PARI

Annual Report 2018

Message from the Director General

Creating Technologies That Contribute to the World

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Yoshiaki KURIYAMA, Director General, PARI

In April 2016, the Port and Airport Research Institute (PARI) restarted as a member institute of the National Institute of Marine, Port and Aviation Technology, which had been established after the integration of PARI, National Maritime Research Institute and Electronic Navigation Research Institute. PARI serves as a research institute responsible for developing technology related to construction and maintenance of ports and airports, and coastal zone management. The Port and Harbour Research Institute (PHRI), the predecessor of PARI, was established in 1962 as an independent institution of the Ministry of Transport. Since then, we have provided technical support for various port and airport projects, including the development of Kashima Port and the construction of Kansai International Airport, and have made research achievements that are highly regarded throughout the world. In order to maximize the achievements in research and development, we further expand and strengthen our cooperation and interaction with researchers in different fields including the two other institutes.

This annual report summarizes PARI's track record in FY 2017, the second year of the first mid-term plan (from FY 2016 through FY 2022). In this plan, PARI is focusing on the following four research and development challenges: 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 FY 2017, our specific approaches included the following: 1. "Coastal Disaster Mitigation and Restoration": we developed diagnosis and countermeasure technologies to improve the disaster-prevention abilities of petrochemical complexes. To develop numerical simulation models of tsunami-induced fires, we conducted a comparison between simulation models and experiments of drift behaviors; 2. "Formation of Infrastructure for Vigorous Economy and Society": we investigated the structural health monitoring system for port facilities to inspect and diagnose infrastructure; 3. "Preservation of Marine Interests and Utilization of Oceans": we conducted verification studies of deep sea/shallow water underwater acoustic video cameras; and, 4. "Creation and Utilization of Coastal Environment": we developed a new coastal-ecosystem model that enables to estimate both the amount of blue-carbon (the carbon stored in marine and coastal ecosystems) in various coastal areas and that of ocean-wave attenuation due to ecosystem.

In executing the above research, PARI pursued its two major goals of maintaining PARI's research levels at the highest global standards and assisting working projects with PARI's research results. PARI also promoted government-led strategic international activities including contributing to the expansion of infrastructure overseas and providing technical assistance to overseas countries.

On April 1, 2017, we newly established the Productivity Improvement Research Center to enhance the technological development for improving the productivity of ports and airports in a cross-sectional manner within PARI. On October 1, 2017, the Ocean Infrastructure Research Center was re-named as Ocean Infrastructure and Offshore Wind Energy Research Center to provide technological support for the promotion of marine development and utilization, which is one of Japan's most important policies. At the same time, we strengthened our technological support activities to promote the introduction of offshore wind-power generation, which also entered the implementation phase in Japan recently.

Two years have passed since the Kumamoto earthquake; however, natural disasters including earthquakes and high waves continually occur. We offer emergency responses and restoration support at the time of coastal disaster including earthquakes, tsunamis and storm surges and conduct awareness activities regarding disaster prevention.

We would greatly appreciate your continued support.

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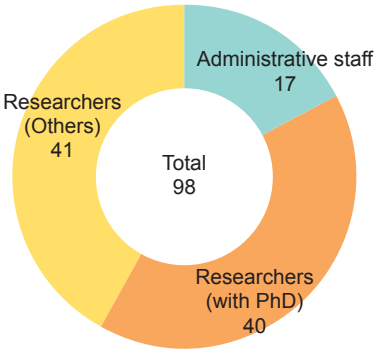
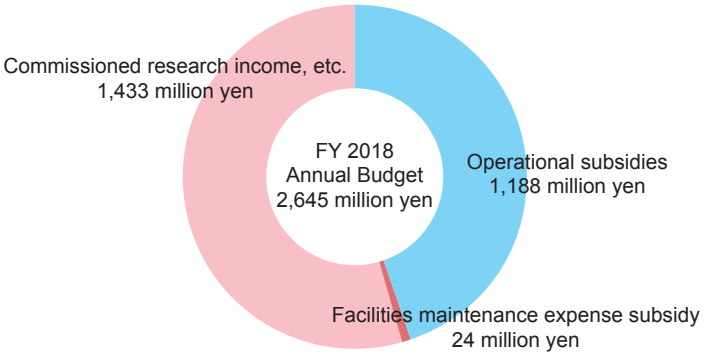
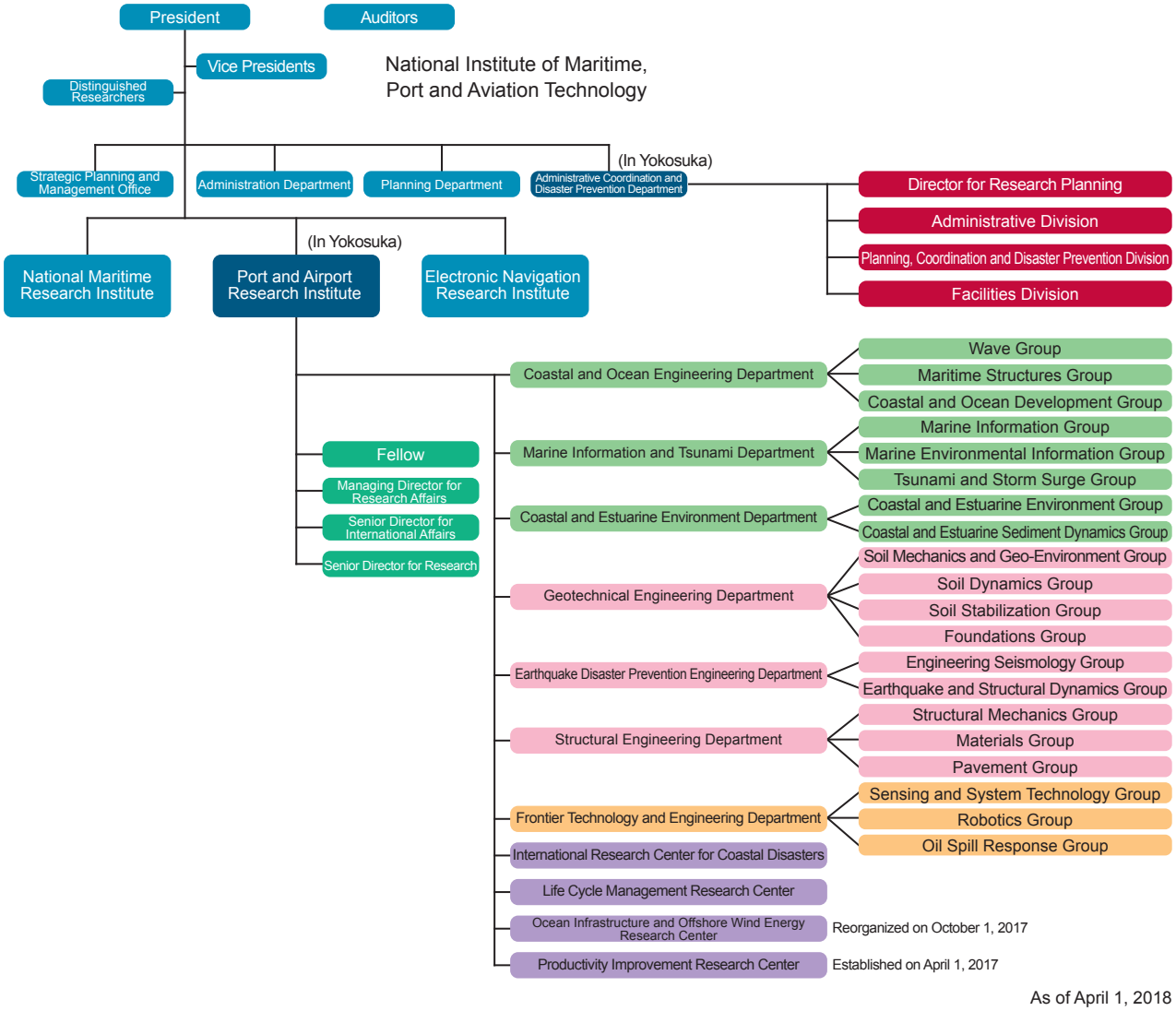




As of April 1, 2018 (In Yokosuka)

Organizational Structure



As of April 1, 2018

Management Strategy

Mid- and Long-Term Objectives (FY 2016 to FY 2022)

The Minister of Land, Infrastructure, Transport and Tourism (MLIT) sets mid- and long-term business goals for the National Research and Development Agency, National Institute of Marine, Port and Aviation Technology to achieve. These goals 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, Port and Airport Research Institute, and Electronic Navigation Research Institute, which were National Research and Development Agencies operated under the jurisdiction of the MLIT, were integrated into the National Institute of Marine, Port and Aviation Technology (hereafter called "PARI") 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 PARI was established to effectively and efficiently conduct their operation.

In consideration of the previous roles of each institution, PARI 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, PARI will constantly review research contents and select research areas to address changes in the social environment. At the same time, PARI will more actively engage in research and development activities to solve policy challenges in each field, such as conducting research in emerging fields.

PARI has promoted research and development in each field, cultivated technological seeds, and accumulated specialized knowledge. Thanks to PARI's legacy, such multidisciplinary research became viable. In consideration of this background, PARI 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, PARI will help put national policies into practice.

Furthermore, PARI considers that it is important to return the benefits achieved through research and development to society, as well as to cooperate with external institutions and to widely disseminate research results. In addition, PARI 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, PARI'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.

Mid- and Long-Term Plans (FY 2016 to FY 2022)

The MLIT sets mid- and long-term goals. In response to such goals, the National Research and Development Agency, National Institute of Marine, Port and Aviation Technology sets mid- and long-term plans to achieve the goals. 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

PARI 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, shipping routes, coasts, and airports and other activities

PARI 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 institutions; countermeasures for facility obsolescence of existing structures; and initiatives to create maritime-development hubs.

Among basic research, PARI 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.

PARI 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

PARI will try to resolve technological policy challenges, to address disasters and accidents, to enforce bridging functions, to promote and utilize proprietary information, and to enhance the transmission and dissemination of information.

4. Promotion of strategic international activities

PARI will contribute to international normalization and standardization and cooperate with non-Japanese institutions.

PARI Operation Management

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

PARI 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 PARI 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 PARI's research

Structure of Research Themes in FY 2017

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 (2A ②)
			Fundamental Research		Investigation of Earthquake Disaster (2A ②)
			Fundamental Research		Development of strong motion estimation method for scenario earthquakes beneath metropolitan area
			Fundamental Research		Study on the evaluation and analysis of liquefied ground behavior and effective contermeasures under sequenced earthquake motions
		② Research on damage-reduction techniques against the greatest earthquakes	Applied Research		The diagnosis and countermeasure technique development related to disaster prevention improvement of industry complex consisting of a wide variety of facilities
			Applied Research		Development of method to seismic peformance evaluation for offshore structure against the largest earthquake motions
		③ Research on the interaction of earthquakes, tsunamis, and high waves with ground dynamics	Fundamental Research		Seabed Soil Dynamics and Stability Assessment of Breakwaters and Seawalls
			Fundamental Research		Study from geotechnical view-point on stability evaluation method of coastal structure subjected to high waves (1C ②)
	1B Research on Mitigation and Restoration of Tsunami Disasters	① Research on ICT-based decision support systems	Development Research		Development of a tsunami-fire model for ports
			Development Research		Development of multi-observation based tsunami forecasting method
		② Research on the development of tsunami-resistant ports	Applied Research		Development of an advanced 3-dimentional simulation model for tsunami inundation
			Fundamental Research		Development of the estimation method for local scour around coastal structures due to tsunami
	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		A study of seasonal and regional statistics on swell observed in Japanese coast
			Development Research		Development of a harbor tranquility analysis method for local wind waves and ship waves in a harbor
			Fundamental Research		Proposal for improvement of prediction accuracy of swell
			Applied Research		Estimation of wave transformation around demaged structures to evaluate remaining performance for sheltering
			Fundamental Research	☆	Development of the maritime and environmental simulation model using meso-scale weather forcasting model
		② Research on the technology to reduce maximum storm surge and wave disasters	Applied Research		A study on the wave force, overtopping, and overflow of wind waves on tsunamis and storm surges over design water level (1B ②)
2. Formation of Infrastructure for Vigorous Economy and Society	2A Research on Enhancement of Port and Airport Performance for Industrial Competitiveness	① Research on strengthening the functions of ports and airports to secure international competitiveness	Development Research		Development and suggestion of efficient and suitable use which contains automated cargo systems through container terminal numerical simulations for multi berths
			Applied Research		A Research about the CIM (Construction Information Modeling) for Economizing on Manpower, Term of Works, and Cost
		② Research on efficient and effective improvement of ports and airports	Applied Research		Development of evaluation method for performance of reclaimed ground taking into account the difference in ground improvement method and landfill material (2C ①)
	2B Research on Life Cycle Management of Infrastructures	① Research on technologies for prolonging the life of infrastructure	Fundamental Research		Evaluation of longterm durability of concrete, steel and various materials based on exposure test
			Fundamental Research		Study on the durability of protective coating method for marine steel structures
			Fundamental Research		Study on the durability of various materials under severe environments
			Applied Research		A study on the improvement of airfield pavement material to prolong the pavement life (2A ②)
			Applied Research		Development of structural design method for strategic maintenance of port and harbour structures
			Applied Research	☆	Systematization of repair and strengthening of marine concrete structures
		② Research on systems for inspecting and diagnosing infrastructure	Development Research		Development of the structural health monitoring system for port structures
			Development Research		Enhancement of ROV system for inspection of concrete superstructures of open-type wharves (2A ①)
		③ Research on maintenance and management systems for infrastructure	Applied Research		Study on maintenance planning of port facilities in term of LCC optimization
	2C Research on Effective Use of Existing Infrastructure Facilities	① Research on techniques to improve or renew existing facilities	Applied Research		Development of evaluation method for performance of reclaimed ground taking into account the difference in ground improvement method and landfill material (2A ②)
			Fundamental Research		Improvement method to non-uniform ground and its effect as a measure against liquefaction (2A ②)
			Applied Research		Study on method for evaluation of bearing capacity of piles for upgrade of port and airport facilities (2A ②)
		② Research on effective use and techniques of treating construction byproducts	Fundamental Research	☆	Enhancement of accuracy of method for evaluating mechanical properties of composite geomaterials based on microstructural feature
			Applied Research		Development of technique increasing capacity of disposal site for dredged soil
		③ Research on management and utilization of waste disposal sites at sea	Applied Research		Structure foundation for high-degree land-utilization at confined disposal facilities
3. Preservation of Marine Interests and Utilization of Oceans	3A Research on Development and Utilization of Oceans	① Research on port construction and management in remote islands	Development Research		Innovation for using berthing and mooring facilities constructed in isolated coral reef sea
			Development Research		Technological development on advanced ship mooring system in port
			Development Research		Research on maintenance inspection and investigation technology for remote island ports (2A ①)
		② Research on infrastructure technology for utilization and development of oceans	Development Research		Development of next-generation acoustic imaging system (2A ①)
			Development Research		Research on adaptation of the machine guidance for an underwater excavator (2A ①)
			Fundamental Research	☆	Field observations and analyses on the formation and stability of carbonate lands
4. Creation and Utilization of Coastal Environment	4A Research on Enhancement and Utilization of Coastal Ecology	① Research on coastal-ecosystem utilization	Fundamental Research	☆	Global estimates of the efficacy of blue carbon as a means of mitigation and adaptation to climate change
			Fundamental Research		Development of integrated prediction and assessment method of coastal benthic ecology and geoenvironmental dynamics
		② Research on the water-environment simulation and analysis in inner-bay	Fundamental Research	☆	Cross-sectional observation and analysis of atmospheric and oceanographic issues at bay mouths
			Fundamental Research		Analytical study of macro-organisms dynamics on a coastal ecosystem simulation
			Fundamental Research		Development of evaluating procedure for biodiversity referring to spatial scale in coastal areas
			Fundamental Research		Study on the mechanisms of coastal current and water environment using data assimilation
		③ Research on countermeasure technologies against sea oil spill	Development Research		Novel oil spill response technology to cope with various sources including natural disaster triggered oil spills
	4B Research on Coastal and Estuarine Processes	① Research on coastal protection and maintenance of waterways and mooring basins	Fundamental Research		Observation of coastal geographical feature change and generalizing of prediction method in considered with influence of global warming
			Fundamental Research	☆	Study on sediment transport in estuary and deposition process in navigation channel
			Fundamental Research	☆	Study on applicability of airborne laser bathymetry for topographic monitoring in coastal zone of sea shore

1A Research on Mitigation and Restoration of Earthquake Disasters

Background and Objectives

- To counter large-scale disasters including Nankai megathrust earthquakes and earthquakes in the greater Tokyo area, the following countermeasures are required: securing necessary trunk line cargo transportation soon after an earthquake and quickly securing the requisite minimum transportation of key emergency supplies for recovery and reconstruction hubs. 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, the themes of this research cover research and development which simultaneously achieves the two goals of improving earthquake resistance and reducing construction costs. These two goals can be achieved through diagnosis and performance verification of earthquake-resistance of facilities which address the properties of long-period and long-duration earthquake ground motion, which is expected to occur during a subduction-zone megathrust earthquake, as well as the properties of earthquake ground motion caused by local ground characteristics. Research and development are being conducted mainly on methods for investigating and diagnosing earthquake resistance as well as construction methods that improve the resistance, while using existing facilities with limited design life that were erected during the era of rapid economic growth.

