



# Annual Report

## 2017

# Message from the Director General

## Creating Technologies That Contribute to the World

1  
2  
3  
4  
5  
6  
7  
8  
9

Message from the Director General

In April 2016, the Port and Harbour Research Institute (PHRI) restarted as the Port and Airport Research Institute (PARI) under the National Institute of Marine, Port and Aviation Technology, one of the national research and development agencies, which had been established after the integration of PHRI, National Maritime Research Institute, and Electronic Navigation Research Institute. PARI serves as a research institute responsible for investigation and research on improving ports and airports, technological development, and other activities. 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. From this point on, we will further expand and strengthen our cooperation and interaction with the other two institutes and with researchers in different fields in order to maximize the achievements in research and development.

This annual report summarizes PARI's work in 2016, the first year of the first mid- and long-term plans (from 2016 through 2022). In these plans, PARI is focusing on the following four research and development challenges: disaster reduction and restoration in coastal zones, infrastructure building to support industries and people's life, maintenance of maritime interests and marine utilization and application, and formation and utilization of the marine environment.

As specific commitments in 2016, regarding "disaster reduction and restoration in coastal zones", PARI used the results of large-scale experiments and developed an earthquake-proof countermeasure method for petrochemical complexes and developed a numerical simulation model for tsunami fires; regarding "infrastructure building to support industries and people's life", PARI adjusted the refractive index of materials which were used in the experiments and then visualized the penetration conditions of agents injected into the ground; regarding "maintenance of maritime interests and marine utilization and application", PARI improved the video-image presentation system of sound video cameras; and regarding "formation and utilization of the marine environment", PARI promoted research on the mitigation and adaptation effects of blue carbon on climate change.

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.

In April 2016, the Kumamoto earthquakes caused severe damages over wide areas. We sympathize with everyone who was affected and hope for rapid recovery and reconstruction. PARI dispatched its researchers to the site from the day after the earthquake; they investigated damages in airport and port facilities, prevented secondary disasters, and provided technical instruction on the restoration of damaged facilities and other matters. Through such activities, we did our best to support early restoration. PARI uses its unique characteristics as a research institution to conduct on-site practical research and development taking into account the severe natural conditions of Japan. We will utilize PARI's knowledge, human resources, and other assets to conduct awareness activities regarding disaster prevention and to offer emergency responses and restoration support at the time of disaster including earthquakes and tsunamis.

We would greatly appreciate your continued support.



所長（理事）栗山 善昭

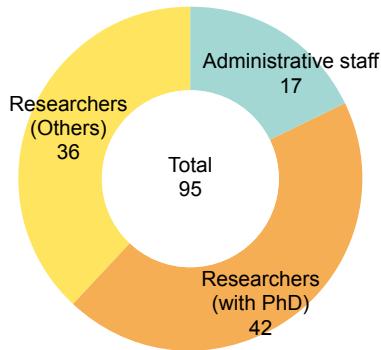
Yoshiaki KURIYAMA, Director General, PARI

## CONTENTS

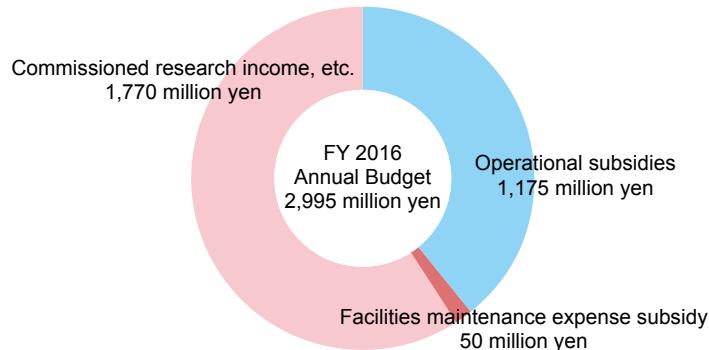
1 Outline of Organization	• • • 02p	6 Published Research Papers	• • • 19p
2 Management Strategy	• • • 03p	7 Public Relations	• • • 20p
3 Structure of Research Themes in FY 2016	• • • 04p	8 Outstanding Research Activities	• • • 21p
4 Research Themes and Activities in FY 2016	• • • 05p	9 PARI Events	• • • 22p
5 Fundamental and Exploratory Research	• • • 14p		

# Outline of Organization

## Administrative Staff and Researchers, and Budget

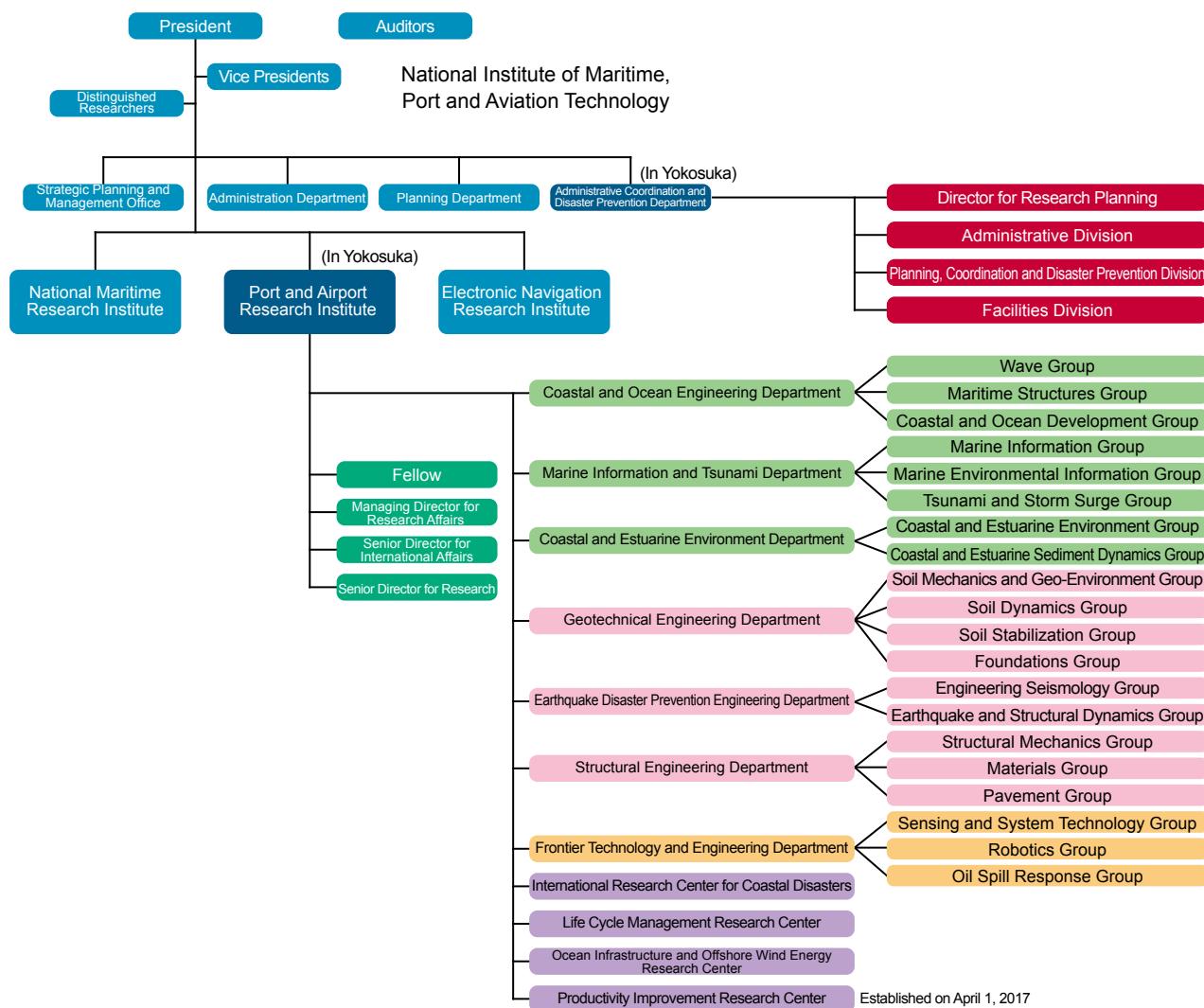


As of April 1, 2017 (In Yokosuka)



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

## Organizational Structure



As of October 1, 2017

# 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 2016

Research Field	Research Theme	Research Subtheme	Type of Research	Items 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 techniques for predicting strong ground motions and damage which may occur in the case of the greatest earthquakes	Fundamental Research	Strong Motion Earthquake Observation in Port and Airport Area (2A ②)
		② Research on damage-reduction techniques against the greatest earthquakes	Fundamental Research	Investigation of Earthquake Disaster (2A ②)
		③ Research on the interaction of earthquakes, tsunamis, and high waves with ground dynamics	Fundamental Research	Development of strong motion estimation method for scenario earthquakes beneath metropolitan area
	1B Research on Mitigation and Restoration of Tsunami Disasters	① Research on ICT-based decision support systems	Applied Research	Study on the mechanism, evaluation and prediction of liquefaction under sequenced earthquake motions
		② Research on the development of tsunami-resistant ports	Applied Research	Study on simple seismic performance evaluation of existing mooring facilities (2A ②)
			Fundamental Research	The diagnosis and countermeasure technique development related to disaster prevention improvement of industry complex consisting of a wide variety of facilities
				Seabed Soil Dynamics and Stability Assessment of Breakwaters and Seawalls
	1C Research on Mitigation and Restoration of Storm and Surge Water Disasters	① Research on storm and surge water and maximum damage estimation	Development Research	Development of a tsunami-fire model for ports
			Fundamental Research	Development of an ocean-earth coupling model for tsunami propagation
			Applied Research	Development of an advanced 3-dimensional simulation model for tsunami inundation
			Fundamental Research	Development of the estimation method for local scour around coastal structures due to tsunami
		② Research on the technology to reduce maximum storm and surge water disasters	Development Research	Elucidation of oceanographic phenomena based on observation data
			Fundamental Research	Proposal for improvement of prediction accuracy of swell
			Applied Research	High performance harbor tranquility analysis with considering harbor waves generated in a basin
			Fundamental Research	Consideration of design forces for unexpected high waves and mitigation of coastal disasters
			Fundamental Research	Study on very intense typhoon wind, storm and surge water characteristics in Japanese bays
			Applied Research	Development of the maritime and environmental simulation model using meso-scale weather forecasting model
				A study on the wave force, overtopping, and overflow under a large wave condition combined with storm surge and tsunami (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	Applied Research	Development and suggestion of efficient and suitable use which contains automated cargo systems through container terminal numerical simulations for multi berths
			Applied Research	Research of the Terminal System on the Export of Infrastructure of Container Terminal
			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 long-term durability of concrete, steel and various materials based on exposure test
			Fundamental Research	Enhancement of cathodic protection design of marine steel structures considering the soil properties
			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	Data base construction for strategic maintenance of port and airport infrastructures
			Development Research	Development of evaluation methods and material improvement for prevention of stripping in airfield asphalt pavement mixture (2A ②)
	2C Research on Effective Use of Existing Infrastructure Facilities	① Research on technologies for prolonging the life of infrastructure	Applied Research	A suggestion for the improvement of airfield pavement material to prolong the pavement life (2A ②)
			Development Research	Development of structural design method for strategic maintenance of port and harbour structures
		② Research on systems for inspecting and diagnosing infrastructure	Development Research	Development of the structural health monitoring system for port structures
	2C Research on Effective Use of Existing Infrastructure Facilities	③ Research on maintenance and management systems	Development Research	Enhancement of ROV system for inspection of concrete superstructures of open-type wharves
			Applied Research	Development of Life-cycle simulation model for port structures
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	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 infrastructure technology for utilization and development of oceans	Fundamental Research	Durability of treated soils with steelmaking slag under marine environments
			Fundamental Research	Enhancement of accuracy of method for evaluating mechanical properties of composite geomaterials based on microstructural feature
		③ Research on management and utilization of waste disposal sites at sea	Development Research	Structure foundation for high-degree land-utilization at confined disposal facilities
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	Continuous observation and statistical analysis of environmental data in enclosed bays
			Applied Research	Establishment of forecast system on environmental dynamics in enclosed bays based on detailed analysis of sediment quality
		③ Research on countermeasure technologies against sea oil spill	Fundamental Research	Development of an evaluation method for benthic biodiversity relating to environmental scale in coastal areas
	4B Research on Coastal and Estuarine Processes	③ Research on coastal protection and maintenance of waterways and mooring basins	Development Research	Study on the mechanisms of coastal current and water environment using data assimilation
			Fundamental Research	Novel oil spill response technology to cope with various source including natural disaster triggered oil spills
			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

1  
2  
3 Structure of Research Themes in FY 2016  
4  
5  
6  
7  
8  
9

# Research Themes and Activities in FY 2016

## 1A Research on Seismic Disaster Prevention and Restoration

### 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 trunk line cargo transportation soon after an earthquake and quickly securing the 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 quake resistance and reducing construction costs. These two goals can be achieved through diagnosis and performance verification of earthquake-resistance which address the properties of long-period and long-duration earthquake ground motion, which is expected to occur during a subduction-zone large-scale 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 erected during the era of rapid economic growth.

