60th Anniversary

Annual Report 2022

Port and Airport Research Institute Annual Report 2022

Message from the Director General

Creating Port and Airport Technologies That Contribute to the World

港湾空港技術研究所長
（うみそら研理事）　高野誠紀

Seiki TAKANO
Director General, Port and Airport Research Institute
(Executive Director, National Institute of Maritime, Port and Aviation Technology “Umisora Institute”)

In April 2016, three research institutes – the National Maritime Research Institute (NMRI), the Port and Airport Research Institute (PARI), and the Electronic Navigation Research Institute (ENRI) – were integrated, the National Institute of Maritime, Port and Aviation Technology (MPAT), (commonly known as “Umisora Institute.”) was launched. We, the Port and Airport Research Institute (PARI), are going to play a role in the Umisora Institute as a research institute responsible for survey, research and technological development related to the maintenance of ports and airports, while inheriting our past steps. Since its predecessor, the Port and Harbor Research Institute (PHRI) of the Ministry of Transport (MOT), was established in 1962, the Institute marks a major milestone and has celebrated its 60th anniversary this year.

In its 60-year history, the Port and Airport Research Institute has played a major role, providing technical support for numerous port and airport projects, including the development of Kashima Port and the construction of Haneda and Kansai International Airports, and have achieved internationally recognized research results.

The Port and Airport Research Institute will further expand, deepen the cooperation and integration of research in different fields by the cooperation with other two integrated institutes (NMRI and ENRI), and maximize the results of research and development by demonstrating the synergistic effect, in addition to the close cooperation with the National Institute for Land and Infrastructure Management (NILIM), Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

This annual report summarizes the results for FY2021, the sixth year of the first Medium to Long-term Plan (FY2016 to FY2022). In the first Medium to Long-term Plan, we will focus on the four R & D issues; "Coastal Disaster Mitigation and Restoration", "Formation of Infrastructure for Vigorous Economy and Society", "Preservation of Marine Interests and Utilization of Oceans", and "Creation and Utilization of Coastal Environment".

In the "Coastal Disaster Mitigation and Restoration", we are proceeding with research on development for making decisions on whether or not to put facilities back into service quickly after an earthquake, and on estimating early inundation damage in the event of a huge tsunami, research on filter materials to prevent reclaimed sand from being sucked out through gaps in caissons. In "Formation of Infrastructure for Vigorous Economy and Society", we are proceeding with research technology which supports operation of container terminals efficiently, the improvement and development of inspection equipment for offshore structures, and the development of core-less ground survey methods.

In "Preservation of Marine Interests and Utilization of Oceans", we are proceeding with research on development of a fender system for automatic vessel berthing/unberthig, research on multifunctionality such as remote control of marine construction machinery, and analysis on horizontal resistance characteristics of pile foundations for offshore wind power generation facilities.

In "Creation and Utilization of Coastal Environment", we are proceeding with research to quantify blue carbon (mitigation effect) and implement the J Blue Carbon Credit program in various coastal areas, and develop a method for predicting global coastal change according to climate change, etc.

In carrying out these researches mentioned above, we will be pursuing the two major mottos of our institute, “The Research level is the highest in the world” and “The Research results are useful the actual projects”. We will be also promoting strategic international activities such as contributing to the overseas expansion of infrastructure promoted by the national government and technical support to overseas countries. Furthermore, in order to respond to technical issues across research fields, PARI internally set up five centers (International Research Center for Coastal Disasters”, “Life Cycle Management Research Center”, “Ocean Infrastructure and Offshore Wind Energy Research Center”, “Productivity Improvement Center”, and “ Innovation Promotion Center”), and we will be further strengthening cooperation with the Regional Development Bureaus of the Ministry of Land, Infrastructure, Transport and Tourism, which have technology implementation sites, and private companies.

In recent years, natural disasters such as earthquakes, storm surges, and high waves have intensified, occurred frequently, and the acceleration and deepening of National Resilience is an urgent issue. In view of the uniqueness of our institute as a research institute that conducts practical research and development closely related to the field under the harsh natural conditions unique to Japan, we will be continuing to utilize the knowledge and human resources of our institute, in addition, we would like to firmly work on emergency response and support for restoration in the event of natural disaster, enlightenment related to disaster prevention.

We would greatly appreciate your continued understanding and support.

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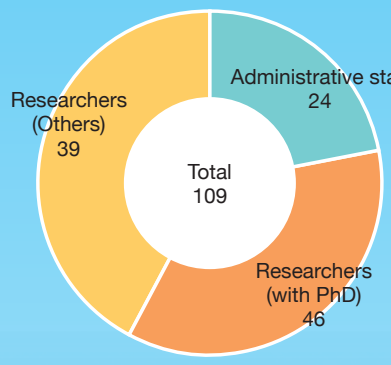
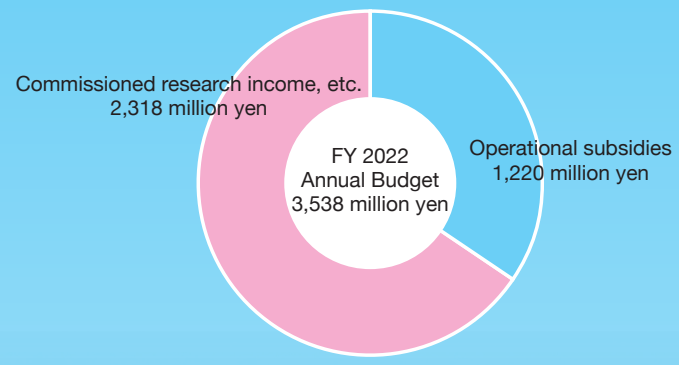
Outline of Organization

Administrative Staff and Researchers, and Budget

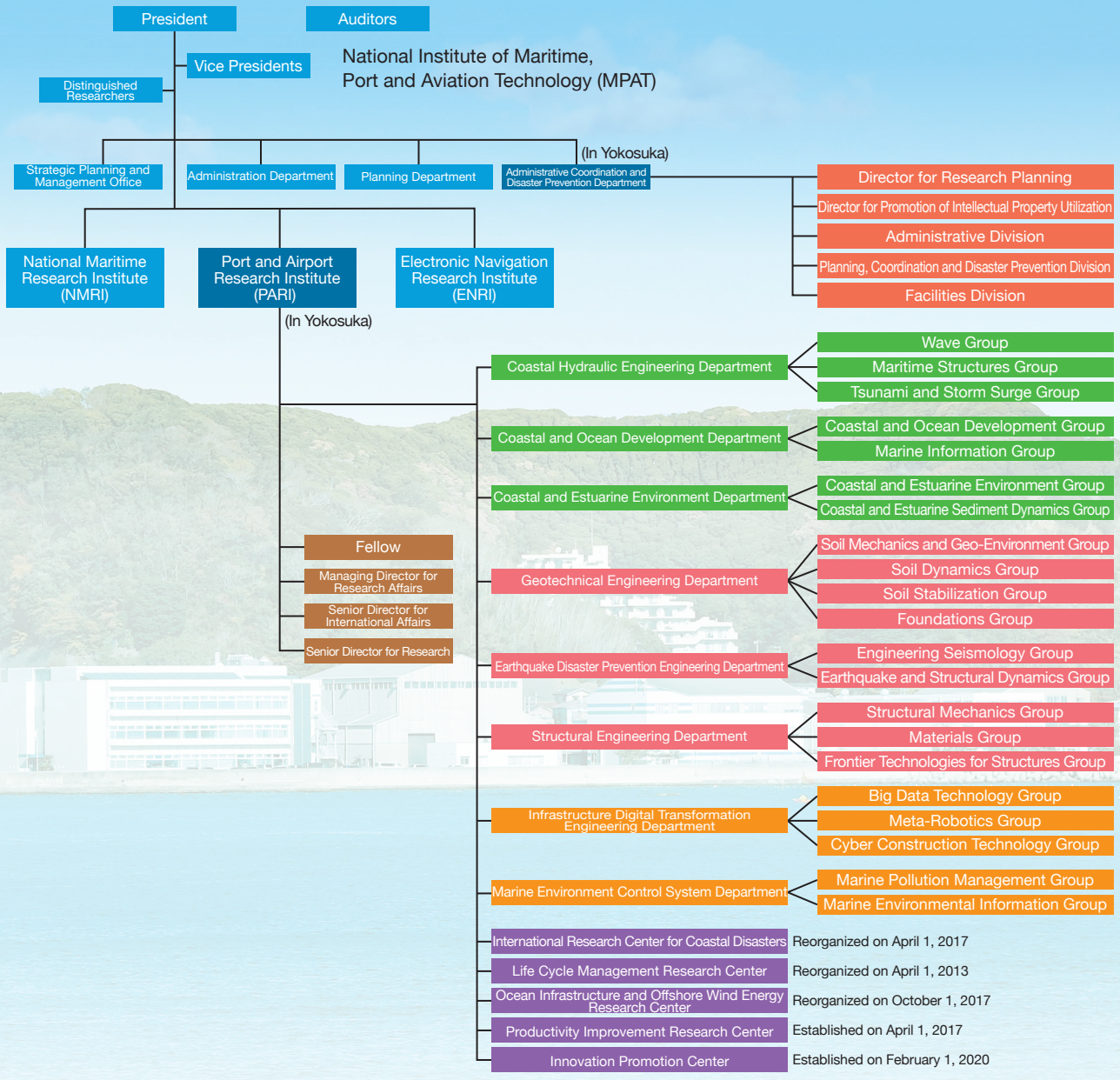


As of April 1, 2022 (In Yokosuka)



* The graph above shows the budget for technical fields related to ports, waterways, coasts, and airports.

Organizational Structure



As of April 1, 2022

Basic Policies of Institute Management

Medium to Long-term Objectives (FY 2016 to FY 2022)

The Minister of Land, Infrastructure, Transport and Tourism (MLIT) sets Medium to Long-term Objectives for the National Institute of Maritime, Port and Aviation Technology, National Research and Development Agency to achieve. These objectives stipulate our operations as follows.

Basic Policies for Structural Reform of Independent Administrative Institutions were decided in a Cabinet decision on December 24, 2013 (hereafter called "Basic Policies for Reform"). Based on these policies, the National Maritime Research Institute (NMRI), Port and Airport Research Institute (PARI), and Electronic Navigation Research Institute (ENRI), which were National Research and Development Agencies operated under the jurisdiction of the MLIT, were integrated into the National Institute of Maritime, Port and Aviation Technology (hereafter called "MPAT") to implement the policies.

Article 2, paragraph 1 of the Act on General Rules stipulates as follows: some clerical tasks and business require sound implementation from the viewpoint of general welfare including stabilization of people's life and socioeconomy, but at the same time do not require government-led implementation. Some of these clerical tasks and businesses face the risk of neglect when their operation is entrusted to private entities, so MPAT was established to effectively and efficiently conduct their operation.

In consideration of the previous roles of each institute, MPAT is required to continue to make full use of its accumulated wealth of knowledge and stature, and to proceed with research and development according to the Basic Policies for Reform. In addition, MPAT will constantly review research contents and select research areas to address changes in the social environment. At the same time, MPAT will more actively engage in research and development activities to solve policy challenges in each field, such as conducting research in emerging fields.

MPAT has promoted research and development in each field, cultivated technological seeds, and accumulated specialized knowledge. Thanks to MPAT's legacy, such multidisciplinary research became viable. In consideration of this background, MPAT will efficiently and effectively implement multidisciplinary research including "Promoting the protection of maritime interests and the utilization and application of marine-resource/marine-renewable-energy development and other projects". Through such implementation, MPAT will help put national policies into practice.

Furthermore, MPAT considers that it is important to return the benefits achieved through research and development to society, as well as to cooperate with external institutes and to widely disseminate research results. In addition, MPAT is committed to strategically implementing international activities as follows: active participation in projects to formulate international criteria and standards; international promotion of Japanese technologies and systems through international cooperation; and other activities.

As outlined above, MPAT's missions are based on the MLIT's Basic Plan for putting MLIT-recommended policies into practice. Today, Japan faces various important challenges. By realizing these policies, we can solve such challenges.

Medium to Long-term Plan (FY 2016 to FY 2022)

The MLIT sets Medium to Long-term Objectives. In response to such objectives, MPAT sets Medium to Long-term Plan to achieve the objectives. Among such plans, important points in maximizing research and development results and improving the quality of other projects are outlined below.

1. Promotion of multidisciplinary research and other activities

MPAT will efficiently and effectively implement multidisciplinary research spanning research fields of the three pre-integration institutions to contribute to putting the following policies into practice: promotion of ocean utilization, enforcement of international industrial competitiveness, and other policies.

2. Research and development of technologies associated with ports, waterways, coasts, and airports and other activities

MPAT will focus on the research and development challenges detailed in the following pages, to devise the following MLIT-recommended initiatives: disaster-prevention and disaster-reduction countermeasures for port and airport facilities; countermeasures for facility obsolescence of existing structures; and initiatives to create maritime-development hubs.

Among basic research, MPAT also actively engages in research to understand the mechanisms of ocean waves and beach transformation and principles and phenomena regarding the dynamic behavior of the ground and structures.

MPAT also uses its foresight and flexibility to accurately address emerging research which might lead to new research results.

3. Returning benefits from research and development results to society

MPAT will try to resolve technological policy challenges, to address disasters and accidents, to enforce bridging functions, to promote and utilize intellectual property rights, and to enhance the transmission of information and publication.

4. Promotion of strategic international activities

MPAT will contribute to international standardization and cooperate with overseas institutions.

MPAT Operation Management

MPAT will focus on rapid decision-making to engage in strategic institutional operations.

MPAT will also hold the following meetings for multi-faceted investigation of various operational agendas from a broad perspective:

1. Management strategy meetings: In-house meetings for making decisions on important issues related to the core principles of MPAT management
2. Board of Directors meetings: Weekly meetings involving all executives and division managers as well as the three directors of the Administrative, Coordination and Disaster Prevention Department
3. Board of Councilors meetings: Meetings to gather insights from independent experts who have broad and deep knowledge
4. External Evaluation Board: An external body in which third parties objectively and technically evaluate MPAT's research