Research Topics

Research and development comprises the following three subthemes:

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

Subduction-zone megathrust earthquakes may cause the greatest and long-duration earthquake motions, so we will develop techniques for predicting such motions. Also, we will develop techniques for predicting liquefaction and structural damage caused by such motions.

ii) Research on damage-reduction techniques against the greatest earthquakes

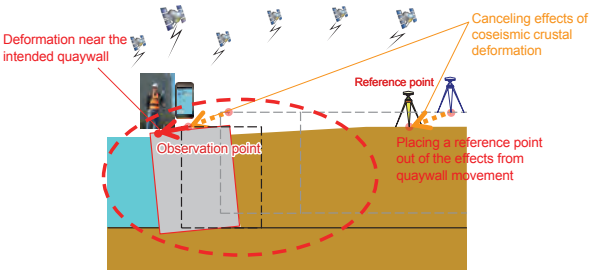
We will suggest the most effective countermeasures under given limitations to effectively promote seismic strengthening of existing structures. In doing so, we will actively utilize damage reduction and strengthening techniques that use novel materials, structures, and construction methods. Especially, as earthquake-resistance countermeasures for industrial complexes, we will consider maintaining the functions while reducing costs for overall plants, and then develop investigation, diagnosis and countermeasure techniques which minimize usage limitations of plants. In addition, we will develop testing methods to rapidly evaluate damage levels on site immediately after a disaster as well as emergency restoration techniques.

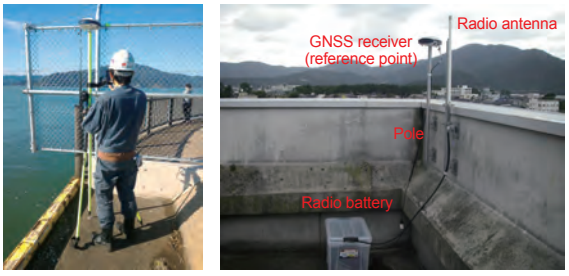
iii) Research on the interaction of earthquakes, tsunamis, and high waves with ground dynamics

We will proceed with research on the following interaction of earthquakes and ocean waves with the ground: stability evaluation against seabed liquefaction, washout, cavity formation and collapse under earthquakes or under ocean waves; a mechanism on how a breakwater foundation loses its bearing capacity in the presence of tsunami; and other interactions. Also, we will use numerical simulation models, model experiments (on a centrifuge and a large-scale fluid tank), and other methods to investigate earthquake-induced submarine landslide development, the resulting tsunami phenomena, ground dynamics under the influence of tsunami and high waves, and the analysis of deformation and instability/destruction mechanisms as well as their countermeasures.

Activities in FY 2017

- We obtained 2864 strong motion earthquake records during the period between January to December 2015. We will organize and analyze these records and will then publish the data as a Technical Note of the Port and Airport Research Institute.
- In collaboration with related organizations including the Ports and Harbours Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, we investigated the on-site introduction of a quaywall deformation measurement tool utilizing RTK-GNSS, which is a technique to assess the post-earthquake damage conditions of port facilities and to determine whether such facilities can be used.
- To develop a technique to estimate strong ground motions to prepare against large-scale earthquakes occurring directly beneath metropolitan areas, we analyzed data from several intraslab earthquakes with different characteristics and then developed and verified source models to explain those ground motions.
- We conducted a study on the evaluation and analysis of liquefied ground behaviour targeting the sequenced earthquake motions and grounds involving fine contents, and elucidated the mechanism of the internal flow characteristics in association with the progress and propagation of liquefied zones.
- To develop diagnostic and countermeasure techniques to improve the disaster-prevention characteristics of industrial complexes, we focused on actual coastal industrial complex facilities and confirmed the earthquake-resistance effects of the countermeasure by the model experiment using the National Research Institute for Earth Science and Disaster Resilience's large shake table (E-Defense) and conducted numerical analyses to re-create the behavior of these facilities.
- We developed a numerical model for steel-pipe members to adequately represent their seismic performance and then proposed a new earthquake-resistant design method, with modified performance specifications applicable for piled piers, steel pipe sheet pile quay walls, and anchorages of sheet pile quay walls.
- We took both breakwater mound/ground dynamics against tsunamis and countermeasure construction against them (reinforcing embankment) into account, and then proposed the method evaluating the stability of breakwaters.
- We conducted centrifugal model experiments to study the ground stability against waves and found that inter-ground stress and water pressure affect ground stability. Also, we investigated how to reproduce wave breaking in narrow vessels, in which there is not enough distance to achieve wave shoaling, and compared the results of centrifugal model experiments with fluid numerical analyses.





A tool to measure quaywall deformation using RTK-GNSS and trial measurement at Tsuruga Port

Research Themes and Activities in FY 2017

1B Research on Mitigation and Restoration of Tsunami Disasters

Background and Objectives

- Since the Great East Japan Earthquake in 2011, we have studied stable structures against tsunami overflows and developed a numerical simulation model to predict the drifting of debris generated by the destruction of structures. However, complex behaviors of run-up tsunamis on land and the resulting damages are not fully understood and modeled yet. In addition, regarding a technique for real-time inundation forecast, which is expected to be utilized for evacuation and other purposes, only data from GPS-mounted wave buoys is used; other valuable data is not fully utilized yet.
- Therefore, we are aimed for changing disaster prevention and reduction countermeasures into a pre-disaster stage from post-disaster one, and will conduct research to establish resilient coastal zones which can withstand the most severe tsunamis, i.e., to protect lives against the most severe tsunami, to avoid catastrophic socioeconomic damages, and to enable early recovery and reconstruction.

Research Topics

Research and development comprises the following two subthemes:

i) Research on ICT-based decision support systems

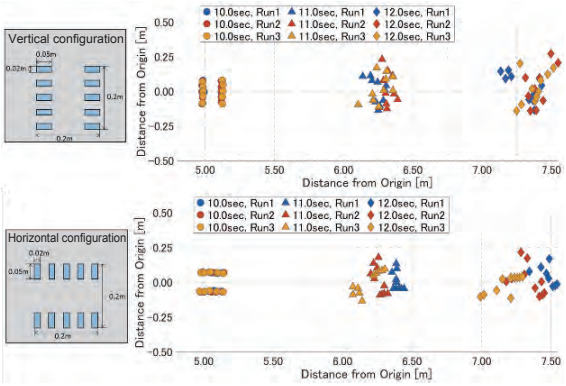
We have previously developed a system for rapid forecasting of tsunami inundation, which utilizes offshore-tsunami waveforms observed by GPS-mounted wave buoys. For highly reliable tsunami prediction, we will additionally utilize ground deformation data obtained by on-land GPS base stations and remote-sensing information including ocean HF radars, and will refine the system. To ensure the safety of evacuation sites, it is necessary to assess not only tsunami-induced inundation depth but also the tsunami velocity and floating objects to determine the resistance of structures and even to assess fires, which are associated with floating objects. So, we will establish an integrated simulation system which can assess these risks.

ii) Research on the development of tsunami-resistant ports

We will clarify the places with strong flow, scour around structures induced by large-scale overflows, and the impact of drifting objects including ships and vessels. Then, we will develop a method of designing tsunami-resistant breakwaters and other facilities as well as a method of planning tsunami-resistant ports. In addition to numerical models we have developed so far, we will develop a three-dimensional multi-physics numerical model based on a particle method with fluid-solid interaction as a tool for the design and planning. Moreover, we will conduct a large-scale model experiment to validate the robustness and accuracy of the numerical model, and will understand complex tsunami phenomena in port cities.

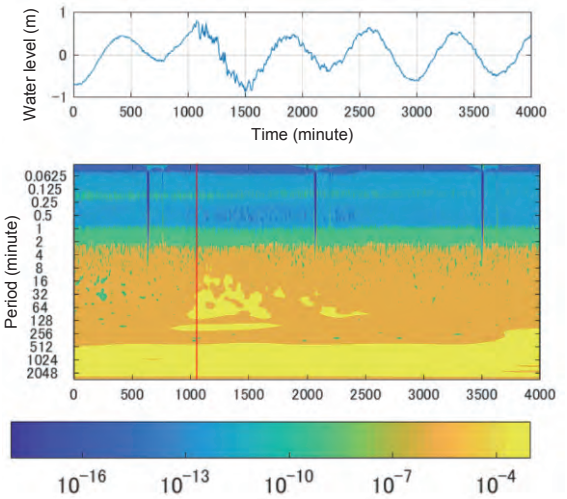
Activities in FY 2017

- In the development of a tsunami-fire model for ports, the generation, transporting, stopping and accumulating processes of debris must be appropriately taken into account; therefore, we improved a part of the fluid-debris interactions of the existing numerical model. Also, we digitized the location of each debris on video images of past experiments and analyzed the characteristics of the debris motions.



Differences in the motions of debris occurred due to the initial directions

- In the development of multi-observation based tsunami forecasting method, we established a method to improve tsunami detection accuracy by combining information on satellite positions and filtering processes through continuous wavelet transform. In addition, we conducted a theoretical analysis to develop a new tsunami source inversion method, which properly weighs several data with different noise characteristics including GPS-mounted wave buoys and ocean HF radars.



Continuous wavelet analysis on tsunami water-level data

- In the development of an advanced 3-dimentional simulation model for tsunami inundation, we introduced a hybrid parallel computation method, which utilizes MPI and OpenMP, to improve the computation efficiency. Also, we verified this simulator in the two cities of Kamaishi and Kochi; moreover, we prepared manuals of this simulator to disclose the source code the next fiscal year, and developed the integrated execution environments including I/O supports tools. In addition, as a method to properly count the performance of protective facilities in various damage levels, we developed an evaluation method utilizing fragility curves. We then applied this method to Tohoku areas and verified using survey data.
- In the development of the estimation method for local scour around costal structures due to tsunami, we confirmed the reproducibility in the topography change according to each sediment transformation equation by comparing with hydraulic experiments on bathymetry like a port and with the survey results in and around Hachinohe Port, which was affected by the 2011 Great East Japan Earthquake.

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

Background and Objectives

- Since the Ise Bay Typhoon struck in September 1959, there have been no devastating storm surge and wave disasters in Japan. However, the U.S. suffered severe damages due to Hurricane Katrina in September 2005, and so did the Philippines due to Typhoon Haiyan in November 2013. In future, global warming might bring higher storm surges and waves than those we have expected 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. Specifically, we will develop a numerical model to estimate the maximum storm surge and wave and their damage and will also develop design methods to build robust structures.

Research Topics

Research and development comprises the following two subthemes:

i) Research on storm surge, wave and maximum damage estimation

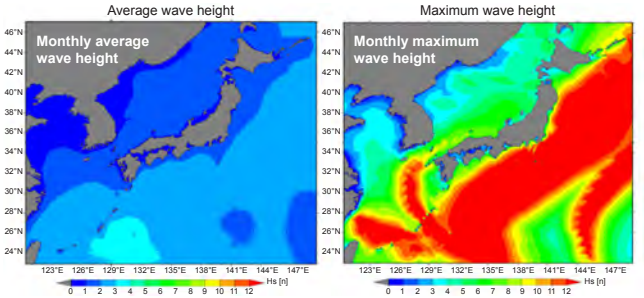
We will develop the following to determine the characteristics of the damage due to the maximum storm surge and wave: an accurate storm surge prediction model, which incorporates a weather model; and a new method based on a 3-D fluid model to simulate tidal levels and flows at the time of storm surge. Also, we will employ a high statistical analysis to estimate the effects of global warming on the maximum storm surge and wave and long-term variations in these statistics. In addition, we will establish a calculation technique to estimate the following wave transformations: the wave sheltering effects of breakwaters damaged through sliding, depression and others; and overtopping prevention effects of seawall having collapsed parapet, dispersed wave-dissipating blocks and other damages.

ii) Research on the technology to reduce maximum storm surge and wave disasters

We will elucidate structural stability under complex conditions in which unexpectedly high water level due to storm surge coincides with high waves. In addition, we will investigate methods of estimating the damage on structures due to storm surge and waves and countermeasure against such damages, and develop a method to design robust structures.

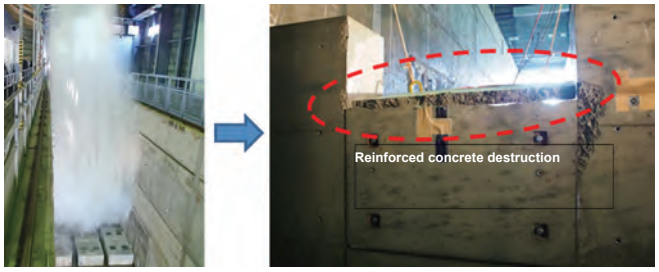
Activities in FY 2017

- In the elucidation of oceanographic phenomenon based on central processing and analysis of observation data, we summarized the statistical analysis of the wave observation data in 2016 from the Nationwide Ocean Wave Information Network for Ports and Harbours into an annual report. Also, we analyzed a tsunami in 2016; moreover, we improved the accuracy of wave data processing.
- In the study of seasonal and regional statistics on swell observed in Japanese coast, we referred to observational wind data to identify wind waves and swells under the wave directional spectrum and then validated the argument that wind waves generally conform to the relation between the wave steepness and the wave directional spreading, which was proposed by Goda, et al., however, swells do not conform.
- In the development of a harbor tranquility analysis method for local wind waves and ship waves in a harbor, we modified our ship wave generation model, in which the locations and courses of ships can be freely set on 2-D calculation grids, with drawing an estimation chart of coefficients to adjust the ship wave heights which vary depending on the grid intervals and water depth. With this chart, the coefficients can be applied to intended ship specifications, such as ship length, width and draft; therefore, the model is expected to be applied for practical works such as an investigation on the effect of ship waves on harbor tranquility.
- In the proposal for improvement of prediction accuracy of swell, we estimated ocean waves around Japan for 3 years by WW3 model with 4 types of switches for energy transfer from wind to wave, energy dissipation and other phenomena. As a result, we found that differences develop in wave statistics including the annual average significant wave height.



