CIVIL ENGINEERING

Kyoto University

Structural Engineering Laboratories

Katsura Campus

Applied Mechanics (応用力学講座)

Structural Materials Engineering (構造材料学分野)

Structural Mechanics (構造力学分野)

Bridge Engineering (橋梁工学分野)

International Management of Civil Infrastructure (国際環境基盤マネジメント分野)

Structures Management Engineering (構造物マネジメント工学講座)

Earthquake and Lifeline Engineering (地震ライフライン工学講座)

Uji Campus

Dynamics of Foundation Structures (耐震基礎分野)

Urban Flood Control (都市耐水分野)

Hydraulics and Hydrology
River, Coastal, and Water Resources Engineering Laboratories

Katsura Campus

Applied Mechanics (応用力学講座) (See page 4)

Environmental Hydrodynamics (水理環境ダイナミクス分野)

Hydrology and Water Resources Research (水文・水資源学分野)

Urban Coast Design (沿岸都市設計学分野)

River System Engineering and Management (河川流域マネジメント工学講座)

Uji Campus

Erosion and Sediment Runoff Control Engineering (砂防工学分野)

Hydroscience and Hydraulic Engineering (防災水工学分野)

Hydrometeorological Disasters Engineering (水文気象工学研究分野)

Coastal Disaster Prevention Engineering (海岸防災工学分野)

Innovative Disaster Prevention Technology and Policy Research (防災技術政策分野)

Waterfront and Marine Geohazards (水際地盤学分野)

Regional Water Environment Systems (地域水環境システム計画分野)

Water Resources Engineering (水文循環工学分野)

Socio and Eco Environment Risk Management (自然・社会環境防災計画学分野)

Geotechnical Engineering Laboratories

Katsura Campus

Geomechanics (地盤力学分野)

Infrastructure Innovation Engineering (社会基盤創造工学分野)

Construction Engineering and Management (土木施工システム工学分野)

Geofront System Engineering (ジオフロントシステム工学分野)

International Urban Development (国際都市開発分野)

Uji Campus

Geotechnics for Hazard Mitigation (地盤防災工学分野)

Yoshida Campus

Environmental Infrastructure Engineering (社会基盤親和技術論分野)

Computational Science (計算科学講座)

Planning Laboratories

Katsura Campus

Geoinformatics (空間情報学講座)

Urban and Landscape Design (景観設計学分野)

Planning and Management Systems (計画マネジメント論分野)

Urban and Regional Planning (都市地域計画分野)

Urban Management Systems (都市基盤システム工学講座)

Intelligent Transport Systems (交通情報工学分野)

Travel Behavior Analysis (交通行動システム分野)

Uji Campus

Disaster Risk Management (災害リスクマネジメント研究分野)

Integrated Disaster Management Systems (総合防災情報システム分野)

Integrated Disaster Reduction Systems (巨大災害情報システム分野)

Crisis Information Management Systems (危機管理情報システム分野)

APPLIED MECHANICS

Associate Professor
Abbas Khayyer

Associate Professor
Jun Saito

Modeling of mechanical behavior and numerical simulation

Safety evaluation of structures from the viewpoint of mechanics is the most important issue at every stage of the infrastructure development. "Comprehensive and reliable modeling of fundamental mechanical behavior" is a key point in applied mechanics and development of a numerical prediction method is necessary in order to explain a measurement of observation or a laboratory experiment, scientifically. Our laboratory studies mechanical theory and its application, and aims to cultivate human resources who can develop studies and pass research achievements to the next generations.

Lagrangian particle methods for multi -physics simulations

The main target is to develop advanced multi-physics multi-scale particle-based computational methods for practical simulation of ocean/coastal engineering problems. The main areas of interest include violent fluid flows, multiphase flows and fluid-structure interactions.

The so-called particle methods or Lagrangian mesh-free methods are appropriate candidates for fluid flow simulations (and their interactions with the environment) in view of their flexibility and potential robustness in dealing with complex moving boundaries. However, since particle methods are relatively new computational techniques there have been several issues corresponding to non-exact momentum/energy conservation, unphysical pressure fluctuations and numerical instability. These issues have almost been resolved by development of accurate schemes for discretization of the constitutive governing equations. The main future/ongoing studies are focused on:

1. further enhancement of accuracy and stability of particle methods by development of further accurate numerical schemes/algorithms
2. further enhancement of the developed multiphase particle-based method by a more meticulous modeling of the governing physics
3. extension of developed particle methods to model hydroelastic fluid-structure interactions (FSI) as well as fluid-porous media interactions (FPI) with rigorous treatment of interface boundary conditions

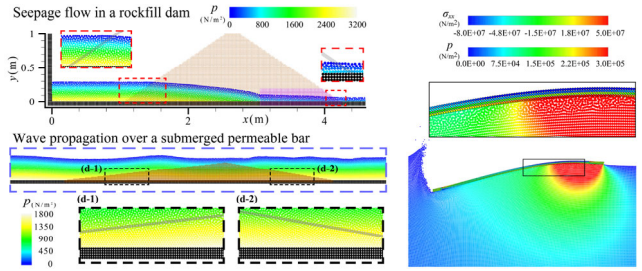


Fig. 1: Multi-physics simulations by particle methods (FPI and FSI) in coastal and ocean engineering

Rigid plastic finite element method for soil structures

When geomaterials and metallic materials undergo large plastic deformation compared to elastic deformation, the rigid-plastic finite element method, which incorporates the finite element method with limit theorems, can be used to numerically represent collapse behavior. In order to apply the rigid-plastic finite element method to real problems, we are improving the method by introducing various constitutive equations and increasing its accuracy.

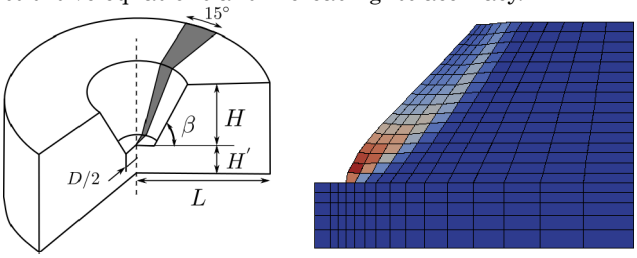


Fig. 2: Stability analysis of excavation

Fluid and structural analysis using particles and grids

We are developing numerical methods using MPM and FLIP, which solve the equations of motion on mesh and solve advection on particles. These methods have the advantages of both mesh-based and meshless methods, and are powerful methods for solids, fluids, and gases. The goal of this research is to perform flow analysis of fresh concrete, seepage flow analysis considering ground deformation, and coupled analysis of fluid and structure.

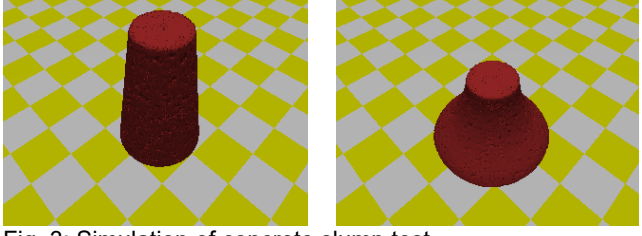


Fig. 3: Simulation of concrete slump test

Structural Materials Engineering

Professor Takashi YAMAMOTO
Associate Professor Satoshi TAKAYA

Strong Beautiful and Durable -Concrete Structures-

In order to keep performance of concrete structures for long years, from molecule structures to civil structures such as deterioration mechanism, evaluation method of deterioration degree, performance of deteriorated concrete structures, mechanism and effectiveness of repair materials are studied in this laboratory.

Deterioration Mechanism

In order to develop more effective and economic maintenance method, it is necessary to make clear deterioration mechanism. And in some cases, chemical analysis or electro chemical measurement are used for making clear the mechanism of deterioration such as reinforcement corrosion and alkali-silica reaction (ASR).
For example, Fig.1 shows the result of Raman spectroscopy of aggregate before and after dissolution test carried out to investigate ASR reactivity of aggregate. As a result, it was observed that background (fluorescence) in low wave-number region decrease after dissolution test. It can be thought that this fluorescence is due to non-bridging SiO_2 (-Si-O・) because of its wave length.

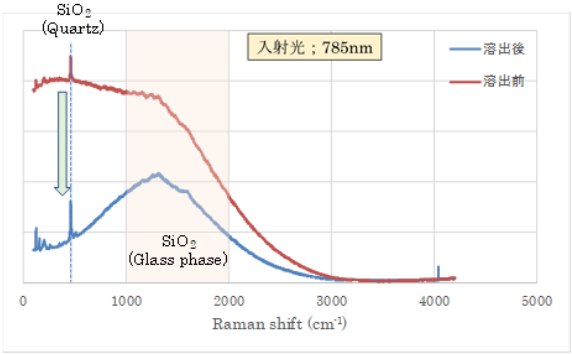


Fig.1 Comparison of Raman spectrum of aggregate before and after dissolution test

Quantitative Evaluation Method

In order to achieve sustainable society, maintenance is essential. However, it is difficult to judge appropriate time of repair or strengthening because quantitative evaluation method of deterioration degree has not been established. Therefore, quantitative evaluation methods based on deterioration mechanism are required.
For example, it has been already confirmed that fluorescence in Raman spectrum of organic coating materials increase as deterioration propagation. And it was also confirmed by IR spectroscopy and quantum chemical calculation that this increase of fluorescence was caused by cutting off of ester bond due to deterioration. The results shows the possibility of quantitative evaluation of deterioration of organic coating materials by fluorescence intensity. In order to make fluorescence intensity quantitative index, normalization with photo breaching curve is suggested in our study. Fig.2 shows change of photo breaching curve of an organic coating material due to deterioration propagation.

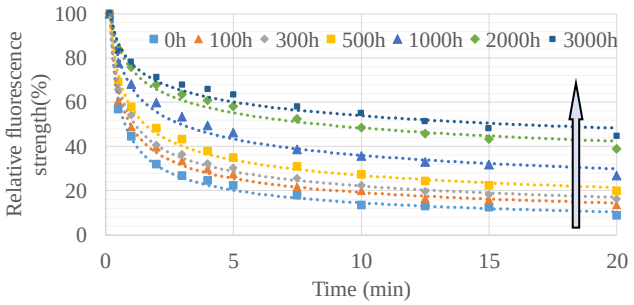


Fig.2 Change of photo breaching curve of an organic coating material due to deterioration propagation

Durability and Scenario Design

Performance-based design approach concerns with the failure probabilities of the structures and/or members in the limited states related to various required performances under the specified loading and/or environmental conditions. Under this topic, various investigations on the concrete structures in the ultimate limited state, serviceability limited state, fatigue limited state and durability limited state are being carried out in order to establish a more advanced and precious design methodology. Fig.3 shows the flexural loading test and FE analysis result of reinforced concrete (RC) beam with the corroded reinforcements.

Fig.3 Flexural loading test and FE analysis result of RC beam with the corroded reinforcements

STRUCTURAL MECHANICS

Professor	Assistant Professor	Assistant Professor
Yasuo KITANE	**Risa MATSUMOTO**	**Akihiko SATO**

Explore “the MECHANICS” and Bridge “the WORLD”

The keywords for this laboratory are "Earth and Human" looking for developing "beautiful", "rich", "pleasant", "safe", "wholesome" and "energetic" societies. The laboratory pursues Structural Mechanics as related to structural design and analysis of Steel/Composite Structures on the short-, middle- and long-term viewpoints flexibly following the socio-cultural developments leading to the heritage of cultural, social and environmental assets under the general philosophy of sustainable development.

Application of Advanced High Performance Materials to Bridge Structures

Due to the developments of high performance structural materials, it becomes possible to design various forms in structures. In order to achieve such a creative design, specific functions such as a simple and easy-to-manufacture assembling, cost-effectiveness, large load-carrying capacity, high stiffness, high durability are considered in the design of structural elements. Furthermore, various advancements of Steel and Concrete including FRP (Fiber Reinforced Polymers) also have been contributed to the rationalization of structures resulted as Hybrid Structures which satisfy the various demands.