Structure of Research Themes in FY 2021

Research Field	Research Theme	Research Subtheme	Type of Research		Item on the Research Agenda (☆indicates special research*)
1. Coastal Disaster Mitigation and Restoration	1A Research on Mitigation and Restoration of Earthquake Disasters	① Research on strong ground motions and damage predictions in the case of the greatest earthquakes	Fundamental Research		Strong motion earthquake observation in port and airport area
			Fundamental Research		Investigation of earthquake disaster
			Fundamental Research		Development of strong motion estimation method for near-fault strong ground motions
			Fundamental Research		Development of new prediction and assessment methods for liquefaction-induced settlement and flows
		② Research on damage-reduction techniques against the greatest earthquakes	Applied Research		Development of countermeasure for early exhibition of seismic performance of coastal facilities
			Applied Research		Research on prediction method for deformation of coastal facilities afterearthquake motion
		③ Research on the interaction of earthquakes, tsunamis, and high waves with ground dynamics	Applied Research	☆	Stability assessment of coastal structures subjected to internal erosion orwave-seabed interaction and development of their countermeasures
			Fundamental Research		Deformation/failure behaviours and reinforcement methods of coastal and geotechnical structures subjected to waves and water flow
	1B Research on Mitigation and Restoration of Tsunami Disasters	① Research on ICT-based decision support systems	Development Research		Development of a 3-dimensional simulation model for drift behavior and its application to a 2-dimensional simulation model
			Development Research		Development of technology for early prediction of the inundation damage in major earthquake and tsunami disasters
		② Research on the development of tsunami-resistant ports	Development Research		Development of particle-based numerical wave tank to examine the wide-range suffer process of port structures by tsunami
			Fundamental Research		A Study on Tsunami Wave Forces on Mangroves and Their Deformation
	1C Research on Mitigation and Restoration of Storm Surge and Wave Disasters	① Research on storm surge, wave and maximum damage estimation	Fundamental Research		Elucidation of oceanographic phenomena based on central processing and analysis of observation data
			Applied Research		Assessment of possible maximum storm surge hazard by using storm-surge-wave coupled model
			Fundamental Research		Improvement of wave prediction model for Coastal Areas of Japan
			Development Research		Development of simulation method for port facility inundation due to wave overtopping and outflow
		② Research on the technology to reduce maximum storm surge and wave disasters	Applied Research		Study on Wave Overtopping and Wave Force on Composite Method Preventing Wave Overtopping
			Applied Research		Study on the stability of suction-preventing filter materials against waves
2. Formation of Infrastructure for Vigorous Economy and Society	2A Research on Enhancement of Port and Airport Performance for Industrial Competitiveness	① Research and development for enhancing the operations of ports, harbors, and airports	Applied Research		Proposal of evaluation method to estimate the productivity of the container terminal system introduced AI and ICT technology or other method
			Applied Research		Proposal of planning method for automated container terminal by quantitative numerical simulation
			Applied Research		Proposal of new technology for container terminal operations
			Development Research		Development of an underwater positioning system
	2B Research on Life Cycle Management of Infrastructures	① Research on technologies for prolonging the life of infrastructure	Applied Research		A study on the effectiveness of the wire mesh an airfield rigid pavement
			Fundamental Research		Evaluation of longterm durability of concrete, steel and various materials based on exposure test
			Fundamental Research		Development of the performance evaluation method in protective coating for marine structures
			Fundamental Research		Study on the applicability of sustainable materials under marine environments
			Applied Research	☆	Study on improvement of productivity of concrete works in port structures
		② Research on infrastructure inspection and diagnosis techniques	Applied Research		Study on application of inspection and diagnosis systems for improvement of performance evaluation of marine structures
			Development Research		Development of adaptive technique for inspection vehicle to disturbance in operation
	2C Research on Effective Use of Existing Infrastructure Facilities	① Research on techniques to improve or renew existing facilities	Applied Research		Development of quality evaluation method for ground improvement using geophysical exploration
			Fundamental Research		Study on process leading to rupture of pier structure for high definition of performance regulation
		② Research on effective use and techniques of treating construction byproducts	Applied Research		Effect of defective part of solidified body on its internal stability
			Fundamental Research		Development of core-less soil investigation and fundamental study to establish Digital Soil Mechanics
			Fundamental Research	☆	Study on the volume reduction of dredged soil by electro-osmosis dehydration
3. Preservation of Marine Interests and Utilization of Oceans	3A Research on Development and Utilization of Oceans	① Study on the preservation and use of remote islands	Development Research		Development of fender system for automatic ship berthing/unberthing
			Applied Research		Technical approach to advancement of harbor tranquility in a remote island
		② Research on infrastructure technology for utilization and development of oceans	Applied Research		Study of wave force and scouring that affect offshore wind power plants
			Fundamental Research	☆	Elucidation of the horizontal resistance characteristics of pile foundations for offshore wind power plants under various fluctuating loads
			Development Research		Study on multifunctional underwater excavator using machine guidance technology
			Development Research	☆	Study of applying acoustic imaging system to ICTconstructions
			Applied Research		Research on load setting method for offshore wind power facilities under waves and winds
			Fundamental Research	☆	Evaluation of mechanical properties and durability of infrastructure materials in deep sea
			Fundamental Research	☆	Experimental study on methods for enhancing marine ecological value on gray infrastructure toward establishing green-gray hybrid structure
4. Creation and Utilization of Coastal Environment	4A Research on Enhancement and Utilization of Coastal Ecology	① Research on coastal-ecosystem utilization	Fundamental Research	☆	Validation of the newly developed global dynamic model for the projection of atmospheric CO_2 uptake rate and inundation control in shallow coastal ecosystems
			Applied Research		Coastal geotechnical/geomorphological design for disaster mitigation and ecological environment
		② Research on the water-environment simulation and analysis in inner-bay	Fundamental Research		Development of the methods for increasing ecosystem functions in eelgrass meadow
			Applied Research		Numerical analysis of coastal current by numerical simulation and data assimilation
			Fundamental Research		Numerical study on responses of aquatic ecosystem to an environmental change
			Development Research		Enhancing platforms for the collection and dissemination of coastal information in enclosed-bay
			Applied Research		Applied cross-sectional observation and analysis of atmospheric and oceanographic issues at bay mouths
		③ Research on countermeasure technologies against sea oil spill	Development Research		Development of oil spill response technology for next generation
	4B Research on Coastal and Estuarine Processes	① Research on coastal protection and maintenance of waterways and mooring basins	Fundamental Research		Observation of coastal phenomena at HORS and development of numerical simulation of topography change for port and surrounding beaches
			Fundamental Research		Developing future projection model of coastal change in the context of climate change
			Fundamental Research	☆	Development of sediment transport control method to minimize harbor siltation

* Special research involves high-priority research topics on which PARI must conduct studies intensively. PARI allocates significant human resources and funding to these projects, and also arranges cross-functional research systems extending beyond the basic organizational structure within PARI as needed, in order to accelerate research.

1A Research on Mitigation and Restoration of Earthquake Disasters

Background and Objectives

In the event of large-scale disasters such as Nankai Trough mega earthquake and earthquake directly under Tokyo Metropolitan area, it is required to secure necessary trunk line cargo transportation soon after an earthquake and to quickly secure the requisite minimum transportation of key emergency supplies for recovery and reconstruction.

In addition, the interaction of earthquakes, tsunamis, and high waves with the ground might cause coastal disasters, so it is necessary to reduce such risks.

Therefore, this research aims to establish techniques for predicting seismic motions and damage to structures caused by the strongest, long-duration earthquakes. Furthermore, the research will develop new techniques for reinforcing existing structures for improving their anti-seismic capacity, assessing damage during on-site damage surveys, and implementing emergency measures. In addition, the research elucidates the phenomenon of tsunami caused by submarine landslides, soil performance against the effects of tsunami, high waves, and flows, and method of countermeasures.

Research Topics

Research and development on earthquake disaster mitigation and recovery will be conducted under the following three sub-themes;

① Research on strong ground motions and damage predictions in the case of the greatest earthquakes

We will develop a composite source model for simulating epicenter strong ground motions that can consider not only the strong ground motions that are caused by the rupture of deep asperities, which have conventionally been reflected in structural designs, but also the effects of fault shallow slip as observed during the Kumamoto earthquake, and will examine its validity.

② Research on damage-reduction techniques against the greatest earthquakes

We will develop techniques that will exhibit in the early period the functions of coastal facilities following earthquakes that involve adding new components to existing facilities and replacing components when damaged by earthquakes.

③ Research on the interaction of earthquakes, tsunamis, and high waves with ground dynamics

We will develop effective design and countermeasure technologies to deter sucking out, caving, etc. that occur to coastal structures under various dynamic external forces.

Activities in FY 2021

Research on strong ground motions and damage predictions in the case of the greatest earthquakes

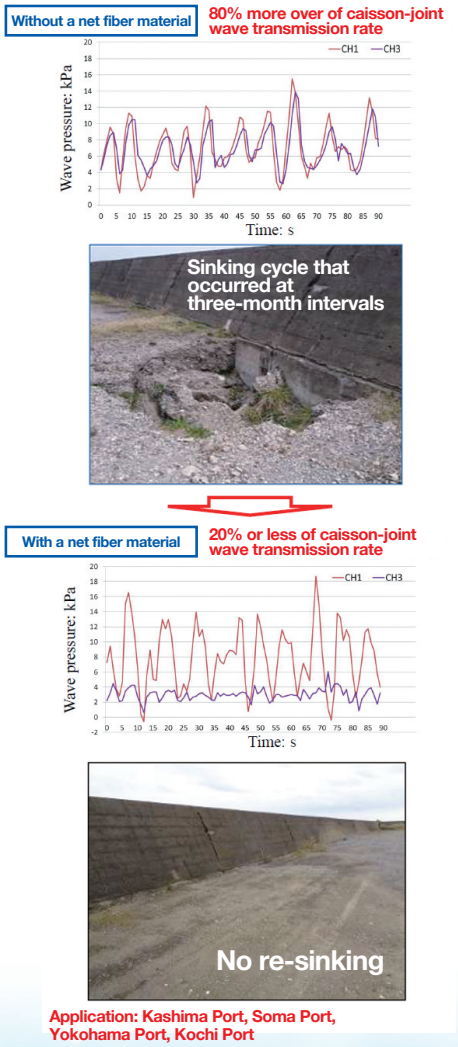
In order to predict waveform and damage in the largest earthquakes, we observed strong ground motions in ports and airports and organized and analyzed their data, investigated earthquake disasters and their causal factors, and worked on the development of novel methods for predicting near-source strong ground motions and liquefaction-induced ground subsidence and flow. As for the development of a method for predicting near-source strong ground motions, we have made progress in developing and examining a source model that is capable of considering not only strong seismic motions that are caused by the rupture of deep asperities on the faults but also the effects of faults shallow slip. Concerning our activity on a system that enables swift and proper determination of the availability judgement of mooring facilities following earthquakes in an effort to improve surveys of earthquake damage and its causal factors, our team has been discussing with the MLIT and its Regional Development Bureaus how to utilize the system and also conducted experiments to test the system on site.

Research on damage-reduction techniques against the greatest earthquakes

Concerning our activity involving damage-reduction technology against the largest earthquakes, we examined ways to predict the deformation that may occur in coastal facilities due to seismic motions and proceeded with developing a technology to allow coastal facilities to exhibit their performance at an early stage.

Research on the interaction of earthquakes, tsunamis, and high waves with ground dynamics

Concerning the interaction of earthquakes, tsunamis, and high waves with ground dynamics, our team proceeded with activities to develop techniques for evaluating the stability of coastal structures against sucking out, sinking, and other adverse phenomena, thus leading to effective countermeasures, and also to develop methods for evaluating the deformation and failure characteristics of coastal geotechnical structures in relation to waves and flows, and for reinforcing the structures against them. In terms of effective novel countermeasures to better protect against sucking out and sinking, the team proceeded working on sucking out prevention method involving filter layers and caisson joint transmission wave reduction method that were proposed in the previous year, by considering a wider range of soil conditions, external forces, and structural conditions and examining the applicability to various conditions. In FY 2021, the filter-layer-based sucking out prevention method was implemented on the seawall for protecting the new runway at Naha Airport, while the caisson-joint transmission wave reduction method was implemented at Yokohama Port. In addition, both of these methods were included in the partial revision of the Technical Standards and Commentaries for Ports and Harbors (April 1, 2022).



Reduction of caisson-joint waves and suppression of collapse by a net fiber material

1B Research on Mitigation and Restoration of Tsunami Disasters

Background and Objectives

Since the Great East Japan Earthquake in 2011, we have developed stable structures against tsunami with overflowing and a numerical simulation model to predict the drifting of debris generated by the destruction of structures. However, complex behaviors of running-up tsunami on land, and the resulting damages are not fully cleared, and then the predicting methods yet. In addition, regarding a technique for inundation real-time forecast, which is expected to be utilized for evacuation and other purposes, only data from GPS wave buoys is used; other valuable data is not fully utilized yet.

In order to switch from a damage-first approach to a countermeasure-first approach to disaster prevention and mitigation, we will conduct research on the establishment of a resilient coastal zone, i.e., one that can protect human lives against the largest tsunami, prevent catastrophic damage to the social economy, and enable early restoration and recovery from the disaster.

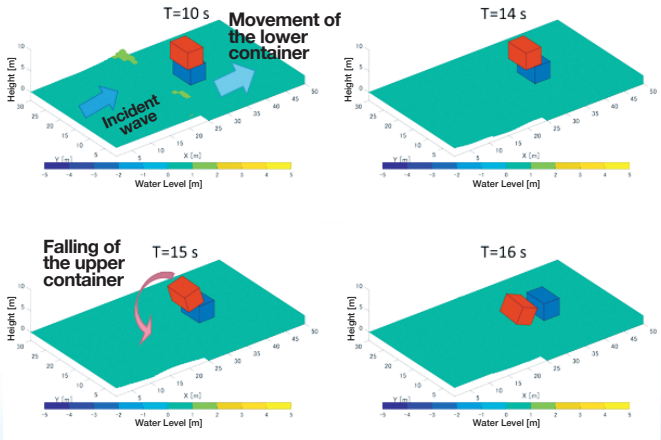
Research Topics

As our research and development on tsunami mitigation and restoration, the following R&D activities will be conducted.

- For our research on simulation model for tsunami drift object, we are examining the accuracy of 3-D simulation model of the behavior of drift object.
- In the research and development of early inundation damage predicting technology for huge tsunami disasters with wide-area crustal deformation, our team is developing a new calculation method to make more efficient crustal deformation prediction, and to confirm the improvement of the prediction accuracy of tsunami waveforms.
- In a study to develop a large-scale numerical wave tank for a group of outer facilities, in addition to improving the accuracy of the particle method model, develop a pre-post GUI and implement an automatic continuous calculation function for large amount calculations.
- For our study on the effects of tsunami wave force on mangroves and their deformation, we are analyzing the results of hydraulic model experiments conducted the previous year and conducting studies on mangrove roots based on literature and also in the field.

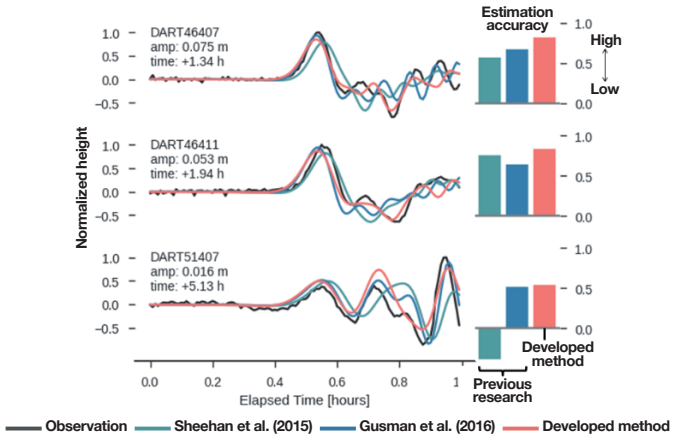
Activities in FY 2021

- We improved the 3-D drift object simulation model that had been developed by the previous year and verified its effectiveness by comparing with experimental results. In addition, we established the local contact model of drift object for the planar 2-D simulation model, and confirmed the effectiveness by comparing with experimental results.



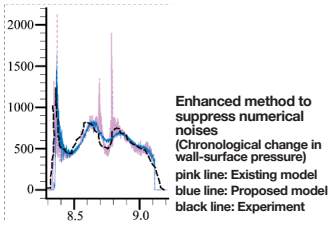
Numerical simulation by 3-D model

- Estimation of earthquake fault planes is essential for estimating crustal deformation, however, there was no efficient way to estimate this from tsunami waveforms. Therefore, we developed an adjoint waveform synthesis method that can instantly evaluate the tsunami waveform at any observation point. The conventional method requires the assumption of a fault plane in advance, and its estimation accuracy is reduced when an earthquake different from the assumed one occurs. The newly developed method can synthesize tsunami waveforms generated from arbitrary wave sources, thereby improving accuracy of tsunami waveform estimation. We applied this method to the tsunami caused by the 2012 Haida Gwaii earthquake, and it is clear that the method improves prediction performance in terms of both rapidity and accuracy.

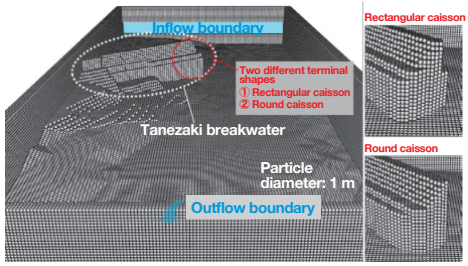


Observed tsunami waveforms resulting from the 2012 Haida Gwaii earthquake, comparative waveforms simulated by different methods, and their estimation accuracy

- We developed a particle- based numerical wave tank and a GUI to accurately and stably handle fluid motions for complex topography. Moreover, pressure calculations and water surface boundary conditions of impact water by improving the accuracy of numerical noise of impact water was improved. Furthermore, we tested anti-scour measures through the developed numerical wave tank to examine their applicability to the breakwaters of actual ports in major tsunami events.