Wave statistics estimated by wave model WW3 with switch ST4

- In the estimation of wave transformation around damaged structures to evaluate remaining performance for sheltering, we chose submerged breakwater with rectangle and trapezoid cross-sections to conduct model experiments on the wave height transmission rate and the periodic-modulation rate. On impermeable cross sections, we found wave conditions for periodic shortening associated with wave dispersion before breaking which markedly reduce wave height transmission rates. We confirmed that wave transformation with trapezoid cross sections can be reproduced by using the existing Boussinesq model. Proper evaluation of port calmness at the time of breakwater damage is expected to be performed using the above-mentioned conditions.
- In the development of the maritime and environmental simulation model using mesoscale weather forecasting model, we used atmospheric pressure and wind predicted by WRF and the Japan Meteorological Agency's prediction MSM to calculate the storm surge caused by Typhoon Choi-wan in 2015 in Nemuro and obtained good reproducible results. We used the Isewan simulator, which incorporates GPV, GSMJP and WRF, to predict short-term environmental change.
- In the study on the wave force, overtopping and overflow of wind waves on tsunamis and storm surges over design water level, we elucidated mound transmitted wave force acting on the backside of seawall and inundation from the mound into the hinterland through hydraulic experiments. Also, we developed a simple method of estimating overtopping and overflowing rate of the seawall. In addition, we studied the characteristics of wave force acting on parapets in the case of wind waves, solitary waves and wind waves with overflow and overtopping. Then, we classified the wave breakers into breakers under overflow influence, Bagnold-type and Wagner-type and investigated the destruction processes of reinforced concrete.



Experiment of wave force acting on parapets

Research Themes and Activities in FY 2017

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

Background and Objectives

- Focused approaches on the following two matters are required: 1. The population is decreasing, society is graying, and accumulated infrastructure is aging in Japan. In view of such problems, studies should be conducted on how to secure port and airport functions, which support the international competitiveness of Japanese industry and the vitality of the nation, and people's lives. 2. With limited financial resources and workforce, studies should be conducted on how to efficiently and effectively implement maintenance, renewal, and repair works while efficiently using existing infrastructure and prolonging the life of overall facilities themselves.
- Therefore, we decided to engage in research and development and other activities which are associated with improving the functions of ports and airports. In these activities, we are conducting comprehensive research and development throughout PARI on subthemes associated with international competitiveness including internationally strategic port policies and improvement of metropolitan airport functions (improvement of Haneda Airport).
- The themes of this research address the development of specific technologies associated with international competitiveness including automated cargo works and construction information modeling (CIM). Regarding development of technologies which efficiently and effectively implement the following matters for port and airport facilities, the themes of other studies (1A, 2B, and 2C) address: improvement of largescale facilities, improvement of the quake resistance of facilities, maintenance and management after facility construction, and improvement of existing facilities.

Research Topics

i) Development and suggestion of efficient and suitable use which contains automated cargo systems through container terminal numerical simulations for multi berths

Focusing on internationally strategic container ports, we aimed to establish methods to effectively utilize Japan's narrow container terminals. With this goal, we will quantitatively evaluate the effects of off-dock loading/unloading as well as the effects of streamlining operations on reducing environmental burden and preventing congestion in front of gates. Then, we will use the evaluation results to establish strategies to effectively and comprehensively utilize container terminals.

ii) Saving labor, shortening the work period, and reducing costs by using CIM

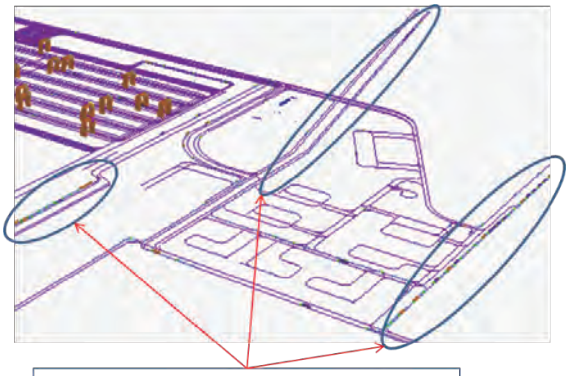
As part of construction information modeling (CIM) utilization, we will use construction-control data from a multi-beam sonar to establish a construction inspection method. With this method, we aim to save labor and achieve international standardization of construction-control inspection. By using CIM, we also aim to establish unmanned marine construction, in which Japan is lagging behind.

Activities in FY 2017

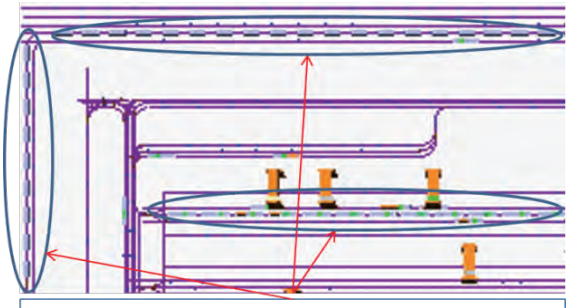
i) Development and suggestion of efficient and suitable use which contains automated cargo systems through container terminal numerical simulations for multi berths

We selected Minami Honmoku Pier MC1-4 of Yokohama Port for the study. In MC1-4, we quantified the number of waiting vehicle in front of gates and its effect on roads outside the terminal under different hypothetical gate conditions, configuration, handling capacities, and a reservation system through a numerical simulation using AutoMod.

After the simulation, we learned that, to avoid traffic jams within wharfs, operators should approach carefully including selecting a proper route for vehicles. Also, it was shown that the reservation system affects traffic-jam time dispersion and other phenomena.

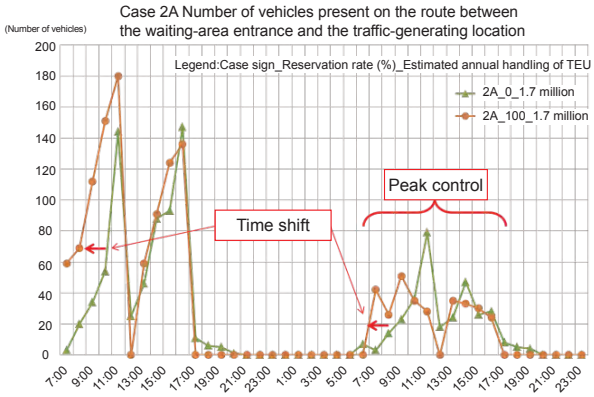


On-route traffic jams were observed between the two bridges and gates.



Traffic jams stemming from empty-container repositioning points at MC-3 and MC-4 were observed.

Observation of traffic-jam conditions under simulation. Carefully devised plans regarding route setting and repositioning points are required.



The example of simulation. Case 2A is a case in which vehicles are relatively concentrated at one gate. As compared to the green line (no reservation), the orange line (100% reservation) indicates that the 100% reservation system results in the earlier development of traffic jams than the no-reservation system; however, on days when vehicle numbers are relatively small (right), the 100% reservation system is controlled its traffic peaks. Regarding traffic-jam causes, the poor traffic capacity of routes in the wharf appears to have a significant effect.

ii) Saving labor, shortening the work period, and reducing costs by using CIM

The Japan Coast Guard and international institutions, which regulate marine charts, addressed multi-beam sonar data; however, such operation even at works directly implemented by the government was included in the subjects of the turnover inspection standard from FY 2017. Therefore, government-led operational support was offered.

2B Research on Life Cycle Management of Infrastructures

Background and Objectives

- The number of port, airport and coastal infrastructures that have been used for a long time is increasing, and yet financial resources and the number of technicians for facility maintenance are limited. Important port, airport, and coastal infrastructure functions should be maintained, and so the strategic maintenance, renewal, and other approaches for such functions are strongly required.
- Therefore, we will establish design methods for structures and materials which are excellent in terms of maintenance, and will develop techniques regarding various countermeasures in the maintenance phase.

Research Topics

Research and development comprises the following three subthemes:

i) Research on technologies for prolonging the life of infrastructure

Regarding various construction materials in marine environments, we will conduct research on the following: evaluation of long-term durability, understanding of deterioration mechanisms, and investigation of the prevention effects of protective methods for steel structures. Especially, assuming that infrastructure is used overseas and on remote islands in Japan, we will improve material characteristics and durability under severe environments and under conditions in which low-quality material is used, and will investigate environmental-burden reduction, durability improvement, and environmental coexistence. Regarding airport pavement, we will investigate methods to detect the stripping of asphalt mixture, measures for prevention of such stripping, the improvement of load-bearing characteristics and the rapid repair methods.

ii) Research on systems for inspecting and diagnosing infrastructure

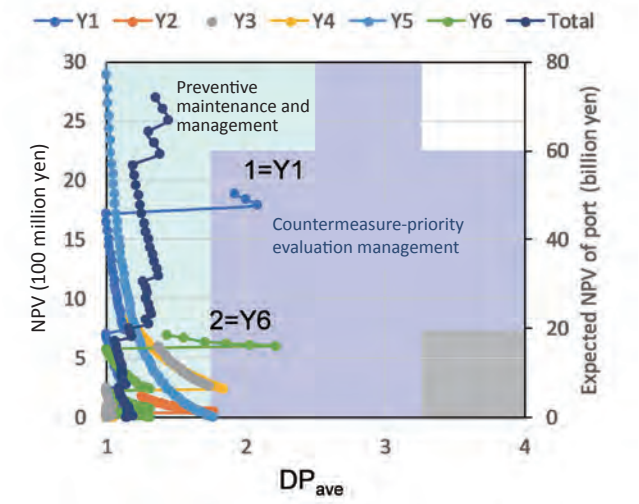
We will research and develop the following: inspection and diagnosing techniques using non-destructive and semi-destructive inspection methods and sensors, unmanned investigation devices including ROVs, non-contact thickness measurement system, and others. Especially, we will propose a health-monitoring system which utilizes sensors, as well as monitoring methods specialized for each member type. In addition, for piers, we will establish a scheme for selecting inspection and diagnosing methods according to the performance of structures to be evaluated and the accuracy of expected output.

iii) Research on maintenance and management systems for infrastructure

We will conduct accelerated deterioration tests of members of port structures, investigate performance deterioration models which cover the entire lifecycle of structures, and validate such models through exposure tests in actual environments and through on-site investigation. We will also take into account the required properties and utilization of individual structures, budgets, and various limitations, and then suggest strategies of management of port-based and district-based groups of port structures.

Activities in FY 2017

- We will use facilities with long-term exposure to predict chloride-induced concrete deterioration, and collect data on the durability of various wood materials.
- We aimed to establish a method to predict the deterioration of protective coating methods for steel structures. With this goal, we continuously conducted exposure tests (33 years have passed) regarding protective coating methods for steel pipe piles at Hazaki Observational Pier. We also conducted accelerated deterioration trials to determine the deterioration mechanisms of petrolatum coating methods.
- We evaluated the durability of concrete, in which low-grade aggregate (gorgonin) and seawater as mixing water had been used and conducted exposure tests to develop a concrete-curing technique using seawater. In addition, we studied exposed specimens to evaluate the durability of highly corrosion-resistant reinforcing steel (stainless reinforcing steel and epoxy-resin reinforcing steel, and others) and surface coating materials.
- We conducted a comparative evaluation through indoor experiments and other approaches regarding aggregate formulation, warm-mix materials, fluidity resistance, peel resistance, water permeability, and other characteristics.
- We collected and organized cases of repairing concrete at existing structures. Especially, the local failure of caisson-type side walls caused by repeated collision of wave-dissipating blocks has increased in number recently. Therefore, we draw a flow chart to select the caisson repair method depending on the level of deterioration. Also, we studied the application of a cross-section repair construction method to prestressed concrete (PC) members with chloride-induced corrosion.
- Focusing on breakwater caissons, we confirmed the dominant indicators in determining cross-section types for members designed under the current standard; moreover, we studied lintegrity evaluation methods when the existing caisson's life is extended or when the existing caisson is converted to another use as well as considerations at the time of design and construction.
- We proceeded with the following: development of anticorrosion-effect confirmation sensors; establishment of inspection systems for port structures; study on proper sensor placement in RC members for efficient corrosion monitoring; development of steel corrosion sensors in concrete; and investigation of monitoring methods to confirm the effectiveness of new construction methods and materials in pilot projects.
- We introduced new operational support functions including a shooting-omission prevention function and an autonomous collision-avoidance function into the ROV for checking the superstructures of piers and then conducted on-site verification. Also, we accumulated data measured through on-site verification on non-contact thickness measurement; moreover, we investigated on-site seasonal biofouling conditions and then set usage conditions.
- To optimize maintenance and management planning for port facilities, we proposed a priority-setting matrix for maintenance of facilities based on Net Present Value (NPV) and performance deterioration levels. Based on this, we set a model pier, which had been modeled under the assumption that the pier is 1) the preventive maintenance type or 2) the countermeasure-priority evaluation management type, and then conducted case studies of maintenance scenarios, in which LCC and the profit/loss of a facility during the countermeasure construction period are taken into account.



Optimization of maintenance scenarios for facilities based on NPV and performance deterioration levels

Research Themes and Activities in FY 2017

2C Research on Effective Use of Existing Infrastructure Facilities

Background and Objectives

- There is strong demand to improve the functions of existing infrastructure to enable active, effective use. Requests include countermeasures against increasing logistics volume and larger ships and vessels, expansion of airport functions, and countermeasures against existing facilities which can no longer be used due to increased external forces and other reasons. In addition, regarding waste disposal sites at sea which accept industrial and non-industrial waste, there is societal demand to ensure highly effective use of the sites. On the other hand, it has become difficult to secure land for soil disposal sites which accept soil dredged from 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 applications of existing infrastructure; techniques to reduce or effectively utilize construction byproducts and other redundancy; and techniques to effectively utilize waste disposal sites at sea.