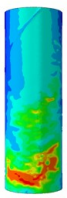
Research focuses on the load carrying and degrading mechanism, the performance evaluation, the rational and life-cycle design of steel, steel-concrete composite and FRP bridges. Fundamental characteristics of these structures are evaluated by advanced loading tests and versatile numerical simulations. In addition, their rational design method, repairing and retrofitting method for aging structures are also developed.

New type of steel pier with steel pipes

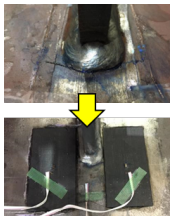
FRP pedestrian bridge

Remaining Load Carrying Capacity of Steel Structures and Repair Methods

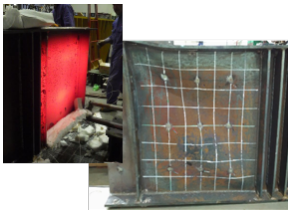
Steel structures will deteriorate over their service lives, and most frequent damages are corrosion and fatigue. Therefore, it is important to evaluate remaining load carrying capacity of steel structures based on periodical inspection results. Also, the evaluation of remaining load carrying capacity is needed when steel structures experience accidental events such as earthquakes and fires. Experimental and numerical studies have been conducted on remaining load carrying of corrosion-damaged, fatigue damaged and fire-damaged steel structures. Furthermore, suitable repair design methods such as steel plate patch repair and CFRP bonded repair have been proposed.



Bending analysis of corroded pipe



Evaluation of remaining fatigue life after CFRP bonded repair

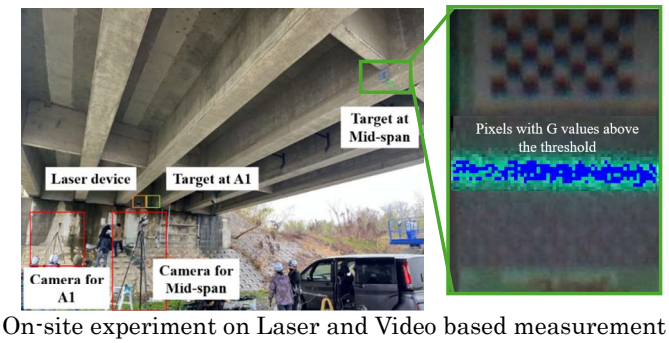


Heated steel girder after shear test

Nondestructive Evaluation of Structural Integrity and Lifetime Assessment

The maintenance technology of the infrastructures is recognized as an urgent issue as many infrastructures built for the rapid economic growth period have been aged, and various damages have been reported. Particularly, as for steel structures, the deterioration causes are corrosion, and fatigue. The development should be made to solve the important problem for sustainability of infrastructure.

In this laboratory, we conduct research using numerical analysis and experiments, focusing on how the mechanical response of structures changes due to deterioration and damage. Our goal is to establish a method for evaluating the remaining performance of structures based on their mechanical responses. To achieve this, we develop efficient methods for measuring structural responses, such as displacement and strain. Additionally, we investigate the applicability of these methods to bridge health monitoring (BHM) in real-world structures.



On-site experiment on Laser and Video based measurement

Bridge Engineering

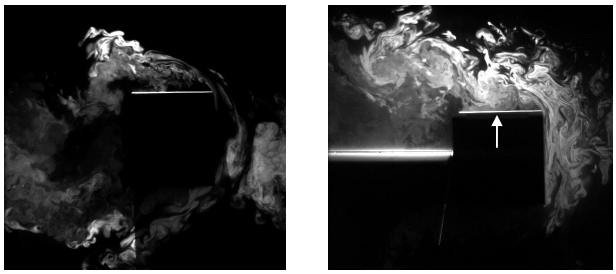
Professor	Associate Professor	Assistant Professor
Tomomi Yagi	**Hisato Matsumiya**	**Kyohei Noguchi**

Bridge Aerodynamics - Mechanics of Structure and Wind -

Under the theme of wind resistance of the structures, the mechanisms of wind-induced vibrations of bridge decks and cable structures, and their countermeasures are investigated using wind tunnel tests and/or Computational Fluid Dynamics (CFD). Also, the research areas which cover both the wind engineering and structural engineering, such as the strong wind disaster prevention and scattering of particles including sea salt and snow and their adhesion to the structure, are conducted.

Bluff body aerodynamics

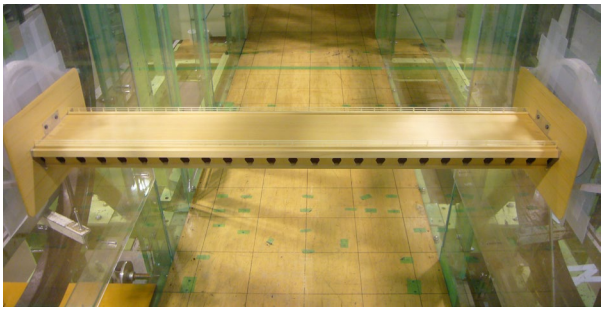
It is important to investigate the aerodynamics of fundamental cross sections such as circular and rectangular cylinders for advancing researches in the aerodynamics of actual bridges. The interactions between the vortex shedding and motion-induced forces are a very complex problem due to their unsteady properties, but they may have vital roles to control the critical wind velocity of various kinds of instabilities.



Flow field around square cylinders

Wind-induced vibration of bridges

When a new bridge is desined and constructed, it is important to investigate aerodynamic stability of the bridge girder in advance. For example, it is well known that the Tacoma Narrows Bridge (USA) collapsed in 1940 because of the torsional vibration caused by the wind action. We conduct wind tunnel tests to investigate aerodynamic characteristics, vibration phenomena, and countermeasures to stabilize a bridge, by measuring wind force acting on the bridge and its response amplitude. Additionally, a bridge with a characteristic cross section, which has openings at the webs, is focused.



Bridge gider model for wind tunnel tests with side openings

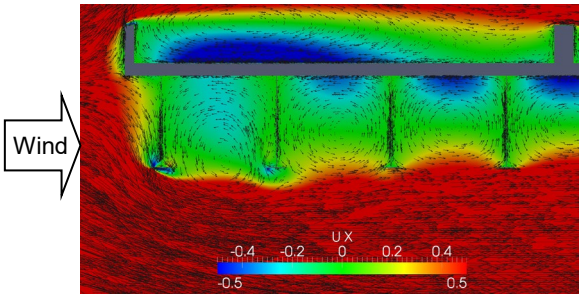
Wind-induced vibration of cable structures

It is well known that the bridge cables vibrate under wind and rain, which is called the rain-wind induced vibration. The generation mechanisms of this complicated phenomenon are considered as water rivulet on the cable surface, axial flow in the wake and so on. Also, a wind-induced vibration called galloping may appear for the transmission lines because of the accretion of snow. We investigate the mechanisms of wind-induced vibrations of cable structures, and develop their countermeasures and precise prediction method of response amplitudes.

Rain-wind induced vibration of a stay-cable

Scattering of particles and their adhesion to the structure

Airborne salt particles, such as sea salt and anti-freezing salt, are transported by wind and adhere to each member of a bridge, which results in deterioration of steel and concrete members. We seek to estimate the amount of salt adhering to bridge surfaces based on a flow field around the cross section of a bridge. In addition, to prevent traffic obstructions caused by falling snow, we experimentally and analytically examine the areas of structures where snow tends to accumulate and the adhesion efiiciency.



Air flow around the cross section of a bridge

Structural Dynamics

Professor
Yoshikazu Takahashi

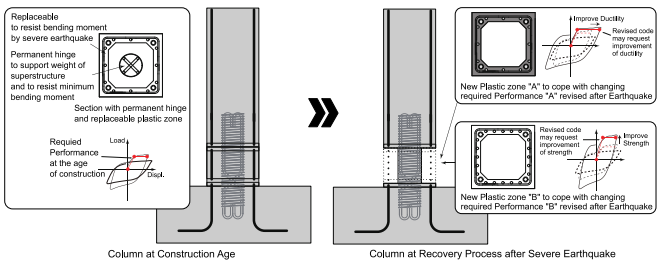
Assistant Professor
Keita Uemura

Earthquake Engineering and Structural Dynamics

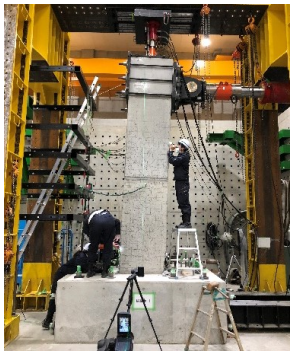
The basis of structural design is to support vertical forces (gravity), but in Japan, it is necessary to guarantee safety against horizontal forces (seismic forces). However, while gravity is a static and deterministic, seismic force is a dynamic and highly uncertain. Our laboratory dedicates research to improve the structural performance against major earthquakes focusing mainly on bridge structures.

Seismic Performance of Infrastructures

In the past, seismic design aimed at constructing structures to be safe during earthquakes. However, following the 1995 Kobe earthquake, Japan revised its approach to modern seismic design, now aiming to create structures that localize and limit damage, and prevent collapse during severe earthquakes. In other words, the structures are designed to fail in a predictable and controlled manner in the event of a severe earthquake. Hence, we are developing new seismic structures based on innovative concepts. These include minimizing the uncertainty of seismic response and developing 'metabolism' structures, which permit the replacement of seismic components while in service.
Since the 1995 Kobe Earthquake, isolation bearings made of laminated rubber have become widely used in bridge construction. However, instances of ruptured laminated rubber bearings were observed during the 2011 Tohoku Earthquake and the 2016 Kumamoto Earthquake. As isolation bearings often play a crucial role in current bridge seismic design, performance evaluation and the development of improved bridge bearing structures are ongoing.



"Metabolism structure" that can metabolize performance in response to social changes

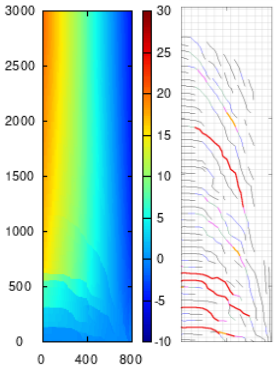


Loading test of a large RC column specimen

Loading test of full-scale seismic isolation bearing (φ1200mm)

Damage Prediction of Infrastructures

To accurately evaluate seismic response of concrete structures through numerical means, it is essential to correctly model propagation of cracks in concrete and deformation characteristics of the structure. We have developed a numerical program utilizing Extended Finite Element Method (X-FEM), capable of simulating discontinuities in structural deformations. This program is currently being used to simulate the seismic response and crack propagation in concrete structures.



Deformation (Unit: mm) Crack pattern

X-FEM analysis of RC Columns

Hybrid Simulation for Large Infrastructures

Experiments of the entire structure on a real scale is impractical to the large scale of infrastructures. Hybrid simulation is an effective method to understand the dynamic response of large-scale infrastructure. In hybrid simulation, loading tests are conducted on structural elements that are difficult to model, while numerical simulations are conducted on other parts simultaneously. We are developing a multi-scale hybrid seismic response system (OpenFresco) that enables hybrid simulations to be performed among geographically dispersed facilities. We are also evaluating the performance of velocity-dependent structural components using a hybrid simulation method (real-time hybrid simulation) while maintaining real-time operation. The hybrid simulation functionality developed by this laboratory are also implemented in E-isolation, Japan's first full-scale seismic isolation test facility constructed in 2023.