Numerical noise improvement achieved by adjusting the model



Mesh created on the GUI representing the end of the breakwater

- As mangroves have numerous roots penetrating the soil, they are highly resistant to tsunami. To elucidate such characteristics of mangroves, we studied and analyzed their behavior under the impact of tsunami in the hydraulic model experiment conducted the previous year. Furthermore, to investigate the tsunami-resisting capability of mangrove roots, we traveled to a mangrove habitat and surveyed the soil characteristics including sand particle size.

Ground survey near mangrove trees

1C Research on Mitigation and Restoration of Storm Surge and Wave Disasters

Background and Objectives

Although Japan has not suffered any major disaster caused by storm surges or high waves since the Isewan Typhoon (Typhoon Vera) that ravaged the country in September 1959, tropical cyclones in other parts of the world have caused severe damage in recent years, including Hurricane Katrina that struck the U.S. in September 2005 and Typhoon Haiyan that devastated the Philippines in November 2013. In future, global warming might bring higher storm surges and waves than those we have experienced in Japan. Therefore, this research is aimed for changing disaster prevention and mitigation measures into a pre-disaster stage from post-disaster one and focuses on how to mitigate damage by the maximum storm surge and wave conditions and how to rapidly recover and reconstruct after the damage has occurred. Therefore, we conduct research to encourage hard and soft measures.

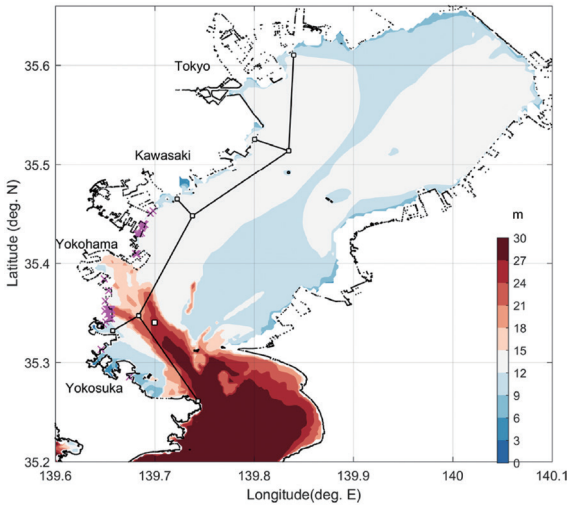
Research Topics

Research and development on the theme of mitigation of disasters caused by storm surges and high waves and disaster recovery cover the following topics:

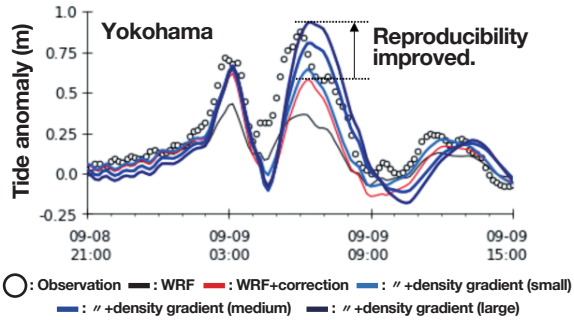
- For our research to elucidate the oceanographic phenomena based on ocean observation data, we are continuously processing and analyzing wave observation data (preliminary and final processing, and statistical analysis).
- For our research project simulating inundation events caused by waves inside ports, we are conducting an experiment using a planar model to study the inundation process on quay walls.
- For our study of wave estimation techniques, we are improving the wave model based on its known shortcomings.
- For our research on wave overtopping and force on seawall, we are conducting a model experiment examining the new types of seawalls that have been suggested in recent years.
- For our research on the stability of filter materials under the impact of waves, we are conducting a model experiment to examine their stability when the seawall is under construction, etc.

Activities in FY 2021

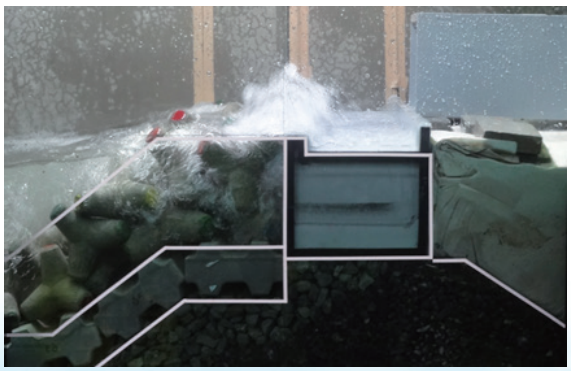
- We organized the wave observation data obtained from the NOWPHAS (Nationwide Ocean Wave information network for Ports and HArbourS) in 2020 and published it as the NOWPHAS 2020 Annual Report. According to the data, the previous maximum significant wave heights recorded at two locations were surpassed, and the annual average significant wave height in the Pacific Ocean off the coast of Shikoku during the year was lower than the average significant wave height during the past decade.
- We simulated the waves that occurred during Typhoon Faxai in 2019 using the spectral model WW3 and discovered that Yokohama Port, which suffered severe damage from the event, was hit by swells that had developed outside Tokyo Bay. Furthermore, we calculated the wave pressure that would impact vertical walls using the non-hydrostatic wave model SWASH and proved that the surf similarity parameter, Iribarren Number, could be used as an effective indicator of maximum swash height (wave pressure intensity).
- We conducted a planar experiment simulating a container pier where inundation would occur due to wave overtopping on quay walls during storm surges and also ran calculations to reproduce the phenomenon. The experiment and calculation elucidated the space-time distribution of the inundation depth and flow speed behind the quay walls that no previous field survey of water marks could obtain, and also shed light on the inflow and outflow rates along the quay walls' normal line as well as on the planar process of inundation.
- We estimated the storm surges that occurred in Tokyo Bay due to Typhoon Faxai in 2019 by applying the ROMS ocean model and analyzed the effects of the vertical distribution and temporal change of density fields on the tide anomaly. In addition, we developed a new method of correcting meteorological fields based on their relation to gradient winds.
- We conducted cross-section experiments involving upright, overtopping-wave-permeable, double-parapet, and flare type seawalls to measure the wave overtopping rate, and calculated their equivalent crest height coefficients. In the case of the gently sloping seawall that we tested, it was found that the granular diameter of the mound rubble would cause the water level inside the mound to rise. We also used the CADMAS-SURF numerical wave flume and learned that granular diameter settings were important.
- We built a nearly full-scale model of stone backfill and a rubble filter and applied waves to them to observe the stability of the rubble filter. It was found that the filter could dissipate waves as high as several tens of centimeters and so its stability could be evaluated by applying Hudson's formula.



Wave intensity index (square root of the product of wave height and wave length) during Typhoon Faxai's passage in 2019



Comparison of tide anomaly calculated under various conditions



Double-parapet seawall experiment

2A Research on Enhancement of Port and Airport Performance for Industrial Competitiveness

Background and Objectives

PARI is responsible for research and development to help improve the functions of ports, harbors, and airports across Japan, as part of the country's efforts to improve the international competitiveness of its industries and promote port, harbor, and airport development in an efficient and effective manner, as they are vital to the daily activities of the nation's citizens. PARI's research in these areas covers the following subthemes and goals that are relevant to Japan's international competitiveness, encompassing the country's global strategic port and harbor policy, improvement of airport functions in the Metropolitan Area (improvement of Haneda Airport), infrastructure export capability, etc. These topics are comprehensively studied by various departments of PARI as part of its overall R&D policy.

Research Topics

Research and development were conducted on the following topics to improve the port and airport functions in order to ensure their global competitiveness.

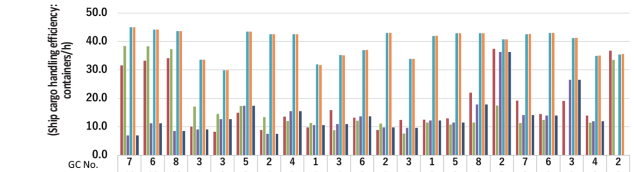
For the particular objective of improving container terminal productivity, we are developing a container damage inspection system, evaluating numerical simulations of terminals where ICT, etc. are used, and studying various implementation plans as part of our efforts to promote digital transformation at ports and harbors, improve their operational efficiency, facilitate the implementation of environmental measures, and enhance their overall functions.

In addition, we are conducting research and technological development on a real-time underwater positioning system that will enable remote execution of underwater construction operations, etc.

Activities in FY 2021

(1) Proposal of evaluation method to estimate the productivity of the container terminal system introduced AI and ICT technology or other method

While our study on the parallel container-stacking layout in FY 2019 revealed that the trucks on standby on the premises became excessive with cargo volumes of 1.5 million TEU per year, as the deployment of a similar number of RTG cranes as MC-3 and MC-4 turned out to be far too few, our study conducted in FY 2020 showed that the gate efficiency would improve if an automated container damage inspection system was used, and the perpendicular (vertical) layout would result in fairly high capacity as the automatic stacking crane (ASC) would be always located on the incoming chassis side in each lane. As it was previously determined that the automated container damage inspection system could not be installed within the width of a lane, our study in FY 2021 had a minimal gate separately installed per lane and compared the perpendicular (vertical) and parallel (horizontal) layouts. We found that while the parallel (horizontal) layout would have significantly negative effects on ship cargo loading/offloading activities unless in-yard cargo handling was optimized, the perpendicular (vertical) layout would result in sufficient capacity. It was also discovered that while no significant difference would arise between reservation rates of 100% and 50% (Case_1_1 and Case_1_2), more operational adjustments had to be made to achieve the desired outcome when using the position data as with Case_2 to have the cranes ready in the container yard in advance. As described above, AutoMod-powered simulations can enable us to examine various future plans by testing different assumptions. As the current Port Plan includes a cargo-handling volume of roughly 1,000,000 TEU per year, there should be sufficient excess capacity according to our simulations.



		GC No.	7	6	8	3	3	5	2	4	1	3	6	2	3	1	5	8	2	7	6	3	4	2
		Ship No.	10	10	10	1	2	3	4	3	4	4	3	5	5	8	8	8	8	8	8	8	8	9
Parallel	Case_1_1		31.6	33.2	34.1	10.0	8.2	14.9	8.9	13.6	9.8	15.8	13.2	8.9	12.4	12.5	12.9	22.0	37.4	19.2	14.5	19.1	13.9	36.7
Parallel	Case_1_2		38.4	38.3	37.3	17.1	14.5	17.3	13.4	12.0	11.3	8.8	12.1	11.1	7.6	11.5	10.8	11.5	17.5	11.3	12.4	0.0	11.4	33.5
Parallel	Case_2		7.0	11.2	8.5	9.0	12.7	17.4	7.5	15.5	10.6	10.9	13.7	9.8	9.6	12.2	11.5	17.8	36.3	14.1	13.9	26.5	11.9	0.0
Perpendicular	Case_1_1		45.0	44.2	43.6	33.6	29.9	43.4	42.5	42.5	31.9	35.2	36.9	43.0	33.8	41.9	42.9	42.9	40.7	42.5	43.0	41.2	34.9	35.4
Perpendicular	Case_1_2		45.0	44.2	43.6	33.6	29.9	43.4	42.5	42.5	31.7	35.1	37.0	43.0	33.8	42.0	42.9	42.9	40.7	42.6	43.0	41.3	35.0	35.6
Perpendicular	Case_2		7.0	11.2	8.5	9.0	12.7	17.4	7.5	15.5	10.6	10.9	13.7	9.8	9.6	12.2	11.5	17.8	36.3	14.1	13.9	26.5	11.9	0.0

(2) Proposal of planning method for automated container terminal by quantitative numerical simulation

The PIANC finished its WG208 report titled *Planning for Automation of Container Terminals* and published it in March 2021. Our team then made a Japanese-translated version in FY 2021, in conjunction with other organizations from the private sector.

In addition, our researchers gave keynote speeches at the Japan-ASEAN WS and other events and shared their knowledge with the world on digital twins, emulation, and simulation technologies applicable to container terminals.

(3) Proposal of new technology for container terminal operations

As part of the PRISM (Public/Private R&D Investment Strategic Expansion PrograM) sponsored by the Cabinet Office, we developed an AI-powered image determination system and conducted its data acquisition test at Daikoku Pier in Yokohama Port during FY2020 with a view to implementing the system in actual port operations in the near future. This system is capable of making determinations using both image processing and laser measurement data. In addition, we examined its applicability to PC-18 on Port Island in Kobe Port and prepared its test manual. In FY 2021, our team aided the MLIT with their on-site empirical test projects.

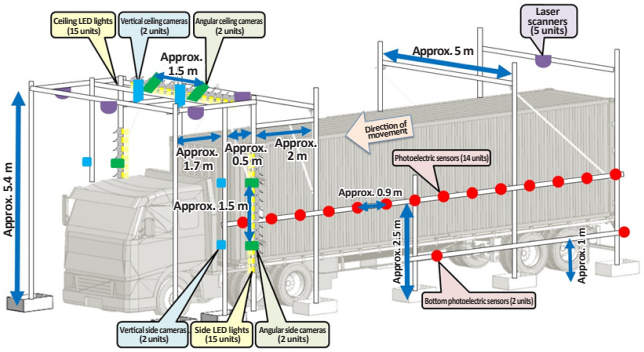
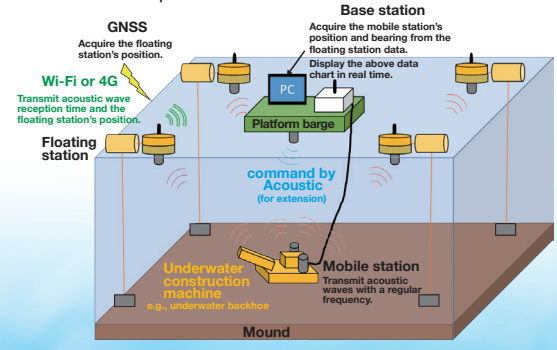


Illustration of the container damage inspection system (prototype installed at Yokohama Port)

(4) Development of an underwater positioning system

Our team is conducting research and technological development on an underwater positioning system that can acquire the position of any moving objects underwater in real time, eventually with the level of precision that will be required for application to actual construction projects. In FY 2021, we examined the designs of floating, mobile, and base stations that would comprise the system, and created prototypes of some of these components.



2B Research on Life Cycle Management of Infrastructures

Background and Objectives

The ports, airports and coastal infrastructures that have been in service for a long time are increasing, but financial resources and the number of engineers for facility maintenance are limited. As important port, airport, and coastal infrastructure functions should be maintained, the strategic maintenance, renewal, and other measures to maintain such functions are strongly required.

Therefore, we are trying to establish methods for structure design and material selection which are excellent in terms of maintenance, and will develop techniques and technologies regarding various countermeasures for maintenance phase.

Research Topics

Research and development were conducted on infrastructure lifecycle management with emphasis on the following subthemes:

- Research on infrastructure inspection and diagnosis techniques
- Research on technologies for prolonging the life of infrastructure

Activities in FY 2021

○ **Research on infrastructure inspection and diagnosis techniques**

- Study on application of inspection and diagnosis systems for improvement of performance evaluation of marine structures

As some parts of marine structures are difficult to inspect by eye, it is necessary to introduce monitoring using sensors and other devices in order to evaluate and predict the process of deterioration of their concrete and the efficacy of measures deployed to suppressdeterioration. In this study, we developed a technique that can evaluate and predict the performance of the structural components as a whole, integrating both numerical analysis and on-site monitoring. Specifically, we focused on the expansion-induced deterioration resulting from the alkali silica reaction (ASR) and were able to successfully simulate the aforementioned deterioration process facilitated by ASR through finite-element analysis. We then developed an analytical platform that can examine the structures of components while factoring in their deterioration conditions and started on-site monitoring of actual marine structures using the platform.