### Research Topics

Research and development comprises the following three subthemes:

#### i) Development of techniques for predicting strong ground motions and damage which may occur 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

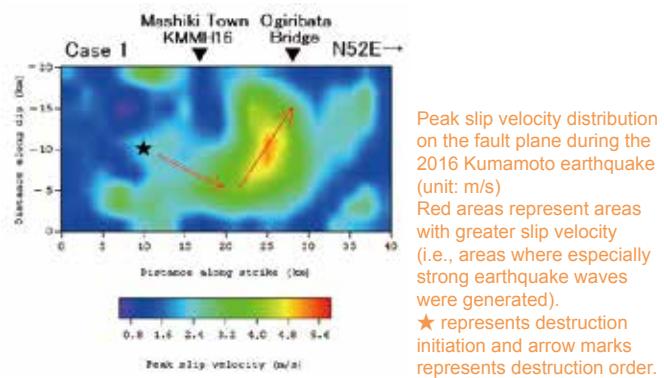
We will suggest the most effective countermeasures under given limitations to effectively promote seismic strengthening of existing structures. In doing so, we will actively utilize damage reduction and strengthening techniques that use novel materials, structures, and construction methods. Especially, as quake-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. 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 conduct research on the interactions of earthquakes and ocean waves with the ground dynamics, including seabed liquefaction at the time of earthquakes and due to wave actions; the mechanism of the instability of breakwater foundation at the time of a tsunami; and other interactions. Also, we will use numerical simulation models, model experiments (including a centrifuge equipped with a tsunami generator and a large-scale wave tank), and other methods to investigate ground dynamics regarding earthquake-induced submarine-landslide development and the resulting tsunami phenomena, as well as geodynamics under the influence of tsunami and high waves. The research will include the analysis of deformation and destruction mechanisms as well as their countermeasures.

### Activities in FY 2016

- We obtained 2488 strong motion earthquake records during the period from January to December 2015. We organized and analyzed these records and published the data as a Technical Note of the Port and Airport Research Institute data.
- Regarding the Kumamoto earthquake in April 2016, we dispatched investigation teams to Kumamoto Port, Kumamoto Airport, Beppu Port, and Yatsuhiro Port to study the damage situations and causes, and then we used the information for technical assistance including restoration activities. In addition, we devised countermeasures against large-scale disaster factors for sheet pile-type quay walls in the 2011 Great East Japan Earthquake.
- In response to the Kumamoto earthquake in April 2017, we estimated the rupture processes of the earthquake source faults, analyzed strong-motion earthquake records near an earthquake source, and developed an earthquake source model to estimate earthquake motions of ports and airports where such records were not obtained.
- We conducted various experiments and analyses regarding liquefaction under combined earthquake motions and summarized the liquefaction characteristics and mechanisms, as well as their prediction and evaluation. We developed a generalized liquefaction prediction and assessment method that is capable of simultaneously considering the irregularity of the waveforms and durations of earthquakes and that can be applied to various simplified methods used overseas, thereby facilitating more rational liquefaction prediction and assessment worldwide.
- We studied whether pier structures can survive after deformation due to an earthquake in terms of general stability, and then organized data for evaluating the aseismic capacity of existing piers. For example, we suggested a model to quantify changes in the plate thickness and yield strength of steel pipes.
- We used E-Defense, a large shake table owned by the National Research Institute for Earth Science and Disaster Resilience (NIED), to conduct a model vibration-table test of 1/8-scale oil tanks, piers, and revetment in an industrial complex. In the test, we created two models, cross sections with or without earthquake countermeasures, and then conducted a comparative study.
- We validated the results predictions by the proposed model regarding the process of development of submarine landslides and gravity flows in light of the latest event of submarine mass movement induced by seabed liquefaction. In addition, we elucidated the mechanism of destabilization of breakwaters, rubble mounds, and foundation caused by the coupling effect of overflow and seepage under a tsunami. We also established a method for evaluating the stability of breakwater foundations under tsunami-induced seepage.



# Research Themes and Activities in FY 2016

## 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 yet. Any method of estimating them has not been developed. In addition, regarding a real-time technique for 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 will conduct research to establish resilient coastal zones which can withstand the most severe tsunamis, i.e., to protect lives against the most severe tsunamis, to prevent catastrophic socioeconomic damages, and to enable early recovery and reconstruction. The purpose is to change disaster prevention and reduction countermeasures into a pre-disaster stage from post-disaster one.

#### Research Topics

Research and development comprises the following two sub-themes:

##### i) Research on ICT-based decision support systems

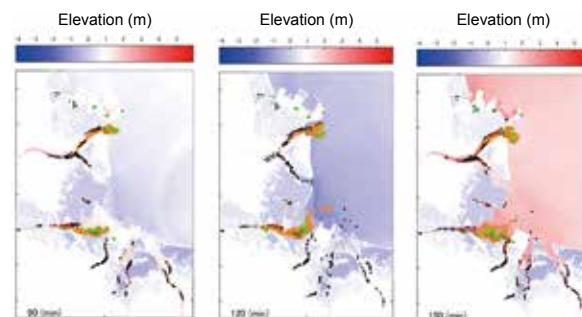
We have previously developed a system for rapid forecasting of tsunami inundation, which utilizes offshore-tsunami waveforms observed by GPS-mounted wave buoys. For highly reliable tsunami prediction, we will additionally utilize ground deformation data obtained by on-land GPS base stations and remote-sensing 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, 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.

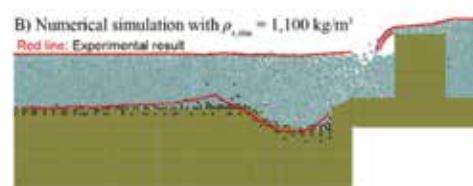
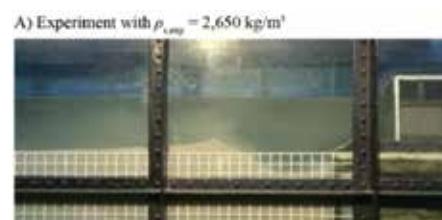
#### Activities in FY 2016

- In the development of a tsunami-fire model for ports, we modeled marine fires at Kesennuma Bay that were induced by the 2011 great east Japan earthquake tsunami. The model applied to Tsu-Matsusaka Port in Mie Prefecture to assess a scenario tsunami including the drifting of cars and fishing vessels, dispersion of spilled oil, and ignition/combustion/extinguishment of debris fires. We will investigate fires in urban areas. This newly-developed model is expected to help disaster-prevention planning with the consideration of tsunami fires.



Numerical simulation of tsunami fires. Yellow green dots indicate drifting cars and fishing vessels. Dark green dots indicate stopped ones. Orange dots indicate spilled oils. Black, red, blue dots indicate debris which are in the state of pre-ignition, burning, post-extinguishment, respectively.

- In the development of an ocean-earth coupling model for tsunami propagation, we add the following effects to a conventional tsunami model: wave dispersion, seawater compressibility, elastic deformation of solid earth under the ocean, and the deformation of gravity potential induced by tsunami generation and propagation. The new model improved the accuracy of waveforms especially for trans-oceanic far-field tsunamis. The model can be connected to existing tsunami-simulator STOC to assess the inundation in coastal areas.
- In the development of an advanced three-dimensional simulation model for tsunami inundation, we established a numerical model which consistently simulates tsunami generation, propagation from the source to the coast, deformation of protection facilities, and tsunami run-up on backlands. With this numerical model, we can understand in detail when protection facilities deform and how inundated areas spread in a target area. Hereafter, we will improve the computational efficiency, accumulate case studies, and prepare to open the model to public.
- In the development of the estimation method for local scour around coastal structures due to tsunami, we added a duration time effect to the conventional equation with a single parameter of overflow depth, on the basis of experimental results. Moreover, the numerical model of the particle method successfully reproduced scouring phenomena. Hereafter, we will investigate the scouring around corners and ends of breakwaters.



Scouring experiment (A) and numerical simulation with particle method (B)

# Research Themes and Activities in FY 2016

## 1C

### Research on Mitigation and Restoration of Storm and Surge Water Disasters

#### Background and Objectives

- Since the Ise Bay Typhoon struck in September 1959, there have been no devastating storm and surge water disaster in Japan. However, the U.S. suffered severe damage 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 and surge water than those we have expected in Japan.
- Therefore, this research focuses on how to mitigate damage by the worst storm and surge water condition and how to rapidly recover and reconstruct after the damage has occurred. The purpose of this research is to change disaster prevention and mitigation measures into a pre-disaster stage from post-disaster one. Therefore, we conduct research to encourage hard and soft measures. Specifically, we will develop a numerical model to estimate the worst storm and surge water condition and damage and will also develop design methods to build robust structures.

#### Research Topics

Research and development comprises the following two sub-themes:

##### i) Research on storm and surge water and maximum damage estimation

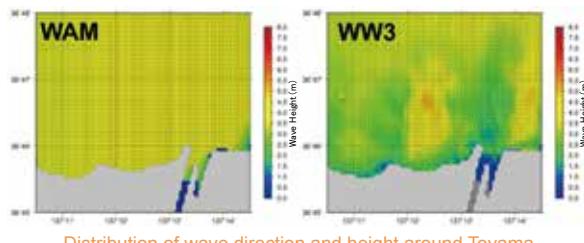
We will develop a highly accurate storm surge and flooding model which incorporates a meteorological model as well as a real-time predicting model for storm and surge water. As global warming progresses, intense typhoons might appear that cause high storm and surge water in coastal areas. We will also utilize the models and wave observation data to elucidate the storm and surge water characteristics.

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

We will elucidate structural stability under a severe condition that storm and surge water height simultaneously become higher than those expected and will establish methods for designing breakwaters and seawalls for the condition.