Implementation of hybrid simulation functionality in E-isolation

Int. Management of Civil Infrastructure

Associate Professor
Sunmin KIM

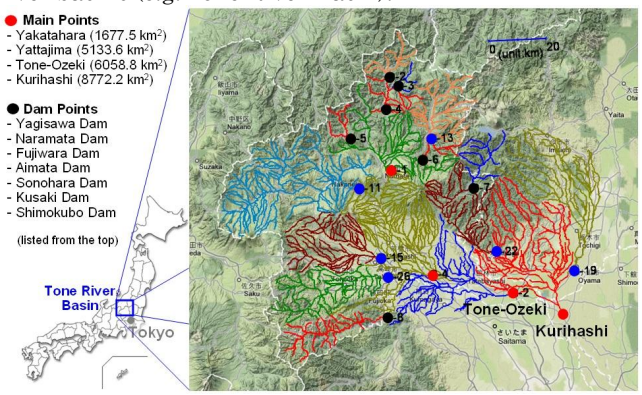
Associate Professor
Kai-Chun CHANG

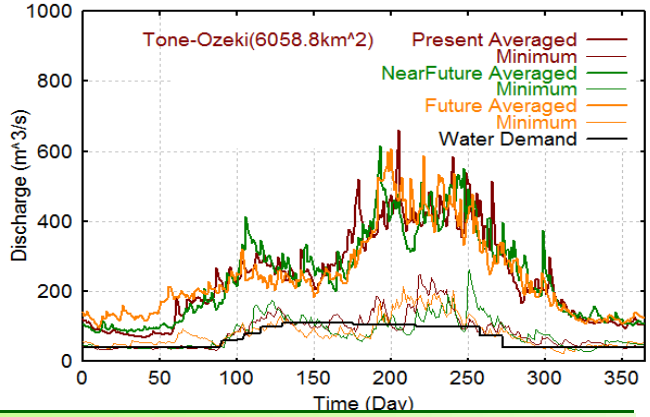
Climate Change Impact Analysis on Hydrologic System, And Health Monitoring of Bridge using Vehicle Vibrations

Researches in International Management of Civil Infrastructure Lab aim to answer questions related to designing and managing of civil infrastructure. The research topics in this interdisciplinary laboratory are composed of two subjects; climate change impact analysis on hydrologic system and health monitoring of bridge using traffic-induced vibrations.

Climate Change Impacts on Water Resources and Flood Risk

Based on Global Climate Model (GCM) output for the future climate projection, changes in heavy rainfall frequency and water resources conditions are analyzed to solve and prevent any water related problems in major river basins (e.g. Tone River Basin).



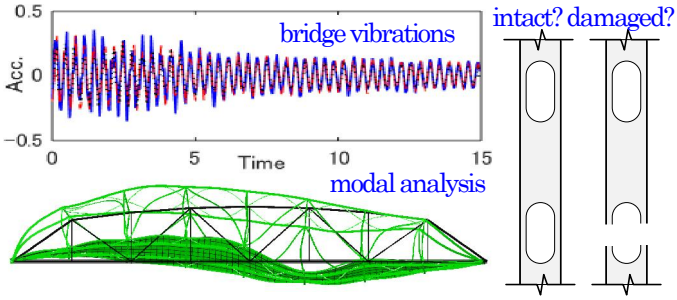


Realtime Flood Forecasting with Weather Radar Observation

Weather radar observation data is utilized into a distributed hydrologic model for a short-term rainfall forecasting as well as flood forecasting, and non-structural countermeasures are investigated to decrease the floods risk.

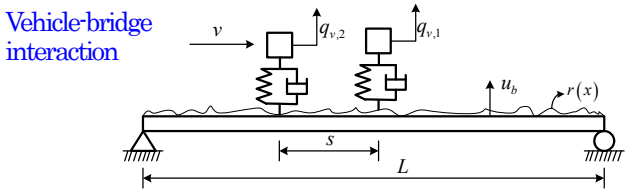
Bridge Modal Analysis & Damage Detection using Traffic-Induced Vibrations

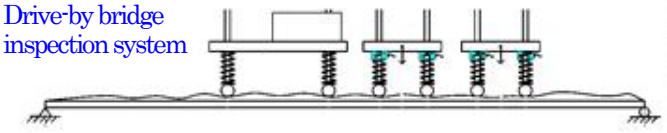
Bridge damage detection has become an important research and engineering issue in facing the pressing problems of aging bridges. Our study focuses on detecting potential damage in short- and medium-span bridges using their daily traffic induced vibrations. Effective indicators are extensively investigated, including modal parameters, time-series coefficients, spectral functions and their derivatives.



Vehicle-bridge Interaction & Its Applications

Vehicle-bridge interaction is the interaction behavior between a bridge structure and vehicles moving on the bridge, which is broadly considered in bridge engineering, seismic design, health monitoring, etc. Our study focuses on its mechanical interpretation and innovative application to bridge dynamic analysis, drive-by inspection, and more.





STRUCTURES MANAGEMENT ENGINEERING

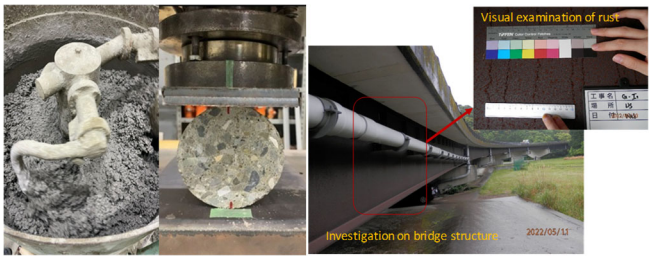
Professor (concurrent)
Yasuo KITANE

Development of New Structures Management

To achieve the sustainability of social life, it is indispensable that the performances and functions of the infrastructures are maintained well to obtain their service longevity and meanwhile the negative environmental impacts are mitigated as well. On top of the traditional construction materials such as steel and concrete, and effectively combining with advanced high performance materials, this laboratory works on developing rational design, durable service life, strategic maintenance and management under low negative environmental impact.

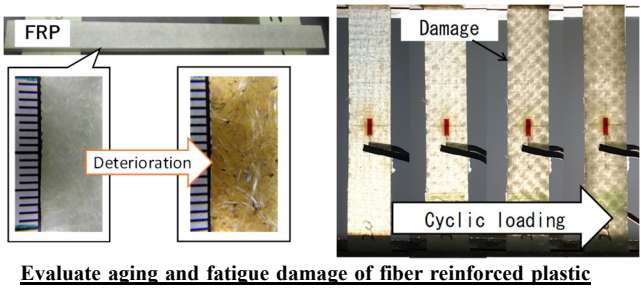
Mechanical behaviors, environmental impact and durability of structural materials

Mechanical behaviors, environmental impact and durability of high performance materials, recycled materials as well as traditional materials are investigated and evaluated.



Evaluate the performance of geopolymer concrete with low environmental impact

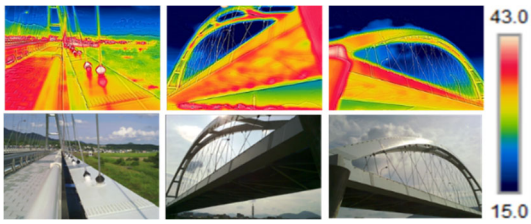
Examine the long-term performance of weathering steel



Evaluate aging and fatigue damage of fiber reinforced plastic (FRP) and reveal its effect on mechanical behavior

Inspection and deterioration prediction of existing infrastructures

Inspection methods for existing infrastructures to know their performances conditions and deterioration prediction system are developed.

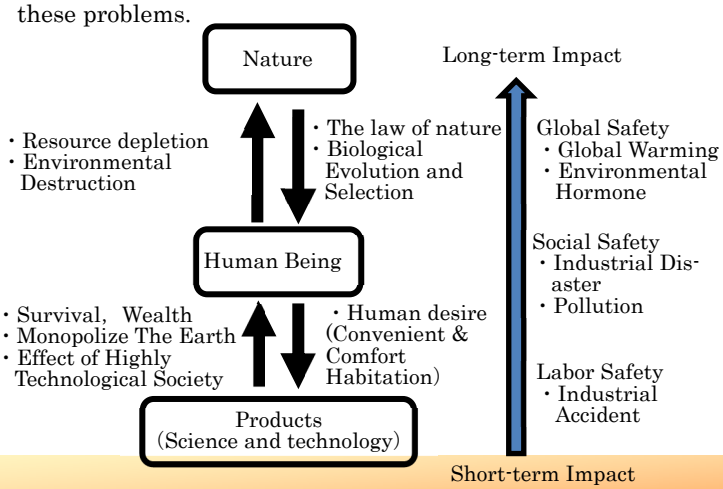


NDT technique for checking health condition of infrastructures by infrared camera

Check the health condition of the structure by vibration characteristics

Management of infrastructures and Forensic structural engineering

In order to maintain infrastructures efficiently, hardware related techniques and software oriented techniques should be effectively combined such as strategic maintenance. Additionally it is important to establish the scheme for engineers to investigate the causes of complicated technological disasters and the code of conduct to utilize advanced technologies. This laboratory works on to solve these problems.



Earthquake and Lifeline Engineering

Professor

Aiko FURUKAWA

Minimizing Earthquake-Induced Structural Damage

Our laboratory conducts research aimed at minimizing structural damage caused by earthquakes by integrating vibration monitoring, numerical simulations, and experimental investigations. Targeting a wide range of critical infrastructure—including lifeline systems, bridges, and historic structures—we work to identify dynamic characteristics and reproduce seismic responses in order to evaluate seismic safety and propose effective strategies for improving earthquake resistance. In addition, we investigate damage mechanisms of structures affected by earthquakes to clarify the causes of damage and support the development of mitigation measures. We are also developing structural health monitoring techniques based on vibration characteristics, with the goal of advancing practical technologies for structural maintenance and management.

Improving the Seismic Safety of Lifeline Infrastructure

Ensuring the resilience of lifeline infrastructure—such as roads, railways, water and sewage systems, gas, electricity, and telecommunications—is vital for maintaining public safety and societal continuity during earthquakes. Our laboratory is engaged in research to improve the seismic performance of these systems, focusing on advanced numerical simulations. We also evaluate the effectiveness of innovative structural solutions to support the development of earthquake-resilient infrastructures.

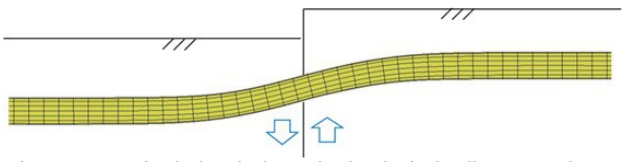


Fig.1: Numerical simulation of a buried pipeline crossing a fault

Protecting Historic Structures from Earthquakes

To protect historic structures and preserve them for future generations, we are developing advanced 3D numerical simulation methods to accurately simulate their seismic behavior and failure mechanisms. Our research aims to assess the earthquake resilience of heritage structures and clarify the causes of damage. While cultural heritage is typically restored to its original form after a disaster, doing so without addressing structural weaknesses risks repeated damage. We therefore explore seismic retrofitting strategies that strengthen these structures without compromising their historical and cultural value.

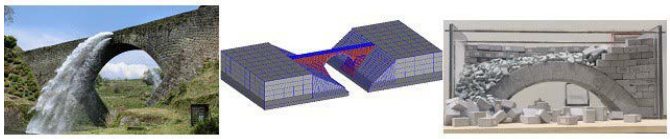


Fig. 2 : Stone arch bridge (Tsūjun Bridge), its numerical model, and example results from shaking table tests

Developing cable tension estimation methos based on vibration measurements

Cable-stayed bridges and other cable-supported structures rely on appropriate cable tension to safely bear loads. For maintenance purposes, it is essential to verify that each cable operates within its load-bearing capacity. Although the higher-order vibration method is commonly used to estimate tension from natural frequencies, it is not directly applicable to special cases such as cables equipped with dampers or intersecting cables found in Nielsen–Lohse bridges. To address this limitation, we are developing advanced tension estimation techniques tailored to these complex configurations, supporting the efficient maintenance of cable-supported bridges.

