex in recent years in terms of location, type, and scale.

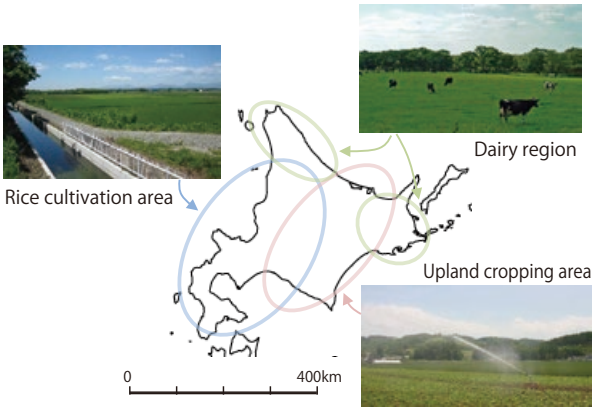
- **Traffic Engineering Research Team** http://www2.ceri.go.jp/eng/koutsu.htm
- **Snow and Ice Research Team** http://www2.ceri.go.jp/eng/bousai.htm

Civil Engineering Research Institute for Cold Region

Cold-Region Agricultural Development Research Group

Cold-Region Agricultural Development Research Group consists of Rural Resources Conservation Research Team and Irrigation and Drainage Facilities Research Team. These teams have been conducting research on civil engineering technology necessary to advance the state-owned agricultural and rural development projects in Hokkaido that deploys the large-scale agriculture with high productivity.
In recent years, natural and socio-economic conditions of agriculture in Hokkaido region are changing greatly due to the situations including global warming, lack of manpower, and international food distribution under TPP etc. In response to such environmental changes, it is necessary to maintain and develop agriculture by taking advantage of abundant land and water resources of Hokkaido. Therefore, we develop technologies for the reclamation and water management of large-sized fields, the improvement of longevity of irrigation and drainage facilities and the conservation of water environment in rural areas.

▶ **Rural Resources Conservation Research Team** http://hozen.ceri.go.jp/
▶ **Irrigation and Drainage Facilities Research Team** http://suiri.ceri.go.jp



Using Hokkaido as a field, where the large-scale agriculture has been running, we develop various technologies such as maintenance and management of large sized field, improving longevity of irrigation facilities, disaster response planning to handle risks at the time of large-scale disaster, assessment and maintenance of water quality environment.

Outreach and dissemination of results to other regions

Civil Engineering Research Institute for Cold Region

Director for Cold-Region Technology Development Coordination

The organization solves technical issues and disseminates research result efficiently which is needed for development and promotion in the cold and snowy regions mainly in Hokkaido. The Cold-Region Technology Promotion Division disseminates research results inside and outside of Hokkaido and promotes use of intellectual properties.
Machinery Technology Research Team conducts research on mechanical technology for snow removal machine in snowy cold regions and inspection technology that contributes to stock management of civil engineering facilities and machinery equipment.

▶ **Cold-Region Technology Promotion Division**
http://chouseikan.ceri.go.jp/suishin/
▶ **Machinery Technology Research Team** http://kikai.ceri.go.jp/

Appropriate and efficient snow removal machine maintenance technology

Civil Engineering Research Institute for Cold Region

Director for Special Research

The 1st century BC Roman architect Vitruvius described “solidity”, “usefulness” and “beauty” as the three essentials for structures. This is why we must consider landscape when developing infrastructure in addition to considering durability and function. In recent years in Japan, the need to ensure scenery landscapes when maintaining infrastructure is increasing, as is the need to contribute to tourism promotion. The promulgation of “The Landscape Act” and “The Basic Act for Promoting a Tourism-Oriented Country” are among the responses to such needs. Also, tourism has become an important industry in Japan, especially in Hokkaido. In response to such needs, the Scenic Landscape Research Team has been established under the Director for Special Research. We conduct research that supports communities in raising the quality and utility of their public spaces and in creating a rich living environment.

▶ **Scenic Landscape Research Team** http://scenic.ceri.go.jp/index.eng.htm

Proposal of planning, maintenance and management techniques for good public space

Introduction of institutions

International Centre for Water Hazard and Risk Management under the auspices of UNESCO (ICHARM)

United Nations Educational, Scientific and Cultural Organization

ICHARM

Introduction of institutions

Center for Advanced Engineering Structural Assessment and Research (CAESAR)

CAESAR

Introduction of institutions

Innovative Materials and Resources Research Center (iMaRRC)

iMaRRC

International Centre for Water Hazard and Risk Management under the auspices of UNESCO (ICHARM)

United Nations Educational, Scientific and Cultural Organization

Having been approved at a UNESCO general session, ICHARM was established in March 2006 as an international centre under the auspices of UNESCO. Its aim is to transfer relevant knowledge and technology fostered in Japan to nations and regions impacted by water disasters based on their needs and conditions and to support their efforts to mitigate future disaster damage.

The mission of ICHARM is to serve as the Global Centre of Excellence for water hazard and risk management by observing and analyzing natural and social phenomena, developing methodologies and tools, building capacities, creating knowledge networks, and disseminating lessons and information in order to help governments and all stakeholders manage risks of water-related hazards at global, national, and community levels. To fulfill this mission, we construct effective information networks globally and carry out practical action tailored to local needs and conditions while combining innovative research with effective capacity building.

Innovative Research

Our current research projects cover the following five areas:

1. Data collection, storage, sharing, and statistics on water related disasters.
2. Risk assessment on water-related disasters
3. Monitoring and prediction of changes in water-related disaster risk
4. Proposal, evaluation and application of policy ideas for water-related disaster risk reduction
5. Support in constructing the applicability of water-related disaster management

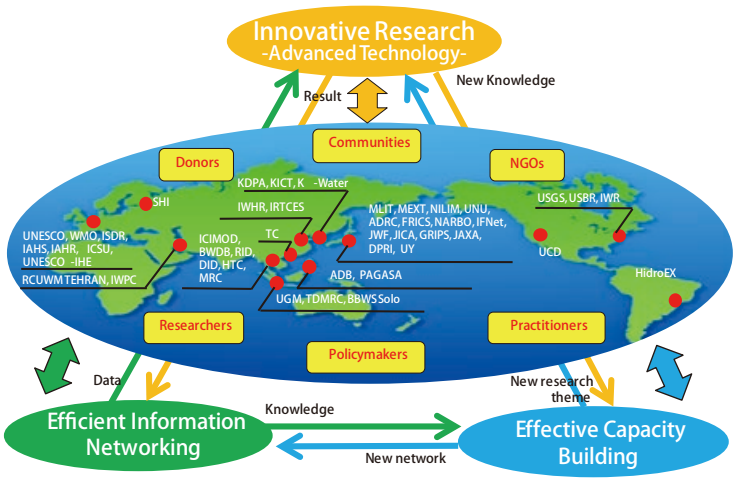
Effective capacity building

We support practitioners, mainly from developing countries, in building their capacity to resolve problems based on scientific and engineering knowledge and to take a lead in disaster prevention and mitigation measures.

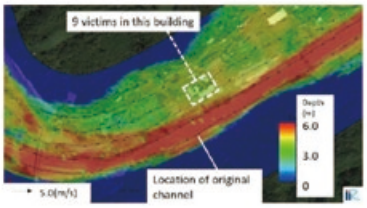
Effective information networking

We maintain and strengthen a global network of researchers, which contributes to the collection, analysis, and sharing of information and experience related to major water disasters around the world. We are also committed to mainstreaming disaster risk reduction in countries around the world by organizing and managing international networks, such as the International Flood Initiative (IFI). One important IFI project is the establishment of a platform on water and disasters in each country, based on the 2016 Jakarta Statement. We assist Asian countries in organizing this platform to reduce water disaster risk in the region in cooperation with other IFI partners and report on this activity at special UN sessions to share information with other countries.

▶ http://www.pwri.go.jp/icharm/index.html



Three main activities of ICHARM



Results of the analysis of flood discharge after change in the riverbed and flow channel of a valley floor river in a semi-mountainous area

Exchanging views with residents while supporting the production of a flood risk management plan

IFAS training

2017 Masters Award Ceremony

Water and Disaster platform (May 2017, Myanmar)

Special session on science and technology at the Third UN Special Thematic Session on Water and Disasters (July 2017, New York)

Center for Advanced Engineering Structural Assessment and Research (CAESAR)

Bridges and Structural Engineering Research Group

Civil engineering structures in Japan have been exposed to severe traffic demand and the natural environment, and aging of many structures to have begun already. There is an urgent need to establish technology for assessing the soundness of structures, as well as technology for maintenance and replacement. The Center for Advanced Engineering Structural Assessment and Research(CAESAR), along with the road administrators, lead to problem-solving for the proper maintenance of the road bridges including earthquake issues. The related researches conducted by CAESAR contribute to standardization for technologies related to design, construction and maintenance for the road bridges, involving accumulated knowledge, research results and integrated technology.

Bridges and Structural Engineering Research Group, with mainly developing technology to assess and predict performance of the bridge structure accurately and promptly , conducts research on comprehensive technologies of design/construction, maintenance/management, inspection/diagnostic techniques, and repair/ strengthening. The group also conducts research on comprehensive maintenance management technology system and establishment of disaster recovery technology system. Of the issues related to the bridges, material properties including soil and specific events unique to the cold regions are studied together with staff of Tsukuba Central Research Institute and Civil Engineering Research Institute for Cold Region. Engineers/ scientists from the road administrator, universities and private sectors join our team aiming improvement of technical capabilities, and cooperate with related fields for solving problems.

Research that prevents "Japan in ruins"

We will work on solving problems by the forensic engineering research approach to prevent collapse and damage due to deterioration of the existing bridges.

- Developing inspection technology to detect conditions of bridges efficiently and reasonably.
- Developing technology to assess impact on soundness of the entire bridge by damage of the material
- Developing maintenance and management system of accumulation and use of information

Research that saves "Japan from becoming fragile country for a disaster"

We will develop and integrate comprehensive countermeasure technologies for large earthquakes.