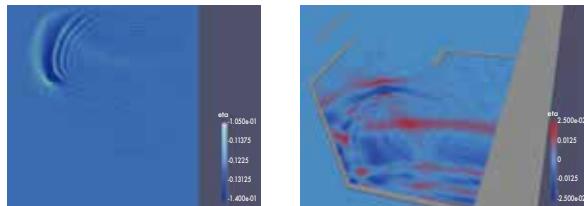
#### Activities in FY 2016

- In elucidation of oceanographic phenomena based on observation data, we summarized the statistical analysis of nationwide wave observation data acquired in 2015 into an annual report. Seabed wave gauges placed at six coastal points and GPS-mounted wave buoys placed at three deepwater points updated records on existing maximum significant wave heights. We will continue to analyze data from 2016. Regarding a directional spectrum estimation method, we avoided convergent calculation to obtain stable solutions through short-time calculation, and could enhance the applicability to swell. We also analyzed winds and waves off Hiratsuka in Sagami Bay to examine the physical processes of breeze.
- In the improvement of the prediction accuracy of swell, we hindcasted Yorimawari-nami Waves, which were observed at Toyama Bay in 2008, and led that WW3 could produce wave heights and periods in the bay better than WAM. In addition, regarding the coastal area which has unique bathymetry and is called Aigame, we input the wave spectra obtained from WAM and WW3 into a Boussinesq model for wave transformation and also discussed the causes of errors in the wave spectral. We will simulate waves in Japan to validate the accuracy of swells.



Distribution of wave direction and height around Toyama

- In the study on high performance harbor tranquility analysis with considering harbor waves generated in a basin, we performed calculations of ship waves in a harbor basin to take into account the differences in lateral flux, which is caused by a ship's thrust, and ship shape. The numerical model can simulate waves which are produced by a turning ship as well as the reflection of ship waves by breakwaters. This model is expected to be used for evaluating port tranquility which takes into account both waves penetrated from the outside of the harbor and generated by ships in the inside. Hereafter, we will study methods of calculating cargo-handling operation rates which take into consideration of harbor waves under strong wind conditions.



Waves generated by a turning ship (left figure) and reflection of ship waves by breakwaters (right figure)

- In the study on the design forces for unexpected high waves and mitigation of coastal disasters, we calculated the wave transformation and the wave setup due to breaking in storms. We confirmed that the wave setup is correlated to the incident wave height regardless of the tide level at each port. Therefore, we estimated the suction and wind-drift effect of storm surge as well as the wave setup due to breaking at tide stations, and then discussed the relationship between the wave height and the storm surge for various return periods.
- In the study on very intense typhoon wind, storm and surge water characteristics in Japanese bays, we showed that a worst-class typhoon can cause storm surge of 3m or higher in Kagoshima Bay, which surpasses the existing maximum value.
- In developing of the maritime and environmental simulation model using meso-scale weather forecasting model, we almost assembled the model and reached the stage to begin various verification and case studies.
- In the study on the wave force, overtopping and overflow under a large wave condition combined with storm surge and tsunami, we collected seawall and dyke failure in Japan through field investigation. In addition, we conducted a series of hydraulic model experiments and demonstrated that water pressure is expressed as the sum of the static pressure corresponding to water levels and the wave pressure, and that the water pressure tends to be proportional to the square root of the product of the wave height and length. Hereafter, we will conduct experiments on transmitted waves through rubble mound and will suggest a wave pressure equation to be used in the design of coastal defense structures.

## Research Themes and Activities in FY 2016

# 2A Research and Development on Port- and Airport-Function Strengthening to Secure International 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 conduct research and development on strengthening port and airport functions and other activities. Currently, we are promoting institution-wide comprehensive research and development on subthemes associated with international competitiveness including an internationally strategic port policy, Haneda Airport improvement, and export capacity of infrastructure.
- The themes of this research address the development of specific technologies associated with international competitiveness including automated cargo works, construction information modeling (CIM), and export capacity of infrastructure. Regarding development of technologies which efficiently and effectively implement the following matters, the themes of other studies (1A, 2B, and 2C) address: improvement of large-scale facilities, improvement of the quake resistance of facilities, maintenance and management after facility construction, and improvement of existing facilities.

### Research Topics

#### i) Development of efficient-use strategies of consecutive container terminals and automation of terminal works

We created models of Minami Honmoku Pier MC1-4 of Yokohama Port for the study. In MC1-4, we will quantitatively evaluate the effects of off-dock loading/unloading as well as the effects of efficient operations on reducing environmental burden and preventing congestion in front of gates through numerical simulation. Then, we will use the evaluation results to establish strategies to effectively and comprehensively utilize container terminals.

Regarding the conventional operation methods and cargo-handling machinery, we will suggest and apply a system to improve terminal productivity.

#### ii) Research on terminal systems for packaged export of container terminals

We will establish cargo-handling facilities, operation systems, and design and planning methods which allow streamlining of container terminals.

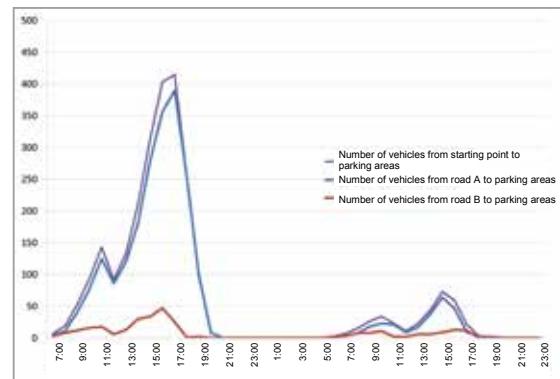
#### iii) Saving labor, shortening the work period, and reducing costs by using CIM

As part of 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 2016

We created numerical models of Minami Honmoku Pier MC1-4 of Yokohama Port for the study. In MC1-4, we quantified the numbers of waiting vehicles in front of gates for different hypothetical conditions regarding gates' conditions, configuration, and handling capacities through a numerical simulation using AutoMod.

- In studies of overseas cases, we quantitatively analyzed the costs of maintenance, fuel, IT investment, depreciation, and others in a scenario that assumed switching a container terminal's cargo handling from the conventional system to an automated system. Then, we determined the effects of the automation on terminal areas, overall costs, and benefits.
- For introduction of multi-beam sonars, the following need to be investigated: data accuracy which satisfies output-test standards, establishment of operation methods, appending information to the output-test standards, and coordination with Japan Coast Guard (JCG). We provided administrative support for such requirements.



# Research Themes and Activities in FY 2016

## 2B

### Research and Development on Lifecycle-Management of Infrastructure

#### Background and Objectives

- The number of port, airport and coastal structures that have been used for a long time is increasing, and yet financial resources and the number of technicians for facility maintenance and management 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 port 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. In addition, regarding airport runways, we will improve methods to detect the separation of asphalt from aggregates, countermeasures against such separation, and the load-bearing characteristics of airport pavement. We will also investigate rapid repair techniques.

##### ii) Research on systems for inspecting and diagnosing infrastructure

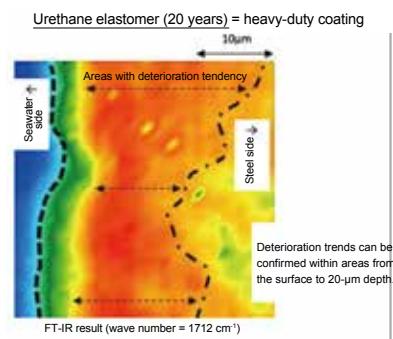
We will research and develop the following: inspection and diagnosing techniques using nondestructive inspection methods and sensors, unmanned investigation devices including ROVs, Non-contact ultrasonic thickness gauging system, and others. Especially, we will suggest a health-monitoring system which uses nondestructive inspection methods and monitoring methods for each type of structure. In addition, for open-type wharves, we will establish a system 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 port structures

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 maintenance and management of district-based groups of port structures.

#### Activities in FY 2016

- We will use facilities with long-term exposure to predict chloride-induced concrete deterioration, and collect data on the durability of various wood materials.
- Regarding the anticorrosion effects of cathodic protection methods on steel materials in actual environments, we compiled the results for many test pieces.
- With the target of establishing methods for predicting the deterioration of protective coating methods, we analyzed samples from port structures which have actually been used for a long time. We also conducted accelerated-deterioration trials to determine the deterioration mechanisms of petrolatum coating construction methods.
- We evaluated the durability of concrete which had been made with low-quality aggregates (coral) and seawater as mixing water and also started exposure trials to develop concrete curing techniques with seawater. In addition, we studied exposed specimens to evaluate the durability of highly-resistant reinforcing steel (including stainless reinforcing steel).
- We answered inquiries from many regional developmental bureaus and bureau managers regarding maintenance techniques.
- We conducted trials to evaluate the separation tolerability at the design phase of newly-paved asphalt pavement, organized separation-prevention methods, and then compiled the results.
- We studied and organized the following: the required performance of aggregate gradation and warm mix asphalt when used in airport-asphalt pavement, and methods for testing and evaluating their performance. Then, we conducted pilot studies.
- We collected cases of structural types and details to reduce maintenance work and then extracted and organized points to be considered for maintenance at both design and construction stages.
- We investigated the following: multicopter drone utilization; development of sensors to confirm anticorrosion effects; inspection and diagnosing systems for port structures; corrosion monitoring to investigate the appropriate arrangement of sensors for RC materials; applicability of spatial statistics for streamlining maintenance; corrosion diagnostic technique for tie rods; development of corrosion sensors for steel material embedded in concrete; and others.
- We refined an ROV for inspecting pier superstructures and noncontact thickness measuring equipment, conducted on-site trials, and identified the challenges and other matters.
- We organized the following: reconstruction of performance degradation chains at mooring facilities; methods for evaluating the soundness of apron pavement with cavities; evaluation and prediction of durability of concrete structures; challenges to studying life extension and improvement of existing facilities; maintenance scenarios and LCC of pier superstructures; flow of selecting pier countermeasure methods; methods of correcting maintenance plans for port facilities; and other matters.



Investigation results of protective coating (urethane elastomer)  
(Deterioration rate of coating material is very slow.)

# Research Themes and Activities in FY 2016

## 2C Research and Development of Efficient Use of Infrastructure

### Background and Objectives

- There is strong societal demand to improve the functions of existing infrastructure to enable active, efficient 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 public demand to ensure highly efficient 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 efficiently improve and renew the functions of existing infrastructure and to efficiently change the applications of existing infrastructure; techniques to reduce or efficiently utilize construction-generated soil and other redundancy; and techniques to efficiently 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 quay-walls. However, such improvements were made using techniques for newly-built structures. Hereafter, we will investigate methods of evaluating ground characteristics, design methods, and subsurface-exploration 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 ground databases, both of which cover residual settlement and other phenomena, with the aim of long-term facility maintenance.

#### ii) Research on efficient use and techniques of treating construction byproducts and other redundancy

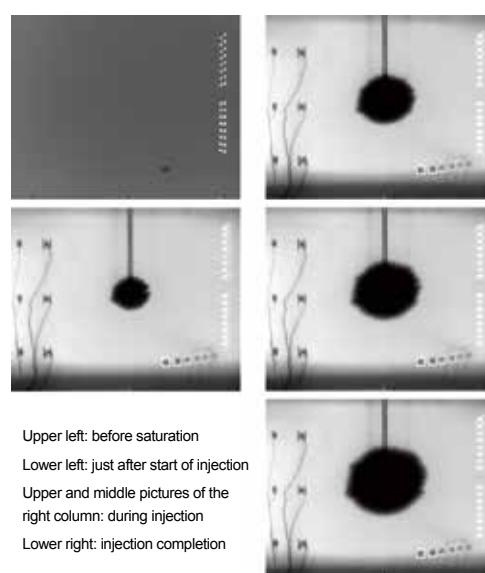
We will investigate the following techniques regarding dredged soil: improvement techniques to transform dredged soil into high-value added materials including composite soil, which provides habitats for benthic creatures, and solidified soil with high water permeability; and new volume-reduction techniques. 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 construction have been developed. However, research on post-construction utilization of such sites has not progressed. Therefore, we will investigate the following which are necessary for utilization: ground-making methods, construction methods, effects on impervious layers, construction methods to manage 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 2016

- Based on measurements of differential settlement regarding reclaimed land, we evaluated individual phenomena through element tests, investigated overall behavior through numerical simulation using case examples, and then predicted the settlement.
- We developed an experiment system which simulates a series of processes ranging from chemical grouting experiments to shaking table test using geotechnical centrifuge. We used a refractive-index matching technique to visualize the ground and developed a technique to directly observe the penetration process of chemical grouting.
- We continued to conduct a model experiment regarding the ground range affecting the bearing strength of piles and the effects of structure construction and other works on the surrounding ground. In addition, we started to investigate methods of evaluating ground characteristics taking construction history into account, through numerical analyses. We also developed a construction method to improve the existing pile castings (soil-improvement work between piles) during the research.
- We conducted erosion tests on steel-slag/clay composite soil and compiled the results regarding durability. The characteristics of erosion of these soils induced by water flow remained unknown, so we developed a new compact erosion test apparatus to quantify such erosion characteristics. Then, we performed a series of erosion experiments by utilizing the apparatus developed. On the basis of the results, we proposed an erodibility chart of consolidated clay, cement treated clay, and steel-slag/clay composite soil.
- We conducted various trials using X-ray CT scanners and three-dimensional molding apparatus (3D printers), and then compared the numerical analysis results using the discrete element method. In a replication analysis of compression tests, we found that the reproducibility of particle-contact points is an important factor. In addition, regarding permeability issues, we found that analyses can obtain similar permeability coefficients when particle diameters and particle configurations are the same.
- We continued to evaluate water-shielding characteristics regarding the peripheral surface of piles installed at a disposal site which had been filled with non-incinerated waste in 2014. We also participated in a field test of pile-installation at a waste site which had been filled with incinerated ash.