Research Topics

Research and development comprises the following three subthemes:

i) Research on techniques to improve or renew existing facilities

We have already conducted research and development on improving existing facilities including deepening existing quaywalls. However, such improvements were made using techniques for newly-built structures. Hereafter, we will investigate methods of evaluating ground characteristics, design methods, and geotechnical survey methods to improve and renew existing facilities. In such methods, the construction history, effects from neighboring structures, and other factors will be taken into account. We will also investigate ground evaluation methods and geotechnical information databases, both of which cover residual settlement and other phenomena, with the aim of long-term facility maintenance and management.

ii) Research on effective use and techniques of treating construction byproducts

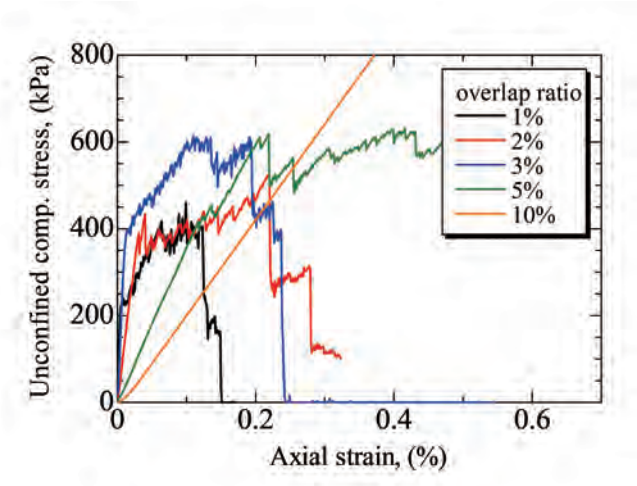
We will investigate the following techniques regarding dredged soil: improvement techniques to transform dredged soil into high-value added materials including composite soil, which provides habitats for benthic creatures, and solidified soil with high water permeability; and new volume reduction techniques. We will also investigate durability when solidified soil and slag composite soil are used in sea areas, the mechanical characteristics of composite ground materials containing various byproducts, crushable materials, and other contents, and methods of evaluating and managing the quality of these materials.

iii) Research on management and utilization of waste disposal sites at sea

Regarding disposal sites at sea, technologies for seepage control works for site development have been progressed. However, research on post-construction utilization of such sites has not been conducted. Therefore, we will investigate the following which are necessary for utilization: foundations, construction methods, effects on impermeable layers, management methods of the internal water level at low cost, techniques to detoxify waste before land reclamation, and the medium- to long-term strength and elution characteristics of solidified soil.

Activities in FY 2017

- Based on measurements of unequal settlement of reclaimed land, we estimated settlement as we did in FY2016. The coefficients of estimated settlement-curve for FY2016 and FY2017 almost converged.
- By using an experimental system which reproduces a series of processes from a grout injection experiment to an shaking table test using geotechnical centrifuge, we conducted injection experiments based on the following assumption: in the ground, there are several layers with high fine contents, which result in poor permeability of the layers. Therefore, liquid chemicals cannot easily penetrate into the layers.
- We aimed to investigate the long-term behavior of piles in soft cohesive soil. With this goal, we conducted model experiments and investigated numerical analysis methods. Consequently, through the numerical analyses, we were able to reproduce the behavior of a single pile in soft cohesive soil to some extent. Also, regarding improving construction methods for existing pile casting through soil improvement work between piles, we conducted centrifuge model tests regarding models of overall cross sections including not only pile casting but also front sheet piles. Moreover, we verified a modeling method based on numerical analysis of each part for application to actual cross sections.
- We conducted a compression test of 3D printed specimens in which shapes and orientations of every particles used for a discrete element model were replicated. With the existing specimen manufacturing methods using 3D printing technique, there were effects of particle-to-particle cohesion. Therefore, we investigated a production method that is free from particle cohesion. Also, using gravel ground, we developed equipment to conduct on-site X-ray CT scanning of a core sampled from the original location at the same original location.
- We investigated volume reduction technique of dredged soil to extend the life of disposal sites through experiment and analysis and conducted numerical analysis investigation regarding the effect of increasing the height of a levee on its stability by using the following parameters: the height of dredged soil, distance of a temporary bank from the bulkhead; structure/mechanical properties of temporary banks; and countermeasures for bulkhead bodies. In addition, we studied volume reduction due to seabed disturbance and found that the previously reported effects had been affected by turbulence at the time of sampling soil specimens. Therefore, the effects might be reduced to some extent.
- We also summarized the results of pile-installation and pile-removal experiments at a waste site that had been filled with incinerated ash. We started to investigate an insolubilization of contaminants by cement improvement technique and investigated deterioration promotion methods to study the deterioration of solidification-treated soil and eluviation of contaminant. As a result, regarding high-early-strength cement, we achieved homogeneous deterioration of the specimens by compulsory permeation.



We studied the effects of particle adhesion. DEM simulation results from uniaxial compression tests (particle overlap at the time of formation = higher overlap ratio indicates greater uniaxial compression force).

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.
- However, 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, seabed soils, 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 comprises the following two subthemes:

i) Research on port construction and management in remote islands

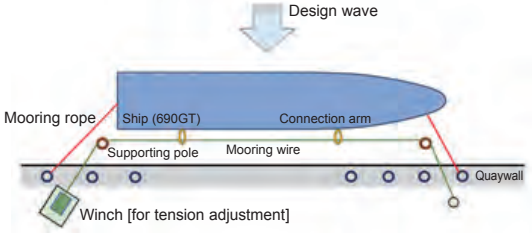
We will develop a wave calculation model for wave transformations on continental shelf boundaries and around isolated islands. We will also propose a technology to create calm water areas against wave propagation and long-period waves around isolated reefs. At the same time, we will develop a new mooring system applicable to remote islands to improve cargo-handling efficiency for ships.

ii) Research on infrastructure technology for utilization and development of oceans

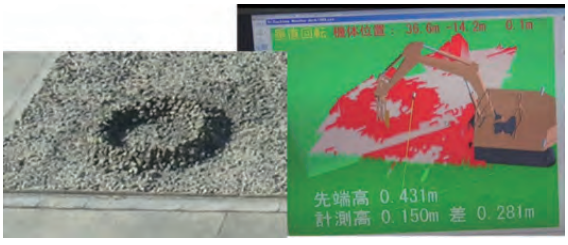
We are trying to downsize and lighten underwater acoustic video cameras, and will also develop an unmanned underwater construction system to construct marine infrastructure. In addition, we will propose an environment protection technology by promoting the attachment of calcifies to structures.

Activities in FY 2017

- In an innovation for using berthing and mooring facilities constructed in isolated coral reef sea, we used the coupling model between a wave hindcasting model (WAM) and a wave transformation model (NOWT-PARI) to estimate the occurrence frequency of ocean waves around isolated islands. Then, we compared the estimated occurrence frequency with ocean wave data from 1-year observations around the Minamidaitojima Island and Kitadaitojima Island and verified the cargo-handling operation rate at quays. Also, we used CADMAS-SURF/3D, which was improved to simulate moored ship motion, to estimate the oscillation magnitude of each moored ship at isolated reef areas.
- In a technological development on advanced ship mooring system in port, we devised a suction-connection combination method, steel mooring fender method, wire strings method, and other methods. Of these methods, we selected the wire strings method as a highly suitable mooring method under remote island conditions.
- In a research on maintenance inspection and investigation technology for remote island ports, we proposed a management method. In the method, we associated inspection underwater photographs with information including the location of photographing. Also, regarding methods of measuring the location information of an underwater running body, which is required at the time of management, we proposed a method of combining acoustic positioning equipment, GNSS, ground speed meters, and hydraulic gauges. In addition, in a simulated experiment of photographing objects placed in a water tank, we demonstrated that the dimensions of subjects, deformation, and others can be measured using underwater photographs, which are taken with the use of parallel line laser radiation.
- In a research on adaptation of the machine guidance for an underwater excavator, we added an acoustic profiler and decided to conduct pre-measurement of rubble mound shapes. Also, we conducted unit tests of acoustic positioning equipment at the actual construction site and confirmed that multiple reflection and noise do not have a significant impact. In addition, we conducted comprehensive tests at Keihin dockyard and confirmed that disparities of seafloor surface coordinates (height) are ±32 mm or less.
- In a development of next-generation acoustic imaging system, we organized the specifications of deep/shallow underwater acoustic video cameras as specifications that can withstand real sea-area conditions. Regarding deep underwater acoustic video camera, we conducted verification tests at Takuyo Daigo seamount, an investigation site near Minamitorishima and then succeeded in taking acoustic images at the depth of 1500 m. Also, regarding shallow underwater acoustic video camera, we conducted trial operations through public works at Minamihonmoku and succeeded in taking acoustic images steel pipe sheet piles.
- In a field observations and analyses on the formation and stability of carbonate lands, we succeeded in estimating ground formation rate on scales ranging from several days to seasons in model site investigations; moreover, we elucidated determinants of calcification rates, which greatly affects the ground formation speed. Also, we used the existing core-sample specimens and succeeded in estimating the ground formation rates on a scale of the past 1000 years. With this success, we proposed a quantitative model of the maintenance conditions of low-water lines. In addition, in a coral coexistence-type tide pool at Urazoe breakwater of Naha Port, we elucidated that the following factors are important environmental conditions to increase coral coverage: levels of disturbance due to water depth, water flow, waves; and gradient and shapes (complexity level) of the coral-adhering surface.



A new mooring system utilizing wires



Geometric measurement using acoustic profilers

Research Themes and Activities in FY 2017

4A Research on Enhancement and Utilization of Coastal Ecology

Background and Objectives

- Rich ecosystems in coastal zones include tidal flats, seagrass meadows, and coral reefs. Coastal zones are valuable places for the global environment. However, during the era of rapid economic growth, intense socio-economic activities caused the deterioration of water quality 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.
- On the other hand, new challenges include the utilization of coastal zone functions for mitigating climate change, as well as countermeasures against large-scale oil spill incidents from maritime industrial complexes and other facilities.
- Therefore, in the themes of this research, we will conduct research and development with the following goals: further restoration of the coastal zone environment, coastal zone utilization for climate change mitigation, and establishment of technologies to counter large-scale oil spill incidents.

Research Topics

Research and development comprises the following three subthemes:

i) Research on coastal-ecosystem utilization

Regarding ecosystem-based countermeasures against the impacts of climate change, we will conduct research on alleviating climate change including carbon separation and storage and atmospheric CO_2 uptake, both of which utilize ecosystems (blue carbon) under various conditions including remote islands such as Minamitorishima Island. In addition, we will expand our technological development internationally. We will also develop a technology to create coastal ecosystems which suffer less damage due to earthquakes and tsunamis and which recover rapidly. Through such technologies, we can continuously reap the benefits of the ecosystem.

ii) Research on the water-environment simulation and analysis in inner-bay

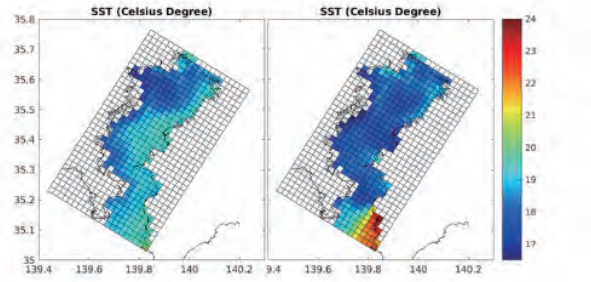
We will develop the following methods regarding the acquisition and utilization of environment observation data: a new method of analyzing marine monitoring data covering currently operating ferries and monitoring posts and others; and a new method of observing parameters for which common methods cannot obtain adequate results. We will also re-analyze existing underutilized environmental data, and will use multi-functionalized GPS wave-observation buoys to continuously observe areas for which environmental data has not been obtained. In addition, we will integrate weather/marine/ecosystem models and utilize in real time the environmental observation data. Through these means, we will develop a system which comprehensively predicts problems that frequently occur in inner bays, including red tides, blue tides, and hypoxia.

iii) Research on countermeasure technologies against sea oil spill

Regarding technologies for dealing with spilled oil, in addition to developing technologies to resolve conventional on-site challenges, we will conduct new research and development on the following: oil-gathering equipment loaded on next-generation oil-recovery ships; and systems which comprehensively recover or treat oil and which can address large-scale oil spill incidents. In addition, we will establish an information system for the risk management of oil pollution based on simulation technology, understand the behavior and mechanisms of oil spilled from dangerous facilities in waterfront areas due to natural disasters including earthquakes and tsunamis, and conduct research and development of quantitative prediction techniques and mitigation techniques for spilled oil. Through such approaches, we will develop innovative countermeasure techniques against oil pollution and improve the ability to respond oil pollution.

Activities in FY 2017

- In a global estimates of the efficacy of blue carbon as a means of mitigation and adaptation to climate change, we almost completed the establishment of a new coastal ecosystem model which achieves both blue-carbon quantification in various coastal areas and predictor models of ocean-wave attenuation which take the ecosystem into account. Also, we organized a nationwide estimated value of CO_2 amount absorbed by blue-carbon ecosystems in both 2013 and 2030, and then made the data public.
- In a development of integrated prediction and assessment method of coastal benthic ecology and geoenvironmental dynamics, we established and proposed a new method to evaluate the ground environment dynamics of tidelands and beaches. Moreover, we succeeded in comprehensively evaluating the effects of typhoon events on benthic ecosystems and ground environment dynamics. Also, we obtained positive results regarding unified evaluation of the mechanical characteristics of coral-gravel composite soil.
- In a cross-sectional observation and analysis of atmospheric and oceanographic issues at bay mouths, regarding atmospheric observation, we investigated affordable measurement methods, used their prototypes, and obtained measurement results. Also, regarding marine observation, we set a unified policy regarding the existing systems and a new marine-observation system on Kanaya-maru.
- In a development of evaluating procedure for biodiversity referring to spatial scale in coastal areas, we compared characteristic properties among the habitat environments of several organisms, and then elucidated that Ebi tideland, an artificial tideland, is a highly unique (complementary) environment.
- In an analytical study of macro-organisms dynamics on a coastal ecosystem simulation, we added new compartments referring fishes into the existing model and re-structured it to a new one.
- In a study on the mechanisms of coastal current and water environment using data assimilation, we could replicate water temperature on the east side of areas around bay mouth in Tokyo Bay, which had not been replicated using a numerical calculation model alone.
- In a novel oil spill response technology to cope with various sources including natural disaster triggered oil spills, we investigated the following regarding a technique to prevent the drifting of spilled oil by using bubble curtains: application to port facilities; application to tsunami fires; and application to oil-collection ships. Also, in the development of oil-leakage real-time hazard maps, we developed an oil drifting simulation by using network-type hazard maps and a γ-version all-time system for providing hazard information (trial-operation version).