Fig.3: CG image of a cable-stayed bridge

Dynamics of Foundation Structures

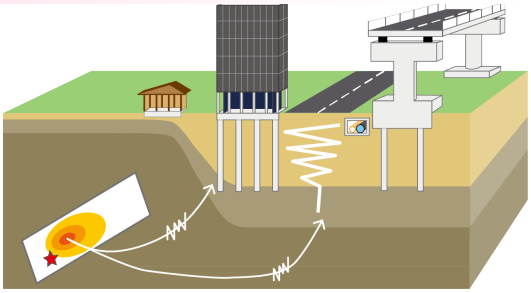
Professor

Hiroyuki GOTO

Pursuit of earthquake disaster science and development of next-generation technologies for earthquake disaster mitigation

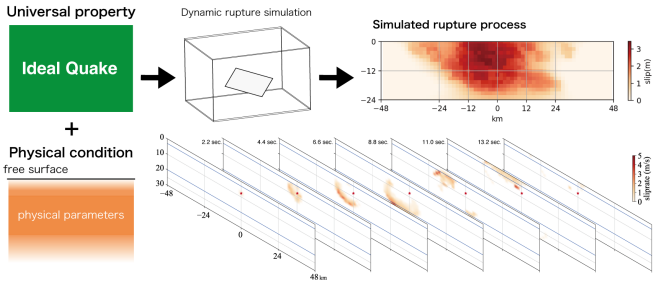
To mitigate the damage caused by earthquake disasters, it is necessary to understand the mechanisms of earthquake disasters and to take rational countermeasures by utilizing state-of-the-art technologies. In this laboratory, we are conducting fundamental research to pursue earthquake disaster science and developing next-generation technologies for mitigating earthquake disasters.

Theoretical investigation of earthquake disaster mechanism

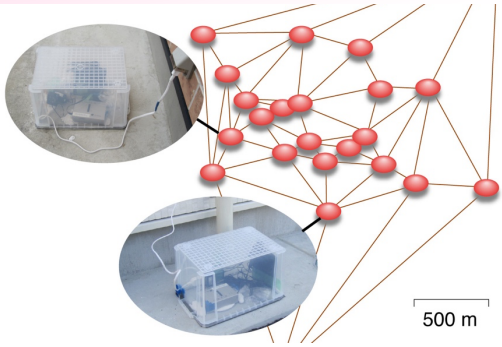


Disasters caused by earthquakes can result in many events at the same time, such as direct human casualties due to collapsed structures; disruption of emergency responses and supply chains due to damage to roads, railways, ports, etc.; difficulty in maintaining a sustainable lifestyle due to damage to lifelines such as water, electricity, and gas in wide areas; and stagnation of economic activities in society. To understand the mechanisms of these events, it is necessary to fully understand the nature of ground shaking that struck the city and the structures and facilities that were affected and to understand whether the conditions of the structures, facilities, and towns were what could have been anticipated.

Our laboratory studies the mechanisms of various events in seismic disasters. Our research covers a wide range of topics from the mechanism of earthquake occurrence, which is the subject of seismology, to the destructive behavior of various types of structures and facilities and is characterized by cross-disciplinary research based on knowledge from a wide range of fields including seismology, applied mechanics, geomechanics, and structural mechanics.

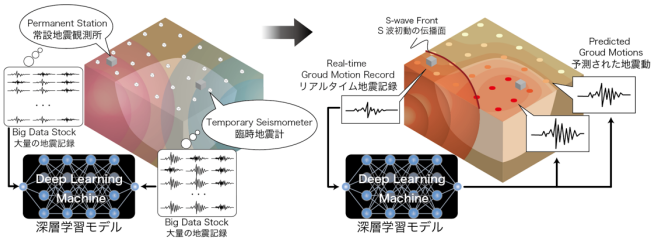


Next-generation technologies for earthquake disaster mitigation



New technologies such as machine learning (AI) and advanced sensing technologies have emerged in modern society and are being used in various aspects of daily life. We are researching and developing next-generation technologies to apply these technologies to mitigate earthquake disasters and create new ways of resisting earthquakes in cities.

In our field of earthquake engineering, we deal with a large amount of time-series data that changes along a time axis, such as data recorded of earthquake ground motions, experimental data of earthquake-induced damages, and monitoring data from normal time to the time of the earthquake. We are required to extract important information from a large amount of data, create appropriate models, and deploy the models for various applications, but are we able to extract all the information from the data sufficiently? In our laboratory, we are studying the problem of forecasting time-series data in earthquake engineering using deep learning methods.



Urban Flood Control

Professor
Akira IGARASHI

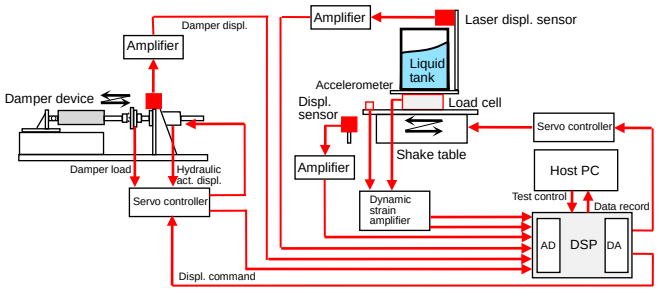
Associate Professor
Nozomu YONEYAMA

Mitigation of Compound / Secondary Urban Disasters Associated with Flood, Earthquake and Tsunami

Urban areas developed in basal zones along the coasts and on the river basin are incessantly exposed to natural hazards. Various compound and secondary disaster can take place in a scale which has not been experienced in the past, if earthquakes, tsunami and flood successively hit an urban area with such a feature. Toward the aim of establishing engineering solutions for mitigation of various disasters in urban areas, the research topics include the analysis, experimental evaluation of dynamic phenomena of coupled systems consisting of structures, fluids or the combination of those, as well as design/assessment/maintenance of infrastructures.

Experimental Validation of Coupled Systems using Real-Time Hybrid Simulation

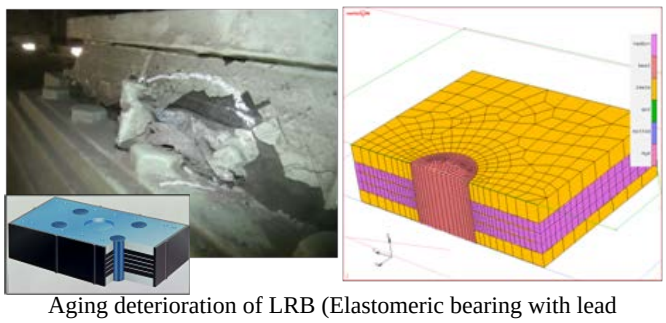
Implementation of advanced experimental systems based on the real-time hybrid simulation is investigated. In this unified testing-computing dynamic simulation, response calculation of the numerical substructure with computers and dynamic loading test of elements using shake tables or dynamic actuators, are synchronously executed on a real-time basis, allowing reliable validation of complicated coupled systems consisting of fluid, structures and mechanical devices.



Hybrid simulation of fluid-structure-device system

Aging Deterioration & Maintenance Measures for Elastomeric Bearings

In infrastructures served for long periods, deterioration of components and facilities due to aging, countermeasures and maintenance issues are of great concern. Aging effect on elastomeric bearings for bridges are investigated by experimental and numerical approach.



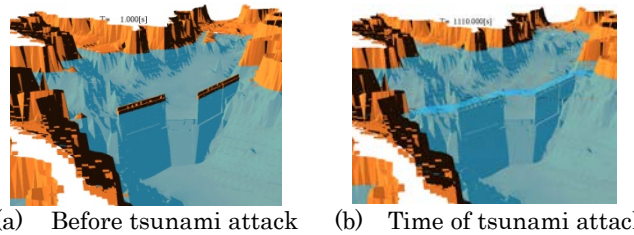
Aging deterioration of LRB (Elastomeric bearing with lead plugs) and numerical analysis

Research Related to the Damage Caused by Large Tsunami Events

Since the 2011 Tohoku Tsunami, forecasting and damage prediction of future tsunami events has become critical. Recently, tsunami inundation behavior, the effects of breakwaters on tsunami mitigation, and the forces of tsunami waves acting on bridges are all under investigation.

Effect of breakwaters on tsunami mitigation

A 3D numerical analysis was conducted to determine the mitigative effect for the 2011 Tohoku Tsunami event for locations along the coast of Kamaishi Bay due to the tsunami breakwater.

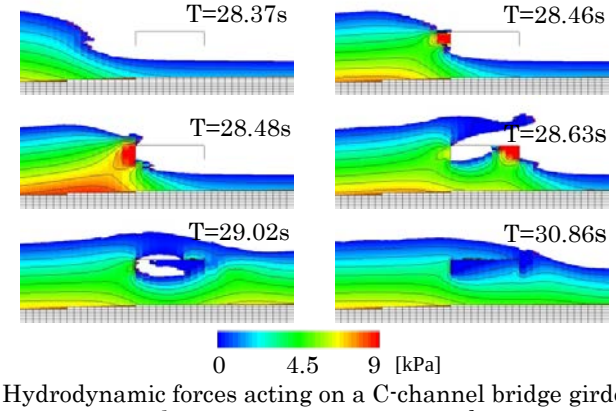


(a) Before tsunami attack (b) Time of tsunami attack

Simulation of tsunami attack in Kamaishi Bay

Assessment of tsunami wave forces acting on bridges

Bridges are important infrastructure, particularly following disasters so that transport operations can run smoothly to provide necessary assistance. Thus, we are investigating the strong tsunami wave forces acting on bridges to help provide guidelines for future construction.



Hydrodynamic forces acting on a C-channel bridge girder due to a tsunami wave attack

Environmental Hydrodynamics

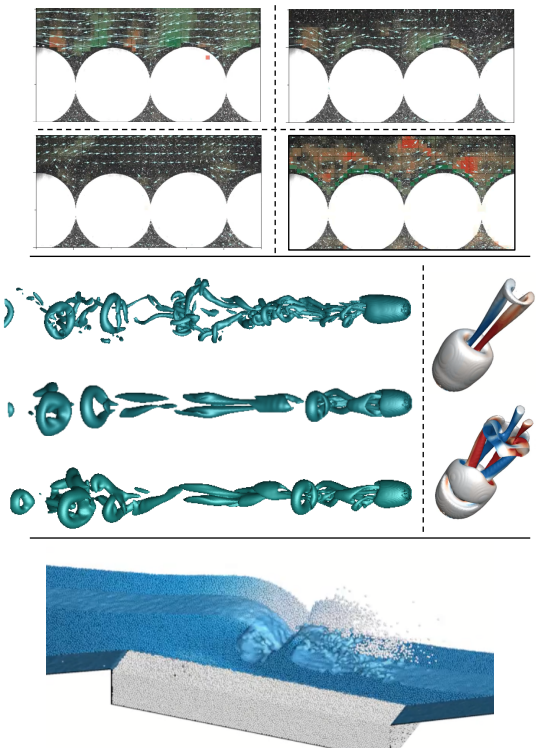
Professor	Associate Professor	Assistant Professor
Eiji Harada	**Shinichiro Onda**	**Takumi Tazaki**

Exploration of movable bed dynamics by computational sediment transport and multiphase turbulence measurements

To clarify sediment transport mechanisms, systems related to multiphase turbulent flows, sand particle motion, and the form of the movable bed boundary must be investigated. In our laboratory, research is being conducted to understand the flow mechanisms in a movable bed interface using both multiphase turbulence measurements and multiphase flow simulations using a granular material model. We are also developing basic research on crowd behavior using a granular material model based on particle-flow analogies. For the details, access to: http://particle.kuciv.kyoto-u.ac.jp/

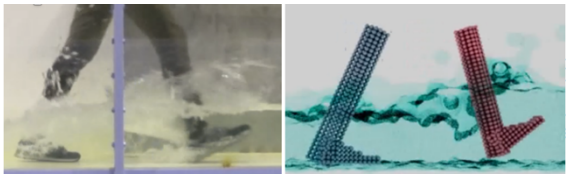
Sediment Hydraulics based on DEM-CFD computation and PIV measurement

Sand particles on river and coastal bottoms are strongly influenced by the surrounding flow field, and a solid-liquid multiphase turbulent flow field with changes in particle configuration and porosity is formed on the moving bed surface. In order to investigate the flow mechanism of movable beds from the particle scale, we are conducting numerical simulations using a granular material model to track the motion of individual sand particles and to evaluate the flow field from the same scale of the particle resolution. The following figures show examples of the results: [upper] Turbulence measurement on bed surface using PIV, [middle] highly resolved simulation of vortex shedding from sphere in uniform flow, [lower] simulation for sediment transport in surf zone by DEM-MPS.