- Development of technology for accurate assessment of seismic behavior, resistance and vulnerability of structures.
- Development of technology for quick recovery from the damage or for proper retrofitting.

More efficient road bridge maintenance using AI

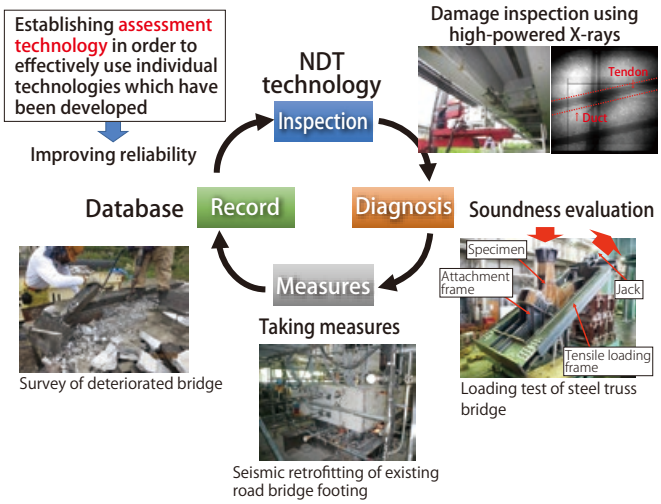
We focus on AI technology that is rapidly advancing, aiming to improve the reliability of inspection, diagnosis, and countermeasure in the maintenance cycle in order to realize efficient management.

- Development of AI that will assist judgments by engineers, after visualizing diagnosis logic based on the tacit knowledge of skilled engineers and past inspection data.
- To deal with the disintegration of concrete decks, establishing technology to quickly detect water using such as electromagnetic wave (radar) and proposing countermeasure methods premised on early detection.

※ For more information about the CAESAR, please refer to the following HP.

▶ http://www.pwri.go.jp/caesar/index-e.html

Development of maintenance and management system for preventing "Japan in ruins"

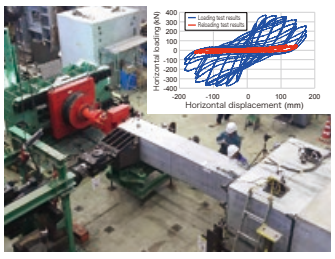


Survey of deteriorated bridge

Loading test of steel truss bridge

Seismic retrofitting of existing road bridge footing

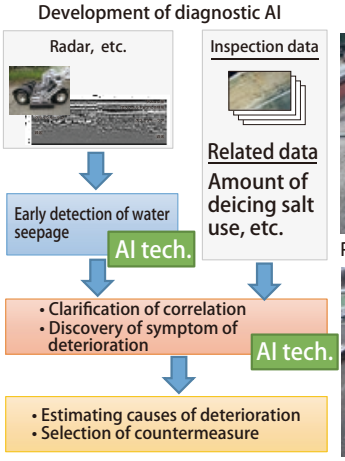
Research that saves "Japan from becoming fragile country for a disaster"

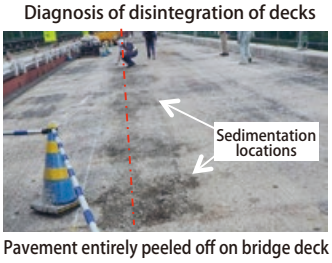


Cyclic loading test to clarify residual capacity of bridge column beyond ultimate limit state.

Loading test of removed precast RC pile to clarify shear capacity of pile constructed based on old technical standards.

More efficient road bridge maintenance using AI





Pavement entirely peeled off on bridge deck

Measurement using radar before peeling the asphalt pavement

Innovative Materials and Resources Research Center (iMaRRC)

Materials and Resources Research Group

In recent years, cases in which deterioration of civil engineering materials affects safety of the structure have occurred. With respect to public infrastructures which will further get older, it is required to repair, apply reinforcing materials and improve the durability of civil engineering materials for prolonged life of infrastructures. It is also necessary to improve durability as well as performances or functions of civil engineering materials. In these circumstances, "realization of effective and efficient maintenance and renewal of infrastructures" was positioned as a focused goal to be achieved in 2030 in "Comprehensive Strategy on Science, Technology and Innovation 2014" adopted by the Council for Science, Technology and Innovation, i.e. it was determined to promote the development of technologies to improve the durability of structural materials for infrastructures. It is also required to examine the applicability of advanced materials to be developed here to the civil engineering sector and carry out research toward practical use of them.

On the other hand, it is also necessary to promote research and development toward a low-carbon recycling society, e.g. promoting effective utilization of construction waste and those derived from other public works and streamlining energy use relating to this utilization. In order to conduct research in these fields, the Innovative Materials and Resources Research Center (iMaRRC) was established. iMaRRC promotes research and development of sophisticating and diversifying material resources in collaboration with other research institutes, and contributes to efficient maintenance and renewal of civil engineering structures as well as building of a low-carbon recycling society. In particular, iMaRRC conducts research on engineering evaluation and suggestion for improvement of advanced materials for site application, as well as studying sophistication of overall civil engineering materials such as durability improvement.

iMaRRC develops advanced structural materials such as FRP or materials which function as sensors for structural monitoring. iMaRRC conducts research on commonly-used materials such as concrete and asphalt as well. For example, developments of durability verification method for concrete through long-term exposure test under severe environmental condition. The research results are reflected in the revision of national design standards and specifications for concrete structures.

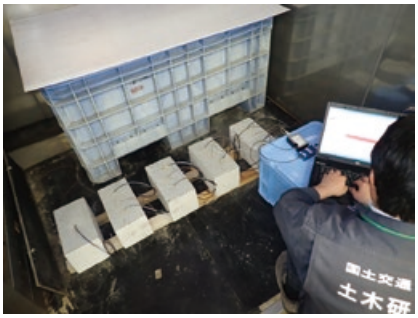
With regard to construction waste, iMaRRC examines new recycling techniques and carries out research on evaluation and improvement of environment safety/energy efficiency.

With respect to technology development, iMaRRC offers required standards to be uniformly applied across the country such as securing of safety and reduction in environmental impact, streamlines safety and environmental preservation measures utilizing regional characteristics and techniques to improve individual and regional energy efficiency and realizes technologies which are able to respond to Japan's various local environments and changes in the local society in the future.

We also realize technologies that will deal with changes in a variety of regional environment and the future of the community of our nation.

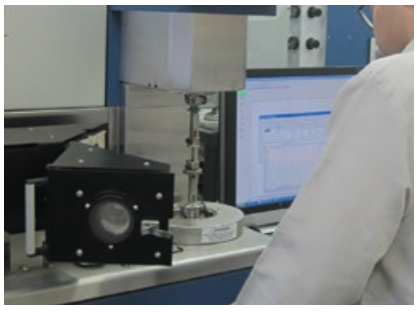
▶ http://www.pwri.go.jp/team/imarrc/english/top.html

Full-scale model experiment of advanced structural materials (experiment of structural FRP)

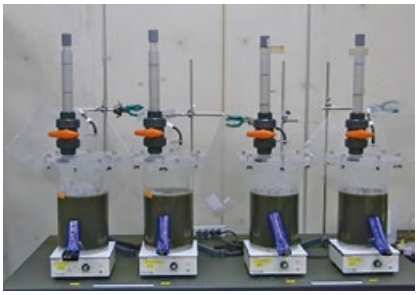


Experiment of materials having sensing functions (neutralization detection sensor)

Outdoor exposure tests of concrete specimens



Experiment of asphalt materials for paving



Methane fermentation experiment using a mixture of sewage sludge and crushed cut grass

Partnership with Other Organizations

1. Partnerships with domestic organizations etc.

In order to maximize all research and development achievements of Japan including a product of research and development by universities, private companies and other organizations, we form appropriate partnerships with domestic public research organizations, universities, private research institutes and so on by actively conducting periodical information exchanges, joint research, research cooperation and personnel exchanges according to the characteristics of research and development, and promote research and development while incorporating technological knowledge of other fields.
We also actively accept researchers from within Japan based on the exchange researcher system.

2. Partnerships with overseas organizations etc.

We undertake joint research and cooperative research with overseas research organizations based on science and technology cooperation agreements. In addition, we actively exchange researchers and hold international conferences.
Also, by aggressively using fellowship systems, we accept superior researchers from outside Japan at the same time as we actively dispatch PWRI researchers overseas.

3. Obtaining competitive funding

We make efforts to aggressively obtain external sources of funds such as competitive research funds etc., by submitting strategic applications in cooperation with other research organizations, to boost the potential of the PWRI and the capabilities of our researchers.
We also aggressively obtain funds through Grants-in-aid for Scientific Research (Kakenhi) projects, the Ministry of Land, Infrastructure, Transport, and Tourism's River Sediment Prevention Technology Development System, and the Cabinet Office's Strategic Innovation Creation Program (SIP) Second Phase.