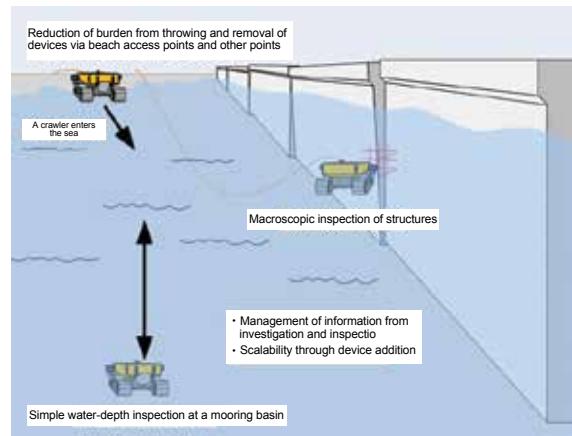
Visualized injection process of chemical grouting in a centrifuge model test

# Research Themes and Activities in FY 2016

## 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 and Okinotorishima to promote marine utilization and development.
- However, these remote islands are surrounded by 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 sound video cameras, as well as marine utilization and development.



### Research Topics

Research and development comprises the following two sub-themes:

#### i) Research on port construction and management in remote islands

We will develop a numerical simulation 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.

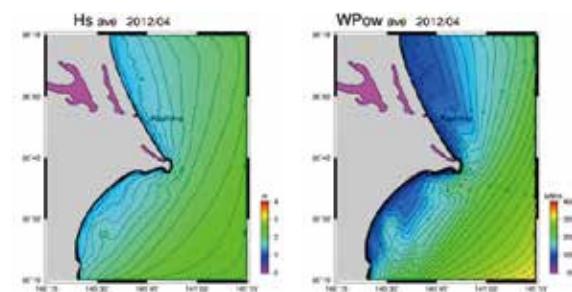
#### ii) Research on infrastructure technology for utilization and development of oceans

We are trying to downsize and lighten 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 calcified organisms to structures.

- In research on Maintenance Inspection and Investigation Technology for Remote Island Ports, we considered reducing the burden of operations and reviewed working platforms. We assumed that a working platform will be used in remote islands and developed a platform. We also conducted basic experiments on the traveling of a compact crawler.
- In the development of a next-generation sound imaging system, we developed an acoustic video camera for deep-sea ROVs and then conducted a field experiment and other tank experiments to confirm the camera's performance. In addition, we also developed image presentation softwares of the acoustic video camera.
- In research on the practical utilization and application of marine energy at ports, we used a sea area off Choshi as an example to present a potential map of marine energy (wave force) at the location. Based on the results of on-site demonstration experiments of a multiple-resonance type wave power generation system, as well as an offshore wind observation system, we proposed practical systems for future expansion of wave power generation and offshore wind power generation.
- In on-site investigation and information analyses regarding the formation and stability of calcium-carbonate ground, we surveyed the geography and biota and sampled coral and sediment at Minamitorishima Island. We also conducted on-site surveys at Rukan reef, Iriomoteshima island, and Ishigaki island, which are sub-sites.

### Activities in FY 2016

- In technological development regarding the utilization and application of mooring facilities which will be constructed in isolated reef areas on the sea, we introduced floating boundaries into the computing fluid dynamics (CFD) model and newly installed a method of analyzing the motion of moored ships and floating bodies taking into consideration the external-force characteristics of complex waves. We also conducted experiments of floating-body motion on a flat sloping bottom and verified the accuracy of the conventional and new motion-analysis methods.
- In technological development regarding new mooring equipment for ships within port areas, we collected and organized information on ship-mooring techniques which are different from conventional techniques using general mooring ropes and fenders, and then evaluated and investigated their applicability.



Potential maps of marine energy (wave force) in a sea area off Choshi

Left: characteristic wave height (monthly average) Right: omnidirectional wave power (monthly average)

# Research Themes and Activities in FY 2016

## 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 storage and atmospheric CO<sub>2</sub> uptake, both of which utilize ecosystems (blue carbon). 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 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.

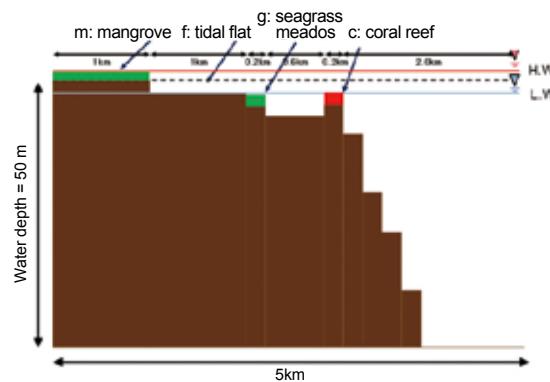
#### iii) Research on countermeasure technologies against sea oil spill

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-spillage accidents. 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

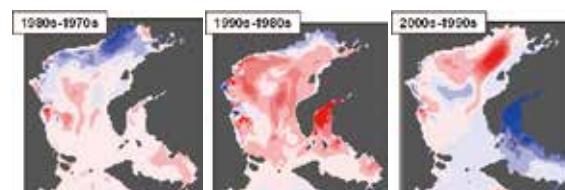
development of quantitative prediction techniques and mitigation techniques for spilled oil. Through such approaches, we will develop innovative countermeasure techniques against oil pollution and improve the ability to respond oil pollution.

### Activities in FY 2016

- Regarding global-scale estimation of the mitigation and adaptation functionings of blue carbon on climate change, we used methods of measuring carbon dynamics, the development of which we have almost completed, and then initiated on-site investigation in coastal zones overseas (estuaries of the Ganges River, India). We also established a numerical model to evaluate coastal-ecosystem functions which affect climate change-induced changes in coastal-zone environments.
- Regarding research on integrated techniques for evaluating and predicting coastal benthic ecology and ground environment dynamics, we established an integrated system for measuring and investigating wide-ranging ground environment dynamics covering the supratidal-intertidal-subtidal zones of tidelands and sand coasts and then conducted on-site feasibility studies.
- In research on the water environment simulation and analysis in inner-bay, we took into account the transitions in the coastal-area utilization of inner-bay areas and used a numerical simulation to evaluate changes in the water quality of inner-bay areas. We also developed methods for assessing the biodiversity in coastal ecosystems. In addition, data-assimilation analytical approaches that reflects the observational data into simulation results were investigated to establish more accurate prediction systems.
- In the research and development of new techniques to prevent various types of spilled oil including natural disasters, we investigated the range of advection and expansion of oil that has spilled from port facilities by tsunamis, investigated the applicability of techniques to prevent the drifting of spilled oil to port facilities, and designed a real-time hazard map of oil spill. Then we developed a beta version of a WWW continuous system for oil-drifting simulation and hazards (server client system).



Model of predicting geographical changes in coral-reef areas



Dissolved oxygen concentration in the bottom layer of Ise Bay  
(red: decreased, blue: increased)

# Research Themes and Activities in FY 2016

## 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 for harbor sedimentation due to sand and also siltation due to silt are proposed. However, in Japan, sedimentation is still progressing in some ports, and in countries which aim to expand their infrastructure overseas, a much greater amount of siltation than in Japan is projected at some channels. 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  $1.6 \text{ km}^2$  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: natural coastline geometry including beaches, mangrove coasts, and coral-reef coasts; and artificial coastline geometry including channel and harbor. 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 in the estuaries of large Asian rivers, mangroves and tidelands, and then propose countermeasures against such phenomena.

#### Research Topics

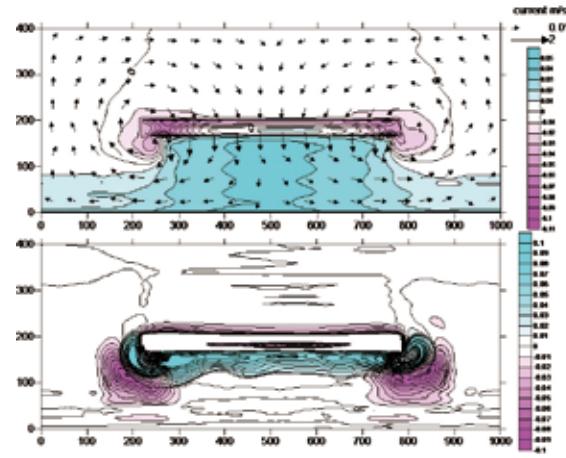
Our researches and developments for the conservation of beaches and maintenance of ports are as follows:

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.

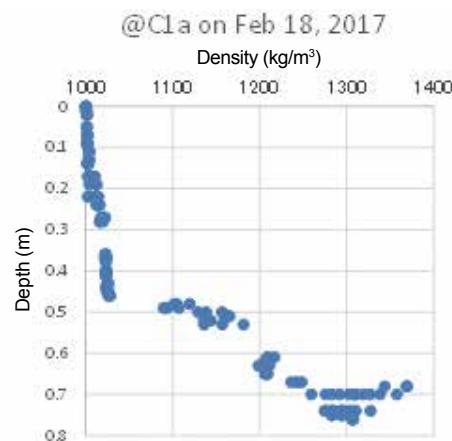
Regarding sediment transport which accompanies port utilization, we will expand the scope of our research to include estuaries of large rivers, mangroves, and tidelands overseas. Then, we will develop monitoring method for topographic change which address regional characteristics and understand the dynamics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

#### Activities in FY 2016

- Regarding field surveys of changes in coastal morphology due to sea level rise and generalized future prediction methods, we consistently collected on-site data from the Hazaki Oceanographical Research Station. Based on on-site data, we also conducted analyses to clarify the long-term beach changes and used numerical simulation to establish a model for simulating changes in geometry around structures. In addition, we used on-site data to understand long-term shoreline changes to sandy coasts where large-scale disposal of dredged sediment had been made in the past.
- To clarify mechanisms of sediment transportation in estuaries and accumulation in channels and harbors, in Japan, we conducted on-site surveys regarding fluid-mud transportation and on-site experiments of bottom-mud movement in estuaries and tidelands around Kumamoto Port. Overseas, we worked with a collaborative research institution in Indonesia regarding survey plans to identify the processes of transportation of fine mud, which is a characteristic of estuaries in Southeast Asia. Then, we conducted on-site surveys of the dispersion of turbid river water in estuaries around Patimban Coast in East Java and succeeded in collecting data for evaluating the distribution characteristics of bottom-mud densities.