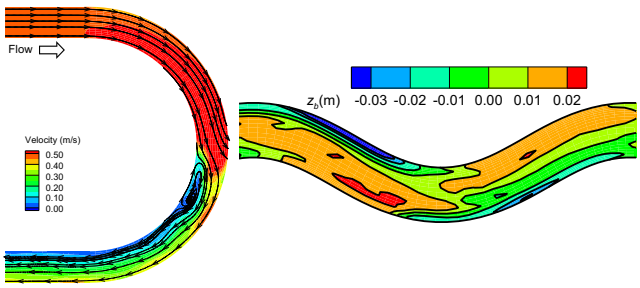
Computational Science of Crowd Behavior by DEM-CFD

To predict the evacuation processes in flooded areas, it is important to assess the hydrodynamic forces acting on evacuees in the water flow. The figure below shows [left] an image of an underwater walking experiment and [right] an example of coupling between a walking model considering a below-knee posture and fluid calculation using the particle method.



Development of Numerical Model for Flows and Bed Deformation in Rivers

Considering flood control planning in rivers, it is of great importance to predict water levels during floods, scouring depths around river bends and hydraulic structures, and design stable river channels. We are studying about development and improvement of numerical model for flows and bed deformation and their practical application to understand the phenomena of flows and morphological changes in rivers. The left figure shows the streamlines of lateral overtopping flows in a curved channel, and the right figure represents the morphological changes in a meandering channel.



Hydrology and Water Resources Research

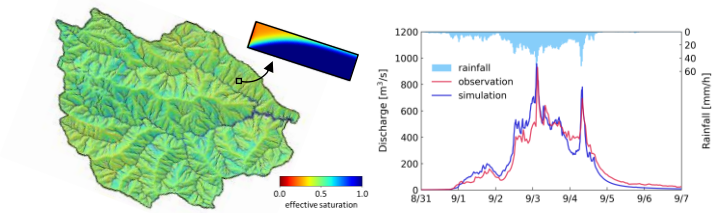
Professor	Assistant Professor	Assistant Professor
Yasuto TACHIKAWA	**Aulia TINUMBANG**	**Sora FUGAMI**

Towards a better relationship between human society and water resources

We study physical mechanisms of the hydrologic cycle with energy and material transport. The research topics include analysis and numerical modeling of hydrological processes such as surface-subsurface flow, atmosphere-land surface interaction with human activities. Based on the understanding of the physical process in hydrology, we develop fundamental technologies for river planning, water resources management, real-time hydrologic forecasting and water-related disaster mitigation.

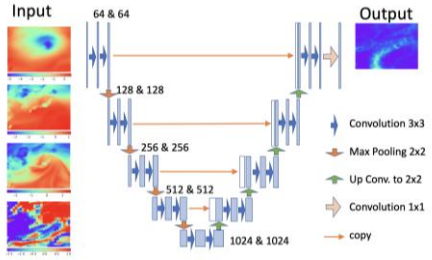
Physically-based Modeling of Rainfall-runoff Processes

In mountainous areas, rainwater flows through the soil and over the ground surface, then flows into rivers. We develop a numerical model that physically and precisely analyzes the rainfall-runoff processes with practical computational efficiency. The figures show the simulated soil moisture conditions within a slope and the overall moisture distribution in the catchment formed by a collection of slopes (left), and a comparison of observed and simulated river discharge (right). By using physically-based modeling of hillslope rainfall-runoff processes, the model accurately reproduces runoff during floods.



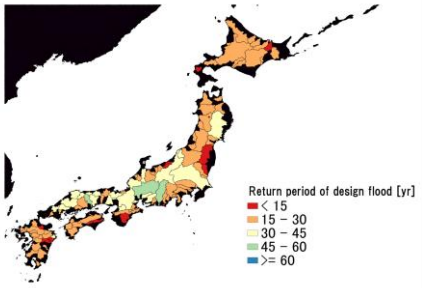
Downscaling of Precipitation Data with Machine Learning Algorithms

Downscaling is crucial for enhancing the regional resolution of general circulation models (GCMs), which are widely used for climate change assessments but often lack the necessary detail for localized analysis. Recent advances in machine learning, particularly deep learning techniques such as convolutional neural networks (CNNs), have shown promise in improving downscaling accuracy and efficiency. Specifically, the U-Net algorithm shown in the figure has been employed to bridge the gap between low-resolution GCM outputs and high-resolution regional predictions, offering a powerful tool for improving downscaled precipitation forecasts.



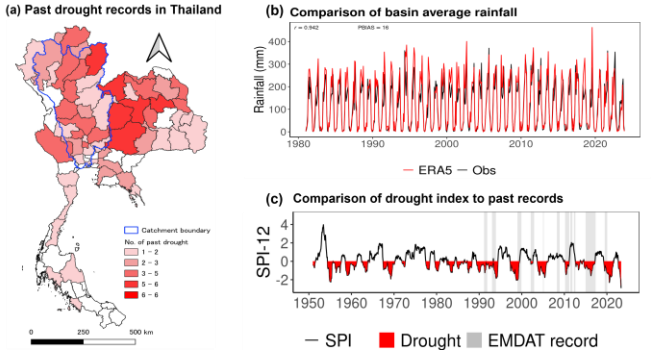
Climate Change Impacts on Floods and Water Resources

Climate change will give us a serious impact on our life. We develop a method to make climate change impact assessments on catchment-scale floods and water resources with global climate model outputs. We construct a nation-scale catchment hydrological model over 109 class-A river basins and analyze the future change of river discharges. The right panel shows the projected return periods of the design flood in 4K warmer climate conditions. It has been found that river flows that occur once every 100 or 200 years, which is the current goal of river maintenance, may occur in less than 50 years by the end of this century.



Drought Mechanisms and the Impacts of Climate Change on Droughts

Droughts frequently occur worldwide, yet they are challenging to predict. This research employs disaster, atmospheric reanalysis, and climate output datasets to elucidate drought mechanisms, identify the critical thresholds that disrupt socio-economic activities, and predict how drought risks change in the future. Below is a case study of a drought assessment in Thailand, employing the EMDAT disaster database and the ERA5 reanalysis dataset.



Urban Coast Design

Professor	Associate Professor	Assistant Professor
Hitoshi Gotoh	**Hiroyuki Ikari**	**Yuma Shimizu**

Simulation engineering by Lagrangian particle method

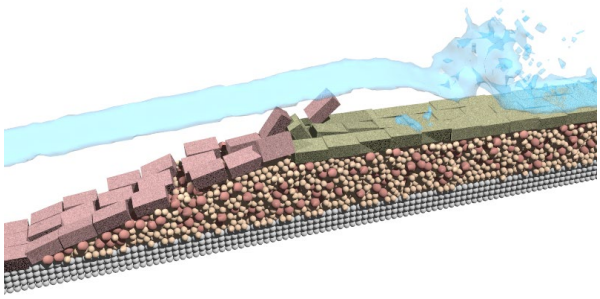
A leading technology in computational science of fluid flow (solid-gas-liquid multiphase flow) by using particle method is developed for dynamics of violent flow. We aim for establishment of the methodology of computational science and engineering, to describe various phenomena in civil engineering by fluid/granular-material analogy. For the details, access to: http://particle.kuciv.kyoto-u.ac.jp/

Particle Method for Computational Dynamics of Free-Surface Flows

In a particle method, or Lagrangian meshfree method, particles as calculating points are moved by interaction between neighboring particles. It enables to track a complicated surface change including fragmentation and coalescence of fluid, which is difficult to simulate in an Eulerian method using a computational grid. We conduct a research on both of a fundamental theory and a practical application of particle method for violent flows in coastal surf zone and mountain streams.

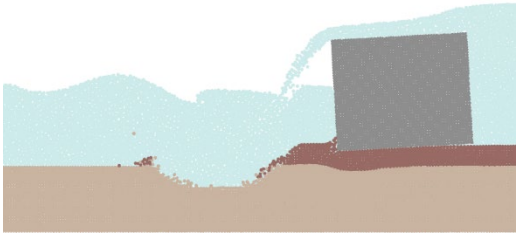
In our laboratory, a numerical wave flume based on a particle method has been developed to estimate a wave force or wave overtopping discharge for design of coastal structure. Development of 3D simulation tool using parallel computing (PC-Cluster and GPU) and fluid-elastoplastic hybrid analysis has also been conducted. Below figures show a plunging breaking wave and failure of a submerged breakwater due to a high wave.

Our laboratory proposed some accurate particle methods (CISPH-HS, CMPS-HS etc.) to improve drawbacks of particle method such as incompleteness of momentum conservation and pressure fluctuation. The accurate methods are known widely in CFD research field and some of our papers are ranked in highly cited papers lists of ISI journals.



Development of numerical tool for design of coastal structures

Recent years, it is predicted that a huge scale of wave or tsunami will act on coastal structures. Under the action by them, a failure or a large deformation of structures or foundation can occur with high possibility. Therefore, in a design of structures, the action numerical model of both solid-liquid two-phase flow and granular assembly has been developed. The numerical simulation for sediment transport under various flow conditions has been performed.



Crowd Behavior by Particle-Based Multi-Agent Simulation Model

Multi-agent simulation with directly handling personal behavior has been developed by using the Distinct Element Method. Evacuation simulation against Tsunami is promising tool in establishing evacuation planning. Moreover, the crowd behavior simulation in the urban pedestrian space is expected to contribute advanced urban design. Below is the computational example for the pedestrian behavior in case of the construction of a wide pavement in the Shijo St., Kyoto.

River System Engineering and Management

Professor

Yutaka ICHIKAWA

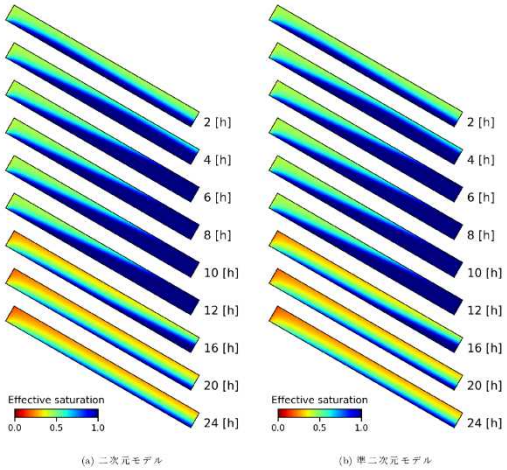
Towards Building a Sustainable Society

To address the multifaceted challenges present in watersheds and urban areas, a comprehensive approach involving analysis of the current state and environmental change factors is required. This includes understanding the intricate interplay between societal/economic activities and natural environment. Our laboratory delves into the foundational analysis and modeling of hydrodynamics within river basins. We aim not only to prevent and mitigate water-related issues but also to explore the management strategies for river basins, with a focus on achieving practical solutions, in order to contribute to fostering a balanced coexistence between human society and nature.

Developing a Physically Based Runoff Model and its Application to River Basins

Most of urbanized areas are in relatively flat regions in lower reaches in river basins of Japan. Therefore, predicting rainfall-runoff from upstream mountainous areas is crucial for urban flood mitigation. Rainfall-runoff processes are influenced by many factors such as terrain, geology, and soil characteristics. We develop a mathematical model that considers these factors in detail and utilize its computational results for capturing the essence of rainfall runoff processes to develop a concise model applicable at the watershed scale.

The lower left figure depicts effective saturation of a surface soil layer in mountainous areas simulated by the detailed two-dimensional model. The lower right figure shows effective saturation simulated by the simplified model (a quasi-two-dimensional model), which was derived from analyzing the results of the detailed model. Both calculations yield highly similar results.