Comparison of numerical calculation results with data assimilation results in Tokyo Bay regarding sea-surface temperatures
(Left: numerical calculation model; right: data assimilation model)

4B Research on Coastal and Estuarine Processes

Background and Objectives

- PARI's research activity of littoral drift was started to examine the critical water depth of sediment movement for harbor planning. Now, prevention methods against sedimentation and also siltation are proposed. However, in Japan, sedimentation and siltation are still progressing in some ports, and in other countries which aim to expand their infrastructure overseas, a much greater amount of siltation than in Japan is projected. Countermeasures against such sedimentation and siltation problem have been inadequate.
- On the other hand, beaches are valuable as they provide protection, environment and utilization functions. However, the area of beaches has been decreasing since the era of rapid economic growth, and is still shrinking at a rate of 1.6 km^2 per year. Various countermeasures have been taken to prevent such coastal erosion, and as a result, the beach area has increased at some coasts. Nevertheless, global warming is expected to cause more severe coastal erosion. In addition, when remote islands and overseas are taken into account, it is important to maintain not only beaches but also coral-reef coasts.
- Therefore, in the themes of this study, we aim to maintain the following under future climate change: natural coastline geometry including beaches, mangrove coasts, and coral-reef coasts; and artificial coastline geometry including navigation channels and harbor basins, which support logistics. We will also estimate changes in coastal-erosion and sedimentation phenomena assuming the progress of global warming, and then propose countermeasures against those changes. Also, 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

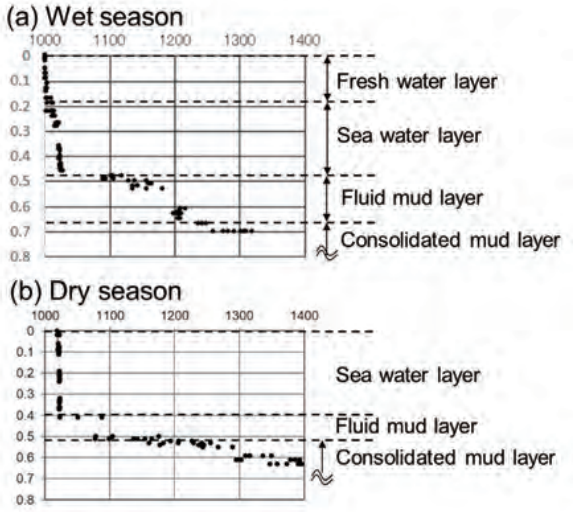
Our researches and developments for coastal protection and maintenance of waterways and mooring basins are as follows:

We will analyze long-term measurement data of the Hasaki coast and conduct short-term, intensive, on-site observation of how beaches respond to different sea levels. Through this, we will understand beach-response mechanisms to sea level rise, and will develop methods of predicting future beach morphology. We will take into consideration the spatial scale of not only the Hasaki coast but also global, and predict long-term coastal changes (including natural sand coasts, sand coasts protected by structures, coral-reef coasts, and pebble coasts) along with variations of coastal disaster risks. In addition, we will develop hybrid beach-maintenance methods, which minimize structure volume and actively introduce sand bypasses, and propose effective beach maintenance methods that account for the disaster risks.

Regarding sediment transport which accompanies port utilization, we will expand the scope of our research to include estuaries of large rivers, mangroves, and intertidal zones overseas. Then, we will develop monitoring method for topographic change which address regional characteristics and understand the dynamics of topographic changes. In addition, we will examine strategies to reduce siltation and sedimentation and will develop the efficient maintenance methods of navigation channels and harbor basins as well as conservation of the surrounding environment of port and harbor facilities.

Activities in FY 2017

- In an observation of coastal geographical feature change and generalizing of prediction method in considered with influence of global warming, we elucidated the following: changes in shoreline position are associated with both tide and wave height; the changes occur 36 days after the day when tide becomes highest and 72 days before the day when wave height becomes highest. Also, we investigated a wave breaking model for numerical simulation, which utilizes the Ursell number, which represents the asymmetric characteristics of waves, however, the calculation results regarding breakers on submerged breakwaters and average water-level reduction are sometimes unstable. Therefore, we found that the breaker model requires further improvement.
- In a study on sediment transport in estuary and deposition process in navigation channel, we compared the results of an estuary turbidity distribution study conducted around Patimban Coast (August, dry season) with the results from a previous study (February 2017, rainy season), and identified seasonal-variation characteristics of highly dense fluid mud. Also, we conducted on-site studies regarding highly dense turbid water at the time of flowing out within Niigatanishi Port and elucidated the process of accumulation of highly dense fluid mud in dredging areas. In addition, we conducted on-site observations and flume experiments, modeled the amount of fluid mud transport, which depends on mud content in the bottom sediment and other factors, and then verified the model.
- In a study on applicability of airborne laser bathymetry for topographic monitoring in coastal zone of sea shore, obtained topography through aircraft sounding utilizing green laser showed good agreement with the cross-section topography through lead sounding, except for areas with many white bubbles caused by wave breaking. Regarding the scouring conditions around piles supporting observation pier of Hazaki Oceanographycal Research Station, correct measurements were made. Although some measurement errors, which appear to be caused by missing sea bottom measurements due to the white bubbles of wave breaking, due to turbidity in deep-water areas and other factors, aircraft sounding accuracy levels are high, showing that aircraft sounding can be an effective method of performing highly accurate topography measurements within breaker zones on a wider and highly-dense scale.



Vertical distribution of bottom-mud densities in rainy season (above) and dry season (bottom) at Patimban

Fundamental Research

Fundamental Research in FY 2017

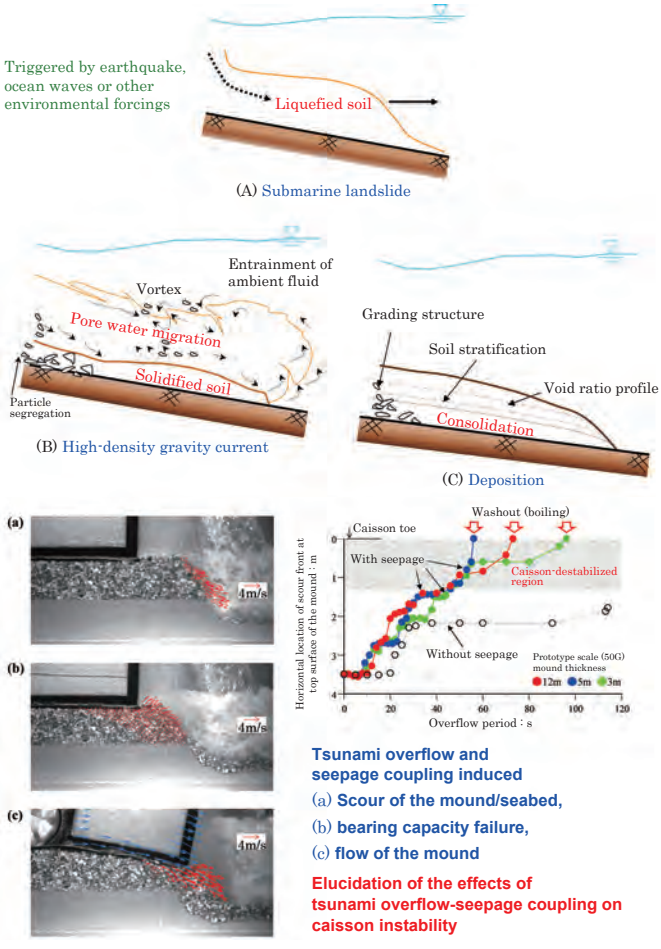
The fundamental research of waves, beaches, ground, earthquakes, environments, etc., is the basis of every study conducted by PARI, and therefore we are actively working on clarifying principles and phenomena, such as the mechanisms of natural phenomena and dynamic behavior of the ground and structures.

	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 scenario earthquakes beneath metropolitan area
4	Study on the evaluation and analysis of liquefied ground behavior and effective contermeasures under sequenced earthquake motions
5	Seabed Soil Dynamics and Stability Assessment of Breakwaters and Seawalls
6	Study from geotechnical view-point on stability evaluation method of coastal structure subjected to high waves
7	Development of the estimation method for local scour around coastal structures due to tsunami
8	Elucidation of oceanographic phenomena based on central processing and analysis of observation data
9	Proposal for improvement of prediction accuracy of swell
10	Development of the maritime and environmental simulation model using meso-scale weather forcasting model
11	Evaluation of longterm durability of concrete, steel and various materials based on exposure test
12	Study on the durability of protective coating method for marine steel structures
13	Study on the durability of various materials under severe environments
14	Improvement method to non-uniform ground and its effect as a measure against liquefaction
15	Enhancement of accuracy of method for evaluating mechanical properties of composite geomaterials based on microstructural feature
16	Field observations and analyses on the formation and stability of carbonate lands
17	Global estimates of the efficacy of blue carbon as a means of mitigation and adaptation to climate change
18	Development of integrated prediction and assessment method of coastal benthic ecology and geoenvironmental dynamics
19	Cross-sectional observation and analysis of atmospheric and oceanographic issues at bay mouths
20	Analytical study of macro-organisms dynamics on a coastal ecosystem simulation
21	Development of evaluating procedure for biodiversity referring to spatial scale in coastal areas
22	Study on the mechanisms of coastal current and water environment using data assimilation
23	Observation of coastal geographical feature change and generalizing of prediction method in considered with influence of global warming
24	Study on sediment transport in estuary and deposition process in navigation channel
25	Study on applicability of airborne laser bathymetry for topographic monitoring in coastal zone of sea shore

Cases of Fundamental Research

Seabed Soil Dynamics and Stability Assessment of Breakwaters and Seawalls

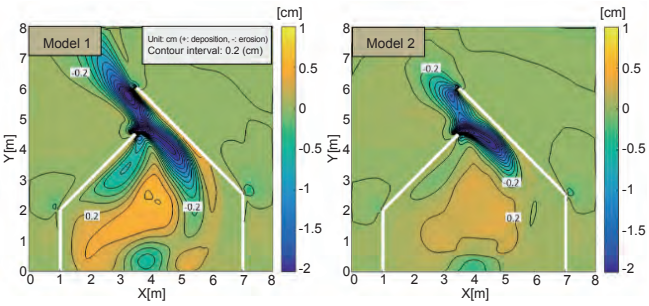
- Seabed ground can flow markedly owing to diverse external loadings such as earthquakes and tsunamis. However, the seabed ground flow dynamics remain largely unclear, since on-site observations are formidable if not impossible. These submarine ground dynamics can greatly affect coastal structures; therefore, it is important to understand the phenomena and establish an evaluation method.
- The submarine liquefied flow dynamics greatly affect coastal and marine structures as well as submarine-landslide tsunamis; on the other hand, the dynamics have previously been difficult to predict. In this study, we established new theories and numerical-analysis methods which can predict and reproduce a series of concurrent processes regarding the submarine liquefied flow dynamics, and then comprehensively validated their effectiveness. In addition, we elucidated the effects of fine contents and percolation on the development of submarine landslides and the associated gravity flows.
- We systemically elucidated the dynamics of the seabed and rubble mound of caisson breakwaters under tsunami-induced seepage, regarding focal ground flow dynamics around coastal structures and its effects. Moreover, for the first time in the world, we elucidated the mechanism of destabilization of a breakwater caused by tsunami overflow-seepage coupling. Then, we established a new stability assessment method for caisson breakwaters that take into account both the dynamics of the breakwater foundation mound/seabed and countermeasures against them (embankment).
- The developed analytical framework for submarine liquefied flow dynamics can be widely used for predicting coastal large-scale processes of submarine mass movements and assessing the impacts of the submarine liquefied flows on coastal and marine structures as well as submarine landslide tsunamis, and thus serve as basis of their rational evaluation and prediction. In addition, the new stability assessment method of breakwaters considering both the dynamics of breakwater foundation mound/seabed against tsunamis and their countermeasures, are comprehensively reflected in the technical standards for ports. Therefore, wider utilization is expected not only nationally but also internationally.



Submarine Liquefied Flow Dynamics and Their Analytical Framework with Experimental and Field Validations: Conceptual charts

Development of the estimation method for local scour around coastal structures due to tsunami

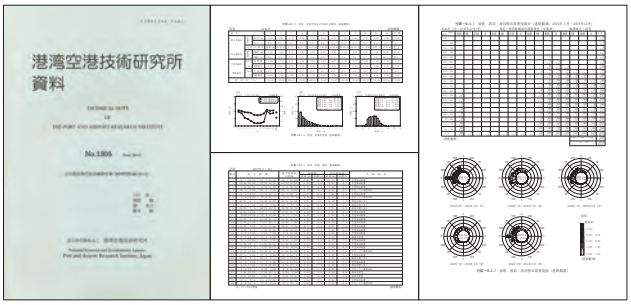
- Tanimoto's formula, the static-pressure formula at the time of overflow, and other formulas have been examined to determine the tsunami wave force to be used in anti-tsunami design for breakwaters. These study results were published as the Guideline for Tsunami-Resistant Design of Breakwaters in FY 2013. However, there are many cases of overflow-induced scouring damages such as the case of the northern breakwater of Hachinohe Port during the 2011 Great East Japan Earthquake. These damages have not been fully investigated.
- Therefore, in this study, we conduct hydraulic-model experiments using a movable-bed regarding breakwaters and their peripheral submarine topography. We vary the sand-deposit conditions including particle diameter and then compare the results. In addition, we investigate the armoring effects of crushed stones of a mound. Through these investigations, we propose a versatile equation for estimating scouring amount. Furthermore, we investigate a method for estimating scouring amount using a particle method.
- Seafloor topography changes through seafloor sand/mud migration, which is caused by tsunami flow. There are various modes in the migration, including sliding, rolling, saltation, and floating. Several theoretical and experimental equations have been proposed for each of these modes. The equations for respective modes need to be combined in the simulation for estimating local scouring amount associated with sediment migration.
- However, the optimal combination for a given phenomenon and the application limitation for the combination have not been fully investigated. In order to establish a model that accurately replicates phenomena that affect local scouring, including armoring effects of crushed stones of a mound, we must first confirm the existing equations and limitations for each of these combinations.
- Therefore, in FY 2017, we conducted many simulations in which various equations were combined. We compared the simulations with the results of experiments in which an artificial tsunami engulfs a landform like a port and with actual tsunami cases including Hachinohe Port, where focal scouring occurred due to the 2011 Great East Japan Earthquake. Through the comparisons, we organized the geometric changes estimated by each estimation model and their combinations, and then elucidated their characteristics.
- In the future, we will continue to investigate the similarity laws, and will calculate flow and seafloor changes using a particle method. After taking the results into account, we will establish an equation for estimating scouring amount, and then will reflect our achievements in technical standards and so forth.



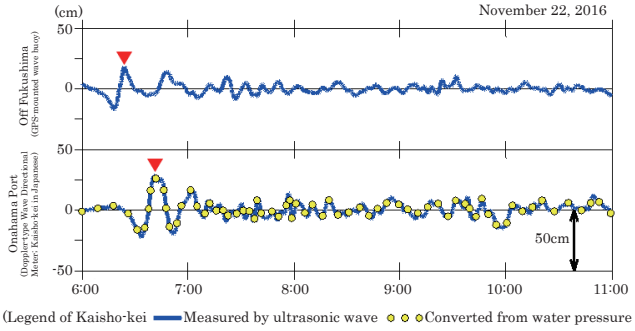
Comparison of geometric change at a landform like a port

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

- PARI has been processing and analyzing ocean wave data acquired by the Nationwide Ocean Wave information network for Ports and HArbourS (NOWPHAS) since 1970. With increasing concern about climate change, we must continue this analysis and provide wave information that is relevant for practical port and coastal works.
- Therefore, in this study, we make out quick and definite information based on data observed at each station on NOWPHAS. We also conduct statistical analyses, compile annual reports on NOWPHAS and accumulate tide level and wind data. In addition, we conduct on-site observation using highly accurate capacitive wave gauges, establish a method to estimate 2-D higher wave number spectra, and develop a method to estimate ocean winds and waves using synthetic-aperture radar including TerraSAR-X.
- In FY 2017, we conducted statistical analyses of ocean wave data obtained in 2016 and compiled the annual report on NOWPHAS. It included the local highest significant wave heights at 14 stations, consisting of 7 stations having seabed wave gauge (e.g. Kushiro and Mutsuogawara) and 7 stations having GPS-mounted wave buoys (e.g. East Aomori). Especially, the high waves caused by Typhoon Lionrock in 2016, which made landfall in the Tohoku region for the first time since 1951 when the Japan Meteorological Agency started to take typhoon statistics, were observed at many stations.
- Also, we extracted the tsunami waves caused by Off-Fukushima Earthquake on November 22, 2016 and confirmed that the tsunami arrived at the Pacific coast of the Tohoku region. Especially, the tsunami height was slightly less than 20 cm and approximately 70 cm at the GPS-mounted wave buoy off the Fukushima coast and the tide station in Sendai-Shiogama Port, respectively.
- In addition, we improved the accuracy of the tsunami profile on a GPS-mounted wave buoy by an appropriate preprocess of the sea surface elevation data.
- Continuously, we intend to compile annual reports on NOWPHAS, to analyze noticeable tsunami and ocean wave events, and to improve wave data processing and analysis methods. We also intend to use the results of our work to design port and coastal facilities and to prevent disasters.