- Development of adaptive technique for inspection vehicle to disturbance in operation

Concerning ROVs for inspecting the superstructures of piers, we integrated into them our technology that would allow them to deal with external disturbances and improved the countersteering capability that was included in the stationary positioning system (i.e., thrust adjustment, countersteering, etc.) implemented in the previous year. We then took the pier superstructure inspection ROVs to three ports (one of which was during the night) and investigated the bottom surfaces of the pier superstructures there, which allowed us to verify the effectiveness of the ROVs and their upgraded stationary positioning capability in executing inspection tasks beneath piers where visibility is low. Furthermore, as the on-site tests investigated different types of piers such as inclined-pile and jacket-covered pier structures, the applicability of the techniques being developed to actual piers was verified.

Stationary-positioning-enabled inspection ROV for investigating the bottom surface of a pier

○ **Research on technologies for prolonging the life of infrastructure**

- Evaluation of longterm durability of concrete, steel and various materials based on exposure test

We set up a long-term exposure test facility to examine a method of predicting concrete corrosion induced by chlorine, the cathodic protection characteristics that affect steel bars in reinforced concrete, the conentrated corrosion mechanism of steel components, and the cathodic protection characteristics present near LWL. We also acquired data on the durability of various wood materials in this study.

- Development of the performance evaluation method in protective coating for marine structures

We have been continuously performing exposure tests (for 37 years as of FY 2021) at the Hazaki Oceanographical Research Station (HORS) to examine various coating methods for protecting steel piles in order to establish a method for predicting deterioration applicable to protective-coated steel structures. In addition, we worked on elucidating the deterioration mechanism of petrolatum-coated structures based on the findings from our accelerated weathering and indoor exposure tests along with the aforementioned exposure tests conducted at the HORS.

We then summarized the results of the study conducted in the previous year (on the 18-year-old surface-coated pier superstructure) to verify the applicability of the anti-corrosion coating (surface coating method) to concrete port structures.

- Study on improvement of productivity of concrete works in port structures

In order to solve the problem with pile head joints using precast concrete for installation at piers, we conducted a loading experiment and numerical analysis involving a 1/2-scale model comprised of steel-pipe piles and RC beams joined together. For this experiment, we used the commonly used method in road bridge construction for connecting the pile foundation and the footing to make the pile head joints. The experiment verified that the newly applied method was superior to the jointing method used in the previous year's experiment in terms of the structure it created, which allowed the pier model to sustain its load-bearing performance as the amount of displacement increased. However, as the model's load-withstanding mechanism involved the steel-pipe piles mainly handling the load on the compression side and the in-built rebars mainly handling the load on the tension side, we were able to determine that the decreased stationarity of the pile heads would not pose any issue in operational application.

- Study on the effectiveness of the design and implementation of concrete pavement at airports

Wire meshs are typically installed on the concrete pavements at airports to prevent the spread of cracks and maintain the integrity of the rebar joints underneath them, while preventing foreign objects from falling into the cracks. However, the effectiveness of this design and implementation method was not enough to be proven, so we conducted a study for this purpose. We used the test pavement that was constructed in the previous year and conducted a dump truck loading experiment on it, with and without wire mesh covering, to compare the results and determine whether the covering had any effect on the occurrence of cracks, but no significant difference was observed in the experiment.

○ **Study on the applicability of sustainable materials under marine environments**

To create a sustainable society, it is desirable to reduce the use of natural resources and CO_2 emissions when constructing buildings (mainly made of concrete). It is also preferable to improve the performance and usable lifespans of structures, and enhance their safety margins against temporal deterioration and natural disasters.

To this end, the use of recycled materials has proven to be effective (various slag frame materials, ground granulated blast-furnace slag, fly ash, etc.). However, these materials have not yet been widely used in actual construction projects. The non-use of these materials might be due to their undefined performance requirements, and the lack of a method for evaluating their long-term durability, etc.

To address this, we conducted various activities, including evaluating the performance characteristics of concrete made of recycled materials (in terms of usability in construction, durability, etc.), outlining the performance requirements that would apply to concrete port structures (mainly non-steel-reinforced), examining methods for evaluating their long-term durability, and assessing the applicability of the nature-friendly materials (especially recycled ones) (comprehensive examination of their environmental impacts (CO_2 emissions, etc.) in addition to their durability that had been covered in previous research), etc.

2C Research on Effective Use of Existing Infrastructure Facilities

Background and Objectives

There is strong demand to improve the functions of existing infrastructure and use them effectively as possible. Requests include measures to handle increasing cargo volume and larger ships and vessels, diversification of airport functions, and countermeasures to deal with existing facilities which can no longer be used due to increased external forces and other reasons. In addition, regarding waste disposal sites at ports which accept industrial and non-industrial waste, there is social demand for the highly effective use of them. On the other hand, it has become difficult to secure disposal sites which accept soil dredged from water channels for shipping routes. Accordingly, it is necessary to prolong the life of soil disposal sites.

Therefore, we will develop the following: techniques to improve the functions of existing infrastructure and to renew and efficiently change the intended use of existing infrastructure; techniques to reduce or effectively utilize construction byproducts; and techniques to effectively utilize waste disposal sites at ports.

Research Topics

Research and development were conducted on the following subthemes for efficient facility renewal, effective use of construction byproduct soil, utilization of waste disposal sites at sea, etc.

- Research on techniques to improve or renew existing facilities
- Research on effective use and techniques of treating construction byproducts
- Research on management and utilization of waste disposal sites at sea

Activities in FY 2021

○ **Research on techniques to improve or renew existing facilities**

- Study on process leading to rupture of pier structure for high definition of performance regulation

While the performance requirements of piers can be broken down into different categories such as usability, repairability, and safety, the current performance specifications only cover the locations and amounts of residual displacement and plasticized hinges, etc. and fail to provide rules on their practical usability and repairability. To address such shortcomings, it is crucial to understand the fracture process of entire pier structures in detail, including the behavior of their components following yielding and plasticization. For this purpose, we examined several performance design concepts that could be applied to piers in the future, and identified potential issues that might exist with their performance assessment methods. Specifically, we considered an optimal approach to defining the performance requirements of non-anti-seismic facilities in withstanding accidental limit states and the performance regulations that would be applied to anti-seismic facilities. In addition, we identified and organized the potential issues that might exist with each of the performance assessment methods.

- Development of quality evaluation method for ground improvement using geophysical exploration

As no effective method currently exists to three-dimensionally observe the status of improved materials underground after chemical grout is injected into inhomogeneous ground to prevent liquefaction, we conducted a study to establish methods of evaluating the quality of improved ground and construction management based on geophysical surveys that would not require soil sampling. Furthermore, we conducted an laboratory model experiment to examine the applicability of our geophysical survey method that is capable of real-time monitoring to the investigation of the changes in ground condition that would occur following chemical grout injection.

○ **Research on effective use and techniques of treating construction byproducts**

- Development of core-less soil investigation and fundamental study to establish Digital Soil Mechanics

To improve the existing ground survey methods that utilize digital data including CT images and also develop a novel ground survey method, we are developing an “in-situ digital sampling method” that involves X-ray CT scanning of the core of in-situ ground, along with a series of testing and analysis techniques for evaluating the engineering characteristics of the ground based on the acquired CT images.

For this purpose, we used the results of the model experiment conducted in FY 2020 to improve our drilling machine that has a built-in X-ray CT scanner and conducted another drilling test, which revealed that the drilling was able to penetrate the ground to the specified depth and scan the core there. The images obtained were so clear that we could discern the gravel particles in the ground.

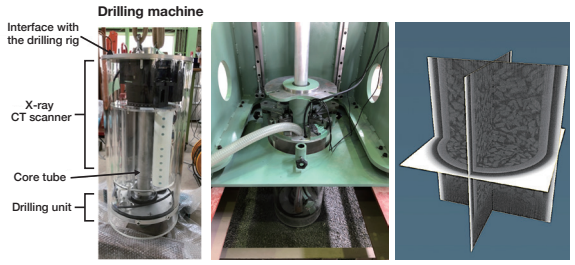
- Effect of defective part of solidified body on its internal stability

We performed numerical analysis to examine how weak sections would affect the stress-strain relationship of unconfined compression test, varying the strength ratio of weak and sound sections, weak section size, and the locations of the weak sections within the specimens. The analysis indicated that, if the solidified specimens contained some weak sections, the strain at failure would not increase, while exhibiting the same effects as crack-type disturbances that would only result in decreased strength.

In addition, we placed a clay slurry that had been frozen with liquefied nitrogen in a mold, poured a slurry of cement-improved soil into the mold, and cured it to create specimens having unimproved weak sections, and conducter uniaxial compression test. The uniaxial test, during which the content ratio and locations of the weak sections were changed in various ways, revealed that the specimen that had weak sections more widely distributed across its mass was less affected in terms of its uniaxial strength deterioration.

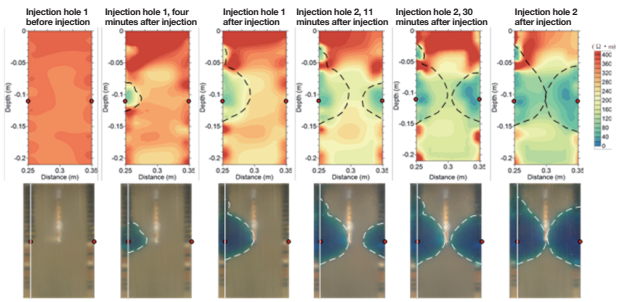
○ **Research on management and utilization of waste disposal sites at sea**

On this research topic, we continueto gather information on the needs related to the land use of the sites and identify the issues involved.

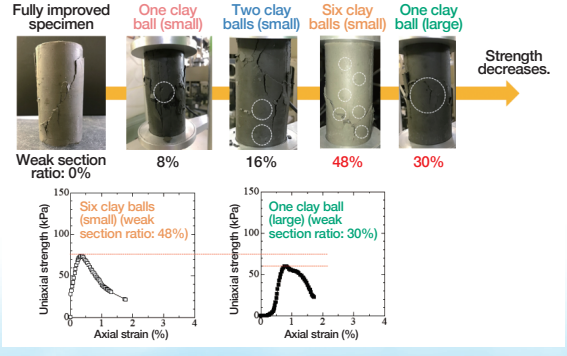


Drilling machine with built-in X-ray CT scanner and drilling experiment

CT image captured underground after drilling



Real-time measurement results
(top: geotechnical survey; bottom: actual ground condition)



Comparison of weak-section ratios and peak strengths

3A Research on Development and Utilization of Oceans

Background and Objectives

Since the 1960s, the importance of marine utilization and development has been pointed out. Various approaches for this purpose have been taken, but the progress remains inadequate. One of the reasons is the lack of infrastructure at sea as a hub. Therefore, marine hub ports should be constructed on remote islands including Minamitorishima Island and Okinotorishima Island to promote marine utilization and development. These remote islands are surrounded by severe sea wave environment and severe sea climate for port construction which are different from those of general ports in main islands. Further technological development is required to ensure smooth ship berthing, cargo-handling, and port construction.

Therefore, in this research theme, we will make maximum use of previously accumulated knowledge regarding waves, sea-bed ground, port structures, and port construction to construct ports on remote islands, and will also promote marine utilization and development. Specifically, we will clarify the characteristics of waves in isolated reef areas, and will develop a new mooring system for ships. We will also develop technologies for downsizing and reducing the weight of underwater acoustic video cameras, as well as utilization and development.

Research Topics

Research and development are being conducted on the following subjects for the development and utilization of oceans.

- For our development of a fender system for automatic ship berthing/unberthing, we are conducting elemental experiments using a scale model focusing on the adsorption mechanism of the fender system to examine its structural stability including the adsorption effect.
- For our research on underwater construction machines that utilize machine guidance technology to integrate multiple functions, we are creating the basic design of a task information presentation system with which the machines can be adapted to other types of work, while modifying the foundation-leveler attachment for better adaptation to actual on-site operations and conducting tests to check the accuracy of the acoustic positioning system.
- For our research on an acoustic imaging system, we are examining the feasibility of implementing the acoustic system in the project for harnessing ICT in dredging, based on the results of actual sea area dredging experiments that had been conducted by the previous year involving seafloor excavation and soil replacement tasks.
- For our research on the wave force and scouring that affect offshore wind power generation facilities, we are comparing and examining the wave force calculation results that were obtained in the previous year from the wave force experiment data and numerical simulation (CADMAS-SURF) and are also conducting a large-scale experiment on scour protection around a circular cylinder.
- For our research on the horizontal resistance characteristics of pile foundations at offshore wind power generation facilities, we are conducting horizontal loading experiments repetitively under such conditions that are more similar to actual related phenomena, including a centrifugal model experiment that involves the use of a wave generation machine and a multi-directional loading experiment.
- For our research on the mechanical properties and durability of infrastructure materials in the deep sea, we are experimentally studying the physical properties of concrete under high water pressure loading. We have also recovered the test specimens exposed to the deep sea floor in the Nankai Trough (underwater depth of approx. 3,515 m). We are analyzing the data of the internal water pressure and the strain data monitored during exposure along with their deterioration condition, etc.

Activities in FY 2021

○ Concerning advancement of harbor tranquility in a remote island, we selected a quay by complex wave field that is created due to multiple wave reflections and performed wave deformation calculations using NOWT-PARI to obtain wave data penetrating the quay. While a remote island quay is also exposed to a similar wave field in an ocean, we applied both the conventional and our novel methods to calculate the amounts of ship oscillation moored there. The former is conducted by assuming that all the waves are one-directional and assigning them to the frequency spectrum, and the latter is conducted by entering the surface wave profiles into CADMAS-SURF/3D which is improved for calculating with floating objects. We then compared the calculation results obtained using the two different methods and examined the differences.

○ As for the development of a fender system for automatic ship birthing/unberthing, we conducted elemental experiments using a scale model to test the adsorption mechanism of the fender system and were able to verify its structural stability including the adsorption effect. Also, we reviewed the results of the numerical calculation using a moored ship oscillation simulation to examine the effectiveness of the fender system in terms of its mooring capability, etc. for ships while they are moored for cargo handling.

○ For our study on methods for enhancing marine ecological values on gray infrastructure toward establishing green-gray hybrid infrastructure, we installed several different types of test specimens along a seawall on the coast of Kitakyushu. Then, we monitored the development of algae. Also, we tested several substrate materials (steel, stainless steel, and acryl) to develop a technique for coral reskinning to clarify the substrate preferred for coral covering. Also, we performed instrumental analysis to elucidate the mechanism of coral covering. Furthermore, we analyzed several existing cases of green-gray hybrid infrastructure installations in Japan and other parts of the world. This was done to organize the ideas on the optimal hybrid infrastructure concept in terms of global land space scale and local structure(s)-scale.

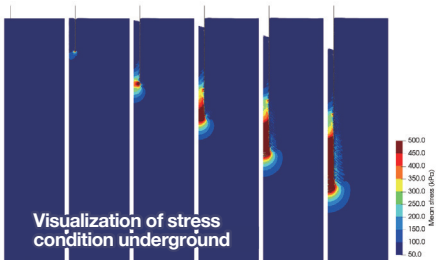
○ For the integration of multiple functions in our underwater construction machines utilizing machine guidance technology, we conducted a review of the functions for adapting our task information presentation system to other types of work. In addition, we took the machines to Naha Port and Ishigaki Port to examine how well adapted the mounted underwater machine guidance technology and the remote operation support system were to actual operation sites and identified potential operational issues that needed to be addressed.

○ For the application of our acoustic imaging system to ICT-based construction projects, we conducted an underwater visualization experiment using acoustic video cameras for real-time monitoring of construction tasks as they were being executed, with the eventual goal of achieving autonomous operation of dredging ships. In addition, we established a multibeam data cloud processing system (AIMS) and conducted a surveying test with it (4G and local Wi-Fi) that involved marine telecommunication. Concerning our ICT-based underwater surveying project, we measured data from the top surfaces of rubble mounds at structures' foundations and verified the measurement precision of our technique by comparing the data to the cross-sections of the structures' designs, and also developed a visualization tool, etc. that could be applied to both underwater and on-ship tasks.