Analysis and Modeling of Watershed Hydrodynamics Using Environmental Tracers

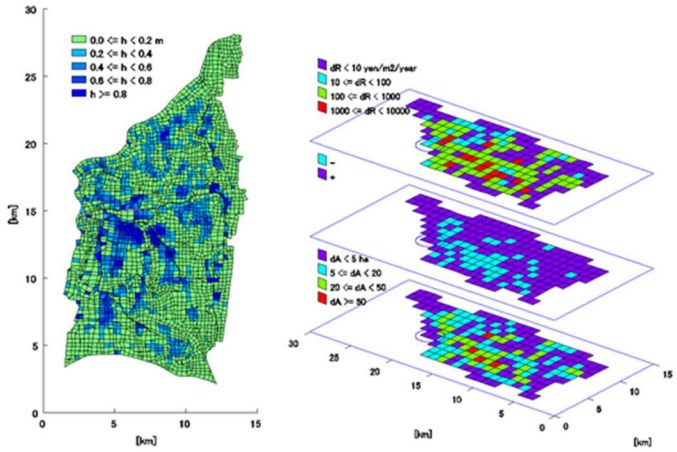
Rainwater flows through a variety of pathways in a basin. In this study, we aim to analyze the path and time it takes for rainwater to flow out of a watershed using substances present in water as tracers. Based on these results, we attempt to model the movement of water within the watershed more accurately and reliably.

Exploring Effective Management Strategies for Rivers and Watersheds to Address Water-related Issues

Various water-related issues such as floods and droughts arise at the intersection of human society and the water cycle. To prevent and mitigate problems associated with water as much as possible while obtaining benefits, it is necessary for human society to coexist harmoniously with the water cycle.

For example, quantifying the flood risk in a watershed and making it publicly available in the form of hazard maps leads to actions by residents to avoid flood disasters. The figure in the lower left shows the estimated maximum flooding depth calculated through flood inundation modeling. Assessing such water disaster risks is an important research topic.

However, such regulations also come with negative effects. We aim to analyze the costs and benefits of these regulatory measures and explore appropriate strategies. The lower right figure shows simulated location of residential households and housing rent change under land use regulations. Based on such analysis, we assess the validity of land use regulations aimed at preventing and mitigating water-related disasters.



EROSION AND SEDIMENT RUNOFF CONTROL ENGINEERING

Professor	Associate Professor	Associate Professor
Kana Nakatani	**Kazuki Yamanoi**	**Shoki Takayama**

Understanding sediment transport mechanisms and preventing sediment disasters from mountains to coasts in fluvial systems, including volcanic watersheds

In a sediment transport system from mountainous area through river area to coastal area including volcanic watershed, disasters occur due to the various kinds of sediment transport phenomena. The phenomena and processes are important factor to produce safe sound sediment environment in river basin. To mitigate the disasters and to understand the dynamics of sediment transport and water in the sediment transport system, various field observations, hydraulic experiments, and development of simulation models and systems are carried out in our division.

Sediment Disaster Prevention

Landslides, debris flow, woody debris, and channel deformation cause sediment disasters. Recently, sedimentation and flood damage have become serious problem, in which sediment generated in mountainous areas moves downstream burying channels and causing damage. Sediment disaster prevention is one of the important social topics. Our laboratory researches on the generation mechanism, prediction techniques, upgrading hazard map with various field observations, hydraulic experiments, and development of simulation models and systems. Recently, numerical simulations are applied for detail hazard zoning and for considering effective countermeasures.

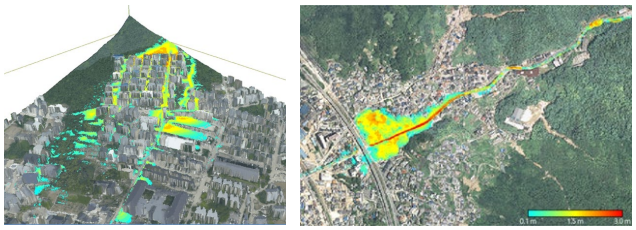


Fig. 1 : Debris flow simulation result(left) and sediment and flood damage simulation result (right).

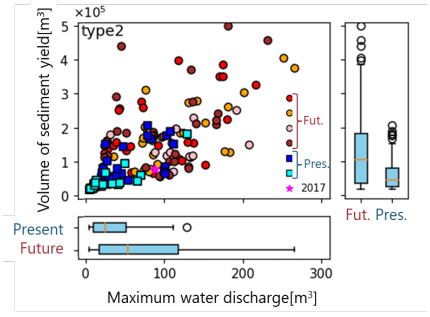


Fig. 2: Projection results of maximum water discharge and volume of sediment yields under rainfall events in present and future climate.

Sediment Runoff Processes in Sediment Transport System

Sediment is produced in mountainous areas and transported to coastal area through rivers. These processes are important factor to produce safe sound basin environment.

With field observations, hydraulic experiments and numerical analysis, we focus on sediment production mechanism and sediment transport processes.

Fig. 3 : Field experiment with hydrophone and other equipment to observe bed load in Hodaka Sedimentation Observatory

Sediment Disaster Mitigation in Volcanic Watersheds

Volcanic watersheds have the potential for diverse and large-scale sediment-related disasters. Volcanic eruptions can trigger not only pyroclastic flows and lava flows but also snowmelt-type volcanic mudflows, which are caused by rapidly melting accumulated snow. Additionally, when volcanic ash covers mountain slopes, it can hinder the rainfall infiltration into the ground, leading to an increased frequency of debris flows.

Based in the Hodaka Sedimentation Observatory near Mount Yake, an active volcano, we are advancing observational research on sediment dynamics in volcanic watersheds and developing prediction methods for volcanic mudflows and debris flows.

Hydroscience and Hydraulic Engineering

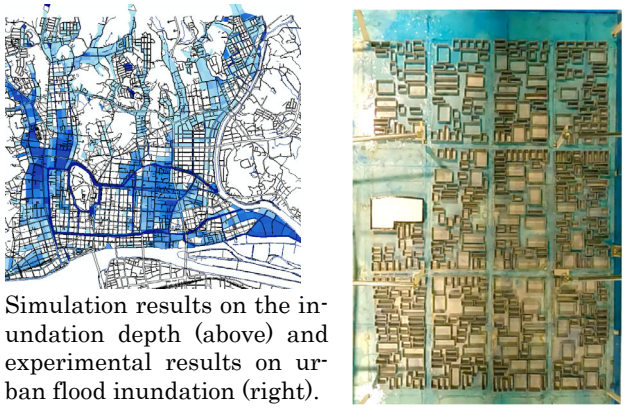
Professor	Associate Professor	Assistant Professor
Kenji KAWAIKE	**Hiroshi TAKEBAYASHI**	**Takahiro KOSHIBA**

Approach to hydraulic aspects of water-related disasters and water environment through hydraulic experiments, field observations and numerical simulations

For prevention of water-related disasters and entrainment of water environment, it is important to understand its hydraulic aspects. In our laboratory we approach to its hydraulic aspects through hydraulic experiments, field observations and numerical simulations. Our specific research is experiments using flumes of large-scale facilities in the Ujigawa Open Laboratory.

Mechanism and Mitigation Strategies of Flood and Sediment Disasters

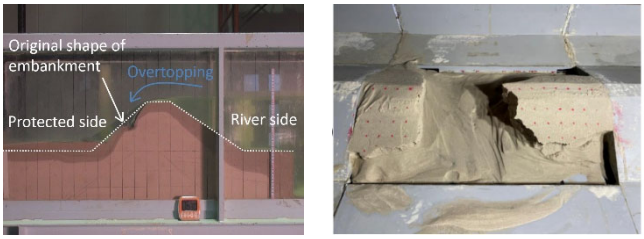
In our laboratory, aiming for prevention and mitigation of the damage of water and sediment related disasters under huge rainfall events, we have been trying to develop numerical models for prediction of inundation flow. Such numerical models would enable to understand where are the vulnerable parts to those disasters in a river basin area, to understand the inundation risk under the more intent rainfall conditions caused by the climate change, to evaluate the mitigation effects of planned facilities, and to obtain useful information to make an evacuation plan. In developing such numerical models, we always need to confirm that the model is appropriately reproducing the actual phenomena, the water depths, flow velocities, and sediment deposition heights are measured at physical experiments, and field measurement data such as water level marks are obtained to be compared with the numerical simulation results. In this way, we have been tried to develop more accurate numerical models to understand the physical phenomena.



Simulation results on the inundation depth (above) and experimental results on urban flood inundation (right).

Strength Evaluation and Maintenance Method of River Embankment

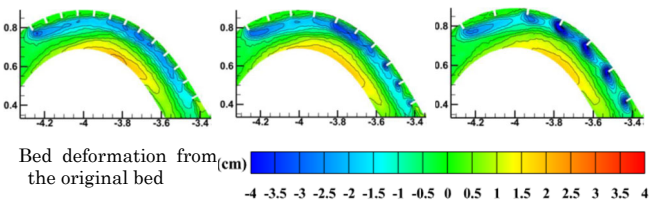
Recently, extreme floods frequently cause dyke breaches in rivers managed by central or local governments. As an urgent requirement, river dykes should be strengthened all over the country. We study the mechanisms of river dyke breach due to flood water overflow by carrying out model experiments. Based on obtained results, numerical simulations of dyke breach are tried to reproduce the experimental results. Furthermore, we also have been studying problem of landslide dam and its collapse, which may bring severe damage to downstream area, by the similar method as river dyke breach.



Experiments on the river dyke breach (left: one-dimensional flume in the cross-sectional direction, right: two-dimensional flood basin with river flow)

Nature-friendly River Design by Harmonizing with Ecology

River restoration projects have been tried in many places to create recreation spaces for local residents. As an example, 'groin' is installed perpendicular to the river dyke to form sand bar around it. But we should clarify its formation mechanism and sediment response to those groins. Therefore we have been carrying out flume experiments and numerical simulations, obtaining some knowledge of sand bar formation by means of groins.



Comparison of simulation results of bed deformation with different installation spaces of groins along a meandering channel
Twice of the groin length (left), four times of the groin length (middle), and six times of the groin length (right)

Hydrometeorological Disasters Engineering

Professor
Kosei YAMAGUCHI

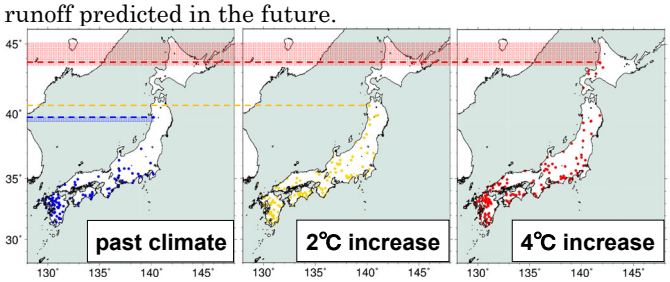
Assistant Professor
Yukari NAKA

Revealing the water behavior linking among atmosphere, geo-sphere and human-sphere toward heavy rainfall disaster prevention

Hydro-meteorological investigations and research on various scales of rainfall events from the localized heavy rainfall and the global climate change are being carried out focusing on the rainfall forecasting by remote sensing information, the global warming impact assessment. And we are challenging research on the human life style related with flood disasters and water utilizations.

Global climate change impact assessment

We analyze characteristics of the abnormal rainfall 30 and 100 years later by using of combination of global climate models (GCM) and regional climate model (RCM) and we try to assess its impact on the human society. For example, we evaluate the frequency variation of the torrential rain occurrence in each region, and we propose the adaptable rule of dam operation to the seasonal variation of rainfall runoff predicted in the future.