Example: SIP Phase 2 "Strengthening National Resilience"

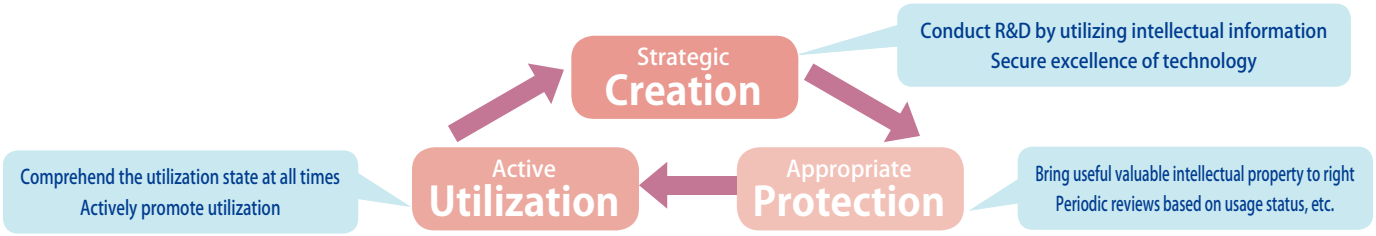
Research performed by the Public Works Research Institute

R&D items	Person responsible for the research	R&D Challenge	Participating PWRI division
Ⅰ. Development of an integrated evacuation/ emergency activity support system	Yuichiro Usuda (National Research Institute for Earth Science and Disaster Resilience)	R&D of an integrated evacuation/emergency activity support system	ICHARM Water-related Hazard Research Group
Ⅱ. Development of a disaster state analysis/sharing system	Naoki Sakai (National Research Institute for Earth Science and Disaster Resilience)	Development of an evacuation decision/emergency activity/ training support and integrated municipal disaster response system	Erosion and Sediment Control Research Group Volcano and Debris Flow Research Team
Ⅵ. Development of a super typhoon disaster prediction system	Yasuto Tachikawa (Kyoto University)	Developing a super typhoon disaster prediction system	Construction Technology Research Department Advanced Technology Research Team

Creation / Protection / Utilization of Intellectual Properties

PWRI manages intellectual properties appropriately based on an Intellectual Property Policy to bring the best possible value to society as a whole in a strategic and active manner.

Concepts of the Intellectual Property Policy



For more information about intellectual property rights of Public Works Research Institute, please see below.

Industrial property rights such as patents

Tsukuba Central Research Institute, ICHARM, CAESAR, iMaRRC
http://www.pwri.go.jp/eng/results/patent/index.html

Civil Engineering Research Institute for Cold Region
http://www.ceri.go.jp/contents/research/research03.html

Program works/Guidelines

Tsukuba Central Research Institute, ICHARM, CAESAR, iMaRRC
http://www.pwri.go.jp/eng/results/offer/index.html

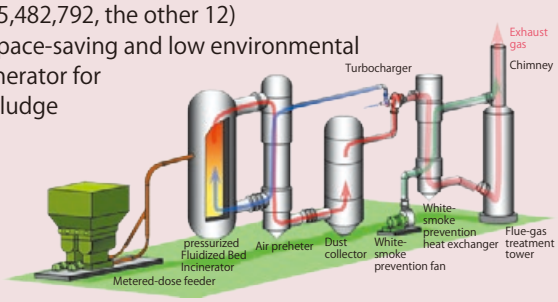
Civil Engineering Research Institute for Cold Region
http://www.ceri.go.jp/contents/center/center07.html

Corporate works (also posted on page 40 in this handbook) http://www.pwri.go.jp/eng/about/pr/publication/index.html#publications

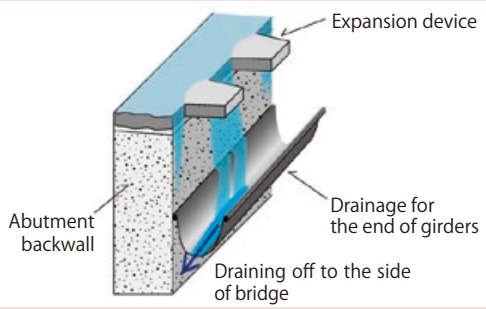
We recommend transfer of technology to private companies so that the new technology with a focus on intellectual property rights is widely used.

Examples of use of industrial property rights

【Fluidized Bed Incineration System with Turbocharger】
(Pat. No. 5,482,792, the other 12)
Energy/space-saving and low environmental load incinerator for sewage sludge



【Drainage System for the end of concrete bridge girders】
(Pat. No.6384906, Pat. No.6410304, Pat. No. 6455753)
Improving the corrosion environments around the ends of concrete bridge girders as quickly as possible



Practitioner recruitment system for underutilized patent

Public Works Research Institute looks for a partner, such as a private company that is able to carry out development, manufacturing and sales of specific products so that the technologies developed can be utilized on actual site.
"Practitioner recruitment system for underutilized patent" is to present the conditions of technical contents and patents which are implemented and to widely recruit partners who want to participate.

Research Consortium

As a national research and development agency, the Public Works Research Institute is actively involved in the promotion of on-site utilization of their own research results. And we are strongly required to contribute to promotion, utilize new technologies, and improve quality of the public infrastructures and reduce costs. etc.
For this reason, for some of the new technologies that the Public Works Research Institute has developed, active follow-up will be carried out until achieve certain level of to self-reliance, through a new attempt of such research consortium.

For overview and use of each intellectual property, please contact Tsukuba Central Research Institute, ICHARM, CAESAR, iMaRRC (Technology Applications Research Team), CERI (Cold-Region Technology Promotion Division). We will provide further information.

Introduction of PWRI-Developed Technologies Utilized at Construction Sites

Infrastructure maintenance award / Infrastructure Technology Development Award

Steel structure paint reinforcement method using sheets of titanium foil
(iMaRRC (Advanced materials and improvement))

Used on steel bridges protected from corrosion by painting, this technology is the application of titanium foil sheets to places susceptible to rusting such as girder ends, splices, or corners of members where it is difficult to ensure sufficient paint thickness, thereby strengthening corrosion protection of the bridge. A thick anticorrosion coating is formed by first applying the corrosion-proofing undercoat (corrosion prevention performance) and a ground coat (blocks causes of deterioration) then a middle or top coat (weather-proofing) on the steel surface. The titanium foil sheet is placed above the corrosion-proofing undercoat as a replacement for the ground coat. Appropriately applying a titanium foil sheet can completely block causes of the corrosion of steel. The execution is easier than a super thick anticorrosion coating, and can lower 100 year running cost by about 7%.
This technology received the Second Infrastructure Maintenance Award.

Fluidized Bed Incineration System with Turbocharger
(iMaRRC (Recycling))

This system improves incineration efficiency by incinerating the composite of sewage sludge and other biomass at approximately 0.15 MPa, and allows utilization of compressed air generated by operating a turbocharger with exhaust gas. It can reduce power consumption by 40%, fuel by 10% and CO_2 by 40%. It can also reduce a great amount of N_2O, which has more of a greenhouse effect than CO_2 when the combustion
temperature is adjusted to the high-temperature zone. Based on good results in an experimental plant located in Oshamanbe, Hokkaido, this system has been adopted at 9 wastewater treatment plants in Tokyo and other places. This technology received the 17th Infrastructure Technology Development Award (MLIT Minister's Award) and the 41st Excellent Environmental Equipment Award (METI Minister's Award).

Turbocharger

Wire Rope Guardrail System
(Traffic Engineering Research Team)

The wire rope guardrail system consists of high toughness wire ropes and thin posts that break when they are hit by a car. By absorbing shocks of vehicle collision mainly with deflection of wire rope, it is expected to drastically reduce fatal accidents. There is no difference between shapes of both sides of the system, thus the width required for installation is narrow and the installation cost can be reduced. Since this guardrail system can be installed and removed by humans, it is possible to partially make opening sections in an emergency to allow car drivers to drive in the opposite lane and complete repair work in a short time. The Ministry of Land, Infrastructure, Transport, and Tourism is responding to the fact that on (toll-charging) expressways, the fatal accident rate on temporary two-lane sections is higher than it is on four lane sections by, as an emergency measure, starting trial installation of these on approximately 113 km of temporary two-lane sections throughout Japan in April 2017, and in FY2018, beginning standard installation on newly opened sections of temporary two lane sections of expressways. The ministry has also decided on a policy of installing them on low priority sections changed to four lanes on existing sections and on newly opened sections.

The wire rope-type protective fence

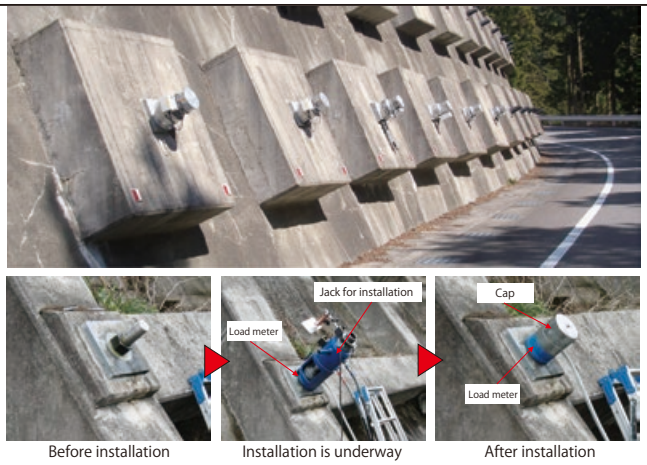
Collision experiment with the large-size car

This technology won the Twentieth Infrastructure Technology Development Award (Minister of Land, Infrastructure, Transport, and Tourism Prize).

PWRI's Focused Dissemination Technologies/Techniques (FY2018) (Example)

Installed anchor tensile monitoring system (Aki-Mos)
(Landslide Research Team)

Ground anchor for slope stability should be maintained property. Especially, it is important to know any changes of the tensile stress in order to maintain ground anchor. However, the tensile stresses are not measured in many cases. We therefore developed continuous monitoring techniques of load for installed anchors. These techniques have enabled us to get the load data remotely by radio. By these techniques, it is possible to monitor the load, which it could hardly be done in the past. As of January 2018, 333 systems have been adopted in 71 locations, such as dams and roads managed by Regional Development Bureaus and NEXCO roads.



Before installation　Installation is underway　After installation

Installation of the technology

Drainage system for the end of concrete bridge girders
(CAESAR)

A rubber or polyethylene gutter-shaped drainage available to insert into the expansion gap from the side of existing concrete bridges allows preventing salt damage of girders and substructures due to leakage water contaminated by deicing salt from expansion joints. This drainage can be easily installed from under the bridges without affecting to traffic flow. They have been installed on expressways in Hyogo Prefecture and Tokushima Prefecture.