Example of simulation results of topography changes around submerged breakwaters



Example of measurements of vertical distribution of density in Patimban

# Fundamental and Exploratory Research

## Fundamental Research in FY 2016

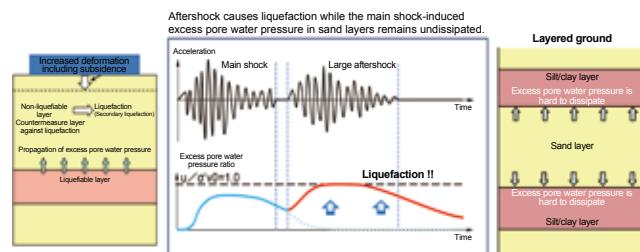
The investigation of waves, beaches, ground, earthquakes, etc., is the basis of every study conducted by PARI, and therefore we are actively working on clarifying principles and phenomena, such as the mechanisms of natural phenomena and dynamic behavior of the ground and structures.

	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 mechanism, evaluation and prediction of liquefaction under sequenced earthquake motions
5	Seabed Soil Dynamics and Stability Assessment of Breakwaters and Seawalls
6	Development of an ocean–earth coupling model for tsunami propagation
7	Development of the estimation method for local scour around coastal structures due to tsunami
8	Elucidation of oceanographic phenomena based on observation data
9	Proposal for improvement of prediction accuracy of swell
10	Study on very intense typhoon wind, storm and surge water characteristics in Japanese bays
11	Development of the maritime and environmental simulation model using meso-scale weather forecasting model
12	Evaluation of long-term durability of concrete, steel and various materials based on exposure test
13	Enhancement of cathodic protection design of marine steel structures considering the soil properties
14	Study on the durability of protective coating method for marine steel structures
15	Study on the durability of various materials under severe environments
16	Improvement method to non-uniform ground and its effect as a measure against liquefaction
17	Durability of treated soils with steelmaking slag under marine environments
18	Enhancement of accuracy of method for evaluating mechanical properties of composite geomaterials based on microstructural feature
19	Field observations and analyses on the formation and stability of carbonate lands
20	Global estimates of the efficacy of blue carbon as a means of mitigation and adaptation to climate change
21	Development of integrated prediction and assessment method of coastal benthic ecology and geoenvironmental dynamics
22	Continuous observation and statistical analysis of environmental data in enclosed bays
23	Development of an evaluation method for benthic biodiversity relating to environmental scale in coastal areas
24	Study on the mechanisms of coastal current and water environment using data assimilation
25	Observation of coastal geographical feature change and generalizing of prediction method in considered with influence of global warming
26	Study on sediment transport in estuary and deposition process in navigation channel

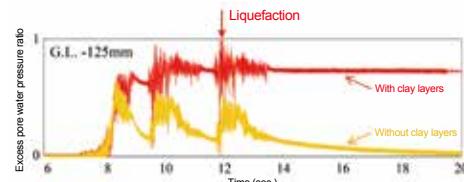
## Cases of fundamental research

### Study on the mechanism, evaluation and prediction of liquefaction under combined earthquake motions

- In the Great East Japan Earthquake, after a magnitude-9 main shock, 132 aftershocks of magnitude 5 or greater occurred on the day of the main shock. Especially, within 30 minutes after the main shock, there were three violent aftershocks of magnitude 7 or greater. In the Kumamoto Earthquake, the importance of continuous earthquakes including foreshocks and main shocks became obvious. Many cases of aftershock-induced liquefaction after the main shock were confirmed; coastal zones in Japan have many layers, with non-liquefiable layers sandwiching liquefiable layers. However, since prediction techniques to evaluate such liquefaction had not been established, it was necessary to investigate such techniques.
- In this research, we systematically clarified the characteristics and mechanisms of liquefaction under such combined earthquake motions, and verified mechanisms and countermeasures of liquefaction in layered ground in which liquefiable layers are sandwiched by non-liquefiable layers. In addition, we developed and proposed a new liquefaction prediction and assessment method which can be utilized universally around the world.
- This new liquefaction prediction and assessment method is a practical method which simultaneously predicts and accounts for the effects of irregularities of the waveforms and durations of earthquake motions, which had been difficult. Also, the method was generalized so that it can be used for various types of liquefaction charts which adopt ground N-values, cone-penetration resistances, and shear-wave velocities from surface-wave exploration.
- Following the recent occurrence of large-scale, long-duration earthquake motions including the Great East Japan Earthquake and Kumamoto Earthquake, the social demands and importance of more appropriate and rational liquefaction prediction and assessment have been increasing, not only in Japan but also internationally. Accordingly, the newly developed liquefaction prediction/assessment method is expected to be used worldwide to mitigate earthquake-induced liquefaction disasters.



Conceptual illustration to systematically clarify the liquefaction mechanism under combined earthquake motions



Liquefaction characteristics of layered ground due to combined earthquake motions

### Development of an ocean-earth coupling model for tsunami propagation

- To accurately predict tsunami propagation on the earth, we should take the following effects into account: effects of wave dispersion which decreases the phase velocity of short-wavelength component, effects of seawater compressibility which decreases the one of all wavelength components uniformly, and effects of earth's elasticity and gravity potential change

# Fundamental Research

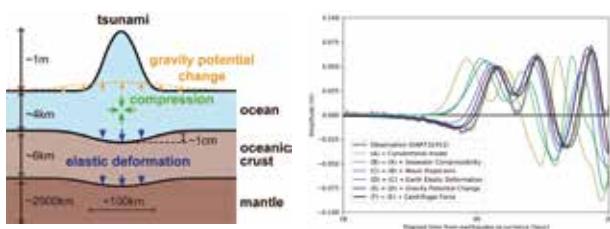
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5 Fundamental and Exploratory Research

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that decrease long-wavelength component. We developed a new numerical tsunami model. The model can consider all those effects by coupling the ocean and the solid earth. The prediction accuracy of far-field tsunami is much improved by the new model.

- We applied the model to the 2011 Great East Japan Earthquake tsunami. By comparison to the conventional model, significant improvement of the model accuracy is confirmed in waveform prediction even in far fields.
- Hereafter, we are trying to increase the resolution of bathymetry in the global tsunami propagation model. Further improvements of the model accuracy is expected. We are going to integrate the ocean-earth coupling model with the existing tsunami-simulator STOC and utilize it to predict inundation in coastal areas.

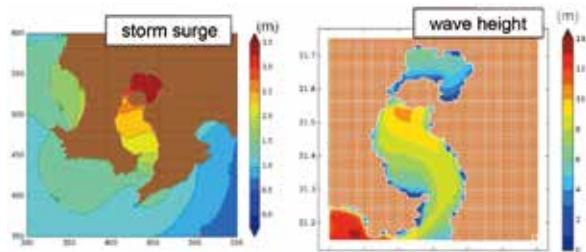


Effects of seawater compressibility and earth elasticity on tsunami propagation

Wave forms of the 2011 Great East Japan Earthquake tsunami observed off the coast of Peru

## Study on hyper intense typhoon wind, storm and surge water characteristics in Japanese bays

- Very intense Typhoon Haiyan struck the Philippines with a central pressure of 895 hPa, causing devastating wind, storm and surge water disasters. Japan was also hit by Typhoon Muroto with a central pressure of 911 hPa. When taking future climate changes into account, it is not unrealistic that a Haiyan-level typhoon may strike Japan.
- Therefore, in this research, we reviewed previous typhoons and storm surges. We used Kagoshima Bay as an example to characterize waves, storm surges and winds assuming that a Haiyan-level typhoon strikes Japan.
- The model typhoon had already been set based on the MLIT's *Guide of Mapping Storm Surge Flood Areas*. In 2016, we set a Haiyan-level model typhoon as the most intense typhoon, added it to the existing model typhoons, and estimated the waves and storm surges. The results showed that a storm surge of 3 m or higher would develop in Kagoshima Bay, which would surpass the existing highest value. In Kagoshima Port, which is located in the middle of the bay, a track of the Haiyan-level typhoon can bring the maximum wave height and storm surge. The peak of the wave height appeared first, and then those of the wind velocity and the storm surge followed.
- These results are basic knowledge when setting design wave and water level based on a scenario typhoon, which will be introduced into the design standard for port facilities.



Maximum storm and surge water height caused by a Haiyan-level typhoon

## Improvement of cathodic protection design for marine steel structures considering soil properties

- In most port steel structures in Japan, treatment to cathodic protection, which is based on a galvanic anode system, is applied to parts that are submerged in seawater when the water level is at the mean low-water level (M.L.W.L.) or lower, and parts which are buried in marine sediment. Although many findings have been obtained regarding the characteristics of cathodic protection, it is difficult to conduct surveys of parts buried in marine sediment, and so the effect of such method is not well understood.
- In this research, we focused on the cathodic protection characteristics of parts buried in marine sediment and, based on on-site survey results, attempted to assess protective current density for such parts. In this on-site survey, we investigated the cathodic protection characteristics of parts buried in marine sediment of the single-pile area of the taxiway which is connected to runway D of Haneda Airport where the footing depth is very deep (approximately 60 m). We also investigated the relationship between cathodic protection and soil electric resistivity (soil resistivity), which had been calculated using boring samples from areas near the on-site survey location. In addition, we used finite element (FEM) analysis to analyze the distribution of the electric potential and current densities of piles, and then investigated a design method for cathodic protection taking soil resistivity into account.
- The results of this research are summarized below.
- We confirmed that electric potential remains at a sufficient level to prevent corrosion for approximately 120 days even at 55 m below the seabed and that the cathodic protection sufficiently prevented corrosion even under marine sediment.
- We sampled soil in the ground survey. Then, we confirmed the correlation between soil resistance which had been measured for the sample and the protective current which flows into steel material (Figure 1 and 2).
- In this survey, we took soil resistance under marine sediment into account and used the FEM method to analyze the electric potential and density distribution when cathodic protection was applied to the piles. The results were relatively close to the actual measurements. The method of FEM analysis with parameter of soil resistance under marine sediment suggests that it could contribute to a highly reasonable cathodic protection design.

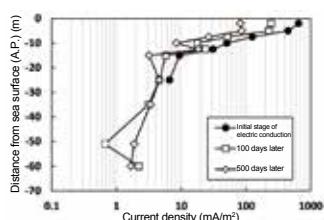


Figure 1. Depth distribution of inflow-current densities

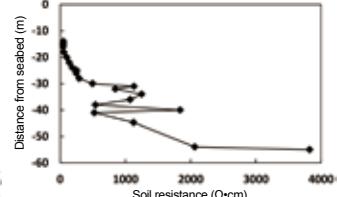


Figure 2. Depth distribution of soil resistance

## 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 soil 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

# Fundamental Research

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 for 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 sediments to create a scientific and technological basis for maintenance of territory, low-water lines, and port-facility geometry.
- In 2017, we conducted the following studies at Minamitorishima Island and other Japanese remote islands (Rukan reef, Iriomoteshima island, and Ishigaki island): aerial photoshooting using a multicopter drone, topographical survey, continuous field observation, sampling of bottom sediments and corals, and analyses of the samples.