The location of heavy rainfall obtained from climate model simulation

Field observation to understand initiation and development of convective storm

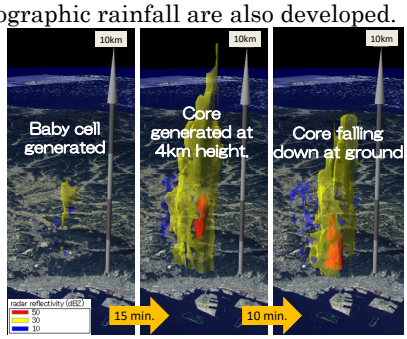
Multi-sensors observation toward the understanding of storm-genesis and its development is carried out at Keihanshin region and Okinawa. We have identified the structure of pairs of positive/negative vertical vortex tubes at the storm-genesis, and discovered a developing storm possesses a hierarchical structure of the vertical vortex tubes in a sense of spatial scale. In addition, the videosonde observation that measures precipitation particles is carried out to utilize particle information for heavy rainfall disaster prevention.

Multi-sensors observation at Keihanshin

Development of short period rainfall prediction method by RADAR information

The latest weather radar can detect raindrop size distribution and hydrometeor classification. New methods of quantitative precipitation estimation and forecast using the radar information based on in-situ campaign observation are being developed as fundamental researches. It is found that the baby cell of torrential localized downpour can be detected earlier in the upper atmosphere as applied researches. Data assimilation method of the radar and forecast method of orographic rainfall are also developed.

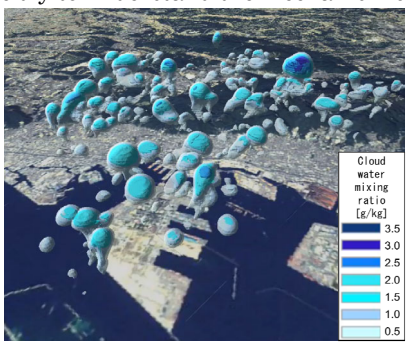
Flash flood at Toga river.



3D radar analysis generated at Rokko

Urban meteorological simulation based on LES for understanding convection genesis

Localized torrential rainfall disasters is caused by single or multi isolated cumulonimbus clouds that grow rapidly within one hour. A trigger of the generating baby-cell is concerned to be much affected by urban area, the heat-island effects. We try to understand the mechanism of the generation by developing our urban meteorological model based on Large Eddy Simulation (LES). We aim to improve the prediction accuracy and suggestion on what we should monitor in real time.



Simulated cumulous clouds over Kobe city

Coastal Disaster Prevention Engineering

Professor	Associate Professor	Associate Professor	Assistant Professor	Assistant Professor
Nobuhito MORI	**Tomoya SHIMURA**	**Yasuyuki BABA** (Shirahama Obs.)	**Takuya MIYASHITA**	**Yuki IMAI** (Shirahama Obs.)

Reduction of Coastal Disaster Risk

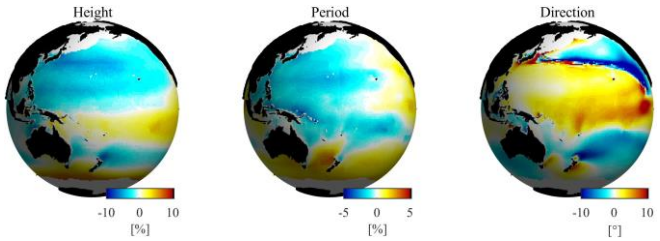
Modeling and Long-Term Assessment of Coastal Disaster Risk

Climate change will change extreme coastal hazard intensity and frequency, and integrated study of engineering and science is required for future projections, impact assessment and adaptation. On the other hand, the 2011 Tohoku Earthquake Tsunami gave catastrophic damages to the Northern part of Japan. We have developed the numerical models for simulating of tsunamis, storm surges and storm waves, and analyzed long-term impact of coastal disaster risk in a range of 100-1000 years extreme events.

Impacts of Climate Change on Coastal Disaster Risk

Impacts of climate change on coastal environment are not only changes of temperature and sea level rise but also changes in ocean wave climate and tropical cyclone activities as the results of changes in global atmospheric-ocean circulation. The changes of frequency and intensity of tropical cyclone give significant impacts on the Western North Pacific regions.

Our research of global climate change impacts on coastal environment is carried out for impact assessments, mitigation and adaptation strategies for future development of human society. Sea level rise and changes in ocean waves and storm surges due to global warming are projected for long-term assessment of coastal disaster risk reduction. We have contributed to the assessment reports of Intergovernmental Panel on Climate Change (IPCC) since the 5th report.

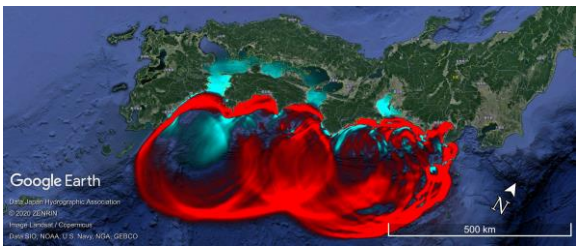


Future projected changes in ocean wave climate.

Assessment of Mega Earthquake Tsunami Hazard and Disaster Reduction

The 2011 Tohoku Earthquake tsunamis gave catastrophic damages to coastal areas in Japan. It is highly expected Nankai Trough Earthquake tsunamis would occur in the western part of Japan near future. However, it is difficult to predict intensity and location of next big one based on current scientific knowledge.

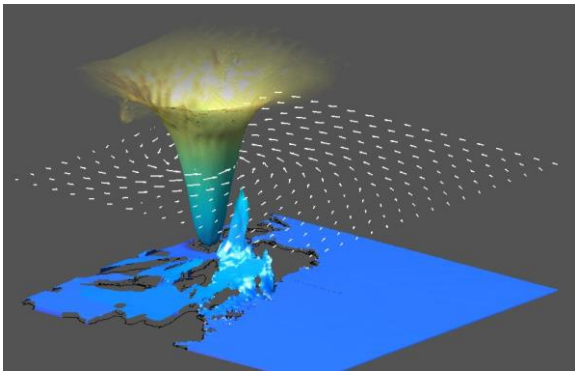
We have developed long-term assessment tools of megathrust earthquake tsunami, probabilistic tsunami hazard assessment model, and engineering technology for urban area inundation for tsunami disaster risk reduction based on the knowledge of the 2011 Tohoku Earthquake Tsunami.



Numerical modeling of Nankai Trough Earthquake Tsunami

Development of Numerical Models for Waves, Storm Surges, and Tsunamis

Numerical models for ocean waves, storm surges, and tsunamis have been developed especially targeting extreme severe conditions such as super typhoon and mega earthquake tsunami. Typhoon generates ocean currents and waves which give extreme wave forces on coastal defense structures. There are common governing equations and parametrization among three different phenomena. The detail processes of momentums and heat transfers from air to oceans has been incorporated into integrated model of typhoon-storm surge-wave for accurate estimation of coastal hazards.



Integrated model of typhoon-storm surge-wave for TC Haiyan.

Innovative Disaster Prevention Technology and Policy Research Laboratory

Professor **Takahiro SAYAMA**
Assoc. Professor **Tomohiro TANAKA**
Junior Assoc. Professor **Florence LAHOURNAT**
Assistant Professor **Eva YAMAMOTO**

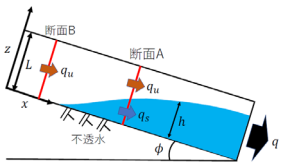
Technology and policy for mitigating disasters induced by extreme weather and socio-environmental changes

Climate change has been causing an increase in the severity and frequency of water-related disasters. Socio-environmental changes in turn affect disaster risks. In order to prevent and mitigate such disasters, it is indispensable to understand hazard mechanisms, improve the accuracy of monitoring and prediction, as well as develop new technology and policy measures, notably those linked to disaster risk reduction and crisis management. Our laboratory focuses on the following three areas: (1) fundamental research to understanding the phenomena and modeling of flooding, (2) technological development for predicting and forecasting water-related disasters, and (3) applied research into the evaluation and mitigation of water-related disaster risks considering social and climate changes.

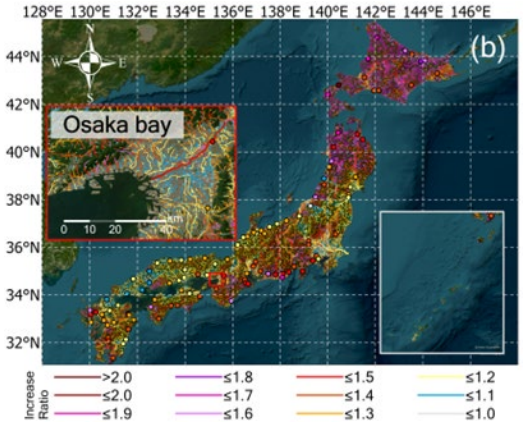
Mitigations of water-related disasters induced by extreme weather

We develop and apply the Rainfall-Runoff and Inundation (RRI) model that analyzes the rainfall runoff and inundation processes in an integrated manner. We are extending a 150-m Japan RRI model to small and medium river basins with new technologies. Its primary applications include real-time flood forecasting and the assessment of climate change impacts (the bottom figure). The model development is based on the studies of rainfall-runoff process (upper figures). We aim to elucidate, through field surveys and numerical analysis, when and through what pathways heavy rainfall on slopes flows out, and how the soil and geology of a watershed affect rainfall runoff.

Field survey in forest slopes



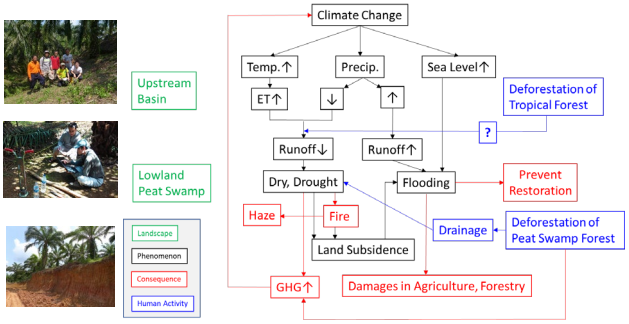
Modeling slope runoff processes



Future change of 100-year flood over Japan

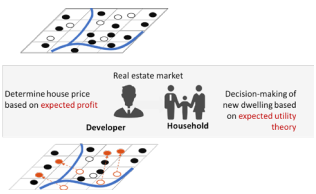
Social and climate changes and their impact assessments on water disasters

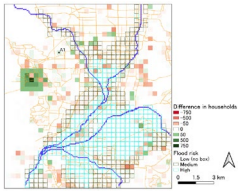
We analyze the social and environmental impacts on water disasters and new technology and policy for better water management. In Sumatra, Indonesia, we study the compound disasters of floods and fires in tropical peatlands.



Our water disaster research covers the social survey of disaster recovery processes from a cultural anthropology perspective and the flood damage/exposure assessment in a socioeconomic simulation approach.

Anthropogenic surveys in landslide areas in Brazil





Flood exposure population simulation in Kyoto

WATERFRONT AND MARINE GEOHAZARDS

Professor

Michio SANJOU

Complicated Dynamics toward Waterfront Geohazards Solution

The research efforts have been directed toward establishing an integrated framework by which to predict the complex behavior of fluid-sediment systems under dynamic environmental loading, with consideration of their inherently multi-scale nature. Measurement activities in the field is one of the shorter ways to obtain the data in situ, and the measured data also have significant value for understanding of the natural phenomena and verification of prediction systems.

Mass Transport Induced by Current and Wind

Wind significantly influences the acceleration and deceleration of river flow and contributes to the generation of wind waves in marine environments. These phenomena involve complex multiphase interactions between air and water. Additionally, the impact of wind cannot be ignored when predicting the distribution of driftwood, suspended sediment, and microplastics. However, research in this area remains in an early stage globally. In this study, we are conducting cutting-edge research using a rare wind tunnel-water channel system that allows simultaneous control of airflow and water flow (Fig. 1)

Sediment Transport in Vegetated Open-channel Turbulence

To simultaneously reduce flood risk in river systems and preserve diverse aquatic environments, it is essential to accurately evaluate the impact of in-channel vegetation on flow fields and sediment transport. As shown in Fig.2, detailed velocity measurements using Particle Image Velocimetry (PIV) are conducted in flume experiments.