Sample execution

Technical Support

Technical support at the time of disasters

Our nation suffers from a lot of natural disasters such human/material damages due to earthquake, heavy rain, landslides, and snow. To prepare to give disaster support immediately after disasters, the PWRI established the Disaster Countermeasure Headquarters to respond to requests for disaster experts from the national government and local governments. Since then it has received requests for disaster support from managers of damaged facilities etc. and responded by sending personnel to the scene to survey actual damage and to provide advanced technical guidance concerning methods of restoring damaged civil engineering structures and saving lives during a disaster.

Kumamoto Earthquake: Inspection of damages at the crossover in the City Road Chuo Line (Apr. 17, 2016)

Typhoon No.10 etc.: Investigation of the overflow and the collapse of embankment in Kitami City (Aug. 21, 2016)

Kumamoto Earthquake: Field survey of the collapsed Aso-Ohashi Bridge and the landslide on the national highway No.57 (Apr. 17, 2016)

Torrential rainfall in July 2018: View of sediment disaster survey in Yasuura-cho in Kure City (July 10, 2018)

Hokkaido Eastern Iburi Earthquake: view of a meeting held to plan an emergency sediment accident survey in the Atsumagawa River Basin (Sep. 13, 2018)

Hokkaido Eastern Iburi Earthquake: View of many surface collapses in the Atsumagawa River Basin (Dec. 6, 2018)

Technical support relating to civil engineering technology in general

We provide technical support by the request from the national and local public organizations even at the time of the non-disaster for the purpose of supporting solution related to agriculture, fisheries and harbors and providing civil engineering technology in cold regions. We also participate in the technical committee, such as the government and relevant societies to provide technical support. Public Works Research Institute has accumulated knowledge and research results that are reflected in the formulation and revision of various technical standards.

A road maintenance technical team assessing the earthquake resistance of a bridge

Technical support on the maintenance and management of the snowbreak woods in Hokkaido

Dispatch of lecturers

We offer the trainings to engineers of College of Land, Infrastructure, Transport and Tourism, Regional Development Bureau, Hokkaido Regional Development Bureau, local governments, and universities. We also organize lectures for the general public including elementary, junior high, and high schools as well as dispatch a lecturer to institutions by request to give guidance and promote civil engineering technology.

Training session for relevant officers in central and local government and for private businesses (58th sediment control and landslide prevention lecture meeting)

Training sessions for civil engineers

Dissemination of Research Findings

Publications of the Public Works Research Institute

Research results of PWRI are published and/or posted on the internet as: Reports of PWRI, PWRI Materials, Joint Research Reports, Monthly Reports of the Civil Engineering Research Institute for Cold Region, etc.

Publications by PWRI

PWRI has published the below books under copyright. These books are available at bookstores.

Book title	Publisher
Eco-cement Concrete Utilization Technology Manual	Gihodo Shuppan
Manual for Inspecting Soundness Level of Concrete Structures Using Nondestructive Tests	Gihodo Shuppan
Collection of Physical and Chemical Information Regarding Human Use Pharmaceuticals	Gihodo Shuppan
Manual of Countermeasures for Ground Contamination in Construction Works (Revised edition)	Kajima Publishing
Guideline for Recycling Waste Wood (Draft)	Taisei Shuppan
Manual of Application Technology of Other Industries Recycled Material in Construction Works	Taisei Shuppan
Manual of Simple Measurement Methods for Dioxins in Soil	Kajima Publishing
Manual for Utilization of Liquefied Stabilized Soil (2nd edition, 2007)	Gihodo Shuppan
Inspection and Maintenance Manual for Ground Anchors	Kajima Publishing
Manual for Recycling Construction Generated Sludge	Taisei Shuppan
Soil Pavement Handbook (for Pedestrial Pavement)	Taisei Shuppan
Manual for Landslide Measurements with Insertion Borehole Inclinometer	Rikohtosho
Manual for Inspection of Concrete Structures by Nondestructive/Micro-destructive Tests	Taisei Shuppan
Manual of Countermeasures for Dioxin-Contaminated Soil in Construction Works (provisional edition)	Kajima Publishing
Integrated geophysical exploration of levee systems – A Guideline for the application to the safety assessment -	Aichi Shuppan
Shape estimation method of landslides line	Kajima Publishing
Manual for Utilization of Soils from Construction (4th Edition)	Public Works Research Center
Practical Guide to Water Drainage Boring for Preventing Landslides	Kajima Publishing
Handbookfor Handling Rocks and Soils Containing Naturally-occurring Heavy Metals at construction works	Taisei Shuppan

Application in Standards

Research findings are reflected in new and revised standards for infrastructure.

■River Bureau, Ministry of Land, Infrastructure, Transport and Tourism
- *Preliminary Technical Guidelines for Landslide Investigation and Its Remedies for Reservoirs*
- *Guidelines for Seismic Safety Evaluation of Dams for Large Earthquakes (Draft)*

■Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism
- *Highway Bridge Specifications and Instruction Manual*

■Ministry of the Environment
- *Guidelines for Applying for Offshore Disposal of Waste*
- *Guidelines for Topographical Changes to Final Disposal Sites*

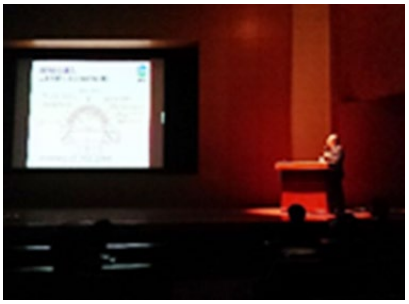
■Related Organizations
- *Standard Specifications for Concrete Structures etc. Japan Society of Civil Engineers*
- *Engineering Bedrock Classification Method, etc. Japanese Geotechnical Society*
- *Guidelines and Commentary on Earthquake Proofing Sewage Treatment Facilities, etc. Japan Sewage Works Association*
- *River Earthwork Manual etc. Japan Institute of Construction Engineering*
- *Manual of Design and Construction of Reinforced Earth Using Geotextiles, etc. Public Works Research Center*
- *Manual of Design and Construction of High-Standard Embankments Foundation for Riverfront Improvement and Restoration*
- *Electronic Delivery Methods for Geological and Soil Research Findings Japan Construction Information Center*

Presentation of Papers

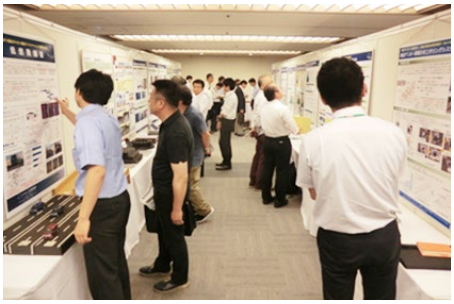
PWRI publishes approximately 1,500 papers each year, including the presentation of papers at international conferences and academic meetings, and the submission of papers for publication in collections of papers and specialist journals. We aim to present high-quality findings, with more than 300 of these papers undergoing peer review before publication.

PWRI New Technology Showcase

The "PWRI New Technology showcase" is a seminar event to explain our new technologies. The panels and models are also exhibited at the events. The researchers provide consultation to introduce our new technologies into actual sites. The Showcases are held every year in Tokyo, and a few other cities. In FY2018, 1601 participants attended the Showcase in the five cities, Tokyo, Osaka, Niigata, Naha, and Takamatsu.



Seminar in New Technology Showcase (Tokyo, Niigata)



Exhibition/Technical consultation corner (Osaka)

PWRI New Technology Seminar / On-site Tour

The PWRI New Technology Seminar gives lectures about selected PWRI technologies for cost reduction, time shortening or other effect, so as to address current detailed technical trends in the respective areas as may be required for application at sites, etc. The seminars are held every year in Tokyo and other cities.
The On-site Tour is held on as many occasions as practical in the field where PWRI developed technology is being actually applied to ensure that the participants can actually see with their eyes, understand application methods and benefits.

New Technology Seminar

Scene of on-site tour

Developmental Technology Seminar

PWRI holds briefing sessions on development technologies regarding subjects which are of interest to engineers in snowy cold regions on related institutions in order to promote the utilization of new technologies researched and developed in snowy cold regions on sites of public works.

Akita

Toyama

On-site Seminar

On-site seminars are cosponsored in various areas of Hokkaido by the Civil Engineering Research Institute for Cold Region and the Hokkaido Regional Development Bureau so that survey methods and countermeasures in snowy cold regions can be effectively utilized at sites and such seminars contribute to the promotion of development in Hokkaido.