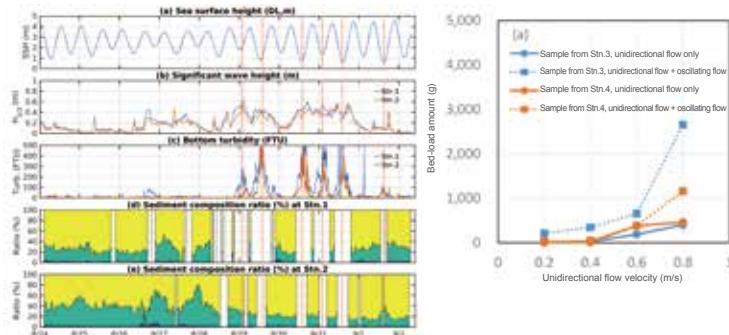
Geomorphic analysis in areas around port facilities in Minamitorishima Island, where construction works are in progress



Cylindrical coral samples collected at a sub-site (Rukan reef)

## Understanding of sedimentary dynamics in estuaries and siltation of navigation channels and harbor basins

- 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 for 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. Problems of maintaining navigation channels and harbor basins are serious also in many ports in South east Asian countries, which have often developed in estuaries of large rivers.
- In this research, we are focusing on estuaries not only in Japan but also overseas including in Southeast Asian countries. We are conducting several field monitoring to understand the sediment transport process including fluid mud behaviors around river mouth. We are also working on modeling of these sediment-transport processes in the estuarine and coastal zones.
- In the field observation at the Patimban coast in Indonesia, we have captured dispersion of turbidity around rivermouth and formation of fluid mud layer near the bed.
- In another field survey in the area around the Kumamoto Port in Japan, we observed the particle-diameter variations of suspended sediments, which depends on the types of deposited sediments. By flume experiments, we investigated the sediment load due to current and waves and the transport rates and their dependency on the sediment type were quantitatively evaluated.



# Exploratory Research

## Exploratory Research in FY 2016

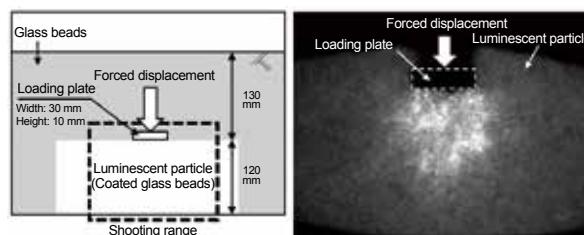
Exploratory research based on innovative and advanced ideas and potentially pioneering research fields for PARI in the future are appropriately conducted with foresight and flexibility.

Research theme (Exploratory research)	
1	Visualizatiuon of stress distribution during liquefaction process using mechanoluminescence
2	A Basic Study of Application of Geostatistics for Strategic Maintenance
3	wavenumber spectra and sea surface roughness in inner bay
4	The Development of an Applicable Sensor in Reinforced Concrete Structures
5	Experimental study on post-liquefaction deformation by density matching technique
6	Development of a corrosion diagnosing techniques for tie rods at sheet pile-type mooring wharves using an electrochemical method

## Cases of Exploratory Research

### Visualizatiuon of stress distribution during liquefaction process using mechanoluminescence

- In this study, we aimed to reveal the liquefaction process by visualizing force state from particle-scale. We developed a force-visualization technique for granular material utilizing the mechanoluminescence(ML) phenomena.
- ML is force-induced light emitting phenomena, which light intensity is proportional to force-rate. The ML material was defect-controlled strontium aluminate doped with europium as the luminescent center ( $\text{SrAl}_2\text{O}_4:\text{Eu}$ ). The surface of the glass beads was coated with an ML paint produced by mixing the ML material with epoxy resin.
- In the experiment, first we conducted loading test for single columns of coated particle to calibrate between the luminance and applied force. As the practical application, we conducted loading test of deep foundation in a centrifuge to visualize the load transmission through the granular material. Following figure shows test condition and luminance appearance - the concentrating luminance has observed under the loading plate. It shows qualitative agreement through the comparison between applied load and luminance variation. Moreover, we conducted shaking table test in dry condition as feasibility study for dynamic phenomenon.
- Hereafter, we continues these experiments to improve its accuracy in quantitative level, and applying to visualize liquefaction phenomena.



# Exploratory Research

1  
2  
3  
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5 Fundamental and Exploratory Research

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## Applicability of geostatistics for streamlining maintenance

- For maintenance of concrete structures in ports, coring and concentration measurement of chloride ions are sometimes performed to confirm the state of penetration of chloride ions. However, the severe work environment and the long length of port structures make it difficult to conduct an adequate number of surveys. So, it is difficult to determine the deterioration condition of an entire structure.
- Therefore, if information from limited-area surveys allows us to recognize the state of penetration of chloride ions for an entire structure, it may be possible to identify areas where focused reviews are required. In this research, first we investigated the necessary number of measurements for estimating the concentration distribution of chloride ions which are present on the surface of pier floorboards.
- On pier floorboards which have been used for approximately 30 years after the structure entered into service, we measured chloride-ion concentrations at 63 locations and calculated the concentration of surface chloride ions ( $C_0$ ) and apparent diffusion coefficient ( $D_{ap}$ ). For the resulting  $C_0$ , we used kriging, which is a geostatistics method, to estimate the distribution of  $C_0$  on an overall floorboard. For data of N points ( $N = 5, 10, 15, \dots, 45$ ), which had been randomly selected from data of the 63 measured points, we used kriging to estimate the distribution of  $C_0$ , and calculated mean square errors (MSE) between the results and  $C_0$  distribution which had been estimated using the overall data (Figure 1). We repeated this calculation for each N point 2000 times, then analyzed the estimated accuracy of the distribution for each number of measurements.
- As a result, we found that the greater the number of data, the smaller the MSE becomes (Figure 2); however, we could not conclude how many measurements are necessary for estimating the distribution of  $C_0$ . Hereafter, we will conduct the same investigation on other floor slabs to increase actual data. We will also conduct simulations regarding the necessary number of measurements for estimating the distribution of  $C_0$ .

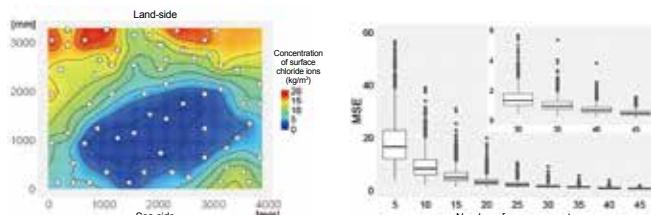


Figure 1. Estimated concentration distribution of surface chloride ions (overall data; white circles represent measured points.)

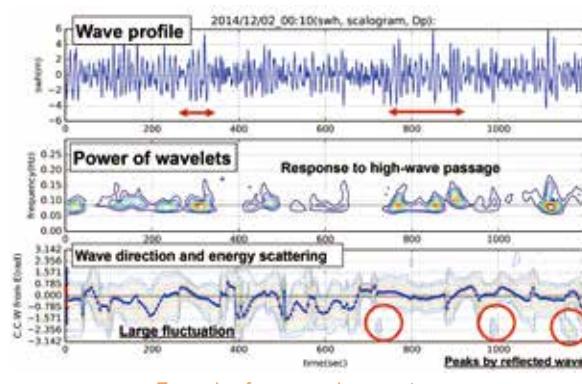
Figure 2. Estimated error for each number of measurements

## The dependence of sea-surface roughness on the wave-number spectrum in inner bays

- In the previous storm-surge simulation, sea-surface roughness was calculated using only a wind-velocity function regardless of wave conditions. To quantify the relationship between wave conditions and sea-surface roughness, a method of estimating wavenumber spectrum needs to be developed.
- Therefore, in this study, we assumed that data of Acoustic Doppler Current Profile (ADCP), which is a general observation method in the Nationwide Ocean Wave information network for Ports and HArbourS (NOWPHAS), will be used in the estimation, and then attempted to develop a method to estimate wavenumber spectrum based on wavelet analysis.
- First, we received advice from Dr. M. Donelan of Miami University, investigated a method of using longitudinal data of observed water levels and velocities to directly estimate wavenumber spectrum, and then concluded that such a method is difficult to use due to ADCP's characteristics. Next, we used

research by Krogstad et al. (2006) as a reference, and investigated a two-stage method, in which directional-spectrum estimation is followed by wavenumber-spectrum estimation. In the directional-spectrum estimation, we adopted the Bayesian approach, which allows robust and high-resolution estimation; in the wavenumber-spectrum estimation, we adopted the grid search algorithm which assumes a linear dispersion relation as the initial value. We verified the validity of this serial estimation method through a numerical simulation, in which water-level/flow-velocity time series were made using the wavenumber spectrum, then the time series was used to inversely calculate the wavenumber spectrum.

- Phenomena which fluctuate depending on time domains (e.g. envelope development in wave-group) could not be analyzed by Fourier analysis, but could be analyzed by introducing the wavelet analysis to spectral analysis. Dropping data and noises seldom interfere with such analysis.
- After analyzing some data from NOWPHAS-based observations using the above method, we found that the time fluctuation of directional spectrum may differ depending on winds, waves. We also determine the timing and frequency of reflected-wave development from the land.



Example of wavenumber spectrum

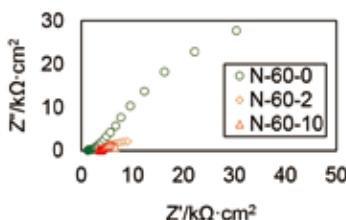
- Hereafter, we will analyze wave phenomena which have not been fully understood using conventional observation equipment and analytical methods, to help understand the mechanisms of generation of such phenomena and assess their effects on coastlines. Such phenomena include "Yorimawari-Nami" in Toyama Bay, the frequency and occurrence condition of reflected waves from the land, whose phenomena can be observed from several observation points of NOWPHAS. In addition, we would like to investigate the introduction of NOWPHAS into our routine works, and development on ocean models including a storm-surge model using sea-surface roughness.

## Development of a sensor for reinforced-concrete structures

- For efficient and effective maintenance of reinforced-concrete structures, it is necessary to accurately diagnose and assess the state of corrosion of steel material in target structures. Nondestructive inspections are performed for this purpose, and a continuous monitoring technique using electrochemical measuring methods is drawing attention.
- For measuring the half-cell potential and polarization resistance of steel material in concrete, noble-metal reference electrodes are generally used as sensors. However, the heterogeneity of concrete components and the environment inside an electrode make accurate measurement of half-cell potential and polarization resistance difficult. Therefore, in this research, we used internal-liquid reference electrodes to develop an embedded-type, 3-electrode sensor, which can accurately measure half-cell potential and polarization resistance.

# Exploratory Research

- To develop the sensor, we took the following two steps: 1. selection of sensor material and study of sensor shapes/configurations, 2. evaluation of effect of different concrete constituent ratios on (1) chloride-ion concentrations, (2) structure densities (cement types and water/powder ratios), and (3) drying. In step 2, we used concrete specimens with different constituent ratios.
- We measured impedance spectra using the electrochemical impedance spectroscopy to determine the effects of chloride-ion concentrations on the spectra. The following graph indicates the results. The figure's legend indicates cement type–water/cement ratio of concrete–concentration of chloride ions in concrete. The order of amplitude of each impedance spectrum was N-60-0>N-60-2>N-60-10. This result indicates the trend that the inclusion of chloride ions reduces the polarization resistance of steel material.
- This research suggested that the 3-electrode sensor could be used for a practical continuous monitoring technique using electrochemical measurement methods.



Effects of chloride-ion concentration on measurement results  
(Legend: cement type–water/cement ratio–concentration of chloride ions)

## Understanding the characteristics of liquefied-ground deformation through a density matching technique

- Previous research pointed out that liquefied ground behaves similarly to a viscous fluid; however, a method of estimating such viscosity has not been established. In this research, we aimed to understand the deformation characteristics of liquefied sand ground from a microscopic viewpoint, i.e. the interaction between sand particles and pore water, through experiments using a density matching technique.
- We selected five resins with different densities (polypropylene, polystyrene, nylon, delrin, and teflon; density = 0.90 to 2.15), formed each of them into a spherical shape with a diameter of 1 to 2 mm, and then used these balls instead of sand. We changed the material densities to replicate the disappearance of interparticle force during liquefaction phenomena.
- We used a rheometer to measure shear resistance, and then quantified the velocity dependence (viscosity) of shear resistance. As a result, we found that dense particles show stronger velocity dependencies (Figure 1 and 2).
- We used a high-speed camera to observe the deformation field and confirmed the following mechanism: deformation regions expanded with increasing rotational speed of vanes and then the shearing resistance increased. Hereafter, we will conduct experiments using a wider range of specimens to systematically understand the phenomena.