○ For our study of the wave force and scouring that affect offshore wind turbine foundations, we conducted a large scale hydraulic experiment on the effectiveness of a stone filled net as a scour protection around the circular cylinder of offshore wind turbines at the Large Hydro-Geo Flume (LHGF).

○ Concerning the research on the horizontal resistance characteristics of the pile foundation at an offshore wind power generation facility, which is subject to various fluctuating loads, we built model piles that have larger diameters than the ones made in the previous year and tested them in a pile penetration and horizontal loading experiment in a large soil tank to examine the effects of pile diameter on the horizontal resistance characteristics of the piles. In addition, we used a numerical analysis method that could simulate the process of piles penetrating the ground to study how the process would affect the horizontal resistance characteristics of the piles.

Horizontal loading experiment involving a large-diameter pile



Numerical analysis of the pile penetration process

○ Concerning the research on load setting method for offshore wind turbines in wind and waves, using meteorological, oceanographic, and structural data corrected in the previous year, we investigated the dynamic response characteristics of 5MW, 10MW, and 15MW offshore wind turbines to wind and waves through a coupled load analysis called OpenFAST.

○ Concerning the research on the mechanical properties and durability of infrastructure materials in the deep sea, we performed loading experiment under high water pressure on the infrastructure materials. Also, we developed the tanks in which low temperature seawater flows. Thanks to these tanks, we clarified the durability of concrete in a low-temperature seawater. As a result, the rate of deterioration is different for different types of cement-based materials. Furthermore, we recovered a circular column specimen from the deep sea floor at 3515 m in the Nankai Trough exposed for 1 year. The specimen was subjected to instrumental analysis. We also started a new exposure experiment involving reinforced concrete beam specimens.

4A Research on Enhancement and Utilization of Coastal Ecology

Background and Objectives

Rich ecosystems in coastal zones include tidal flats, eelgrass meadows, and coral reefs, the coastal zones are valuable places for the global environment. However, during high economic growth period, intense socio-economic activities caused the deterioration of water quality especially in coastal inner bays and enclosed waters, resulting in ecosystem damage. Thanks to subsequent countermeasures, water quality has gradually been improving in some coastal zones; however, recovery of the coastal zone environment including ecosystems remains a formidable challenge. Meanwhile, there are new challenges looming, including the need to utilize the coastal zone functions to alleviate climate change and to address the issue of large-scale oil spills from coastal industrial complexes, etc.

Therefore, we are focusing on activities to help restore the coastal environment, alleviate climate change, and develop technologies to better deal with large-scale oil spills. The greenhouse gas absorption effect (blue carbon) of coastal ecosystems and propose measures to effectively utilize this function. In addition, we will also develop a system to predict the water environment in Tokyo Bay and Ise Bay using real-time data, such as the occurrence of red and blue tides. Furthermore, we will be developing a next-generation oil recovery system for use by the oil recovery fleet owned by the Ministry of Land, Infrastructure, Transport and Tourism, along with a new technology to deal with oil spills from coastal industrial complexes, etc. that are caused by earthquakes and tsunami.

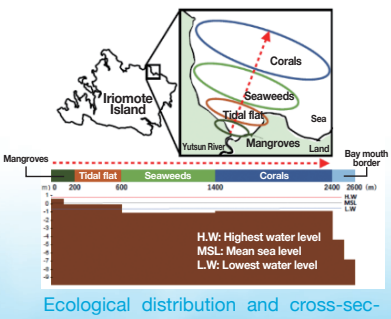
Research Topics

For research and development on the preservation and utilization of coastal ecosystems, we are focusing on the following subthemes.

- For our research on examining the previously developed global dynamics model for predicting the rate of carbon dioxide absorption and flood suppression effects in shallow coastal areas, we are verifying the model by comparing its calculation results with the observed carbon dynamics data, while consolidating and improving its sub-models that simulate the elements constituting the related processes (wave model, topography and seabed sediment model, and ecological model).
- For our initiative to create coastal topography and geo-designs that would facilitate both disaster mitigation and ecological environment preservation, we have consolidated all the knowledge and insights that have been obtained thus far and are in the process of creating and proposing coastal topography and geo-designs as described above that will be conducive to mitigating disasters that could be caused by various types of dynamic external forces in coastal areas while promoting biodiversity.
- For our research on techniques to improve the functions of eelgrass meadow ecosystems, we are examining methods of maintaining and restoring eelgrass meadows while studying model cases from the Seto Inland Sea, etc. In addition, we are evaluating the function of eelgrass meadows as feeding grounds by conducting experiments involving seagrass-inhabiting fauna to observe their feeding behavior, etc.
- For our research and development on techniques for mitigating oil pollution, we are improving our network-adaptive oil movement prediction system. In addition, we are conducting experiments to enhance the function of bubble curtains in terms of their oil collection characteristics, etc., studying the feasibility of implementing bubble curtains on environment management vessels, and examining techniques for extracting oil from sunken vessels.

Activities in FY 2021

○ For our research on examining a global dynamics model for predicting the rate of carbon dioxide absorption and flood suppression effects in shallow coastal areas, we developed and examined our global carbon circulation and ecosystem model and wave and topography model, while continuously gathering related topographical and ecological data and performing analysis using GIS. In addition, we conducted on-site observations and experiments related to carbon dynamics in large-scale seaweed farm, performed numerical model analyses, and prepared a report summarizing the results. Furthermore, we conducted a trial operation of the new carbon credit scheme (J-Blue Credit) and published the crediting scheme guidance, which is a joint project between the Japan Blue Economy Association (JBE) and the MLIT.



Ecological distribution and cross-sectional topography of the model site

○ For the creation of coastal topography and geo-designs that would promote both disaster mitigation and ecological environment preservation, we have created and proposed our coastal topography and geo-designs as described above that can help mitigate disasters that could be caused by various types of dynamic external forces in coastal areas while promoting biodiversity, based on our consolidated knowledge and insights obtained thus far.

○ For the monitoring and analysis of atmospheric and oceanographic environments that typically exist at bay mouths, we started conducting atmospheric monitoring that involves continuous observation and measurement of the atmosphere using small sensors that had been developed by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC). Meanwhile, we have been continuously conducting oceanographic monitoring that involves observation of oceanic flows and water quality. In this connection, we have analyzed massive amounts of data obtained over the years related to Tokyo Bay and examined the complex 3-D flows and water quality components that occur at its bay mouth.

○ For the numerical examination of how aquatic ecosystems respond to changes in their environments, we have used the numerical simulation model that had been developed by the previous year to perform another analysis of past data on Ise and Mikawa Bays in order to evaluate the impact of the environmental changes on their topographical and influx load changes as well as how the changes in water quality there were affected.

○ For the development of techniques to improve the functions of eelgrass meadow ecosystems, we studied the Seto Inland Sea, etc. as a model case and organized the data indicating the environmental conditions of eelgrass meadows and the degree of ease with which their seeds could be introduced in the region to evaluate more effective eelgrass restoration methods (environmental improvement or transplant). In addition, for the development of methods to evaluate the function of eelgrass meadows as feeding grounds, we conducted an investigation applying environmental DNA techniques along with a feeding experiment involving the fauna that inhabit eelgrasses, and evaluated eelgrass meadows for their feeding ground function.

○ For the elucidation of oceanic flows and water quality conditions in coastal areas through data assimilation, we analyzed the results of year-round data assimilation that used actual water temperature and salt content data obtained from Ise Bay, and examined the differences that arose due to different assimilation techniques.

○ For the initiative to improve platforms for gathering and providing coastal information applicable to major inner bays, we started wave monitoring at the mouth of Tokyo Bay using 4K high-resolution imaging technology. In addition, we started developing a new output platform for distributing information obtained from biodiversity databases, coastal inundation maps, Tokyo Bay statistics, data observed by ferries, etc.

○ For the research and development of new techniques that can be used to prevent and remove various oil spills caused by natural disasters and other events, we have developed a web-based application system that can predict oil drifts using a web browser from any terminal connected to the internet. Meanwhile, for the development of a new oil recovery system, we are developing a system that collects oil by combining underwater bubble curtains and terminal ejectors for oil suction, which have no oil collection boom or oil recovery pump. The pertinent technologies applied in this system are registered or being registered as our intellectual property rights. In addition, to address the present phenomenon of drifting pumice clasts, we examined a pumice collection apparatus, partially utilizing the elements of the aforementioned oil recovery system.

4B Research on Coastal and Estuarine Processes

Background and Objectives

Sediment transport research at the Port and Airport Research Institute began with the study of the depth of movement limit to prevent navigation channel burial, currently the research has shown that the method of preventing channel burial is not only for sand, but also for silt. However, in Japan there are still ports and harbors that are in the process of being buried. In addition, overseas, there are ports and harbors where much more sediment is expected to be deposited than in Japan, and the technology to deal with the burial of these navigation channels and anchorage is not sufficient. Meanwhile, many precious natural beaches were lost during the period of rapid economic growth, and this negative trend is yet to be reversed. Although the many benefits that beaches yield for protection, environmental conservation, and human use are clearly recognized, and they are being restored on certain coastlines by taking measures to suppress coastal erosion, global warming is also expected to exacerbate coastal erosion in the future. Also, when remote islands and overseas are taken into account, it is important to maintain not only beaches but also coral-reef coasts.

PARI is currently focusing on identifying means for effectively preserving both natural coastal topography, such as beaches, mangrove shorelines, and coral-reef coasts, and artificial coastal features, including navigation channels and anchorage that are crucial for logistics, despite the ongoing trend of climate change. In addition, PARI is working to predict key changes in coastal erosion as well as sedimentation and siltation affecting navigation channels and anchorage, and to suggest measures to effectively address these issues while assuming that the trend of global warming might persist. Furthermore, we will clarify siltation processes in the estuaries of large rivers, mangroves and intertidal zone in the Asian countries, and then propose countermeasures against such phenomena.

Research Topics

For research and development on the formation and preservation of coastal topography, we are focusing on the following.

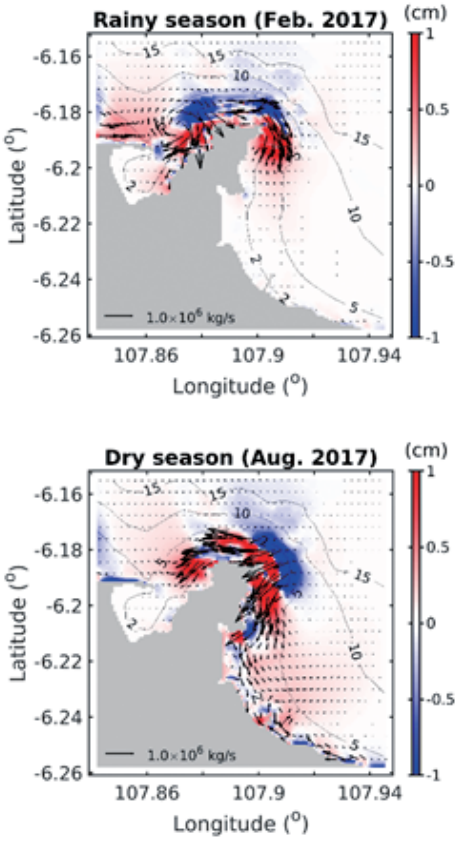
- For the development of a global-scale prediction method of beach morphological changes induced by global climate change, we are generalizing the parameters of an existing equilibrium-based shoreline change model and applying the model to predict future shoreline changes in various beaches in response to the future climate change scenarios. We are also developing the beach profile change model using deep neural networks.
- For the observation activity at the Hazaki Oceanographical Research Station (HORS) and the development of a coastal topographical change prediction model, we are continuously conducting on-site observations at the HORS while examining the predicting methods for topographical changes that would arise around the ports and coastal areas.
- For the development of sediment transport control methods to mitigate channel and anchorage siltation, we are incrementally applying the sand-mud-mixture sediment model to actual coastal and harbor areas. For this purpose, we are developing a simulation system that reflects the sediment dynamic characteristics of each sea area to be studied, and to study measures to mitigate the amount of sediment deposited in the sea.

Activities in FY 2021

○ For the development of a global-scale prediction method of beach morphological changes induced by global climate change, we have developed a beach profile change model using deep learning and reproduced temporal beach profile changes and temporal components obtained from REOF analysis of beach profiles.

○ For the observation activity at the HORS and the development of a coastal topographical change prediction model, we have developed a monitoring method of wave directions with photographic data obtained from our oceanographic observation cameras. We also examined our coastal topographical change prediction model that can consider the topographical changes due to breaking waves.

○ To elucidate the mechanisms of sediment transport near estuaries and accumulation in navigation channels and anchorage, a bottom sediment transport tool was established for the Patimbang coast of Indonesia, taking into account the variation of external wave forces due to changes in the wind field specific to the Java Sea (i.e., monsoons and onshore-offshore breezes), and further improved into a numerical tool that can take into account the detailed geometry of port facilities (navigation channel dredging topography, outer facilities, etc.).



Sediment transport simulation, reflecting the typical characteristics of changes in wind fields in a tropical region

Fundamental Research in FY 2021

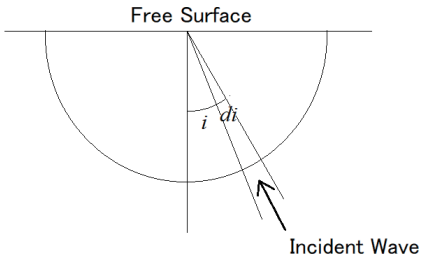
The fundamental research of waves, beaches, ground, earthquakes, environments, etc., is the basis of every study conducted by PARI, and therefore we are actively working on clarifying principles and phenomena, such as the mechanisms of natural phenomena and dynamic behavior of the ground and structures.

	Research theme (Fundamental research)
1	Strong motion earthquake observation in port and airport area
2	Investigation of earthquake disaster
3	Development of strong motion estimation method for near-fault strong ground motions
4	Development of new prediction and assessment methods for liquefaction-induced settlement and flows
5	Deformation/failure behaviours and reinforcement methods of coastal and geotechnical structures subjected to waves and water flow
6	A Study on Tsunami Wave Forces on Mangroves and Their Deformation
7	Elucidation of oceanographic phenomena based on central processing and analysis of observation data
8	Improvement of wave prediction model for Coastal Areas of Japan
9	Evaluation of longterm durability of concrete, steel and various materials based on exposure test
10	Development of the performance evaluation method in protective coating for marine structures
11	Study on the applicability of sustainable materials under marine environments
12	Study on process leading to rupture of pier structure for high definition of performance regulation
13	Development of core-less soil investigation and fundamental study to establish Digital Soil Mechanics
14	Study on the volume reduction of dredged soil by electro-osmosis dehydration
15	Elucidation of the horizontal resistance characteristics of pile foundations for offshore wind power plants under various fluctuating loads
16	Evaluation of mechanical properties and durability of infrastructure materials in deep sea
17	Experimental study on methods for enhancing marine ecological value on gray infrastructure toward establishing green-gray hybrid structure
18	Validation of the newly developed global dynamic model for the projection of atmospheric CO_2 uptake rate and inundation control in shallow coastal ecosystems
19	Development of the methods for increasing ecosystem functions in eelgrass meadow
20	Numerical study on responses of aquatic ecosystem to an environmental change
21	Observation of coastal phenomena at HORS and development of numerical simulation of topography change for port and surrounding beaches
22	Developing future projection model of coastal change in the context of climate change
23	Development of sediment transport control method to minimize harbor siltation

Cases of Fundamental Research

Development of strong motion estimation method for near-fault strong ground motions

One of the important factors that determine the characteristics of strong seismic motions is site amplification characteristics. The site amplification characteristics can spatially vary significantly, even within the same port & harbor. For the zoning of site amplification characteristics, the horizontal-to-vertical Fourier spectral ratio of constant-microtremor (constant-microtremor H/V spectrum) is used. While this constant-microtremor H/V spectrum is an essential tool for practical purposes, there is still a debate on how it can be interpreted in terms of elastodynamics. Although some scientists have argued that the spectrum indicates the particle trajectories of Rayleigh waves, a highly plausible new theory has recently been proposed that claims that the spectral ratio of the reflected waves that occur when horizontal and vertical impulse excitations are applied at the ground surface represents the constant-microtremor H/V spectrum (Sanchez-Sesma et al., 2011). To prove the veracity of this theory, a wide range of preconditions must be satisfied, one of which is that the energy ratio of the S-to-P waves transmitted through the bedrock must be $2(\alpha/\beta)^3$. As for our FY 2021 activity related to this theory, we conducted theoretical reviews to determine whether the aforementioned precondition could be met and also published parts of our research findings in a scientific journal in English (Nagasaka and Nozu, 2022). According to our study, when S-waves and P-waves are isotropically incident on a free surface leading to repeated reflections, the energy ratio of the S-to-P waves might increasingly approach $2(\alpha/\beta)^3$ regardless of the initial conditions.