Asahikawa

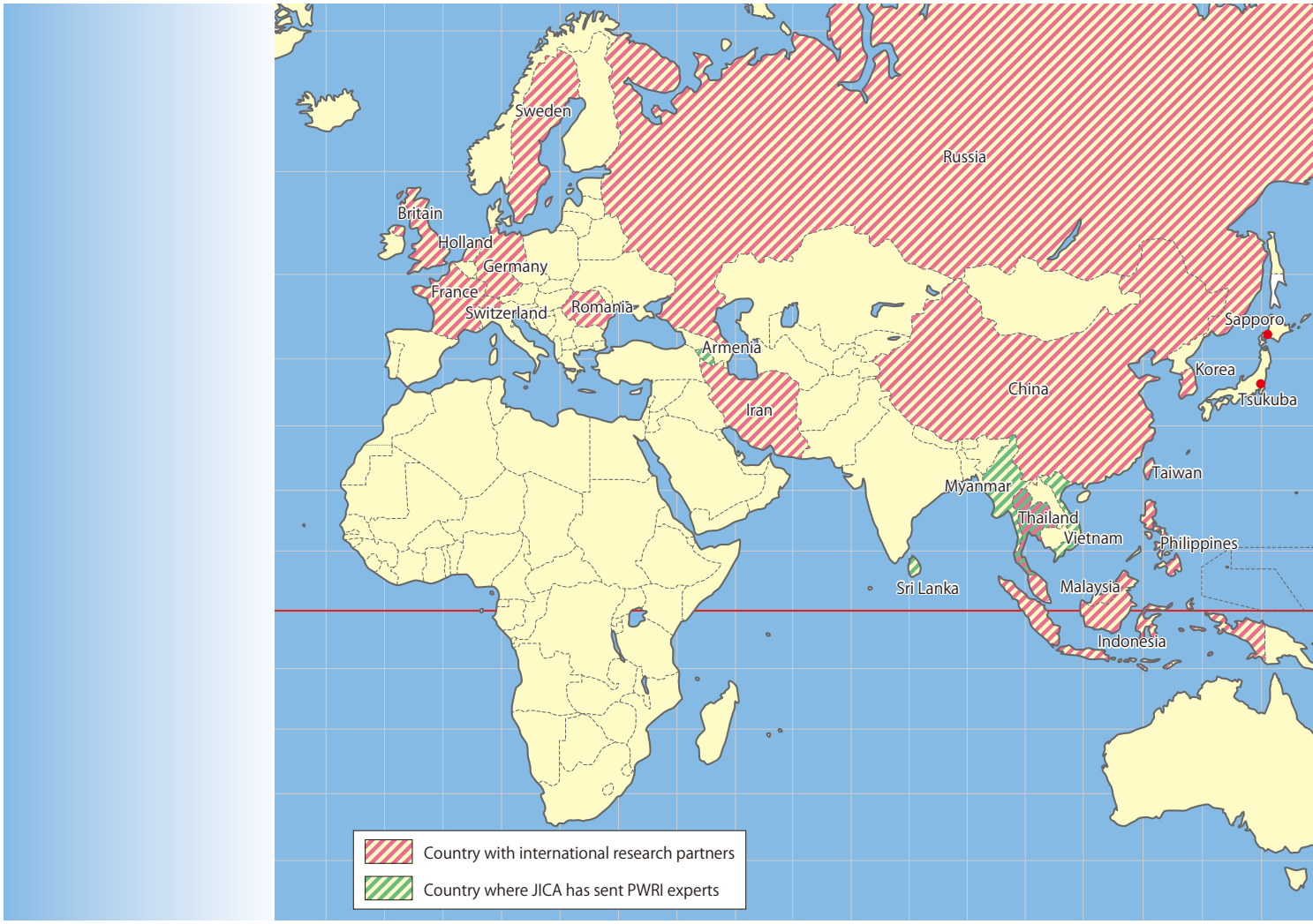
Abashiri

International Contribution

The Public Works Research Institute (PWRI) has been active in conducting research and on-site activities in collaboration with international organizations and research institutes in Asian and other regions.
One example is an international project, "Transformation of Urban Management (TA8456 MYA)," in which the International Centre for Water Hazard and Risk Management (ICHARM) has been involved since July 2014. The project is led by the Asian Development Bank and specifically developed for Myanmar. Assigned to strengthen the nation's urban flood management capacity, ICHARM has provided local government personnel with training and technical assistance needed to perform flood and storm-surge risk assessment and hazard mapping. ICHARM is also involved in a UNESCO-funded project, "Strategic Strengthening of Flood Warning and Management Capacity of Pakistan Phase II." Furthermore, it has been the secretariat of the International Flood Initiative (IFI), a global framework to promote collaboration on flood management with major international organizations such as UNESCO, the World Meteorological Organization (WMO), and the United Nations University. PWRI will continue to plan and implement a wide range of activities in partnership with donor organizations such as the Japan International Cooperation Agency (JICA) and the World Bank.

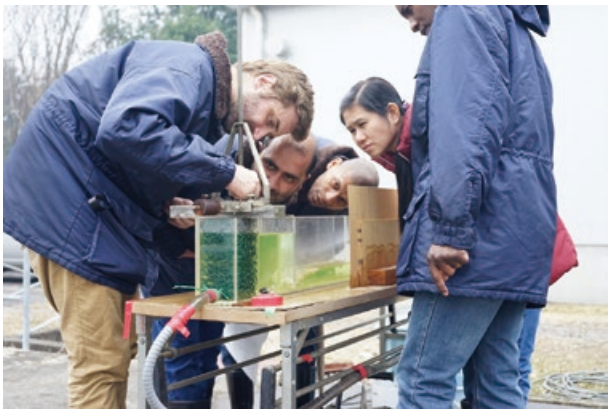
Workshop for Improvement of Flood Management Capacity in Myanmar (TA84656MYA)

International Flood Initiative (IFI) Workshop (Jan. 2017)



Human Resource Development

The Public Works Research Institute accepts trainees of civil engineering technology field of more than 300 people every year from Africa, Asia, and Central and South America. We also dispatch a large number of instructors in specialized training of civil engineering that JICA organized to work on human resource development.
In particular, the three parties, ICHARM, the National Graduate Institute for Policy Studies (GRIPS) and JICA jointly launched a one-year Master's course "Disaster Management Policy Program and water disaster risk management course". ICHARM also launched a three-years Ph.D. program "disaster prevention science program" with GRIPS..