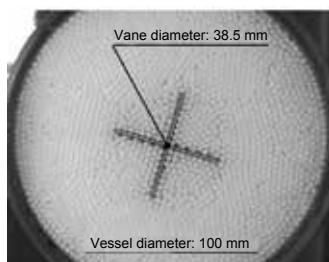


Figure 1. Viscosity measurement by a rheometer  
Resistance is measured against the rotation of the vanes.

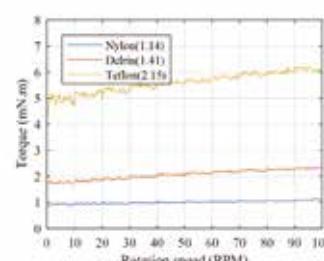


Figure 2. Relation between shear resistance and rotational speed of the vanes  
With heavy-density particles (teflon), the shear resistance increases with the rotational speed of the vanes (resulting in a high apparent viscosity).

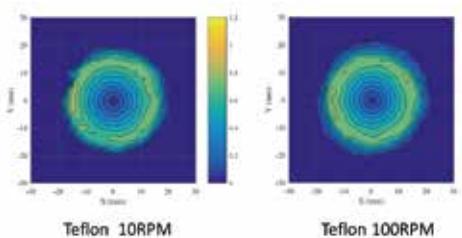
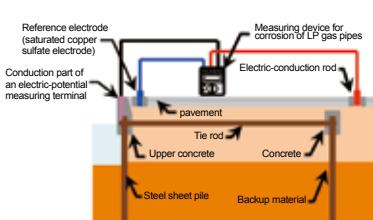


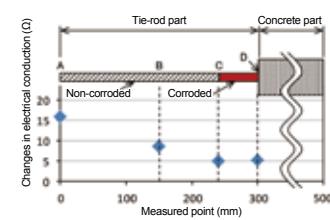
Figure 3. Velocity distribution (Velocity was normalized with the rotational speed of the vane tip.)  
Deformed area expands with increasing rotational speed of the vanes (right figure).

## Development of a corrosion diagnosing techniques for tie rods at sheet pile-type mooring wharves using an electrochemical method

- As a method of inspecting tie rods at sheet pile-type mooring wharves, there is currently only one method in which the use of facilities is stopped and then apron areas are excavated. However, surveys using this method require time and effort, and so few inspections of tie rods have been conducted. Therefore, in this study, we aimed to propose a nondestructive-inspection method for tie rods without excavation of apron areas.
- In an inspection of LP gas pipes which are buried in the ground, electrochemical nondestructive inspections are conducted to determine the presence of corrosion. In this research, we conducted indoor experiments using model specimens, and on-site experiments at sheet pile-type mooring wharves, to investigate whether this method can be applied to tie rods.
- The results of the indoor experiments indicated that the method can be used to estimate the locations of corrosion by comparing the changes in electrical conduction between measurement points. However, in on-site experiments, we confirmed that changes in electrical conduction at measurement points markedly vary depending on ground conditions and water contents in earth-covered areas, and that the dispersion of flowing current to other areas than tie rods hinders the accurate measurement of changes in electrical conduction.
- Regarding application of the inspection method for LP-gas pipes to tie rods, many challenges remain for the diagnosis of tie-rod corrosion: proposal of a method to assess electrical resistivity in earth-covered areas; a method of assessing changes in electrical conduction which takes flowing-current dispersion into account; and appropriate thresholds of changes in electrical conduction.



Changes in electrical conduction value in a simulated test specimen



Changes in electrical conduction value in a simulated test specimen

# Published Research Papers

## Number of Peer-reviewed papers in FY 2016

Number of papers in Japanese	Number of papers in non-Japanese languages	Total	Rate of papers in non-Japanese language
62(50)	70(23)	132(73)	53%(32%)

\*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 2016

No.	Title	Author(s)	Language	Month/Year
055-02-1	Numerical Simulation on Tsunami Inundation and Debris Damage by STOC Model	Takashi TOMITA, Kazuhiko HONDA, Yu CHIDA	Japanese	June 2016
055-02-2	Field Observations and Numerical Analyses on the Effect of Vegetation on the Hydrodynamics of a Shallow Water Using a New Hydrodynamic Model	Hirotada MOKI, Yasuyuki NAKAGAWA, Kenta WATANABE, Tatsuki TOKORO, Shigeru MONTANI, Tomohiro KUWAE	Japanese	June 2016
055-02-3	Mechanical properties of coral-gravel soil –a parametric study using reconstituted samples–	Yoichi WATABE, Takashi KANEKO, Shinji SASSA	Japanese	June 2016
055-02-4	Submarine Liquefied Flow Dynamics and Their Analytical Framework with Experimental and Field Validations	Shinji SASSA	Japanese	June 2016
055-03	Mechanical properties of coral-gravel soil – an integrated governing parameter for undisturbed samples –	Yoichi WATABE, Takashi KANEKO, Shinji SASSA	Japanese	September 2016
055-04	Research Perspectives for Improving the Productivity and the Sustainability of Port Management	Koji TAKAHASHI	English	December 2016
056-01-1	Design method of joint plates installed in a caisson type seawall	Kojo SUZUKI, Yuichiro TAKEBE, Kazuki HORII, Yoshio NISHIO	Japanese	March 2017
056-01-2	Enhancement of accuracy of prediction of tsunami force in overflow for design of tenacious breakwater	Naoki TSURUTA, Kojo SUZUKI, Tsukasa KITA, Masafumi MIYATA, Masahiro TAKENOB	Japanese	March 2017

## Papers Published in PARI Technical Notes in FY 2016

No.	Title	Author(s)	Language	Month/Year
No.1319	Annual Report on Nationwide Ocean Wave Information Network for Ports and Harbours (NOWPHAS 2014)	Koji KAWAGUCHI, Satoshi SAKURABA, Takashi FUJIKI	Japanese	June 2016
No.1320	Sediment Transport and Near-Bed Dynamics by Currents and Waves in Muddy Environments of Inner Bay	Yasuyuki NAKAGAWA	Japanese	June 2016
No.1321	Applicability of piled foundation at confined disposal facilities in coastal area – in situ demonstration for pile-driving and impermeable performance at untreated wastes ground –	Yoichi WATABE, Takaaki MIZUTANI, Takashi KANEKO, Koichi MASUKADO	Japanese	June 2016
No.1322	Annual Report on Strong-Motion Earthquake Records in Japanese Ports (2014)	Atsushi NOZU, Yosuke NAGASAKA	Japanese	June 2016
No.1323	Strong Ground Motion Simulation with Pseudo Point-source Model -Application to the 2005 Central Chiba Intraslab Earthquake-	Yosuke NAGASAKA, Atsushi NOZU	Japanese	June 2016
No.1324	Studies on the estimation of durability of protective methods for steel pipe pile based on the long term marine exposure test (after 30 years)	Toru YAMAJI, Kazuhide YONAMINE, Yoshikazu AKIRA, Masami ABE, Noriyoshi HARATA, Ryuta TANAKA, Takashi KADONO, Kazuya KODA, Ken KANASUGI, Hiroaki GOTO, Hideki MATSUDA, Hiroyuki EGUCHI, Yoshinori MATSUI, Kei-ichiro KISHI, Kazuo KUBOTA, Naoya NAGAO, Masahiko HOSHINO, Yoshiyuki KAWASE, Fumito KOIZUMI, Yutaka KOBAYASHI, Kazuhiro MASUDA, Yukio YOSHIKAWA, Satoshi NAKAMURA	Japanese	June 2016
No.1325	A Basic Study for Application of Multicopter in Visual Inspection of Port and Shore Protection Facilities	Shuji NOGAMI, Koji YAMAMOTO, Ema KATO, Yutaka TANAKA	Japanese	June 2016
No.1326	Development of countermeasure method using pile-type stabilization against lateral flow due to liquefaction	Yoshiyuki MORIKAWA, Hidenori TAKAHASHI, Wakaki TSUDA, Naoki TAKAHASHI, Goji TOMURA, Ikuo TOWHATA	Japanese	September 2016
No.1327	Development of simulation model for oil transport resulting from a tsunami	Yoshitaka MATSUZAKI, Isamu FUJITA	Japanese	September 2016
No.1328	Practical Approach to Maintenance of Mooring Facilities ~ Towards Practical Inspection based on Performance Degradation Chains~	Ema KATO, Yuichiro KAWABATA, Mitsuyasu IWANAMI, Hiroshi YOKOTA, Toru YAMAJI, Atsushi FUJII, Hideharu NAITO, Sosuke KITAZAWA, Hiroshi INOUE, Hirohiko KASHIWABARA, Eiji SUEOKA, Michio YOSHIDA, Shuji YAMAMOTO, Norio NAKANO, Tsutomu INADA	Japanese	December 2016
No.1329	Fundamental study on rational design of structural member of caisson in breakwater	Kenji UNO, Ema KATO, Yuichiro KAWABATA	Japanese	December 2016
No.1330	Development of a method for complementarity of species assemblages and an application for the data of benthic marine animals obtained in a bay	Shinya HOSOKAWA	Japanese	December 2016
No.1331	Annual Report on Strong-Motion Earthquake Records in Japanese Ports (2015)	Atsushi NOZU, Yosuke NAGASAKA	Japanese	March 2017
No.1332	Reconsideration of the Methods for Eelgrass Restoration	Shinya HOSOKAWA	Japanese	March 2017

# Public Relations

## Annual Report, Technical Journals, and E-mail Newsletters

The Annual Report 2016 (Japanese version) and the PARI Annual Report 2016 (English version), which summarized the activities in FY 2015, were produced as a record of achievements, and were distributed to the parties concerned and published on PARI's website.

Each issue of the PARI Technical Journal contains articles on selected research themes and introduces the application of research achievements as well as the experiment and on-site measurement facilities of PARI. Approximately 1,800 copies of the PARI Technical Journal were distributed to 1,700 places.

The PARI website continues to publish the latest information of the Institute, such as research achievements, research facilities, seminars, symposiums, and other events and news. The website attracted approximately 260,000 visits in FY 2016. Bi-monthly newsletters were sent out six times via e-mail to approximately 1,300 subscribers.



The PARI Technical Journal

## 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 9, 2016 in cooperation with the National Institute for Land and Infrastructure Management, which was attended by approximately 230 participants.

### Port and Airport Technology Special Lecture in Region

In order to disseminate information on the research activities and achievements of PARI and collect information such as research needs in each region of Japan, we held six lectures throughout the country in cooperation with the National Institute for Land and Infrastructure Management, Regional Development Bureaus, and others, gathering approximately 800 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 13, 2017, which was attended by 61 people.

## Open House

### Summer Open House

Our Summer Open House (Saturday, July 23, 2016) held a variety of demonstration experiments, including "Let's feel the power of a giant tsunami!" and "Let's make concrete!", hands-on events including "Let's touch creatures in tidal flats!", "Let's experience a construction machine simulator", and "Let's see under the sea with an underwater camera", and exhibitions including "Let's see a jumbo jet tire!" 1,271 people visited PARI that day.



Summer Open House

### Other Facility Tours

Other than the Summer Open House, we held 90 facility tours, with 1,358 visitors. We introduced PARI facilities and PARI-associated research to visitors from 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 (59 in total) were brought in and we ran hands-on workshops using models and other tools.