Annual report on NOWPHAS

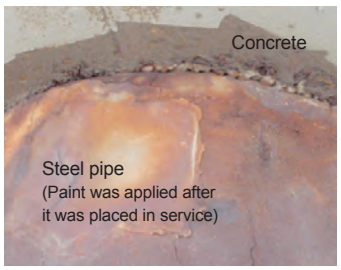


Tsunami profiles caused by Off-Fukushima Earthquake in 2016

Study on the durability of protective coating method for marine steel structures

- The combination of two types of prevention methods, namely cathodic protection and protective coating, has been used for marine steel structures, ensuring their long-term durability. Regarding the protective coating method, deterioration characteristics including life expectancy have been clarified from the past exposure test results. However, methods of checking the performance of each protective coating method at the time of design, methods of evaluating current protective performance at the time of maintenance and management, and methods of predicting future situations have not yet been established.
- Maintenance and management costs remain high and there are not enough technicians, so more efficient methods of maintaining and managing the above social capital urgently need to be developed.
- In this theme, we are working on establishing the following methods: a method to check the performance of each protective coating method at the time of design, a method to evaluate the current protective performance at the time of maintenance and management, and a method to predict the future situation.
- Investigation (1): We elucidated the deterioration mechanism of the petrolatum coating method and conducted accelerated deterioration tests to establish a method to evaluate the performance of petrolatum material.
- Investigation (2): We conducted field studies on the protective coating construction method and corrosion at the boundary of the existing concrete superstructure at Hazaki observation pier.

Investigation (1): Accelerated deterioration tests to establish a method to evaluate the performance of petrolatum anticorrosion material
(A steel pipe was wrapped with anticorrosion materials and rotated in tap water at 60°C.)



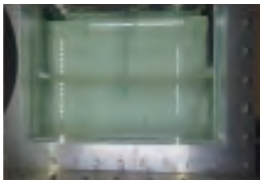
Boundary between concrete superstructure and the existing steel pipes that were painted after being placed in service.
(Corrosion advanced at the boundary.)

Fundamental Research

Improvement method to non-uniform ground and its effect as a measure against liquefaction

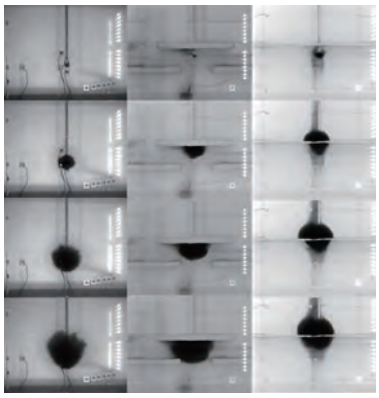
- Countermeasures for earthquakes and liquefaction are now made at ports and airports, so it is essential to make existing facilities earthquake-resistant. As a construction method to prevent liquefaction of ground directly under existing facilities and ground surrounding buried structures, the density increasing method and the chemical grouting method are frequently used. Generally, when the ground of the original location is heterogeneous and when the fine content is relatively high, construction tends to be challenging. But if construction is performed forcibly, problem such as localized deformation at the surrounded ground will be developed. Therefore, in this study, the improvement effects on heterogeneous ground by the chemical grouting and the densification method are investigated.
- In this study, visualization technique such as a transparent soil was employed to visualize ground deformation. As the transparent soil, we used crushed transparent quartz particles and refractive index matching solution to make the model ground transparent. In centrifuge model tests, we simulated grout injection and investigated the effects of different ground conditions on the improved area.
- This new visualization method is practical, and can visualize complex intraground penetration and deformation behavior, both of which have been challenging previously. Going forward, we will conduct numerical simulations and other strategies regarding phenomena observed in experiments and will use the results to develop a method to predict ground improvement effects. Also, this experiment method is expected to be applied to various geotechnical engineering problems other than ground improvement.

Before saturation



After saturation

Saturation processes

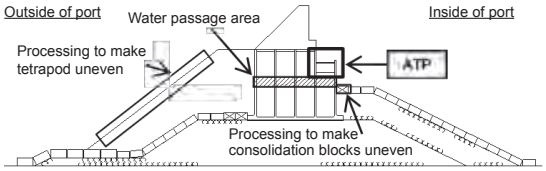


Homogeneous ground　Fine layer 1.0 m　Fine layer 0.25 m

Grout injection processes

Field observations and analyses on the formation and stability of carbonate lands

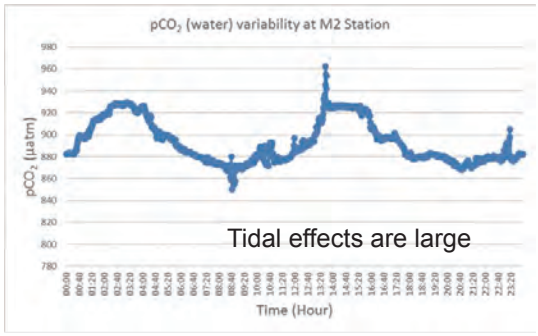
- The importance of remote island-based marine development and utilization has been increasing. The low-water lines of remote islands are the baseline for the exclusive economic zone. Thus, in order to conserve national land for remote islands, it is necessary to maintain not only territory but also low-water lines.
- Remote islands located in the southern part of Japan including Okinotorishima Island and Minamitorishima Island have different soils from those of Honshu and other main islands where the main material is silicates. The soil and sediment of these remote islands are composed mainly of calcium carbonate formed by corals and foraminifers (calcifiers). Therefore, conservation of the national land depends on whether the rate of formation of land by calcifiers exceeds the rate of the rise of sea level and erosion.
- External stresses including climate changes, bottom-sediment changes, and environmental changes can be not only threats for calcifiers but also threats from the viewpoint of national land conservation.
- Therefore, in this research, we aim to understand the determinants of the ground formation rate by calcifiers as well as the processes of movement, settlement, and erosion of sediment to create a scientific and technological basis for maintenance of territory, low-water lines, and port facility geometry.
- This fiscal year, we conducted in situ investigations at model sites (Rukansho, Naha Port, Hirara Port, Ishigaki Port, Akashima Island, Iriomotejima Island, Ishigakijima Island, and Furenko Lake), and analyzed the existing core-sample specimens. Also, we investigated the relationship of coral coverage with the environmental conditions in a coral coexistence-type tide pool at the Urazoe breakwater of Naha Port.



Coral symbiosis-type tide pool at the Urazoe breakwater of Naha Port

Global estimates of the efficacy of blue carbon as a means of mitigation and adaptation to climate change

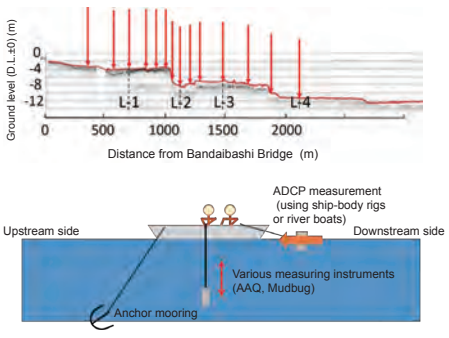
- Climate change countermeasures in port and coastal projects are urgent challenges. Recently, it is being confirmed that blue carbon (carbon captured by marine organisms) in marine ecosystems is effective for mitigating climate change (atmospheric CO_2 absorption and carbon storage). Also, coastal ecosystems are expected to adapt to climate change, including dissipating ocean waves and sediment deposition. Therefore, comprehensive investigation of the two functioning is necessary. However, quantification of the extent of dissipation of ocean waves and sediment deposition by coral reef ecosystems, seagrass beds, and other conditions has only just begun worldwide.
- In the study, we will utilize the ability of blue carbon to mitigate and adapt to climate change to improve the cost effectiveness of port and coastal projects. Leveraging the improvements to propose new climate change countermeasures, we will develop a method to quantify the mitigation and adaptation functioning of blue carbon against climate change (investigation, analysis and modeling). In addition, using newly developed methods, we will estimate the mitigation and adaptation functioning at coastlines on a global scale.
- This fiscal year, we conducted the following studies: new establishment of the coupled mangrove-coral reef ecosystem model, geometric/ecosystem data collection and GIS analyses for estimation on a global scale, and modeling of shallow coastal ecosystems in terms of wave attenuation and inundation reduction. Also, we conducted in situ investigations on carbon dynamics at seagrass beds, tide flats, coral reefs, and mangroves both in Japan and overseas. In addition, we led the Blue Carbon Study Group in Japan, which consists of experts from academia, related organizations, and so forth.



24-hour continuous study of carbon dynamics

Study on sediment transport in estuary and deposition process in navigation channel

- In ports located around estuaries, countermeasures against sedimentation of navigation channels and harbor basins due to the deposition of discharged sediments through rivers are required. Examining countermeasures against sedimentation and siltation is important research subjects to resolve the following existing challenges: shortage of disposal site of dredged sediments and reducing the cost of maintenance dredging. Maintaining navigation channel and harbor basins are more serious problems in many ports in Southeast Asian and other countries, which are situated next to cities developed in estuaries of large rivers.
- In this research, focusing on estuaries not only in Japan but also overseas including in Southeast Asian countries, we aim to understand the transport dynamics of sediment supplied by rivers including the transport of highly concentrated fluid mud and its seasonal variations, taking regional characteristics into consideration. We also make a simulation model of these sediment transport processes in the estuarine and coastal zones.
- This fiscal year, in a collaborative study under a joint-study agreement with the Indonesian government agency BPPT, we studied estuary turbidity distribution around Patimban Coast (August). Also, we conducted on-site studies of highly concentrated turbid water where the Shinanogawa River flows out into the estuary and in an area within Niigatanishi Port (November, December). In addition, we conducted transport experiments of local bottom mud transported by waves and flows, and quantitatively evaluated changes in transport amount depending on mud content rates and other factors.



Studies of highly concentrated turbid water where the Shinanogawa River flows out into the estuary and in an area within Niigatanishi Port

Exploratory Research in FY2017

In FY 2017, 8 exploratory researches based on ingenious and/or advanced ideas and potentially pioneering research fields for PARI in the future were carried out, considering foresight and mobility.

1. Development of educational tools for inspection and diagnosis using simple VR

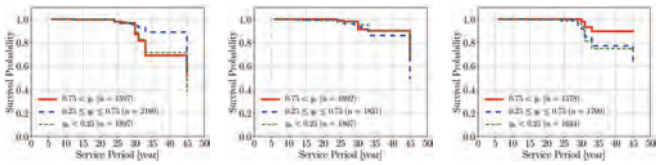
- Port administrators including local government should be largely responsible for the maintenance and management of port facilities, but with limited budget and manpower. Therefore, the burden of maintenance and management work is increasing. As a result, the number of cases in which structural safety has declined due to the deterioration of structural members resulting in serious accidents, is increasing in aged facilities. In view of this trend, the proper and efficient inspection and diagnosis of port facilities is required. Therefore, in this study, we created educational tools that enable young technicians and inspectors to study the following easily: mechanisms of deterioration and deformation in port structures and inspection points.
- We proposed the following educational tools and methods: 1) 3D animation films for each type of port structure (piled piers, steel sheet pile quaywalls and breakwaters covered with wave-dissipating blocks) regarding degradation chain mechanisms. 2) Important points of visual inspection in pier superstructures by analysis of the viewpoint of skilled inspectors using the viewpoint camera (GoPro). 3) The virtual experience tool for a visual inspection of piled piers using a head-mount display (HMD) and an omnidirectional camera (Gear360). 4) The method of diagnosis in pier superstructure using 3D-development diagrams created by SfM/MVS software.

Figure 1. 3D animation film

Figure 2. Virtual space experience through HMD

2. Analysis of Visual inspection data of superstructure of open-type wharves using survival analyses

- Even at the same open-type wharf, deterioration of the underside of superstructure is known not to proceed homogeneously. We empirically know that members located on the sea or land side tend to deteriorate more progressive, but do not understand what factors affect the deterioration progress and to what extent such factors affect the deterioration progress.
- Regarding facilities subject to technical standards, routine inspection and diagnosis has become mandatory, and are carried out at least once every 5 years. Routine inspections include visual inspections, so visual inspection data are expected to accumulate. Regarding visual inspection of the underside of superstructure of open-type wharves, to diagnose the degree of deterioration of all members, analysis of visual inspection data of the underside of superstructure of open-type wharves, which will be accumulated quantitatively, may allow identification of the characteristics that contribute to deterioration progress. Therefore, in this study, we used the method of survival analysis to analyze visual inspection data of the underside of superstructure of open-type wharves (from 19 open-type wharves) and investigated the factors contributing to deterioration progress.
- After analyzing the visual inspection data, each member type appears to have different factors affecting deterioration progress. As an example, Figure 1 shows an estimated survival function for each member type depending on the location of members in perpendicular direction to the normal line of an open-type wharf. BH (Figure 1 (a)) shows that members located on the sea or land side tend to deteriorate more progressive; BV (Figure 1 (b)) shows no difference in deterioration progress depending on locations of members; S (Figure 1 (c)) shows that members located on the sea side tend to deteriorate more progressive.