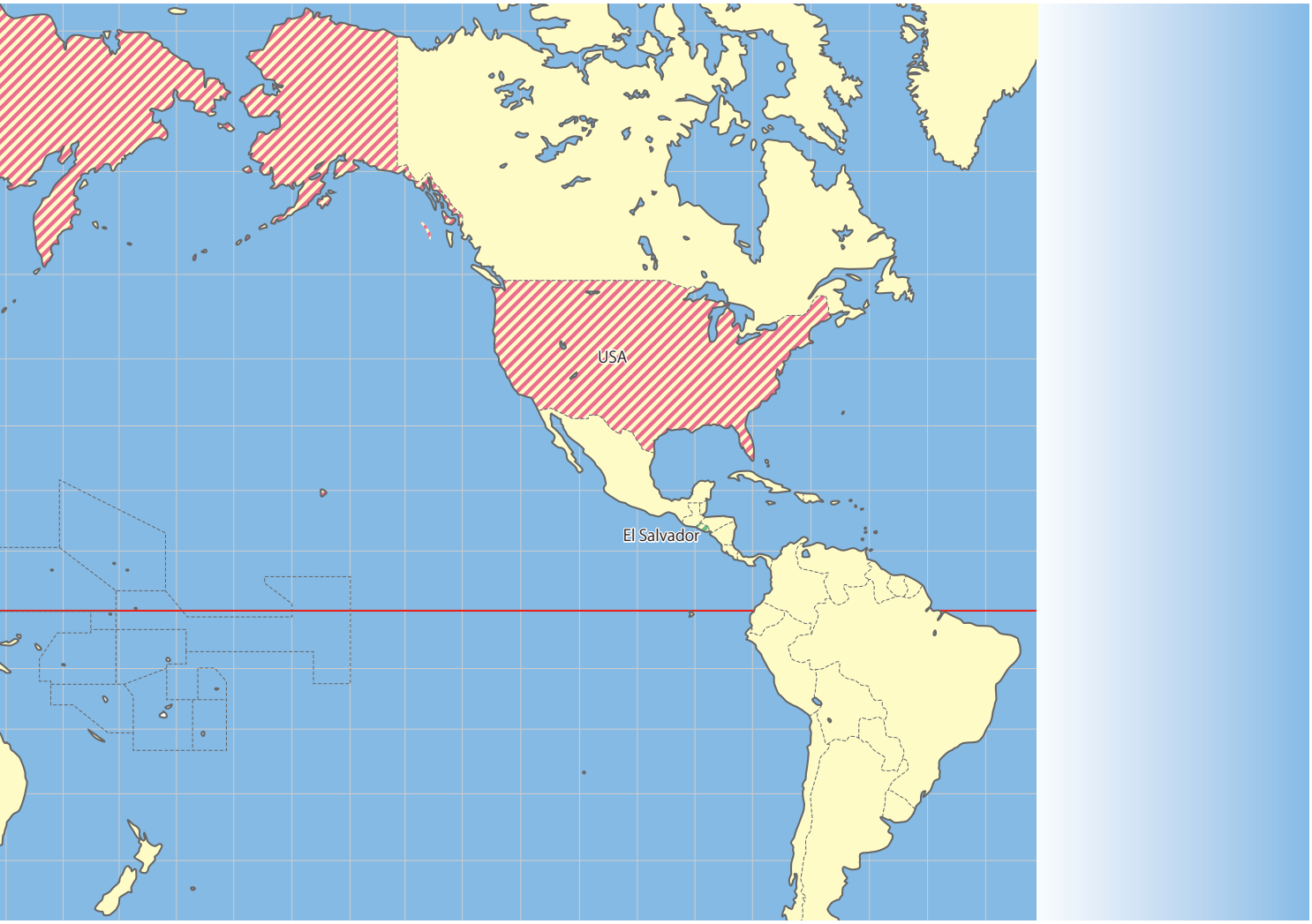


Hydrological exercises for trainees

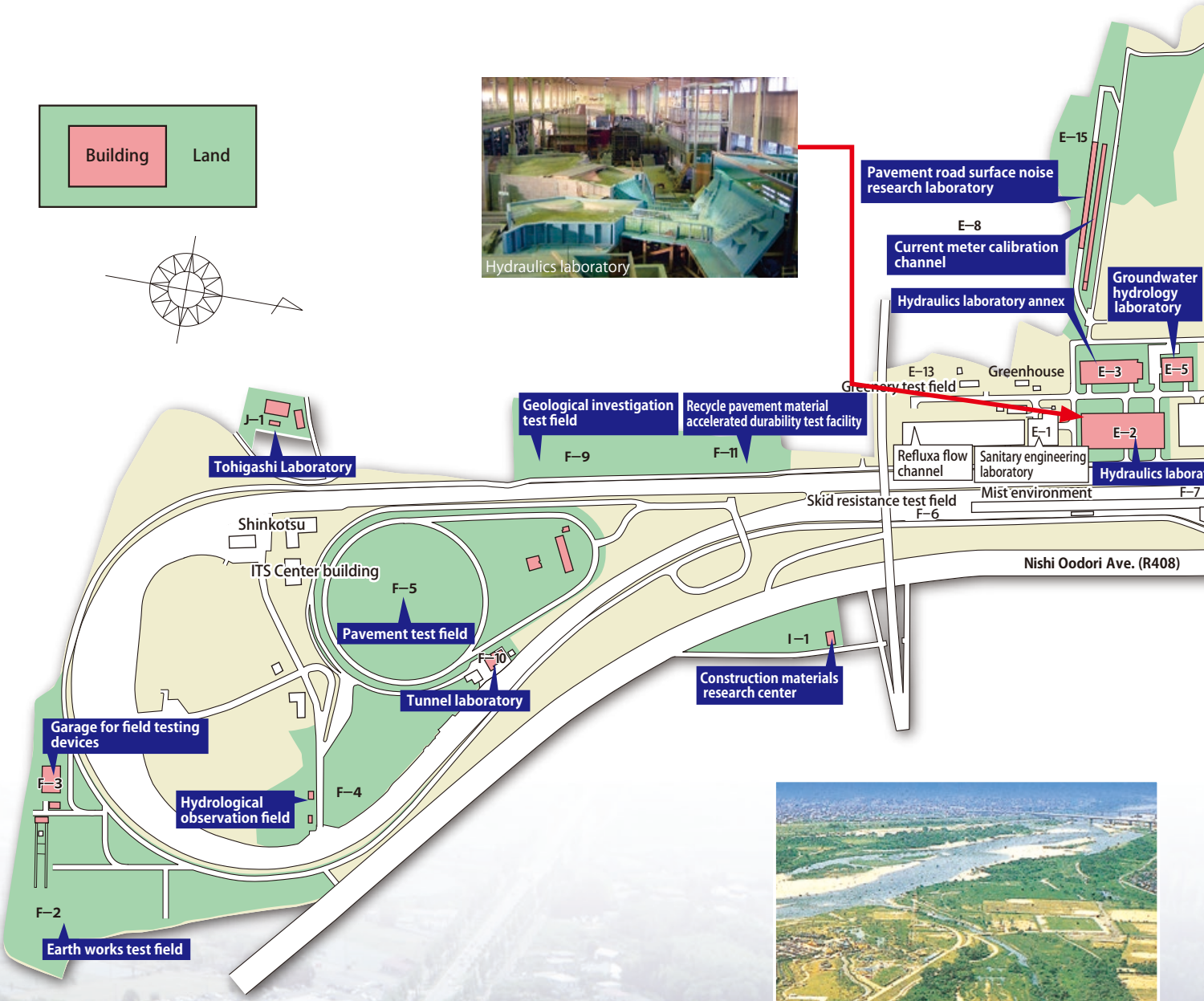
Overseas Technical Support

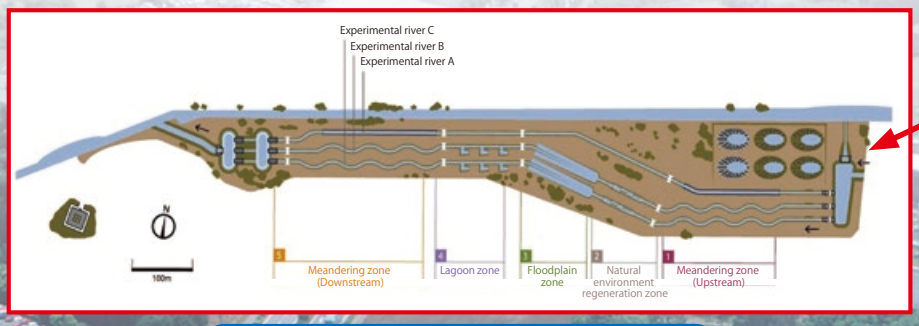
As a reply for requests made by JICA, foreign governments, and foreign research institutes, PWRI dispatches engineers to foreign countries, and disseminates technical knowledge and research outcomes of PWRI, depending on the need.
At the end of May 2017, after flooding in Sri Lanka, we investigated the scene as part of a specialist international emergency assistance team. We observed and prevented secondary damage and provided guidance and assistance related to infrastructure recovery and improvement.

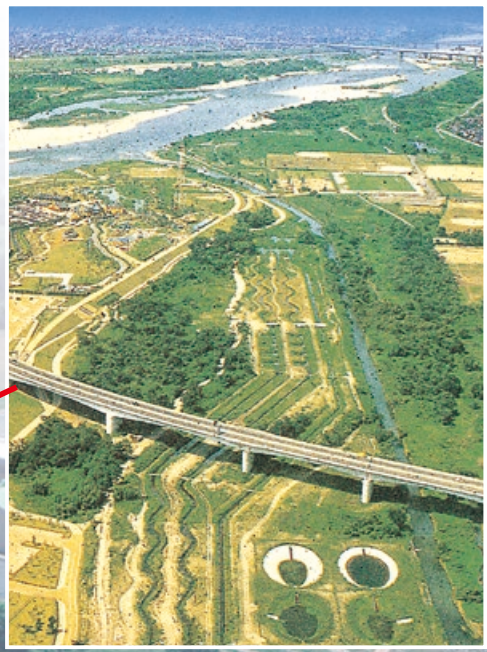
Meeting with Sri Lanka's government minister responsible for disaster prevention



Tsukuba Central Research Institute
International Centre for Water Hazard and Risk Management
Center for Advanced Engineering Structural Assessment and Research
Innovative Materials Resources Research Center



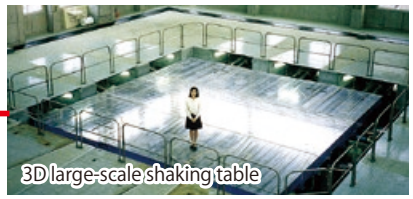




Aqua Restoration Research Center (Gifu)

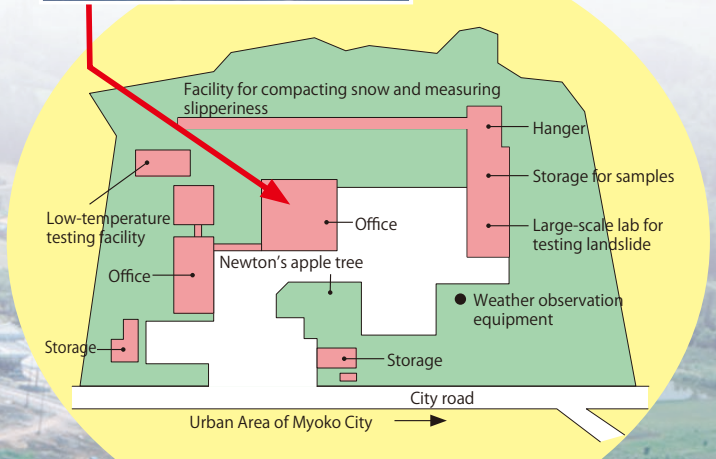

Tunnel lining loading test


30 MN large-scale universal test machine


3D large-scale shaking table


Wheel running machine

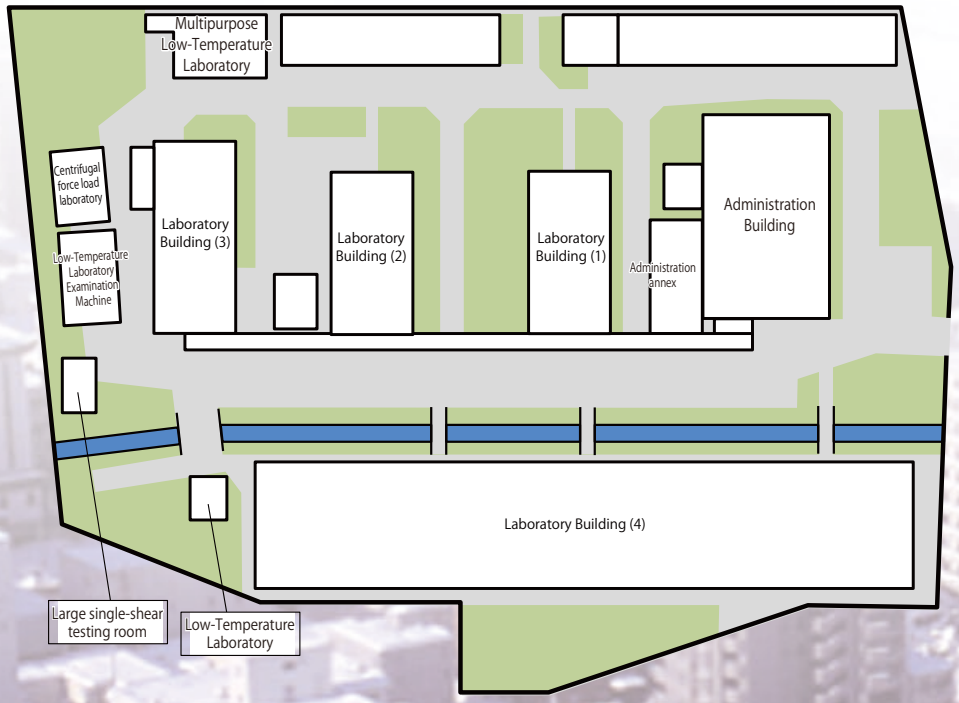
Earth structure laboratory



Snow Avalanche and Landslide Research Center (Niigata)