Plane waves incident on a free surface from an arbitrary direction (Nagasaka and Nozu, 2022)

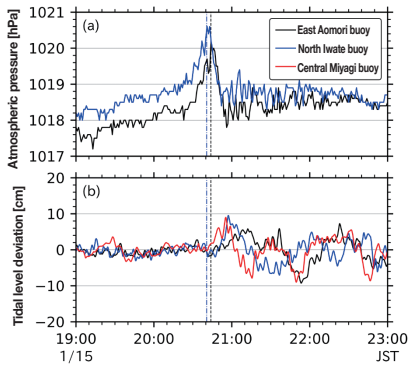
Elucidation of oceanographic phenomena based on central processing and analysis of observation data

In this research, we are continuously processing and analyzing oceanographic observation data obtained by the Nationwide Ocean Wave Information Network for Ports and HArbours (NOWPHAS) to elucidate the characteristics of wave occurrence at each port, and conducting detailed analysis of the most remarkable marine oceanographic cases that occurred during the relevant year.

In recent years, waves and storm surges caused by Typhoon Jebi (Typhoon No. 21) in 2018 and Typhoon Faxai (Typhoon No. 15) in 2019 caused significant damage to port facilities in Osaka Bay and Tokyo Bay, respectively. However, the waves that were observed and analyzed during 2020 indicated that no major high waves occurred along the coast of Japan, as few typhoons formed near Japan or approached it.

On the other hand, as a remarkable example of oceanographic other than waves, we analyzed the tidal change (tsunami) reaching to the Pacific coast of the Tohoku region following the eruption of a submarine volcano in Tonga on January 15, 2022.

As a result of the analysis, a maximum tsunami of about 106 cm was observed at the tide station at Kuji Port, and a tide level deviation occurred immediately after the rapid rise and fall in a short period, of the onboard barometer on the GPS wave buoys installed offshore, suggesting that at least the initial tide level deviation was caused by an air vibration phenomenon due to atmospheric waves, we were able to obtain valuable observation results.



Chronological changes in atmospheric pressure (a) and tidal level deviation (b) measured by GPS wave buoys.
★The figures clearly indicate that the tidal level deviations occurred immediately following the sudden fluctuations in atmospheric pressure.

Evaluation of longterm durability of concrete, steel and various materials based on exposure test

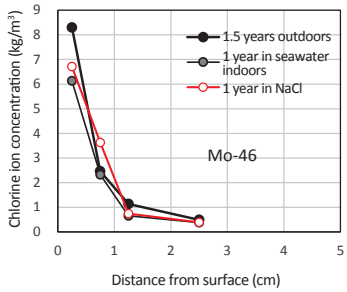
Port and airport facilities are generally required to have the useful lives of 50 to 100 years. On the other hand, the environment in which they are located is extremely harsh, being a marine environment. Long-term durability evaluation of various types of construction materials (concrete, steel, anti-corrosion agents, etc.) under such harsh environment will be evaluated based on exposure tests under the same actual environmental conditions will be expected.

In this study, we are assessing the long-term durability of various construction materials in marine conditions based on long-term exposure tests conducted under the same actual environmental conditions as those where they would be used, to provide useful information for deciding which materials might be suitable for constructing specific facilities. Our main activities conducted in FY 2021 are as follows.

We examined methods of predicting chlorine-induced concrete deterioration (salt diffusion characteristics, etc.) and studied how concrete itself progressively degrades under the effects of seawater, etc.

We conducted exposure and other tests in seawater circulation tanks and actual environments and examined the intensive corrosion mechanism that affected steel components, along with the cathodic protection characteristics that would typically manifest near L.W.L.

We studied the durability of various wood materials in seawater and air.



Result of test on Moroccan-made concrete
(chlorine ion penetration after 1.5 years of exposure)

Study on the volume reduction of dredged soil by electro-osmosis dehydration

According to increase size of vessels, a large amount of dredged material is occurred every year by dredging for the purpose of maintaining and improving navigation channels and anchorage areas, as well as for the purpose of increasing the depth in front of the wharf, etc.

It is thought that the consolidation dehydration is effective volume reduction method of dredged soil.

One of the measures to dispose of more dredged soil is to reduce the volume of dredged soil.

One particularly promising approach is consolidation dehydration method by electro-osmosis. The electro-osmotic dehydration is the application of electric current to the soil through electrodes that are inserted into the saturated soil where water can be drawn from the anode to the cathode via electro-osmosis. By this process, dehydration of pore water occurs on the cathode side.

For this research, the objective of the project is to examine the applicability of electro-osmotic dehydration as an effective method of reducing the volume of dredged sediments. As for our activities conducted in FY 2021, we built a consolidation test apparatus that could conduct electricity. We examined the electro-osmotic consolidation tests of Tokyo Bay clay and Kaolin to consider the effectiveness of electro-osmotic dehydration.

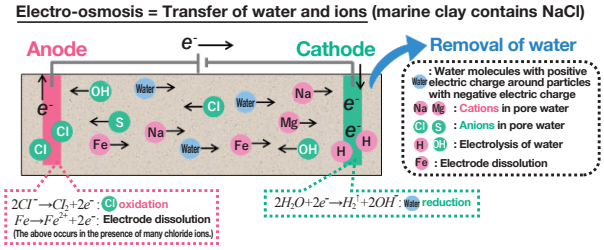
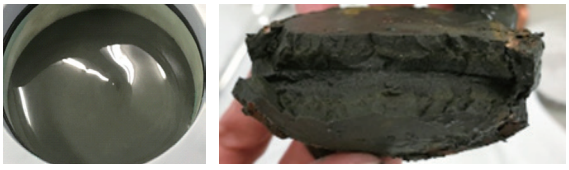


Illustration of electro-osmosis



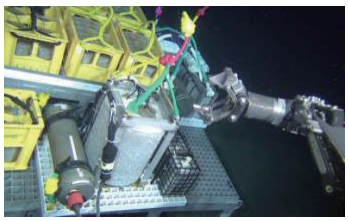
Clay sample from Tokyo Bay, before and after the electro-osmotic consolidation and dehydration test

Evaluation of mechanical properties and durability of infrastructure materials in deep sea

Japan is a maritime nation surrounded by the sea, with its vast territorial sea and EEZ mainly consisting of deep sea areas with 200 m or more deep. As in recent years, the utilization of the deep sea has been considered in various fields, so the need for deep-sea infrastructure for these activities is also becoming increasingly recognized.

Infrastructure materials such as cementitious materials and steel infrastructure materials, are important materials for building, however how they behave in the extreme environment of the deep sea is largely unknown.

In particular, the deep sea zone between 100 to 300 m below sea level is considered the optimal range for deploying floating offshore wind turbines, etc. in the future, for which concrete and other materials could be used to make anchors, but more basic data is needed.



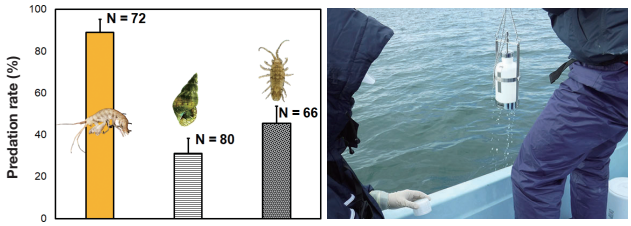
On-site measurement of exposure test specimens near the seabed at a depth of 3500 m

In this research project, the objective of which is to evaluate the mechanical properties and durability of infrastructure materials in the deep sea, we first installed hardened cement-based materials 3500 m below sea level in FY 2020 and recovered them in July 2021. The specimens were then investigated to elucidate their mechanical properties and to assess the characteristics of their surface degradation, etc. We also conducted in-situ measurement of their strain and internal water pressure to clarify the deformation behavior, etc. of the specimens under the deep sea. Furthermore, we conducted an indoor experiment using an X-ray CT scanner and clarified the relationship between the process of liquid water infiltration into the hardened cement-based materials and the specimens' strain development under high water pressure.

Development of the methods for increasing ecosystem functions in eelgrass meadow

Port development and operations often entail nature conservation measures, including the development of artificial shallow areas and seagrass meadows. However, as the functions of seagrass meadows widely vary by location and time, it is not easy to evaluate how their functions would manifest and what they signify in terms of humans' attempts to protect the environment.

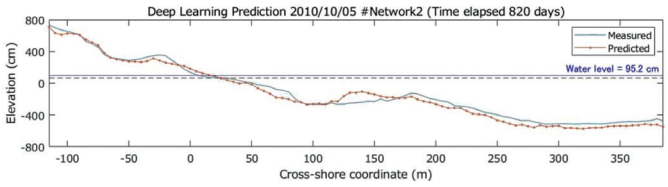
In this study, which focuses on the function of seagrass meadows as feeding grounds for fishes, etc., we conducted a large-scale on-site experiment and revealed that amphipods and other crustaceans would be good prey for fishes, etc. Furthermore, we developed a low-cost research method for monitoring the functions of seagrass meadows using environmental DNA metabarcoding. These findings indicate that such artificial development of seagrass meadows, which provide stable habitats for gammaridean amphipods and other crustaceans, might allow those seagrass meadows to serve as viable feeding grounds for fishes, etc. We have also identified a practical method of monitoring their functions.



Useful findings for improving the function of seagrass meadows
(Left) Result of on-site experiment in seagrass meadows
(Right) Research method utilizing environmental DNA

Developing future projection model of coastal change in the context of climate change

There is a growing need to precisely predict beach morphological changes caused by future sea level rise and wave climate changes, and to devise appropriate countermeasures for addressing the coastal disaster risks induced by such coastal changes. In this research project, we aim to develop a numerical model predicting the shoreline changes caused by climate change applicable to various beaches based on long-term beach monitoring data. We have established a prediction model using LSTM network, which is one of the deep neural networks. Against this model, it was trained using the daily changes of coastal topographic section over the past 18 years observed at Hasaki coast and the daily changes of coastal topographic section for the following six years were predicted, and verified. Although the prediction accuracy of longshore bar morphology was not necessarily good enough, for foreshore topographic is stable for long period, it could be predicted high precisely. For climate change and related topographic change of prediction, further research will be needed.



Beach profile predicted by the LSTM network (brown) roughly two years following the start of calculation and observed profile (blue)

Exploratory Research in FY 2021

In FY 2021, exploratory research projects based on ingenious and/or advanced ideas that could potentially lead to new research fields for PARI in the future were carried out.

Impact evaluation and nonlinear dynamic simulation of submarine liquefied flow on floating offshore wind turbine and marine structure

The liquefaction and landslides that occur in the seabed due to earthquakes and waves cause severe damage to marine facilities and structures, including broken mooring chains and lost anchors that hold offshore wind turbines in place, collisions among floating structures, destruction of pile foundations, scouring of their surrounding ground, etc. However, no specific technique currently exists in Japan or elsewhere that can evaluate instances of such damage in detail, including the scale and effects of each incidence of damage, frequency of damage occurrence, etc. Therefore, this research project was started with the objective of developing a numerical computation method (particle method: MPS (moving particle simulation)) that can assess the sequence of impact events that are triggered by the sediment flows caused by landslides in the seabed that ultimately affect floating offshore wind turbines and other marine structures' foundations, and examining the applicability of the simulation model to actual floating wind turbines and other marine structures that will be deployed in the sea.

To evaluate the characteristics of submarine liquefied flow, we applied to MPS our numerical model, which is capable of analyzing flow processes where the effective stress is zero and the structural skeleton of the soil is completely destroyed, based on the experimental data and observation data obtained previously. We also applied the simulation model to mono-pile offshore wind turbines installed in relatively shallow coastal areas to examine how the impact pressure and liquefied ground flow affecting the power plants' foundations influenced the fluid fields causing sea level changes. These experiments confirmed that the impact pressure affecting the structures' foundations was significantly influenced not only by the impact pressure of the sediment flow but also by the pressure generated by sea level changes due to disturbances. Furthermore, we verified that the model could accurately estimate the frontal cross-section bordering the liquefied ground and the fluid as well as their two-phase mixture behavior and validated our MPS model's applicability to the studied phenomena.

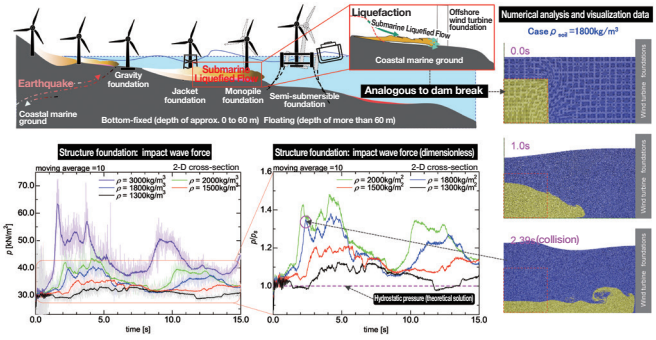


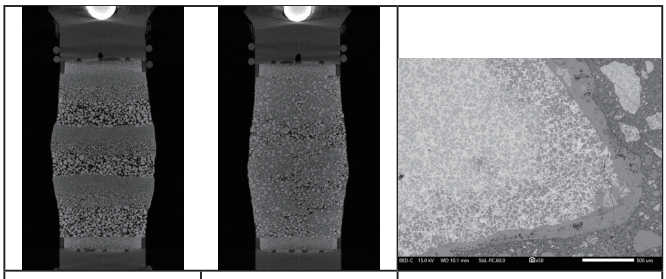
Illustration of disaster events triggered by liquefied sediment flow on the seabed and affecting offshore wind turbines, and other key research findings

Experimental research on the mechanical and physiochemical properties of slag having layered structure

This research project aims to experimentally investigate the mechanical and physiochemical properties of slag that has a layered structure, with emphasis on slag that are used as backfill material. While it is known that the presence of slag as well as granular sediment in the ground significantly affects the mechanical properties of the entire ground due to their uneven material and density structure in terms of granular orientation and other structural anisotropy, sand-clay strata, etc., it is expected that the presence of slag – especially steel slag – might make the ground's mechanical properties more complicated, because the material itself has a hydraulic property.

On the other hand, although it has been revealed that the layered structure of granular ground has significantly higher strength (against static compression and liquefaction) than a uniform structure, researches that have identified this mechanism are very limited. In addition, if we could shed more light on the long-term reactivity of slag and its solidification characteristics, it would be possible to evaluate the behavior of various ground materials throughout their lifecycles, which would in turn enable the development of a novel design protocol that factors in their temporal axles.

In this research project, which involved slag typically used as backfill material along with several different ground specimens for comparison, we conducted triaxial compression and mechanical tests while focusing on the degree of their classification and solidification reactivity, and chemical analysis of the target materials using X-ray imaging, SEM, etc. The triaxial compression test and the deformation characteristic analysis we conducted using X-ray CT scan revealed that the parts of the materials' layered structure that had particularly large granular diameters would exhibit significantly expansive behavior and that the difference in their deformation behavior largely contributed to enhancing the strength of their layered structure. In addition to, our various chemical analyses of the tested slag provided some key indicators that could be used to quantitatively evaluate the slag's solidification reactivity. Our next steps in this research include the relationship between the sedimentary structure of ground and its solidification in details more, which we will use the long-term behavior evaluation of slag.