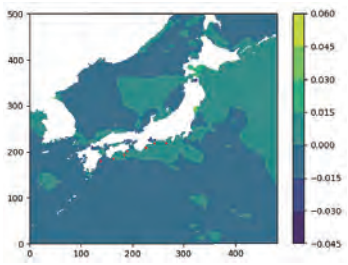


(a) BH (beams in the direction horizontal to the normal line) (b) BV (beams in the direction vertical to the normal line) (c) S (floor slab)

Figure 1. Results of an estimated survival function of each member, with locations in perpendicular direction to the normal line of an open-type wharf
(Legend: Red = members located on land side of an open-type wharf, Blue = central, Green = sea side)

3. Development and evaluation of a storm surge numerical model using a Kalman filter

- When a typhoon appears, it is important for coastal disaster prevention to conduct an accurate storm surge forecast (SSF). However, it is difficult to closely observe meteorological fields in time and space on the open ocean, and the initial values used for typhoon forecast might greatly cause the difference between the typhoon forecast and the actual one. Since differences in meteorological fields cause differences in storm surges, the accurate SSF is still a great challenge.
- Therefore, in this study, we used the Regional Oceanic Modeling System (ROMS) to develop a storm surge numerical model which successively assimilates ocean observation data. In this model, the calculation is revised every time after observed values are obtained, and so is expected to suppress differences in prediction from occurring. The assimilation method uses the Ensemble Kalman Filter (EnKF), which derives the analytical value from multiple first guesses with different initial conditions.
- For model verification, we conducted the following twin experiment for the case of Typhoon Lan in 2017. 1) We calculated the storm surge with the meteorological analytic value MSM-GPV (grid interval: 5 km) as an external force (calculation period: between 0:00, October 21, 2017 and 12:00, October 24, 2017; calculation area: lat. 22.5° to 47.5° N, long. 125° to 149° E; grid interval: 5 km), handled the results as true values, and then made the observed values by adding Gaussian noises on the true values. 2) We used the LAF method to set seven different initial conditions. With each condition as a starting point, we calculated the storm surge with the meteorological forecast value GSM-GPV (grid interval: 20 km) as an external force. 3) Regarding the calculations, we assimilated the observed values every hour at points where GPS-mounted wave buoys are positioned.
- As a result, we confirmed that the assimilation affected the overall calculation area, even though the observed values were given at the points. However, the assimilation did not improve forecast accuracy.
- In the future, we will investigate the following optimal model setting: applying the Breeding method for making new initial conditions, increasing the number of ensemble members, and shortening the assimilation interval.



Revision of storm surge by the assimilation (●: Location of GPS-mounted wave buoys)

4. Attempts to establish a technique for the retrieval of near-surface marine information from GNSS-R

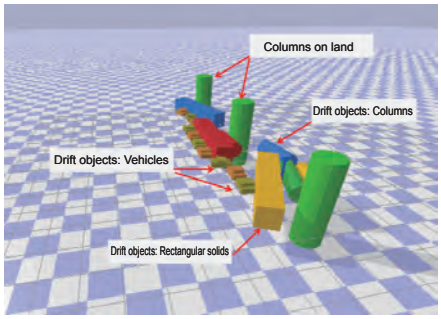
- The broad term for positioning satellites, including GPS launched by the United States, is Global Navigation Satellite Systems (GNSS). Of GNSS, remote sensing utilizing the phenomenon whereby signals from positioning satellites are reflected on the sea surface and the land is called GNSS-R (Reflectometry). GNSS-R utilizes existing positioning signals, making simultaneous observation from several sites possible. Therefore, GNSS-R now has excellent potential as a low-cost monitoring method for natural phenomena that change quickly, including typhoons and bomb cyclones.
- In estimating physical parameters, including sea surface winds, ocean waves, tsunamis, and storm surges, using GNSS-R, we should focus on the following important points: we will elucidate the physical phenomena of “wavelets” in actual sea areas, and will then quantitatively evaluate the relationships of such physical phenomena with dispersion signals from the sea surface.
- In this study, we conducted comprehensive in-situ observations of ocean waves and associated physical parameters, sea surface winds and wave-induced mixing, at Hiratsuka observation tower, University of Tokyo Ocean Alliance between March 28 and April 5, 2018. Moreover, we used a GNSS antenna to measure the magnitude of GNSS signals reflected from the sea surface.
- Going forward, we will analyze the obtained data. In particular, regarding direct measurement of higher wave number spectra with wavelengths of up to approximately 10 cm and source balance at their frequency zones, there are many unknowns. In estimating wavenumber spectra, the wavelet directional method proposed by Donelan et al. (1996) is used. In addition, we aim to clarify independently the following: the physical processes of the ocean wave boundary layer using measured ocean wind turbulence; turbulence mixing associated with breakers using marine surface layer turbulence, and the effects on higher wave number spectra, which are associated with turbulence mixing.

Observation equipment in Hiratsuka observation tower

Exploratory Research

5. Development of drift model using arbitrary object

- Various models for tsunami-induced drift objects have been developed; however, in these models, drift objects of various shapes, such as vessels and vehicles, are expressed as mass points, rectangular solids, and combinations of particles. Shibuya et al. (2012) suggested that the ability to express object shape is important for the reproduction of trapping phenomenon caused by structures for capturing drift wood in rivers. Drift objects caused by tsunamis have various shapes including vessels, containers, vehicles, and house rubble. Therefore, the ability to express shape is essential for predicting complicated phenomena in which these objects interact.
- Therefore, in this study, we tried to develop a drift model which can express drift objects of arbitrary shape. In calculating drift motions, the following models are required: a fluid model which calculates water levels and flow velocity and a drift model which calculates drift motions.
- Regarding the fluid model, we used the Python programming language to develop a numerical model based on Navier–Stokes equations, considering the ease of the connection with the following drift model.
- Regarding the drift model, we used the Pybullet, which was the Python version of the physical engine library "bullet" and the open-source library using a zlib license, for translation and rotation of objects as well as collision, for each time step. Pybullet can express arbitrarily shaped objects by combining basic shapes including spherical, box and columnar shapes or by feeding .obj files, which is a data format for expressing 3D objects. Also, many physical engines containing Pybullet can perform high-speed calculation of 3D physical motions, and so they are used for physical calculation in games. In this drift model, we used fluid force calculated using water levels and flow velocity obtained from the fluid model and calculate the motion of drift objects at each time.
- In the future, we will validate this drift model by comparing the existing experimental results. Regarding the physical engine used in the drift model, real-time performance was shown to be more important than calculation accuracy. Therefore, a quantitative assessment of the reproducibility of actual phenomena is required. In addition, we will study the following: improving the fluid force evaluation method for the drift model; improving the interaction method of the fluid model and the drift model; comparing these models with existing models; and evaluating debris dam and accumulation in inundation areas and on collision of debris with land structures.



Drift objects expressed by combining various basic shapes

6. Proposal of an corrosion protection method using a technique to form self-assembled monolayers (SAMs)

- Epoxy-resin coating and galvanization are direct methods for preventing the corrosion of reinforcing steel bar as for reinforcing-steel concrete structures. However, these methods costs more than regular reinforcing steels; therefore, reasonable, simple and highly effective anticorrosion methods are being developed.
- One method to prevent the corrosion of precious metals and highly reactive metals is to confer water repellency by surface modification of reinforcing steel bar using self-assembled monolayers (SAMs). Surface modification using SAMs is a simple method in which metals are just immersed in a solution containing functional molecules. Therefore, such surface modification come to be great advantage for civil structures that use a lot of reinforcing steel. In this study, we aimed to apply SAM-based anticorrosion techniques to reinforcing steels.
- To confirm the anticorrosion performance of SAMs on reinforcing steel bar, we evaluated the following anticorrosion properties: 1) corrosion protection performance confirmed through accelerated deterioration tests that replicate alkaline environments and salt-damage environments, and 2) corrosion protection performance confirmed through electrochemical measurements.
- Figure 1 shows the results of accelerated deterioration tests involving a cycle of dry and humid conditions. The test specimens with SAM-modified surfaces showed no corrosion in the alkaline environment, but showed corrosion at the first cycle in the salt-damage environment.
- Based on measurements of corrosion speed of the test specimens immersed in seawater (Figure 2), we investigated the effects of SAM on corrosion speed. The results showed that corrosion is faster in the following order: no SAM > SAM No. 1 > SAM No. 2 > SAM No. 3 > SAM No. 4. Therefore, we found that corrosion is slower than with no SAM when surfaces are treated with SAMs in the presence of corrosion. Accordingly, these results indicated that surface modification with SAM can reduce corrosion speed compared with regular reinforcing steels.
- In future studies, we need to investigate the durability of SAMs and actual anticorrosion effects by burying test specimens with SAM-modified surfaces in concrete.

Figure 1. Confirmation of anticorrosion performance through accelerated deterioration tests using SAM-modified specimens

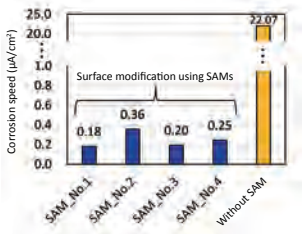
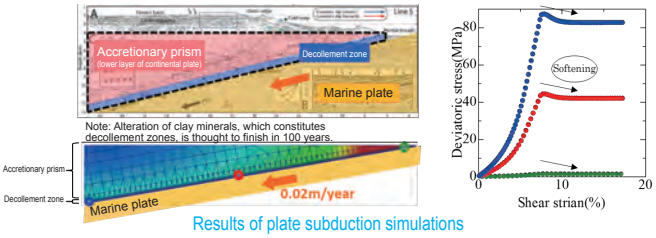


Figure 2. Results of corrosion speed measurements

7. Elucidation of mechanisms of earthquake-induced tsunami by numerical analysis methods

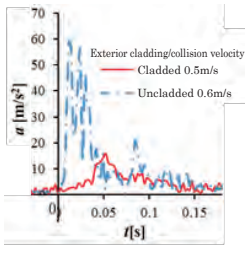
- In faults called the decollement zone located in shallow areas of plate subduction boundaries, we observed slow earthquakes in which slip failure proceeds more slowly than regular earthquakes. At the time of an earthquake, if the decollement zone slips fast together with the earthquake, the slip might evolve into a large earthquake that causes a large tsunami. Large Nankai megathrust earthquakes are expected to occur, so it is urgently necessary to clarify the causes of the unstable behavior of the ocean's crust where slow earthquakes can develop in the decollement zone.
- Around plate boundaries, clay minerals are known to alter due to high temperature and pressure. Therefore, we aimed to develop a numerical analysis method that expresses the dynamic changes in soil quality that are accompanied by such clay mineral alteration, and to investigate the dynamic behaviors of the ocean's crust which alters while bearing shearing force.
- The results of analyses in which plate subduction was assumed (bottom figure) showed that gap water pressure increases in the upper areas of the decollement zone, and in response, the strength of the decollement zone tended to soften after temporary hardening. Hardening causes sticking between plates and softening causes the development of slow earthquakes. This suggests that clay mineral alteration is a cause of crust variance resulting in tsunamis.
- Going forward, we will focus on changes in ion density and temperature in decollement zones as these affect the speed of alteration, and will then improve the model.



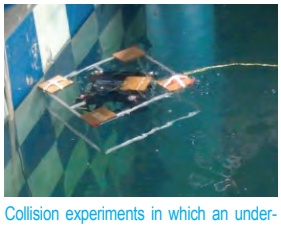
Results of plate subduction simulations
(Left: Excess gap water distribution, Right: Stress-strain relationships at each depth (3 points)

8. Investigation of impact mitigation at the time of collision by applying exterior claddings to underwater robots

- Although underwater robots, including inspection ROVs for maintenance purposes, are being researched and developed as effective tools, they are basically designed not to collide to objects. However, in the case of unpredictable disturbance including wave turbulence under piers and near structures and ship waves, underwater robots are difficult to manipulate, and so they might collide with structures and be damaged. This risk prevents their wider use.
- In this study, we cladded the exterior of hovering-type underwater robots. We aimed to mitigate the maximum velocity of these robots accelerated by collision to enable them to continue to operate without breaking. With this goal, we investigated the impact mitigating effects of the cladding.
- We cladded underwater robots with several exterior claddings including aluminum frames, measured the acceleration velocity acting on the robot bodies when they collided with concrete walls and steel pipes, and evaluated these measurements quantitatively.
- We aimed to reduce the maximum acceleration velocity which occurs during collision by lengthening the time from collision to stopping, and proposed exterior claddings including a cladding shaped so as to make the robots' bodies rotate upon collision. In addition, the combined use of springs and dampers further reduced the maximum acceleration velocity.
- We are going to investigate the effects on collided structures and efficient operation methods.



Time variation difference of acceleration velocity (a) which occurs upon collision between cladded robots and uncladded robots



Collision experiments in which an underwater robot is collided with a concrete wall

Published Research Papers

Number of Peer-reviewed Papers in FY 2017

Number of papers in Japanese	Number of papers in non-Japanese languages	Total	Rate of papers in non-Japanese language
75(64)	48(12)	123(76)	39.0%(15.8%)

*The above numbers contain proceedings that only reviewed the abstract.(Numbers in parentheses indicate the number of journals.)

Papers Published in PARI Reports in FY 2017

No.	Title	Author(s)	Language	Month/Year
56-2	Proposal of Modeling of Circular Steel Tube for Seismic Performance Evaluation	Yousuke OHYA, Yoshio SHIOZAKI, Eiji KOHAMA, Yuichiro KAWABATA	Japanese	June 2017
56-3-1	Lateral Resistance of Coupled Piles with Its Intermediate Soil Stabilized by Cement Treating Method	Satoshi MATSUMURA, Takanobu MATSUBARA, Naruhiko FUJII, Takaaki MIZUTANI, Yoshiyuki MORIKAWA, Makoto SATO	Japanese	September 2017
56-3-2	Evaluation of Deformation Process of Granular Materials Based on Image Processing and Development of Numerical Simulation Method	Daiki TAKANO	Japanese	September 2017
56-3-3	Numerical Analysis and Model Testing on a Method for Evaluation of Coastal Parapet Levees' Seismic Coefficients for Level-1 Earthquakes	Eiji KOHAMA, Hirofumi FUKAWA	Japanese	September 2017
57-1-1	Rupture Process of the Foreshock and Main Shock of the 2016 Kumamoto Earthquake and Simplified Source Models to Explain Damaging Ground Motions	Atsushi NOZU, Yosuke NAGASAKA	Japanese	March 2018
57-1-2	Technological Development of Sheet-pile Quaywall Reinforced by Geogrids	Hidenori TAKAHASHI, Yoshiyuki MORIKAWA, Takaaki MIZUTANI, Katsuya IKENO, Tomohiro TANAKA, Suguru MIZUTANI, Toshiyasu MIYOSHI, Kentaro HAYASHI	Japanese	March 2018

Note: 56-4 is not available, and is not published.

Papers Published in PARI Technical Notes in FY 2017

No.	Title	Author(s)	Language	Month/Year
No.1333	Annual Report on Nationwide Ocean Wave Information Network for Ports and Harbours (NOWPHAS 2015)	Koji KAWAGUCHI, Satoshi SAKURABA, Takashi FUJIKI, Hitoshi TAMURA	Japanese	June 2017
No.1334	Field measurement and Flume Experiment Studies on Sedimentation in River Mouth Port, a Case Study in the Port of Niigata	Yasuyuki NAKAGAWA, Noriko TAKASHIMA, Takumi SHINOZAWA	Japanese	June 2017
No.1336	Practical Approach to Preventive Maintenance of Port Steel Structure	Ema KATO, Nozomu SOMEYA, Yuichiro KAWABATA, Hiroto TADO, Toru YAMAJI, Nobuhito NAKATANI	Japanese	September 2017
No.1337	Generation and Characteristics of Multi-directional Waves in Shallow Water - For Distributed Directional Spectra along Linear Boundary in Constant Depth -	Katsuya HIRAYAMA, Yasuhiro AIDA, Akinori NAKAMURA	Japanese	September 2017
No.1338	Application of Modeling of Circular Steel Tube Considering Diameter-to-Thickness Ratio to Various Port Facilities	Yousuke OHYA, Yoshio SHIOZAKI, Eiji KOHAMA, Yuichiro KAWABATA	Japanese	December 2017
No.1339	Study on Chloride Ion Diffusion Property of Concrete Based on Long-Term Exposure Test and Investigation to Actual Structure	Kazuhide YONAMINE, Toru YAMAJI, Ema KATO, Yuichiro KAWABATA	Japanese	March 2018
No.1340	Proposal of Regression Equations for Displacement Tonnage of Ships	Haruo YONEYAMA	Japanese	March 2018
No.1341	Study on Tractive Forces of Ships Acting on Mooring Posts and Bollards	Haruo YONEYAMA	Japanese	March 2018

Note: No. 1335 is being re-edited; the timing of publication is unknown.