Large-scale Geotechnical Dynamic Centrifuge

Civil Engineering Research Institute for Cold Region



Concrete combined-deterioration accelerating test apparatus

Irregular oscillatory water tunnel

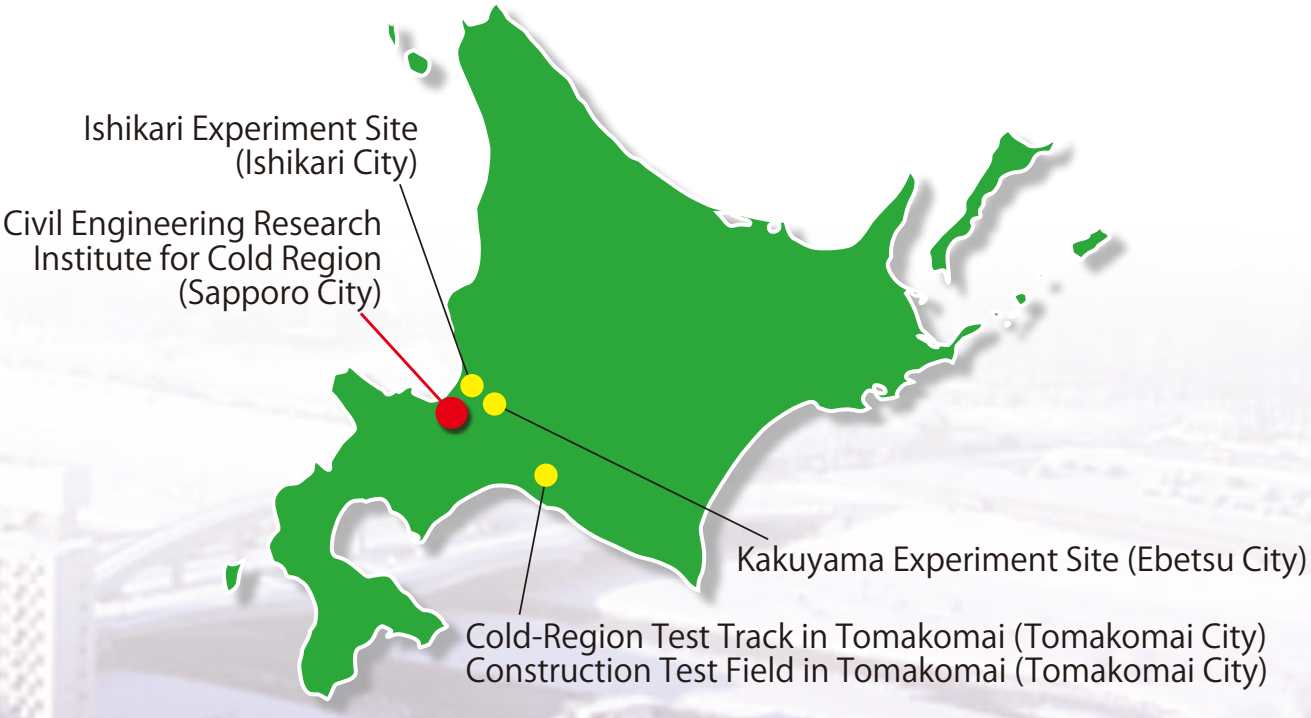
High-speed hydraulic channel

Off-Site Facilities

Ishikari Experiment Site

The Double Fence Intercomparison Reference (at the Ishikari Experiment Site)

Wind tunnel experimental apparatus (at the Ishikari Experiment Site)



Cold-Region Test Track in Tomakomai

Construction Test Field in Tomakomai

Kakuyama Experiment Site

Lease System of Facilities

PWRI leases test facilities and equipment in its possession to national institutions, local governments, universities, public-interest corporations and private research organizations as a rule. There are special civil engineering test machines that are expensive or difficult to maintain properly. Some of the lease-signers are from fields other than civil engineering.

Examples of lease

Civil engineering-related experimental research


Experiment using a wheel running machine


Channel to generate waves and reproduce the phenomena in 2D

Other experiments


Experiment using a 3D large-scale shaking table


Cold-Region Test Track in Tomakomai

Other facilities for lease

Tsukuba
30 MN large-scale universal testing machine
Earthquake engineering laboratory
Current meter calibration channel
Earth Structure Laboratory
Differential settlement
Earthwork experimental laboratory
Large-scale Geotechnical Dynamic Centrifuge
Dam hydraulics laboratory
Pavement test field
Large-scale box shear test apparatus

Civil Engineering Research Institute for Cold Region
Impact acceleration tester
Wind tunnel experimental apparatus
Ishikari hydraulic experimental station
Wheel tracking test machine
Ishikari Blowing-Snow Test Field
Freeze-thaw testing machine
Raveling testing machine
Centrifuge
Inclinable channel

Other civil engineering facilities

■ Please check our homepage for application procedures, forms and regulations.

Check our homepage → Application → Receipt → Approval → Agreement → **Lease**

Open House

We organize open house for the general public to get to know more about our research. Research institutions, corporate officials, university students and vocational school students as well as the residents of the region who have no contact to our research visit our facilities so they can observe part of our activities. We also accept the facility tour if it is pre-registered.

Public Works Research Institute

The research facilities of Tsukuba, Ibaraki Prefecture, has an open house during "Science and Technology Week (April)" and on the "Civil Engineering Day" (November) in collaboration with the National Institute for Land and Infrastructure Management.
We introduce civil engineering in recent years and the mechanism of disasters through hands-on events and demonstration/experiment.
We also introduce special vehicles used in the field in cooperation with Ministry of Land, Infrastructure and Transport Kanto Regional Development Bureau.
At open house in November, we hold the bridge making contest for elementally students with support from the city Board of Education cooperation. We display the bridges which elementally students create.


The works of the bridge contest



Teleoperation of unmanned construction machines


Experience of striking sound test of concrete


Introduce damage due to debris flow and its countermeasures

Civil Engineering Research Institute for Cold Region

CERI in Sapporo, Hokkaido has held open house every year in July since 1983 in conjunction with the "Land, Infrastructure, Transport and Tourism Day". The purpose of this event is to provide the general public including children with understanding and outreach of our institution's role, research result and research themes that we are correctly working on.
Every year each team displays unique exhibition and visitors can enjoy and play with hand-on exhibits. We also have the section dedicated to the professional civil engineers.


Model experiment of snowstorm


Experience section to touch creatures of the sea


Test drive experience of the snow removal vehicles

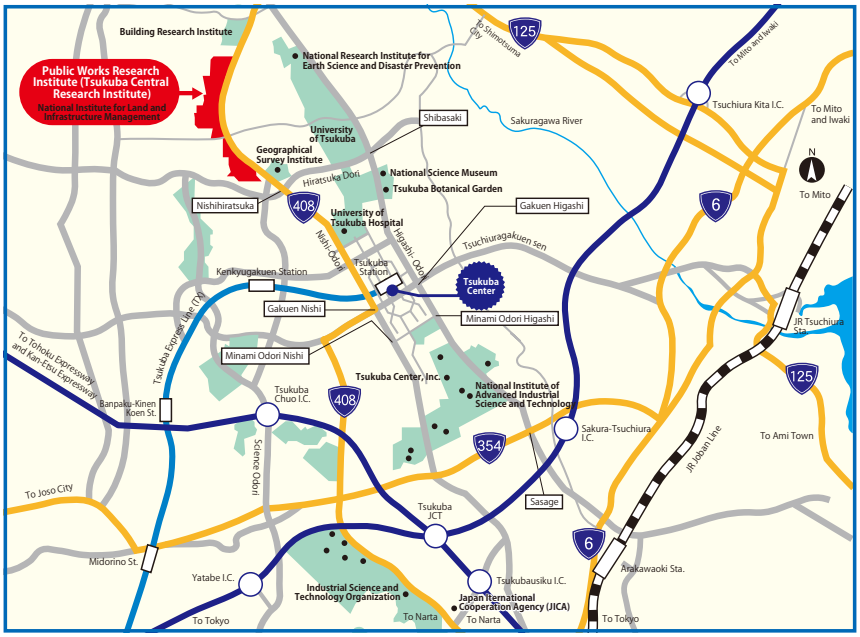

Facility tour quiz rally

Aqua Restoration Research Center

In the Aqua Restoration Research Center (Kakamigahara, Gifu Prefecture), guided tours are conducted according to appointments through the year. The purposes of the tours are to propagate knowledges of studies on preservation and conservation of river environment and to advise river management methods.
The tours help you learn practical contents related to the nature-oriented river management, such as importance of river morphology and flow and sediment regimes for riverine organisms, some points in selection of revetment blocks to consider river landscape, and installation methods of crossing structures to consider physical environment in rivers.

Tour of the experimental river held for engineers

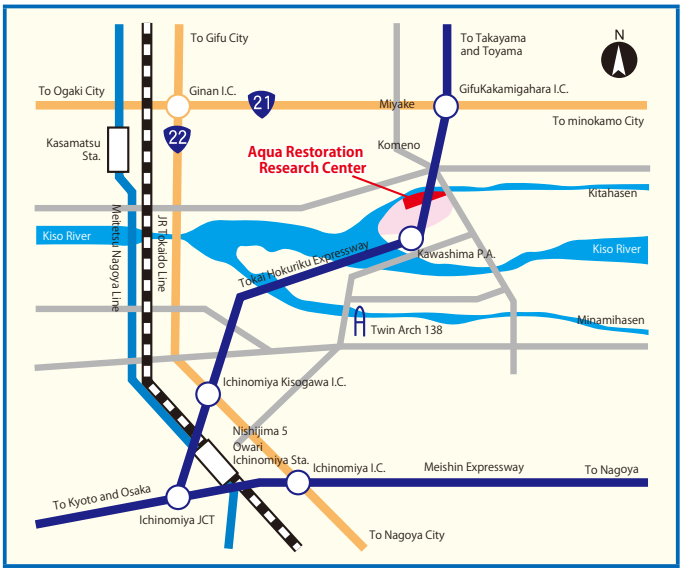
Map and Access to PWRI (Tsukuba) (ICHARM, CAESAR, iMaRRC)