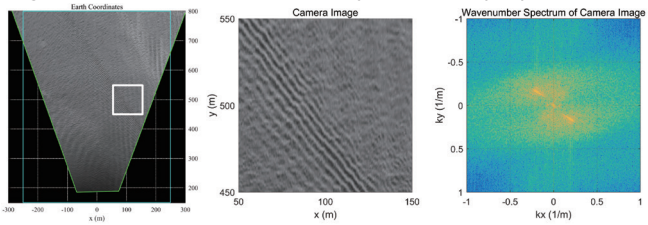


Observation of the deformation condition of a layered structure (vertical fault image obtained by X-ray CT scan)	Observation of the deformation condition of a uniform structure (same image acquisition method as left)	SEM image of slag extracted from solidified ground (calcium carbonate covering around the slag and traces of reactivity seen up to 0.5 mm from the slag surface)

Coastal disaster monitoring with 4K cameras and analysis of related big data

The fierce sea winds caused by Typhoon Faxai in 2019 caused the highest waves ever officially recorded in Tokyo Bay, leaving the coastal areas near Yokohama Port severely damaged by destroying many coastal structures and flooding the hinterland. Real-time confirmation of high-definition surveillance camera images contributes to the identification of disaster areas and early restoration. In addition, understanding the oceanographic conditions at the time of the disaster through post-disaster analysis is an effective research method for clarifying the causes of the disasters. With the rapid spread of 4K cameras in the broadcasting, and medical fields, and etc., although technological innovation is also progressing in the field of surveillance and security cameras, the following two essential criteria must be met for such cameras to be used for the prevention and mitigation of coastal disasters: 1) High-pixel camera to capture wave phenomena; and 2) all-weather type, capable of taking pictures at night and during storms. Recent innovative technological developments in CMOS sensors are clearing these conditions, and their potential for use in coastal disaster prevention is rapidly increasing. Based on this technological trend, this research project aims to develop a unique monitoring system that utilizes 4K cameras, so that eventually the coastal surveillance data that will be obtained through the system, including footage of port facilities, can be shared with relevant government agencies and used for disaster prevention and mitigation.

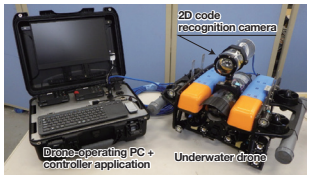
As for the project activities conducted so far, we developed a real-time coastal disaster surveillance system integrating high-definition 4K IP cameras (image resolution: 3840×2160, 15 fps continuous recording, night photography-enabled) and deployed it on multiple locations to obtain related big data. We then used the ocean surface luminance spectrum discerned from the obtained 4K video data to estimate corresponding 2-D wave number vectors and succeeded in computing the wave directions. As we have also been developing an algorithm for estimating wave statistics, if we could infer wider-ranging wave statistics with it, they could become novel means of wave observation. The 4K-camera system that we have established can be installed at any coastal location that has a platform available. Therefore, if we could share the big data obtained through the system with regional municipalities and other concerned parties, it would be aid their disaster mitigation and elucidate the causes of any disasters they experience.



4K camera images captured at the Kannonzaki radar facility and ocean surface luminance spectrum estimation

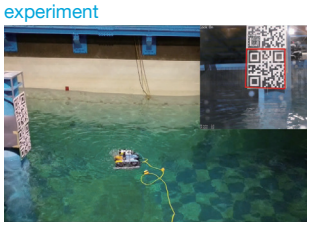
Feasibility study on the automation and remote operation of underwater robots utilizing 2D codes

In this study, which aims to enable the automatic operation of underwater robots using 2D codes, we examined a simple method of providing operating instructions to underwater robots using QR and other 2D codes. To achieve this objective, we developed an application software program. This software could recognize instructions from the 2D code and control an underwater drone accordingly. In addition, we selected a low-cost and high-speed telecommunication capability camera, for which we fabricated a custom-made waterproof case and installed it on the drone. We then attached 2D code panels to a pier model located inside a water tank on PARI's premises and conducted a demonstration experiment under a 0.2 m wave height condition. In the experiment, we observed the automatic drone operation by 2D code instructions and identified any potential issues that might arise.



Underwater drone used in the experiment

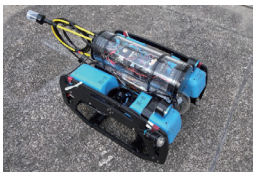
The experiment indicated that the underwater drone could recognize the attached 2D code instructions, automatically move to any specified position, and keep the position even amid the waves. We could also identify several issues, for example, the frequency of the 2D code recognition.



Experiment in progress amid artificial waves

Study on automatic operating methods of inspection underwater robots of underwater port structures

This research project was conducted to confirm the underwater condition of emergency structures in the event of a disaster and underwater structures and visual survey of underwater structures by divers will be implemented effectively in order to promote using to grasp situation in advance, the purpose of the project is to automate part of the underwater robot's navigation.

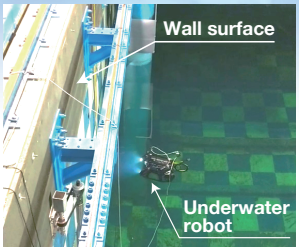


Robot used in the experiment

The robot was automated to acquire images of the underwater portion of an upright wall of a structure using an underwater robot based on a commercially available underwater drone as the base machine.

First, we installed a wireless communication capability on the base machine to avoid the risk of cable entanglement with target structures. We then installed a wireless communication antenna on it in order to be able to receive data from the robot remotely operate it for the operator on land

via radio communication (wireless LAN) when the robot is moving along the water surface. In addition, as it is not possible to communicate with the robot while it is submerged, we created an external module that will be attached to the robot to enable it to operate autonomously. We also installed an underwater camera on the robot for inspection purposes.



Experiment in progress

We then conducted water tank experiments to test the robot's autonomous navigation function, which allowed us to verify the robot's ability to automatically operate itself while aiming its underwater camera at the vertical wall and travelling along the structure while maintaining a specified distance.

Development of a method for exploring corrosion in steel rebars inside reinforced concrete and assessing damage in a manner similar to palpation

Electrochemical impedance spectroscopy (EIS) is a technique commonly used to inspect for any corrosion that may be present in steel rebars inside structures made of reinforced concrete. As this technique involves passing electric currents through the steel rebars from the concrete's surface to measure their corrosion condition, it requires connecting a power supply to the rebars through which electricity is to flow. Therefore, it is often necessary to drill holes into parts of the concrete to attach lead wires to the steel rebars inside, which impedes the inspection operation.


Figure 1: Corrosion diagnosis unit incorporating the new method

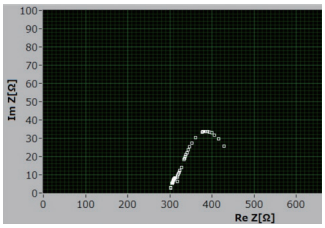


Figure 2: Data measured by the new corrosion diagnosis unit

In this research project, we developed a new method that involves installing several electrodes onto the concrete surface to form a separate electric circuit so that EIS can be applied without connecting the steel rebars directly to the power supply. In other words, this method eliminates the need to drill holes in the concrete. We then built a corrosion diagnosis unit (Figure 1) incorporating the method and compared the measurement data obtained using the conventional method (direct connection to the steel rebars) and this new method (no direct connection). Figure 2 indicates sample data measured using EIS, which is known as a Nyquist plot. As the Nyquist plots obtained through the two different methods were almost identical, it was proven that our new method enables EIS without having to drill the concrete.

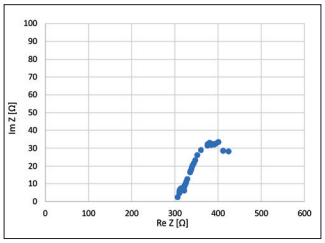


Figure 2: Data measured using the conventional method

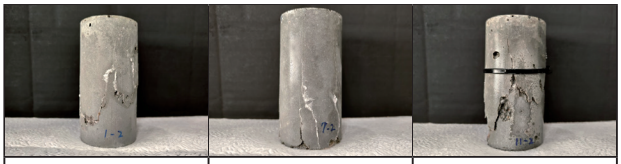
Feasibility Study on Development of Shirasu Based Capsules for Bio Self-Healing Materials in Concrete

Cracks that tend to be the starting point of deterioration of concrete structures can be repaired by concrete itself, repair cracks and maintain the sound of concrete structures, "self-healing concrete", which has been attracting attention.

Self-healing concrete is broadly classified into three categories: inorganic, organic, and microbial. Microbial systems are characterized by their ability of function to close cracks through biological metabolism.

In this research project, we focused on the aerobic bacterium *Bacillus subtilis var. natto* and developed a high-function self-healing concrete that can not only fill cracks by the metabolism of organisms but can also use the bacterium's breathing to deprive the concrete of oxygen and thus suppress corrosion of the steel rebar inside, in addition, we implemented development of a microcapsule material that can be used to efficiently apply *Bacillus subtilis var. natto* to concrete. We selected shirasu balloon and shirasu pumice as microcapsule materials, which are both natural pozzolans, to which the *Bacillus subtilis var. natto* could be absorbed to achieve micro-encapsulation, it would be also expected a secondary benefit of this technique: further concrete precision resulting from the pozzolan reaction of the volcanic glass.

The photos below show mortar test specimens in which cracks were induced after *Bacillus subtilis var. natto* had been applied, before they were exposed in water for a certain period to verify the efficacy of the bacterium *Bacillus subtilis var. natto* and microcapsules working in combination. While the mortar to which the bacterium *Bacillus subtilis var. natto* was not applied did not confirm any sign of its cracks being filled, in the specimens to which shirasu balloon and shirasu pumice had been absorbed the bacterium *Bacillus subtilis var. natto*, a calcium-derived substance was being deposited in their cracks closed them.



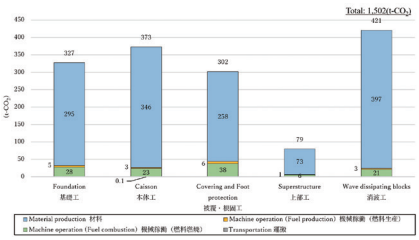
Specimen of shirasu balloon infused with *Bacillus subtilis var. natto*	Specimen of shirasu pumice absorbed with *Bacillus subtilis var. anatto*	Mortar with no infusion of *Bacillus subtilis var. natto* * No crack-filling observed.

Observation of mortar test specimens' ability to self-healing artificially induced cracks

Proposal of Green Transformation (GX) strategy for port structures to achieve carbon neutrality

With the trend toward global decarbonization gathering pace, efforts are underway to achieve Carbon Neutral Port (CNP) in the Japanese port sector. Thus, it is becoming increasingly important to minimize CO_2 generation in terms of the construction of port structures. To efficiently facilitate this process of CO_2 emission mitigation, it is crucial to first quantify and understand the characteristics of the CO_2 emissions that occur during port structure construction, and then explore effective ways to achieve the carbon mitigation goals. However, there is still not enough research on the amounts of CO_2 emissions that occur when port structures are built.

In this research project, we organized information on CO_2 emission computation methods and quantified the amount of CO_2 emissions that typically arise in a project to build a breakwater covered with wave-dissipating concrete blocks. Our calculations revealed that nearly 90% of the CO_2 emissions caused in such a project mainly arose from the material manufacturing activities, of which roughly 70% was attributable to concrete. It was also discovered that the majority of the CO_2 emissions that resulted from machine operations was from the work vessels, as the machines being operated on land produced less CO_2. Having clarified the CO_2 emission characteristics, we could determine the direction of our technological development to achieve each of the defined reduction goals, etc. Furthermore, after carefully investigating the concrete that was responsible for the majority of CO_2 emissions, we found that the total CO_2 emissions that occurred in each construction project could be reduced by 30–45% simply by switching to the optimal cement type (regular, blast furnace type B, or blast furnace type C). This confirmed the effectiveness of switching to low-carbon materials where possible and the necessity of developing low-carbon materials that can be applied to and withstand the marine environment that surrounds port structures. Regarding our initiative to develop low-carbon materials, we are continuously conducting basic research on carbon fixation methods that utilize CO_2 nano-bubble water and dredged soil to verify their efficacy and identify any potential issues.



CO_2 emissions from the construction of breakwaters covered with wave-dissipating concrete blocks

Published Research Papers

Number of Peer-reviewed papers in FY 2021

Number of papers in Japanese	Number of papers in non-Japanese languages	Total	Rate of papers in non-Japanese language
61	63	124	50.8%

* The above numbers contain proceedings that only reviewed the abstract.

Papers Published in PARI Reports in FY 2021

No.	Title	Author(s)	Language	Month/Year
60-1-1	Cyclic beach morphological changes in the swash zone due to tidal range fluctuations	Masayuki BANNO, Yoshiaki KURIYAMA	Japanese	June 2021
60-1-2	Ocean swells induced by the Typhoon Faxai hit Port of Yokohama in 2019	Hitoshi TAMURA, Koji KAWAGUCHI, Takumu IWAMOTO, Takashi FUJIKI	Japanese	June 2021
60-1-3	Dynamics of ocean swells in Toyama Bay	Hitoshi TAMURA, Koji KAWAGUCHI, Takashi FUJIKI	Japanese	June 2021
60-1-4	Study on stability of temporary armor units against waves	Kojiro SUZUKI, Hiroki KUBOTA, Tsutomu TANAKA	Japanese	June 2021
60-1-5	Study on wave pressure acting on receding parapet type seawall	Kojiro SUZUKI, Hiroki KUBOTA, Naoki TSURUTA	Japanese	June 2021
60-1-6	Study of slow slip mechanism on plate boundary fault decollement zone	Yuri SUGIYAMA, Shinya TACHIBANA, Yoshiyuki MORIKAWA	Japanese	June 2021
60-1-7	Development of frictional contact algorithm using weighted least squares for MPM–rigid body simulation and its application to behavior of open-ended pile driven into the ground	Keita NAKAMURA, Satoshi MATSUMURA, Takaaki MIZUTANI	Japanese	June 2021
60-2-1	Development of analytical method to detect position of breakwater applying template-matching	Satoshi MATSUMURA, Takaaki MIZUTANI, Masaru SAKEI, Masatoshi SAKIMOTO, Hideyuki MATSUMURA, Eri TAKEUCHI	Japanese	September 2021
60-3-1	Numerical analysis on structural performance of deteriorated open-type wharf with prestressed concrete superstructure	Yutaka TANAKA, Yuichiro KAWABATA, Ema KATO, Yoshikazu SUZUKA, Shusaku KAWABE, Michio NAKAJIMA, Tsuyoshi ISHII, Hisao TATEGAMI, Tetsuya OGASAWARA	Japanese	December 2021
60-3-2	Analytical study on the bearing capacity of open-ended straight and tapered piles using MPM	Keita NAKAMURA, Satoshi MATSUMURA, Takaaki MIZUTANI	Japanese	December 2021