### Cooperation with Super Science High school (SSH) Projects

We explained PARI's research contents and held facility tours for first-year high school students of Kanagawa Prefectural Yokosuka High School, which was designated as an SSH by the Ministry of Education, Culture, Sports, Science and Technology, to stimulate their interest in science and mathematics.

### Exhibition at Tokyo-wan Daikanshasai 2016 [Tokyo-Bay Thanksgiving Day 2016]

In October 2016, we set up an exhibition booth at Tokyo-wan Daikanshasai 2016, 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 2016 [Tokyo-Bay Thanksgiving Day 2016]

### Media Appearances

Representatives of PARI frequently appear in the media as a part of public relations. One TV program introduced our model experiment which used a large vibrating table and other PARI activities. Articles about PARI's various activities were featured in newspapers, technical journals, and other printed publications a total of 64 times.



NHK News 7 feature on a model experiment using a large vibrating table (aired on February 25, 2017)

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7 Public Relations

# Outstanding Research Activities

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8 Outstanding Research Activities

## Awards for Papers and Others in FY 2016

	Name		Award	Institution	Date	Remarks
1	Yuichiro KAWABATA and 3 others	Senior Researcher, Structural Mechanics Group	Cement Science and Concrete Technology, Best Paper Award	Japan Cement Association	May 11, 2016	Evaluation of Influencing Factors for DEF Expansion Based on Long-Term Laboratory Tests
2	Takaaki MIZUTANI	Head, Foundation Group	FY 2016 The Ports and Harbours Association of Japan, Best Paper Award	The Ports and Harbours Association of Japan	May 26, 2016	Variance of Dynamic Load Test Results of Piles at a Single Construction Site
3	Eiichi MIYOSHI	Research Specialist, Coastal and Estuarine Environment Group	FY 2016 Persons of Merit Award of the for Meritorious Service in Port Affairs in FY 2016, The Ports and Harbours Association of Japan Commendation	The Ports and Harbours Association of Japan	May 26, 2016	
4	Kenichiro SHIMOSAKO	Special Senior Director for Research	FY 2016 Technology Award of the The Ports and Harbours Association of Japan Technology Award	The Ports and Harbours Association of Japan	May 26, 2016	Development of Flap Gate Flap-Gate Type Land Locks against Tsunamis and Storm Surges
5	Yuichiro KAWABATA	Senior Researcher, Structural Mechanics Group	FY 2016 Japan Concrete Institute, Best Paper Award	Japan Concrete Institute	June 20, 2016	Evaluation of alkalinity of pore solution based on the phase composition of cement hydrates with supplementary cementitious materials and its relation to suppressing ASR expansion
6	Daiki TAKANO	Senior Researcher, Soil Stabilization Group	FY 2015 Japanese Geotechnical Society Young researcher Award	Japanese Geotechnical Society	June 8, 2016	
7	Daiki TAKANO and 3 others	Senior Researcher, Soil Stabilization Group	2016 C. A. Hogentogler Award (Best paper published in Geotechnical testing journal in 2015)	ASTM International	July 3, 2016	
8	Nozomu SOMEYA	Research Officer, Structural Mechanics Group	FY 2016 Annual Paper Encouragement Award	Japan Concrete Institute	July 8, 2016	
9	Kenichiro SHIMOSAKO	Special Senior Director for Research	Infrastructure Technology Development Award, Award of Excellence	Japan Institute of Country-ology and Engineering	July 26, 2016	Development of Flap Gate Flap-Gate Type Land Locks
10	Nozomu SOMEYA	Research Officer, Structural Mechanics Group	The 70th Annual Meeting of Cement and Concrete Engineering, Excellent Lecture Award	Japan Cement Association	August 1, 2016	
11	Akihiko KONDO	Research Officer, Earthquake and Structural Dynamics Group	Presenter Award of the 51st Japan National Conference on Geotechnical Engineering	Japanese Geotechnical Society	September 13, 2016	Experimental verification of DEM – SMAC simulation using duplication of microstructure focusing on permeability issue
12	Tomohiro TAKAGAWA	Head, Tsunami and Storm Surge Group	Coastal Engineering Journal Citation Award of 2015	Japan Society of Civil Engineers	November 16, 2016	Research on the Inundation Characteristics of the 2011 Tohoku Tsunami
13	Naoki TSURUTA	Research Officer Researcher, Maritime Structures Group	FY 2016 Hydrographic Technology, Encouragement Award	Japan Hydrographic Association	March 6, 2017	

# 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 to the designation, PARI 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 including tsunami disasters. In October 2016, we awarded the prize to Nobuo Shuto, professor emeritus of Tohoku University, and Eddie Bernard, a former director of the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Laboratory (PMEL) and a member of Oficina Nacional de Emergencia del Ministerio del Interior (ONEMI) of the Republic of Chile.



A prize awarding ceremony and commemoration lecture of the Hamaguchi Award(October 31, 2016, Tokyo)

In June 2016, seven researchers from the Korean Institute of Ocean Science and Technology (KIOST) and Ministry of Transport's Waterborne Transport Institute (China) visited Japan to attend our Marine-Environment International Symposium.

In October 2016, we also held a Japan-Korea Coastal Development Workshop, where we made presentations in the following four technical sessions: coastal disaster prevention, coast management, coastal environment, and technological development.

## Broad Research Exchange with Japanese and Non-Japanese Research Institutes

We aim to improve the quality and efficiency of research through actively promoting joint research among Japanese and non-Japanese research institutions. Toward these goals, we concluded a total of 35 research cooperation agreements with 9 Japanese and 26 overseas institutions between FY 2003 and FY 2016. In FY 2016, we concluded a cooperation agreement with the Ministry of Transport's Waterborne Transport Institute (WTI) of China and Jadavpur University of India. Regarding the collaborative study agreement concluded with Badan Pengkajian dan Penerapan Teknologi of Indonesia (BPPT) in FY 2015, the agreement stipulates not only the exchange of researchers but also implementation of collaborative studies on ports and coasts in Indonesia, mainly regarding siltation and drift sand. In February 2017, PARI researchers conducted on-site surveys of geomorphological changes and shipping-route burial in Indonesian coasts.

Regarding research exchanges within Japan, in September 2016, based on an agreement on research collaboration, PARI and the University of the Ryukyus held a special lecture on the characteristics and challenges of recent destructive earthquakes and giant tsunamis and a briefing session on several studies conducted under severe environments including in Okinawa, which was attended by 142 people.



Concluded a research collaboration agreement with Jadavpur University of India (January 29, 2017, Kolkata)

## Conclusion of Education and Research Collaboration Agreements

We concluded agreements with national, public and private universities. Under these agreements, PARI researchers serve as grad-school professors or other such 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 Tokyo Institute of Technology and Nagoya University. In FY 2016, we dispatched 11 researchers as lecturers. We also dispatched four researchers to universities which are not under the graduate school linking system, including Ehime University and Tsukuba University.

## Promotion of Administrative Support

### Dispatching of PARI Technical Emergency Control Force (TEC-FORCE)

In Kumamoto, magnitude-7 earthquakes were recorded on April 14 and 16, 2016, causing severe damage to transportation infrastructure including ports, airports, roads, and railways. From the day after the earthquake, PARI dispatched investigative teams to the damaged areas to assess the state of damage to port and airport facilities and to provide technical assistance, thus contributing to early restoration.

### Dispatching of Researchers to Various Technical Committees

We dispatched a total of 196 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 390 researchers were dispatched by PARI, and actively tackled technical issues faced by governments and other organizations.

### Dispatching Lecturers to Training Courses for Domestic Engineers

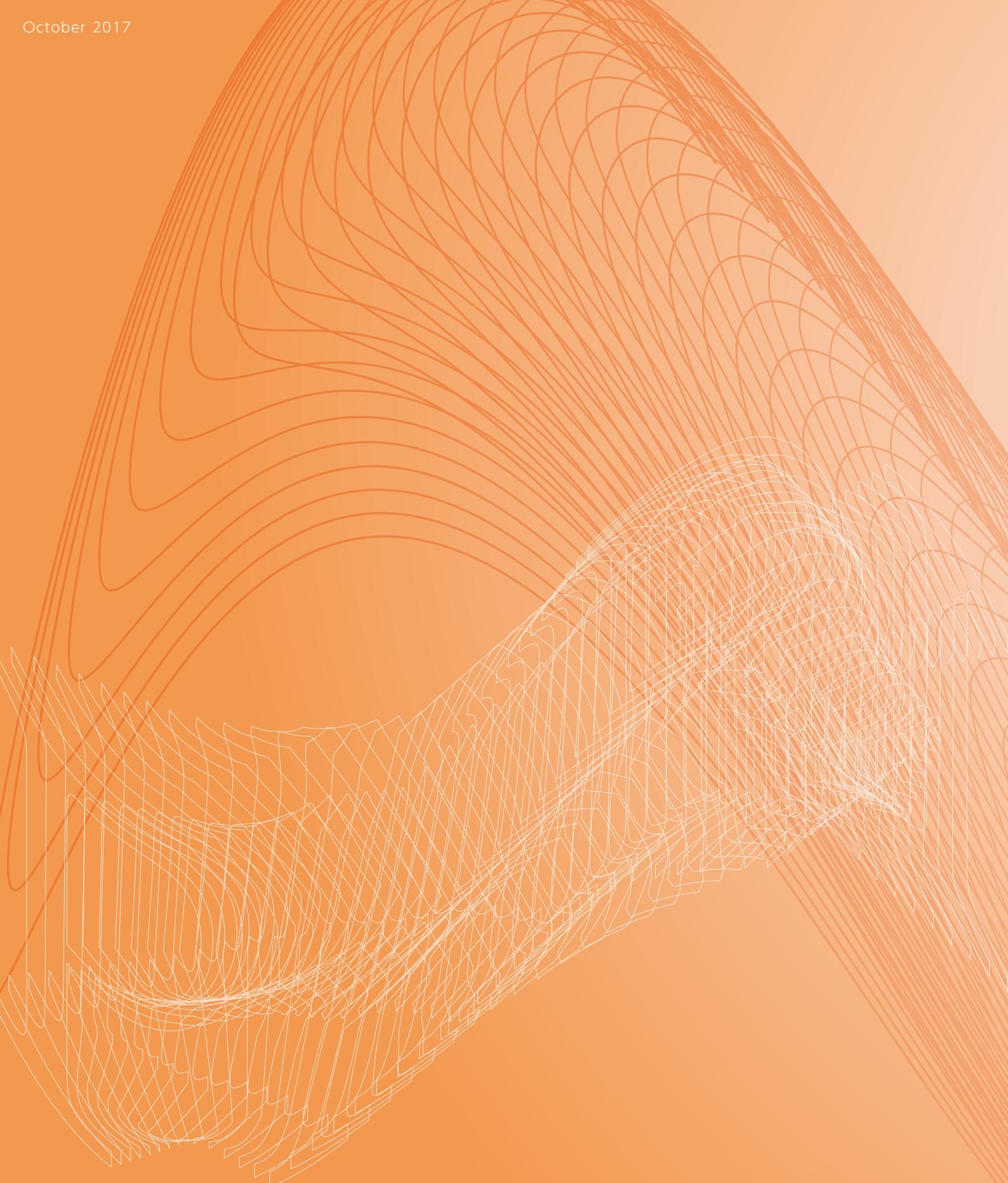
Training courses for national and other public service engineers are held by the National Institute for Land and Infrastructure Management. We actively participate from the planning stage and have dispatched a total of 38 researchers to 14 training courses as lecturers.

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

Regarding technical standards for port facilities, our researchers in FY 2016 once again 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 FY 2016, in response to a request of the Ministry of Land, Infrastructure, Transport and Tourism (including regional development bureaus), PARI continued to offer 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.



—Creating Technologies that Contribute to the World—  
**National Institute of Maritime, Port and Aviation Technology  
Port and Airport Research Institute**