Public Relations

Annual Report, Technical Journals, and Website

The Annual Report 2017 (Japanese version) and the PARI Annual Report 2017 (English version), which summarized the activities in FY 2016, were produced as a record of achievements, and were distributed to the parties concerned and published on PARI's website.

Regarding the technical journal PARI, we selected special articles for each study theme for every issue to introduce utilization situations of study results and PARI's experiment and on-site observation facilities. Approximately 1,800 copies of the PARI Technical Journal were distributed to 1,700 places.

The PARI Technical Journal

On PARI's website, we provided various information on events and news including PARI's summarized information, achievements, facilities, symposiums on a real time basis; we got approximately 250,000 accesses in this fiscal year.

Lectures for the General Public

Port and Airport Technology Lecture

Aiming to present and disseminate the achievements of investigations, research, and technical developments carried out at PARI, we held a Port and Airport Technology Lecture in Tokyo on December 21, 2017 in cooperation with the National Institute for Land and Infrastructure Management, which was attended by approximately 250 participants.

Port and Airport Technology Special Lecture in Region

Aiming to widely provide information on the research activities and achievements of PARI and collect information such as research needs in each region of Japan, we held 4 lecture meetings throughout Japan in cooperation with the National Institute for Land and Infrastructure Management, the Regional Development Bureau, and others, gathering approx. 650 participants.

Port and Airport Research Symposium

We held the Port and Airport Research Symposium in cooperation with the National Institute for Land and Infrastructure Management in Yokosuka City on January 12, 2018, which was attended by more than 100 people.

Open House

Open House

Our Open House (Saturday, July 22, 2017) held a variety of demonstration experiments, including "Let's feel the power of a giant tsunami!", hands-on events including "Let's touch creatures in tidal flats!", and exhibitions including "Let's see a jumbo jet tire!". 1,085 people visited PARI that day.



Summer Open House

Other Facility Tours

Other than the Open House, we held 91 facility tours, with 1,393 visitors. We introduced PARI facilities and PARI-associated research to visitors from private companies, the government, municipalities, and educational institutions to broaden understanding of PARI's activities and the social importance of researchers. We also carried out activities to increase understanding of disaster prevention, such as providing various information on earthquakes and tsunamis.

Other Outreach Activities

Cooperation with "Yokosuka Children's University for Disaster Prevention"

We helped run the "Yokosuka Children's University for Disaster Prevention" event, which is a summer disaster-prevention initiative to educate fifth-grade elementary schoolchildren living in Yokosuka City. Two groups of children (37 in total) were brought in and we ran hands-on workshops using models and other tools.

Cooperation with Super Science High school (SSH) Projects

For first-year students from Kanagawa Prefectural Yokosuka High School and second-year students from Miyagi Prefectural Sendai Daiichi High School, both of which are SSHs designated by the Ministry of Education, Culture, Sports, Science and Technology, we explained our studies and organized tours to PARI's facilities to enhance students' interest in science and math.

Exhibition at Tokyo-wan Daikanshasai 2017 [Tokyo-Bay Thanksgiving Day 2017]

In October 2017, we set up an exhibition booth at Tokyo-wan Daikanshasai 2017, which was held at Yokohama Red Brick Warehouse and its surroundings. There, we promoted PARI's activities to many visitors including families with children.



Tokyo-wan Daikanshasai 2017 [Tokyo-Bay Thanksgiving Day 2017]

Media Appearances

We distributed information via media outlets, including experimental films explaining the dangers of tsunamis and other materials broadcast on news shows and other programs of Japanese TV stations. The technical journal *Monthly AIRLINE* introduced our research on airport pavement. In addition, articles on various activities of PARI appeared in newspapers, technical journals, and other printed media, a total of 47 times.

Secrets of airport pavement, *Monthly AIRLINE* (September 2017 issue)

Outstanding Research Activities

Awards for Papers and Others in FY 2017

	Name		Award	Institution	Date	Remarks
1	Hidenori TAKAHASHI	Head, Soil Stabilization Group	The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology (The Young Scientists' Prize)	The Ministry of Education, Culture, Sports, Science and Technology	April 19, 2017	
2	Masayuki BANNO	Senior researcher, Coastal and Estuarine Sediment Dynamics Group	The Maeda Engineering Foundation Yamada Kazuie Award	The Maeda Engineering Foundation	June 2, 2017	Shoreline Response on Multi-time Scales and Future Shoreline Projection
3	Yutaka TANAKA	Researcher, Structural Mechanics Group	Japan Society of Civil Engineers The Yoshida Award, Encouraging Prize	Japan Society of Civil Engineers	June 9, 2017	Development of Spatial Distribution Model for Deterioration Factors in Marine Concrete Structures with Spatial Statistics
4	Satoshi MATSUMURA	Researcher, Foundations Group	Japanese Geotechnical Society, Research Encouragement Award	Japanese Geotechnical Society	June 9, 2017	
5	Hidenori TAKAHASHI Shinji SASSA Yoshiyuki MORIKAWA	Head, Soil Stabilization Group Head, Soil Dynamics Group Director, Geotechnical Engineering Department	Japanese Geotechnical Society, Technological Development Award	Japanese Geotechnical Society	June 9, 2017	
6	Shinji SASSA	Head, Soil Dynamics Group	Japan Society for the Promotion of Science, Examination Committee Award	Japan Society for the Promotion of Science	August 4, 2017	
7	Naruhiko FUJII	Member, Soil Stabilization Group	Japanese Geotechnical Society, Excellent Presentation Award	Japanese Geotechnical Society	August 27, 2017	Strength property of lime treated soil cured for thirty seven years
8	Yuichiro KAWABATA	Senior Researcher, Structural Mechanics Group	The 17th JSMS Symposium on Concrete Structure Scenarios, Distinguished Paper Award	The Society of Materials Science, Japan	October 13, 2017	Modeling of ASR Expansion Behaviors of Concretes Tested by Accelerated Concrete Prism Test with Alkali-wrapping
9	Tomohiro TAKAGAWA	Head, Tsunami and Storm Surge Group	Hydrographic Technology, Encouragement Award	Japan Hydrographic Association	February 27, 2018	Development of an Ensemble Tsunami Forecasting Method Based on Offshore Tsunami Data

PARI Events

Active Commitment in International Meetings, Workshops, and Other Projects

In December 2015, the United Nations General Assembly officially designated November 5th, which has already been designated as Tsunami Prevention Day in Japan, as World Tsunami Awareness Day. In response, we established the Hamaguchi Award (Minister of Land, Infrastructure, Transport and Tourism Award), which rewards persons who have made remarkable contributions in the field of coastal disaster prevention technology including tsunami disasters. In November 2017, the award was given to the following two persons and one group: Philip Li-Fan Liu, vice president and distinguished professor at the National University of Singapore and professor emeritus at Cornell University; Julio Kuroiwa, professor emeritus at National University of Engineering, Peru and director and general manager of Disaster Risk Reduction Peru International SAC; Kuroshio town (Hata district, Kochi).

A prize awarding ceremony and commemoration lecture of the Hamaguchi Award (November 1, 2017, Tokyo)

In September 2017, we held the “2017 Japan-Italy Technology Exchange Workshop Regarding Coastal Disaster Prevention” in Venice, Italy, where we actively exchanged opinions on countermeasures against tsunami and storm surges.

Also, in November 2017 in Seoul, South Korea, we held the KIOST-PPA-PARI Workshop in collaboration with the Korean Institute of Ocean Science and Technology (KIOST) and the Philippine Ports Authority (PPA). In the workshop, we exchanged opinions on studies on grounds and earthquakes and deepened our relationships.

Broad Research Exchange with Japanese and Non-Japanese Research Institutes

To improve the quality and efficiency of research, we actively collaborated on research with domestic and overseas research institutions and signed a total of 35 research cooperation agreements with 9 Japanese and 26 overseas institutions as of FY 2017. In FY2017, we renewed research cooperation agreement with the Swedish Geotechnical Institute (SGI).

Also, to facilitate emergency disaster countermeasures and smooth activities, we signed a cooperation agreement with the National Institute for Land and Infrastructure Management of the Ministry of Land, Infrastructure and Transport on March 30, 2018.

Conclusion of Education and Research Collaboration Agreements

We signed agreements with national, public and private universities. Under these agreements, PARI researchers serve as grad-school professors or take other positions at the universities. Under the graduate school linking system, in which postgraduate students receive instructions at research institutions, we concluded collaboration agreements with 11 universities including the Tokyo Institute of Technology, Nagoya University, and Nagaoka University of Technology. In FY 2017, we dispatched 10 researchers as lecturers. We also dispatched a total of two researchers to universities which are not under the graduate school linking system, including Tsukuba University.

Promotion of Administrative Support

Dispatching of Researchers to Disaster Sites

On April 14, 2017, a sediment collapse accident caused tremendous damage at a waste disposal site in Colombo, Sri Lanka. PARI dispatched two researchers as members of an expert team of the Japan Disaster Relief Team to help investigate the cause, prevent secondary disasters, speed up restoration, and other initiatives.

Strengthening Collaboration in Dispatching the Technical Emergency Control Force

On March 30, 2018, we signed a cooperation agreement to strengthen various collaboration initiatives with the National Institute for Land and Infrastructure Management of the Ministry of Land, Infrastructure and Transport (Yokosuka) in dispatching the Technical Emergency Control Force (TEC-FORCE).

Concluded a collaboration agreement with the National Institute for Land and Infrastructure Management (March 30, 2018)

Dispatching of Researchers to Various Technical Committees

We dispatched a total of 55 researchers to various technical committees organized by governments and other organizations to solve technical issues concerning the execution of port, coastal, and airport public works by national and municipal governments and local administrations. Including technical committees on improving ports, coasts and airports established by various institutions, a total of 360 researchers were dispatched by PARI, and actively tackled technical issues faced by governments and other organizations.

Dispatching of Lecturers to Training Courses for Domestic Engineers

Training courses for national and other public service engineers are held by the National Institute for Land and Infrastructure Management. We actively participate from the planning stage and have dispatched a total of 23 researchers to 2 training courses as lecturers.

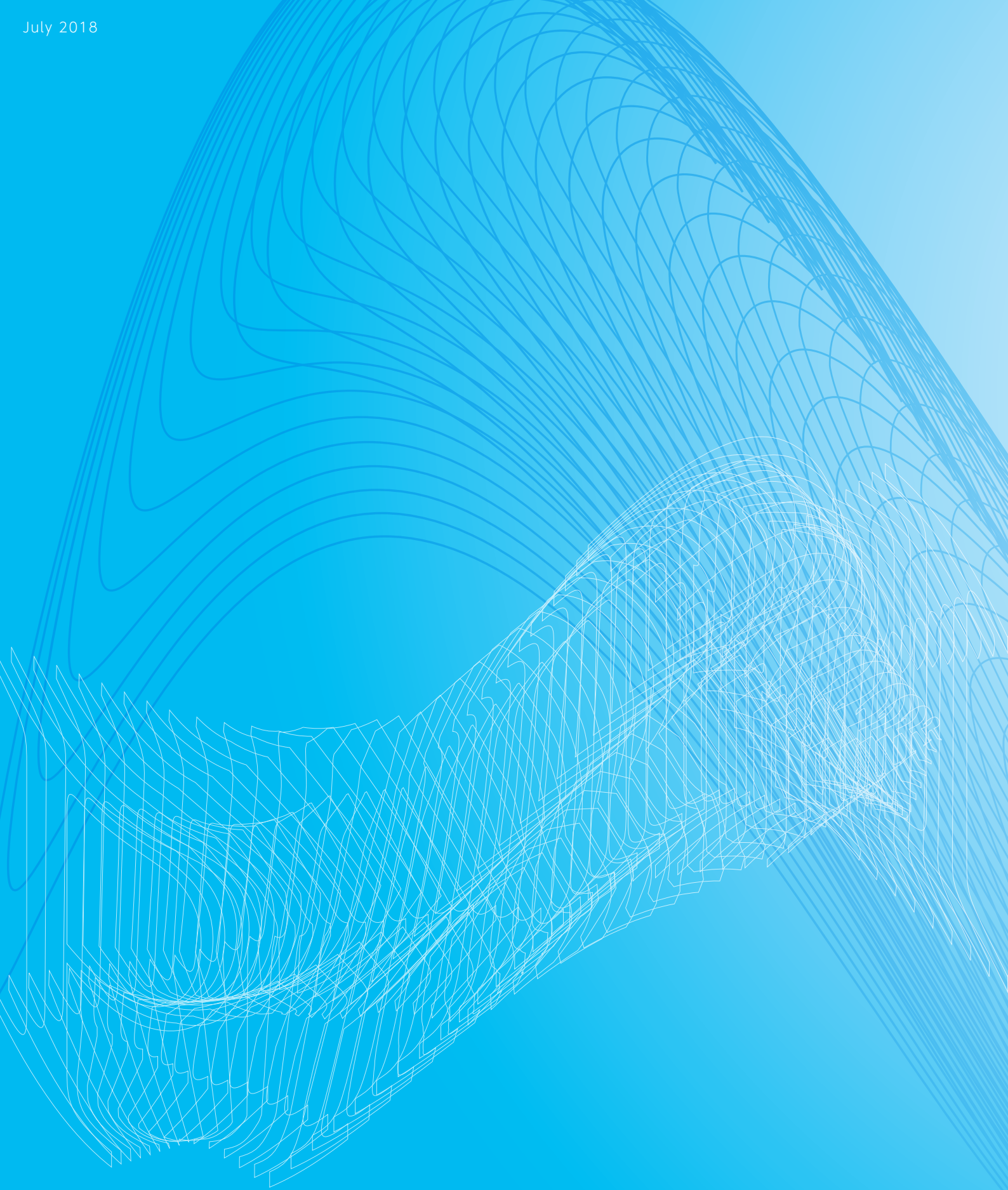
Providing Operational Support for Technical Standards for Ports, Airports, etc.

Regarding technical standards for port facilities, our researchers took part in technical committees set up by the Ports and Harbours Bureau of the Ministry of Land, Infrastructure, Transport and Tourism. Our researchers also gave lectures at the National Institute for Land and Infrastructure Management, conferences, and seminars organized by other relevant organizations, and contributed to the spread of technical standards. Regarding airport facilities, our researchers participated in various investigative commissions in preparation for the smooth introduction and operation of technical standards for airport civil engineering facilities.

Support for Evaluation of New Technologies

In response to a request of the Ministry of Land, Infrastructure, Transport and Tourism (including regional development bureaus), PARI offered technical support by dispatching researchers to the New Technology Utilization Evaluation Conference established by each organization for evaluating the practicality and applicability of the technologies to be registered in the New Technology Information System (NETIS) in order to promote the application of useful new technologies.

July 2018



—Creating Technologies that Contribute to the World—

National Institute of Maritime, Port and Aviation Technology

Port and Airport Research Institute

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