Papers Published in PARI Technical Notes in FY 2021

No.	Title	Author(s)	Language	Month/Year
No.1385	Fundamental study on wave reduction effects by a wave power generating floating breakwater	Haruo YONEYAMA, Hiroaki KASHIMA	Japanese	June 2021
No.1386	Annual Report on Strong-Motion Earthquake Records in Japanese Ports (2018)	Yosuke NAGASAKA, Atsushi NOZU	Japanese	June 2021
No.1387	Effect of consolidation settlement on horizontal resistance of soft landing moundless structure with piles	Satoshi MATSUMURA, Takaaki MIZUTANI, Masaru SAKEI	Japanese	September 2021
No.1388	Analysis of pile driving records in the Tobishima area of Nagoya Port and consideration on construction management methods	Takaaki MIZUTANI, Satoshi MATSUMURA, Toru FUJITA, Yasuhiro TAKEUCHI, Masaya KANI, Hiroyuki SAEGUSA, Yasushi KISHI	Japanese	September 2021
No.1389	Field measurement of seasonal variation in sediment transport around the Patimban coast, Indonesia	Yasuyuki NAKAGAWA, Masayuki BANNO, Taichi KOSAKO, Hitoshi TAMURA, A. Bagyo Widagdo, Dinar C. Istiyanto	Japanese	September 2021
No.1390	Construction of the prototype of underwater machine guidance system for an underwater excavator and accuracy verification	Tsukasa KITA, Taketsugu HIRABAYASHI, Shunsuke TAKAO, Muneo YOSHIE	Japanese	September 2021
No.1391	Large-scale model test for the bearing capacity of open-ended straight and tapered piles	Keita NAKAMURA, Yusuke MOTOMIZU, Satoshi MATSUMURA, Takaaki MIZUTANI, Eiji OSHITA, Satoshi SHINGAI, Yasutaka SAKAMOTO, Naoaki SUEMASA	Japanese	December 2021
No.1392	Study of maintenance for cathodic protection applied to marine steel structures	Toru YAMAJI, Masayuki HARA, Ken-ichi NOTOYA, Nobumitsu YAMANOBE, Yasuhiro TAKAHASHI, Shigenori KOBAYASHI, Masaharu WATANABE	Japanese	December 2021
No.1393	Caisson joint wave reduction method for suppressing internal erosion and collapse of seawalls and quaywalls	Shinji SASSA, Osamu ISHIZAKA	Japanese	December 2021
No.1394	Annual report on strong-motion earthquake records in Japanese ports (2019)	Yosuke NAGASAKA, Atsushi NOZU	Japanese	December 2021
No.1395	Statistical analysis on parallel body lengths and wind receiving areas of ships	Haruo YONEYAMA, Hiroaki KASHIMA	Japanese	December 2021
No.1396	Proposal and performance test of attachment for realization of remote operation of rubble mound leveling work with underwater backhoe	Tsukasa KITA, Taketsugu HIRABAYASHI, Shunsuke TAKAO, Hiroshi KINJO, Naoki OSHIRO, Atsushi UEYAMA	Japanese	December 2021
No.1397	Experiments on resistance of various wood materials against marine borers and weathering	Masao YAMADA	Japanese	March 2022
No.1398	Annual Report on Nationwide Ocean Wave Information Network for Ports and Harbours (NOWPHAS 2020)	Koji KAWAGUCHI, Kanichiro YOSHIDA, Hitoshi TAMURA	Japanese	March 2022
No.1399	Fundamental study on the calculation of CO_2 emissions from construction of port structures – Investigation on the pre-estimation method and trial calculation of CO_2 emissions from construction of port structures –	Sumire NAKAMURA, Yuichiro KAWABATA, Daisuke TATSUMI	Japanese	March 2022
No.1400	Guideline for maintenance and management of PC wharf superstructure for port engineers	Ema KATO, Yutaka TANAKA, Yuichiro KAWABATA, Tetsuya OGASAWARA, Hiroshi WATASE, Tsuyoshi ISHII, Shusaku KAWABE, Akira MIYAZAWA, Yoshinao NAKAYAMA, Michio NAKAJIMA, Hisao TATEGAMI, Nobuyuki YONEKURA, Yoshiko AMEMIYA, Yoshikazu SUZUKA, Tatsuyuki FUJIMURA	Japanese	March 2022
No.1401	A composite source model capable of generating fling steps	Atsushi NOZU, Shuanglan WU, Yosuke NAGASAKA	Japanese	March 2022
No.1402	Investigation for durability of corrosion prevention by petrolatum lining	Takahiro NISHIDA, Toru YAMAJI, Nagate HASHIMOTO, Yoshiyuki KAWASE, Shinsuke SHIZURU, Takuya ICHINOSE, Atsumi IMAI, Atsushi KOBAYASHI, Michio YOSHIDA	Japanese	March 2022

Outstanding Research Activities

Awards for Papers and Others in FY 2021

	Name	Award	Institution	Date	Remarks
1	Tomohiro KUWAE Head, Coastal and Estuarine Environment Group Coastal and Estuarine Environment Department	Recycle Promotion Award	Recycle Solution (incorporated non-profit organization)	May 25, 2021	Contribution to the environmental preservation and restoration in shallow coastal areas over the years; and the quantitative evaluation, raising of public awareness, and popularization of blue carbon.
2	Hidenori TAKAHASHI Head, Soil Stabilization Group Geotechnical Engineering Department Yoshiyuki MORIKAWA Director, Geotechnical Engineering Department	JGS Research / Paper Award (English category)	Japanese Geotechnical Society (JGS)	June 4, 2021	Collapse of concrete-covered levee under composite effect of overflow and seepage
3	Yoshiyuki MORIKAWA Director, Geotechnical Engineering Department Takaaki MIZUTANI Head, Foundations Group Geotechnical Engineering Department Eiji KOHAMA Head, Earthquake and Structural Dynamics Group Earthquake Disaster Prevention Engineering Department Satoshi MATSUMURA Senior Researcher, Foundations Group Geotechnical Engineering Department	The Ports & Harbours Association of Japan Technology Award	The Ports & Harbours Association of Japan (public interest incorporated association)	June 9, 2021	Improvement of seismic performance of sheet pile quay walls by stabilizing the ground between anchor piles
4	Tomohiro KUWAE Head, Coastal and Estuarine Environment Group Coastal and Estuarine Environment Department Kenta WATANABE Senior Researcher, Coastal and Estuarine Environment Group Coastal and Estuarine Environment Department Toko TANAYA Senior Researcher, Coastal and Estuarine Environment Group Coastal and Estuarine Environment Department	JSCE Distinguished Paper Award	Japan Society of Civil Engineers (JSCE)	June 11, 2021	Nationwide estimate of the annual uptake of atmospheric carbon dioxide by shallow coastal ecosystems in Japan
5	Yoshiyuki MORIKAWA Director, Geotechnical Engineering Department	Continuing International Contribution Award	Japan Society of Civil Engineers	June 11, 2021	Contribution to the development of civil engineering and/or the development of infrastructure outside Japan
6	Takahiro NISHIDA Senior Researcher, Materials Group Structural Engineering Department	Engineering Encouragement Special Award	Engineering Advancement Association of Japan (general incorporated foundation)	July 12, 2021	Development of novel construction techniques for desalinization, re-alkalization, and electro-deposition
7	Kentaro KOIKE Senior Researcher, Materials Group Structural Engineering Department	Excellent Paper Award	The Society of Materials Science, Japan (JSMS) (public interest incorporated association): The 21st JSMS Symposium on Concrete Structure Scenarios	October 15, 2021	Clarification and Estimation of Distribution Property of Airborne Chloride Ion in Yoron Island, Kagoshima
8	Shinji SASSA Head, Soil Dynamics Group Geotechnical Engineering Department Soonbo YANG Postdoctoral Researcher, Soil Dynamics Group Geotechnical Engineering Department	Coastal Engineering Paper Award	Japan Society of Civil Engineers Coastal Engineering Committee	October 18, 2021	Processes and the extent of influence of internal erosion under transmitted waves with their countermeasure using a two-layer filter
9	Hitoshi TAMURA Senior Researcher, Marine Information Group Coastal and Ocean Development Department Koji KAWAGUCHI Head, Marine Information Group Coastal and Ocean Development Department Hiroaki KASHIMA Senior Researcher, Coastal and Ocean Development Group Coastal and Ocean Development Department	Coastal Engineering Paper Award	Japan Society of Civil Engineers Coastal Engineering Committee	November 10, 2021	Wave force at the Port of Yokohama due to Typhoon Faxai in 2019
10	Kazuki MURATA Researcher, Soil Dynamics Group Geotechnical Engineering Department	JACZS Research Symposium Excellent Lecture Award	Japanese Association for Coastal Zone Studies (JACZS)	November 11, 2021	
11	Toru YAMAJI Director, Structural Engineering Department Head, Materials Group	AI & Data Science Encouragement Award	Japan Society of Civil Engineers	November 30, 2021	
12		5th Infrastructure Maintenance Grand Prize, Technological Development Category, Special Award	Ministry of Land	January 21, 2022	Safety and quality improvement related to the maintenance and management of piers using replaceable slabs
13	Shuji NOGAMI Senior Researcher, Meta-Robotics Group Infrastructure Digital Transformation Engineering Department Ema KATO Principal Researcher Infrastructure Digital Transformation Engineering Department	Best Paper Awards on Infrastructure Maintenance	Japan Society of Civil Engineers Committee on Infrastructure Maintenance	March 14, 2022	A feasibility study of an underwater drone for visual inspection of port structures

Annual Report, Technical Journals, and HP

"The Annual Report 2021" (Japanese version) and "The PARI Annual Report 2021" (English version), which concisely summarized our activities in FY 2020, were prepared as a record of our achievements and distributed to the related institutions and posted on PARI HP.

Regarding "The PARI Technical Journal", we selected special articles of each research theme for every issue to introduce utilization situations of research results and PARI's experiment and on-site observation facilities. Approximately 2,000 copies of "The PARI Technical Journal" are distributing to approximately 1,600 places.

The PARI Technical Journal

On HP, we provided various information on events and news including our institute summarized information, results, facilities, symposiums on a real time basis; we got approximately 130,000 accesses in FY 2021.

Implementation of lectures for the General Public

Port and Airport Technology Lecture

In cooperation with the National Institute for Land and Infrastructure Management (NILIM), a web-based lecture on port and airport technology was held on January 31, 2022 for the purpose of publicizing and disseminating the results of surveys, research and technological development conducted by PARI. The lecture event in FY 2021, which was entitled "*Achievement of Carbon Neutrality and a Carbon-Free Society by 2050*," included special lectures given by speakers invited from private enterprises as well as presentations delivered by various PARI and NILIM researchers on their research results, and was attended by 250 individuals.

Web-based lecture

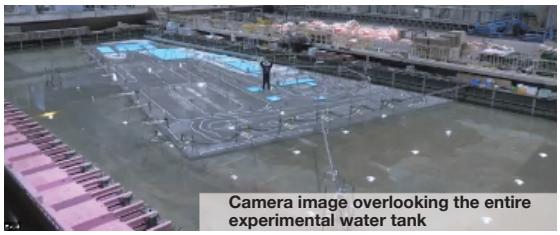
Port and Airport Technology Special Regional Lecture

In cooperation with the National Institute for Land and Infrastructure Management (NILIM), Regional Development Bureaus and other organizations, the web-based seminars were held in four regions across Japan, each of which had more than 100 attendees and for approximately 440 attendees in total, for the purpose of providing wide-ranging information on the Institutes' research activities and results, and gathering information on research needs in each region.

Institute Facility Open to the Public

Open to the Public

The FY2021 facility open house has been cancelled due to the expansion status of the COVID-19. Instead, videos were posted on the National Institute of Maritime, Port and Aviation Technology (MPAT) website as a virtual open house, and also an online open experiment was conducted on February 15, 2022 (involving recreation of quay-wall-overtopping waves and inundation resulting from high waves during storm surges). This open experiment, the first of its kind offered by PARI, was attended by 288 individuals, many of whom were elementary school students and others affiliated with educational institutions.


Camera image overlooking the entire experimental water tank


Images from a fixed camera at the bottom of the experimental water tank

Open experiment (web-based) in progress

Other Outreach Activities

Cooperation with Super Science High school (SSH) Projects

For students of Kanagawa Prefectural Yokosuka High School is designated as an SSH school by the Ministry of Education, Culture, Sports, Science and Technology, we provided guidance on the preparation of research projects and conducted tours of the institute's facilities, in order to encourage students' interest in the institute.


Students listening to a researcher's lecture

Active participation in International Conferences, Workshops, and etc.

Following the establishment of November 5, Japan's Tsunami Disaster Prevention Day, as “World Tsunami Awareness Day” at the United Nations General Assembly in December 2015, the Goryo HAMAGUCHI International Prize (Minister of Land, Infrastructure, Transport and Tourism Prize) was established in 2016 for those who have made outstanding achievements in the field of coastal disaster prevention technology, including tsunami disaster prevention. The award was presented on November 29, 2021 to two persons and one organization: Dr. Hideo MATSUTOMI (Professor Emeritus at Akita University and Visiting Professor at Chuo University’s Research and Development Initiative); Dr. Gerassimos A. PAPADOPOULOS (Chairman, International Society for the Prevention and Mitigation of Natural Hazards (ISPMNH)); and the Pacific Tsunami Museum (Hawaii, USA).

A prize awarding ceremony and commemorative lecture of the Goryo Hamaguchi Award (November 29, 2021, Tokyo)

PARI held a joint research workshop with Indonesia’s Badan Pengkajian dan Penerapan Teknologi (BPPT; Agency for the Assessment and Application of Technology) in April 2021.

In addition, PARI hosted and chaired a meeting of the International Society for Soil Mechanics and Geotechnical Engineering’s Technical Committees in October 2021, which was attended by a total of 32 Committee members from 14 countries and saw active technical exchanges among researchers representing PARI and other overseas research institutes.

Wide Range of Exchanges with Domestic and Overseas Research Institutes

In order to further improve the quality and efficiency of our research, we have been actively promoting collaboration with domestic and overseas research institutions, and as of FY2021, we have concluded a total of 56 research cooperation agreements: 29 in Japan and 27 overseas.

Conclusion of Education and Research Cooperation Agreements

Based on the "Cooperative Graduate School System," in which the institute and national, public, and private universities conclude an agreement and researchers from the institute become professors at graduate schools and supervise graduate students in research books, etc., the institute has concluded cooperative agreements with 13 universities including Tokyo Institute of Technology, Nagoya University, and Nagaoka University of Technology.

In FY2021, we dispatched 15 lecturers. In addition to the cooperative graduate school system, a total of five lecturers were dispatched to the Nagoya Institute of Technology, etc.

Promotion of Administrative Support

Dispatch of researchers to disaster-affected sites

In FY 2021, PARI conducted on-site surveys in the Izusan area of Atami City in July in response to the disaster caused by debris flows, in conjunction with the MLIT’s Ports and Harbours Bureau, etc. In addition, PARI continuously contributed to disaster recovery efforts based on the needs of affected areas by swiftly dispatching its researchers to the disaster sites. Examples of such dispatches include on-site investigation of the drifting pumice that resulted from the eruption of the submarine volcano Fukutoku-Okanoba in November (Okinawa Prefecture) and port disaster assessment following the earthquakes that occurred off the coast of Fukushima Prefecture in March 2022 (Fukushima Prefecture and Miyagi Prefecture), as part of the joint investigation teams organized with the National Institute for Land and Infrastructure Management (NILIM).

On-site investigation of drifting pumice

Disaster assessment at Soma Port

Dispatching of members to Various Technical Committees, etc.

A total of 164 researchers were dispatched to serve as members of various technical committees held by the national and local governments to solve technical problems related to the implementation of public works such as ports, coasts, and airports.

In addition, if we include the technical committees established by various institutions for port, coastal and airport development and airport maintenance, we have dispatched a total of 410 members, who have responded energetically to solve technical problems faced by the government and other organizations.

Support for Operations related to Technical Standards for Ports and Harbors

With regard to technical standards for port facilities, we have cooperated by participating as a member of committees established by the Port and Harbor Bureaus of the Ministry of Land, Infrastructure, Transport and Tourism. We also cooperated in the dissemination of technical standards at workshops held by the National Institute for Land and Infrastructure Management, academic societies, and related organizations. As for airport facilities, we cooperated with various study committees for the smooth dissemination and operation of technical standards for airport civil engineering facilities.

Support for the Evaluation of New Technologies

At the request of the Ministry of Land, Infrastructure, Transport and Tourism (including regional development bureaus, etc.), we dispatched researchers to the "Evaluation Council for New Technologies" established by each organization to evaluate the applicability of technologies registered in the "New Technology Application System for Public Works, etc. (commonly known as NETIS)" to the field in order to promote the use of useful new technologies, and provided technical support.

National Institute of Maritime, Port and Aviation Technology
Port and Airport Research Institute

3-1-1 Nagase, Yokosuka, Kanagawa 239-0826, JAPAN
TEL +81-46-844-5040 FAX +81-46-844-5072
URL https://www.pari.go.jp

Annual Report 2022 July 2022