Train	Akihabara Sta.	Tsukuba Express Line (about 50 minutes by semi-rapid)		Kenkyu-Gakuen Sta.	Tsuku-bus [Yoshinuma Shuttle] (about 25minutes)	Doboku Kenkyusho Mae (PWRI)
		Tsukuba Express Line (about 45 minutes by rapid) Tsukuba Sta.		Tsukuba Sta. (Tsukuba Center)	Kantetsu Bus, Gate No. 5 bound for Shimotsuma Sta. or Kenchiku Kenkyusho /Building Research Institute (about 25 minutes)	
	Ueno Sta.	JR Joban Line (about 60 minutes)	Hitachinoushiku Sta.		Kantetsu Bus bound for University of Tsukuba (about 25 minutes)	
		JR Joban Line (about 60 minutes)	Arakawaoki Sta. (West Exit)		Kantetsu Bus bound for University of Tsukuba (about 25 minutes)	
		JR Joban Line (about 70 minutes)	Tsuchiura Sta. (West Exit Bus Terminal 2)		Kantetsu Bus bound for University of Tsukuba (about 25 minutes)	
Highway Bus	Tokyo Sta.	At Tokyo Station, go to bus gate No. 5 Yaesu South exit. Take Tokkyu (express) Tsukuba-Go bound for Tsukuba Center or University of Tsukuba (about 70 minutes).				
Car	Tokyo	Shuto Kosoku (Metropolitan Expressway)	Misato I.C.	Joban Expressway (about 30 minutes)	Yatabe I.C. or Sakura-Tsuchiura I.C.	Suitable route (about 20 minutes)

Public Works Research Institute (Tsukuba Central Research Institute) 1-6 Minamihara, Tsukuba-shi, Ibaraki-ken 305-8516 Phone: +81 29-879-6700

Aqua Restoration Research Center

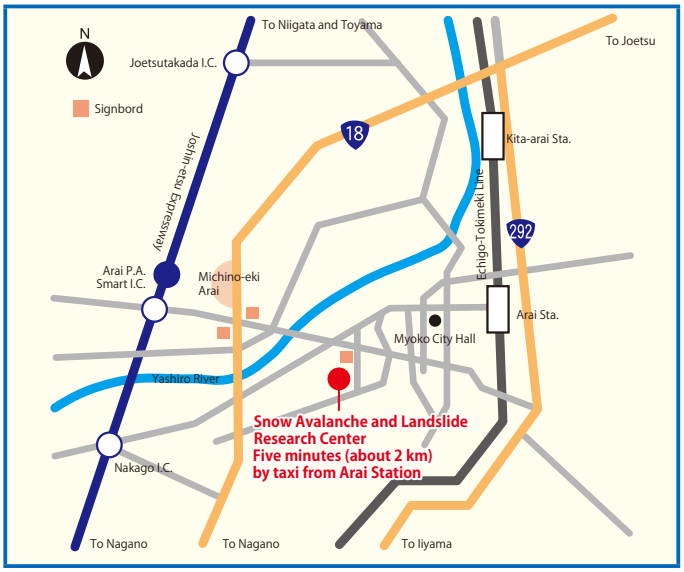


Kan-yuchi-mubanchi Kawashimakasada-machi, Kakamigahara-shi, Gifu-ken 501-6021
Phone: +81 586-89-6036

[Train]
- Meitetsu (Nagoya-Kasamatsu) About 30minutes
- Taxi (Kasamatsu-ARRC) About 10 minutes

[Car]
- About 10 minutes from Gifu Kakamigahara I.C. on the Tokai Hokuriku Expressway
  (Use the west parking area in the Water Eco Park)
- The ARRC is also within waking distance from Kawashima P.A. on the Tokai Hokuriku Expressway

Snow Avalanche and Landslide Research Center

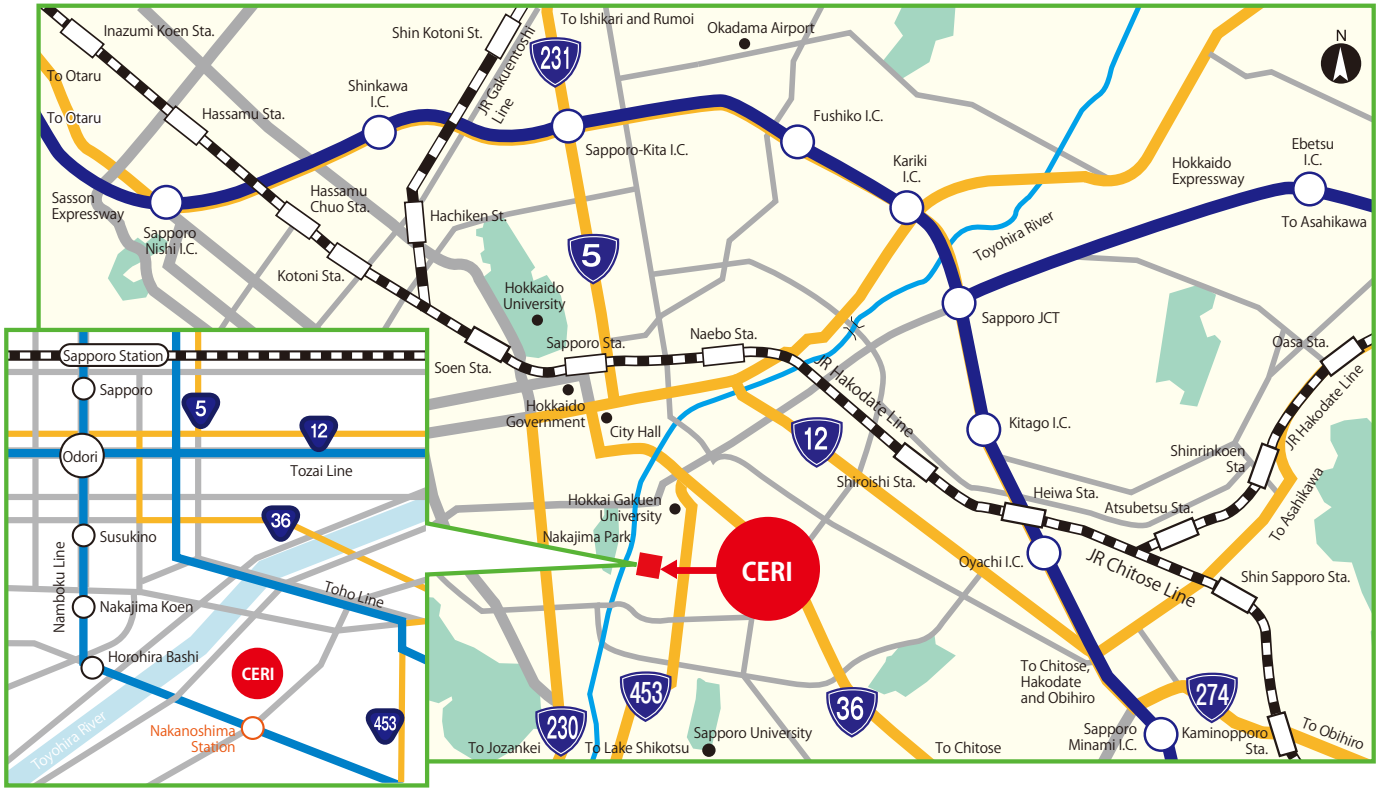


2-6-8 Nishiki-cho, Myoko-shi, Niigata-ken 944-0051
Phone: +81 255-72-4131

[Train]
- Hokuriku Shinkansen (Tokyo-JoetsuMyoko) About 2 hours
  Echigo-Tokimeki Line (JoetsuMyoko-Arai) About 10 minutes
  Total ..... About 2 hours and 10 minutes
- Niigata-Naoetsu-Arai..... About 2 hours and 30 minutes
- Five minutes (about 2 km) by taxi from Arai Station

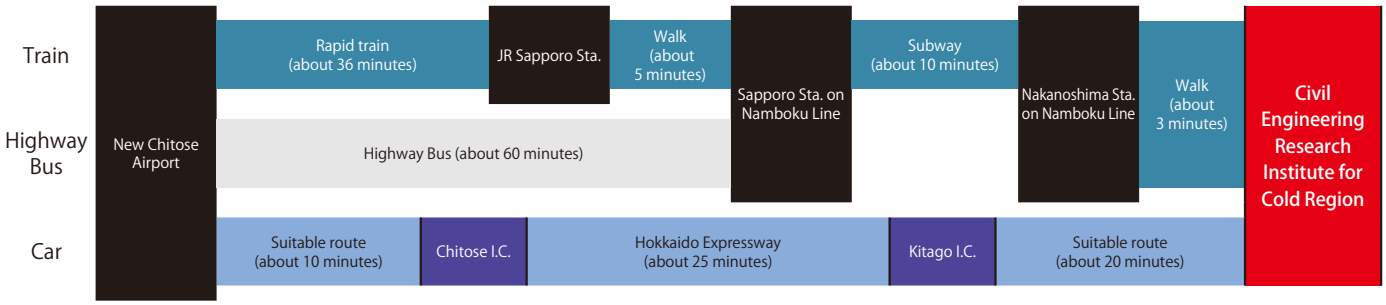
[Car]
- From Arai Smart I.C. on Joshin'etsu Expressway ..... About 3 km 7 minutes
- From Nakago I.C. on Joshin'etsu Expressway ..... About 4 km 10 minutes

Access to Civil Engineering Research Institute for Cold Region



Access

CERI is located on the eastern side of the Toyohira River that goes through the center of Sapporo City, in an area called Hiragishi in Toyohira-ku. The institute is about 200 meters north of, or 3 minutes walk from, the Nakanoshima Station on the Namboku Line of the Sapporo City Subway System.



Civil Engineering Research Institute for Cold Region 3-1-34 Hiragishi Ichijo, Toyohira-ku, Sapporo-shi 062-8602 Phone: +81 11-841-1624

Public Works Research Institute

Tsukuba Central Research Institute
International Centre for Water Hazard and Risk Management
Center for Advanced Engineering Structural Assessment and Research
Innovative Material and Resource Research Center

1-6 Minamihara, Tsukuba-shi, Ibaraki-ken 305-8516
Phone: +81 29-879-6700
http://www.pwri.go.jp/eindex.html
e-mail：www@pwri.go.jp

Civil Engineering Research Institute for Cold Region

3-1-34 Hiragishi Ichijo, Toyohira-ku, Sapporo-shi, Hokkaido 062-8602
Phone: +81 11-841-1624
http://www.ceri.go.jp/english/index.html
e-mail：info@ceri.go.jp

Recycled paper
ISSN 1880-5612