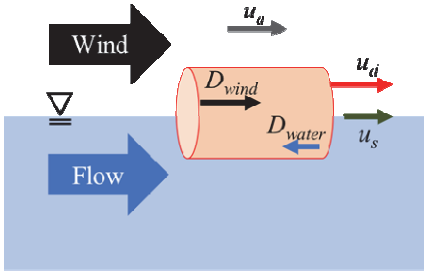


Fig. 1 Drag forces on floating material by current and wind

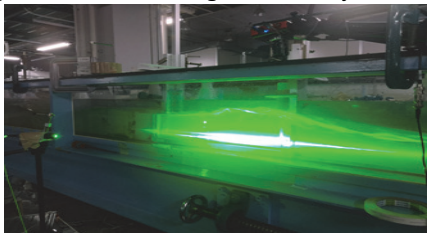


Fig. 2 Flow visualization by laser sheet

Gas Transport Promoted by Submerged Breakwater

Wave breaking induced by submerged breakwaters in coastal areas is believed to enhance the transport of atmospheric oxygen and carbon dioxide into the water. Furthermore, seagrass and seaweed bed formation can trap these gases in the ocean, contributing to CO2 reduction in the atmosphere. Specifically, we investigate the relationship between turbulence generation associated with wave breaking and the gas transport mechanisms beneath the water surface (Fig.3).

Sediment Dynamics in Coastal Zone

Japan's coastline has been chronically affected by coastal erosion (Fig.4). To protect sandy beaches, which are highly susceptible even to small waves and currents, it is crucial to accurately understand the mechanisms of coastal deformation and erosion. This study focuses on elucidating the physical mechanisms of these phenomena based on turbulence dynamics and evaluating the impact of coastal structures such as revetment blocks. Additionally, we utilize observational data from the Ogata Wave Observatory to explore practical field applications.

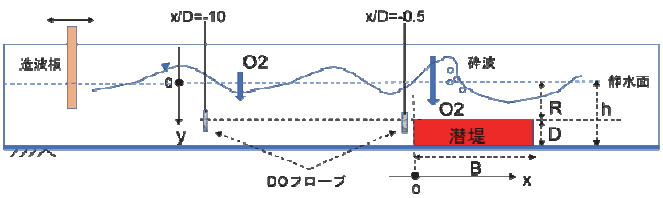


Fig. 3 Gas transfer by submerged breakwater

Fig. 4 Eroding Ogata coast(Joetsu city)

REGIONAL WATER ENVIRONMENT SYSTEMS

Professor **Kenji TANAKA**
Associate Professor **Kazuaki YOROZU**
PS Associate Professor **Yoshiya TOUGE**

Sustainable Water Resources Development and Management

Water is one of the most precious and unevenly distributed natural resources in the world. Human beings have adapted to changing natural hydrological systems and increasing water demand. Learning from past experiences, we develop the concept of integrated water resources management for promoting sustainable development under socioeconomic and climate change conditions.

Integrated Water Resources Management Model

The "integrated water resources management model" consists of a distributed hydrological model, land surface process (LSP) model, groundwater (GW) model, water quality (WQ) model, sediment transport model, food chain model, crop growth model, reservoir operation model, socioeconomic model, etc. is being developed. This model is an integrated model which describes not only natural hydrological systems but also artificial systems such as those capable of regulating floods and releases from reservoirs in order to satisfy the demand from each sector. The model structure is shown in the figure below. This model is expected to be applied to various kinds of topics, such as diagnosis of the reliability of the current water resources system, decision support for water resources planning, evaluation of risks related to floods, droughts and ecosystems under future climate change, and proposal to risk reduction and adaptation measures to the anticipated impact from climate change.

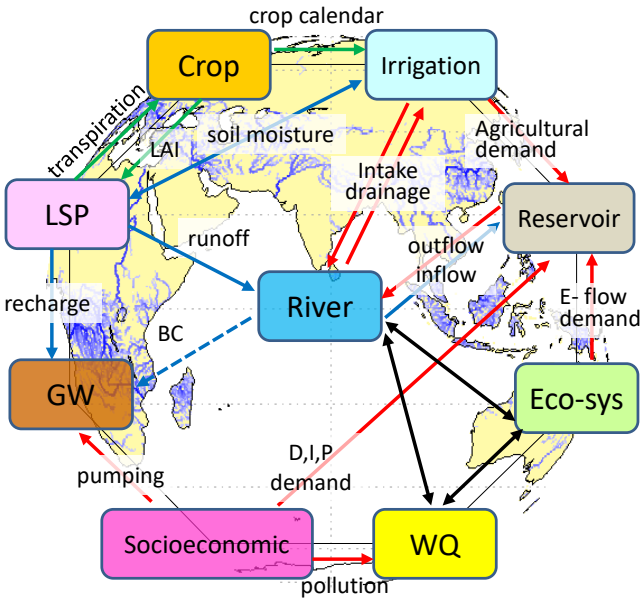
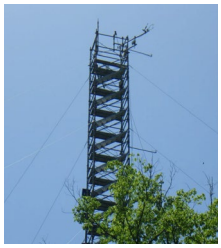


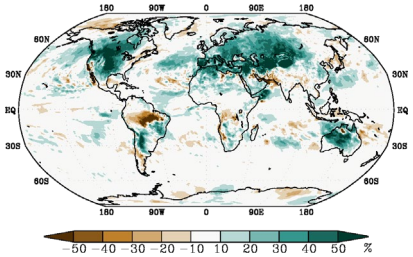
Figure: Structure of integrated water resources management model.

Understanding Hydrological Cycle on a Local to Global Scale

To create better water resource management, we conduct in-situ observations to understand the natural water cycle on land. The lower left photo shows our observation tower in the forest. At this site, water, heat, and mass transport such as precipitation, evapotranspiration, radiation, and carbon dioxide concentration are observed.
Also, we developed a numerical model that covers not only the natural water cycle but also the use of water resources by human activities. By using such a model, the impact of agricultural irrigation on summer precipitation on a global scale is estimated as shown in the lower right figure.



Observation tower.



Irrigation impact on summer rainfall.

Localized Dryness Research

- Wildfire and hydrology

Since moisture acts to suppress the spread of fires, wildfires are more likely to increase and become larger in dry conditions. In some regions, global warming is expected to exacerbate this damage. Since the moisture in forests is determined by the water cycle, we are working on proposing a hydrological approach.

Photo: Investigation of fire burned severity

- Endorheic lakes

Endorheic lakes are closed inland lakes that have no outflowing rivers, maintaining their area through the balance between inflow from rivers and evaporation from the lake surface. They are sensitive to climate change and human water usage within the basin. We are developing an endorheic lake model targeting the Aral Sea, based on an integrated water resources management model.

WATER RESOURCES ENGINEERING

Professor
Tomoharu HORI

Assistant Professor
Masafumi YAMADA

Interaction between Water Dynamics and Human Activities

The research is focused on analyses of interaction between global water dynamics and human activities seeking solutions for water resources issues. The current research topics include development of a global water dynamics model considering social economic activities and water resources management systems considering real-time hydro-meteorological information, and design of mitigation or response measures against water-related disasters.

Flood Evacuation Simulation Model Considering Detailed Field Information

There is a growing concern about catastrophic flood disasters, the scale of which exceeds the design level of mitigation systems, as a consequence of climate change. Emergency response by residents and communities is getting more important to prevent and to mitigate damage caused by large floods. There are also many regions where construction of large scale flood control facilities is difficult for geographical, economical or environmental reasons.

Considering the situation mentioned above, a computer model to simulate resident's evacuation is being developed. The system comprises mainly three parts: a mental decision process model, a moving model and a communication process model. The mental model treats resident's decision about action based on their attitude to the flood risk and obtained information. The moving model simulates people's action of traveling to evacuation centers, which is affected by inundation water dynamics. The communication model simulates information transmission from municipalities to residents and information interchange in the community.

Taking advantage of these simulation models, it comes to be possible to analyze how the social systems for flood disaster mitigation work in various situations.

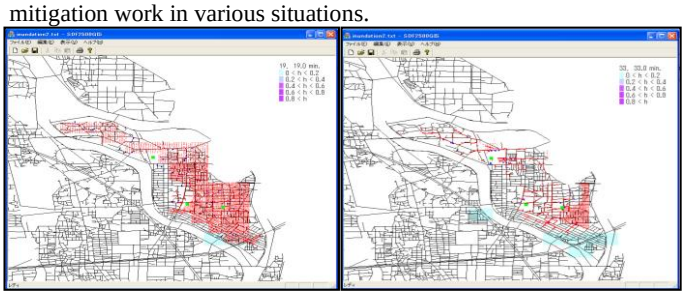


Fig. 1: Flood evacuation simulation with detailed road network

Numerical Crop Growth Model and Advanced Reservoir Operation for Irrigation

Food production requires the huge amount of water. It is important to know the detailed withdraw process of agricultural sectors and the impact of climate change. A numerical crop growth model is developed to estimate water demand for irrigation as well as crop yield according to various climate conditions and water management options. Optimum reservoir operation scheme is designed based on the daily water demand and distribution management processes.

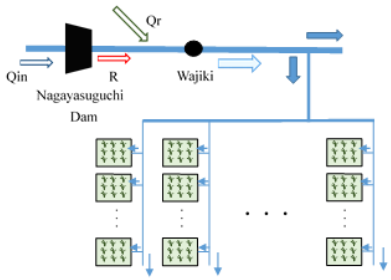


Fig. 2 Crop growth and optimum reservoir operation

Integrated Water Dynamics Model for Dual-Evaluation of Flood and Drought

One of the characteristics of recent heavy rainfall and flood disasters is that the damage is not confined to a single basin but extends over multiple basins and regions, and that flood damage occurs simultaneously from large rivers to small and medium-sized rivers. In order to cope with such wide-area disasters, it is important to construct a flood inundation model that comprehensively covers a wide-area river channel network as well. In addition, as the effects of climate change become more apparent in the future, it will be necessary to optimize watershed development strategies not only for flood control but also for water utilization. Therefore, we are promoting the development of an integrated water dynamics model that can simultaneously consider the benefits and risks of flood control and water utilization, covering the whole of Japan. We aim to improve the accuracy and reproducibility of the model by introducing all flood control infrastructure such as levees and sluice gates, and water utilization infrastructure such as irrigation dams and waterway networks.

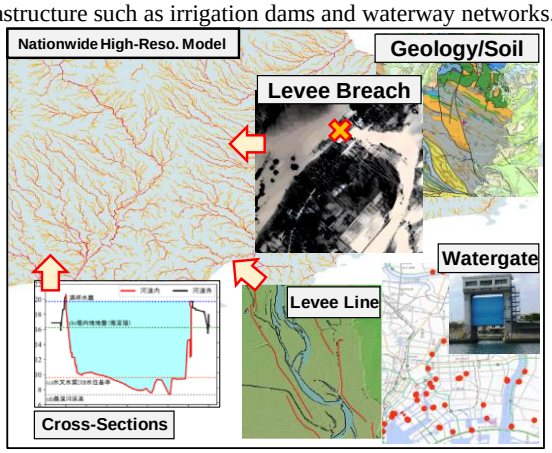


Fig. 3: Integrated Water Dynamics Model

Socio and Eco Environmental Risk Management

Professor
Sameh Ahmed KANTOUSH

Associate Professor
Sohei KOBAYASHI

Flood mitigation, water resources, and ecosystem conservation by proper dam operation and river management

With increasing risks of heavy rainfalls and droughts due to climate change in the future, our requirements for dam reservoirs for flood control and water utilization will increase. On the other hand, dam reservoirs can negatively impact water resources and river ecosystems in the long term. For a vibrant society by maximizing the function and potential of dam reservoirs and obtaining natural benefits, we 1) develop concepts and techniques of dam reservoirs such as updating operation rules, facility maintenance, and environmental conservation by sediment management, 2) explore ecosystem health in rivers such as habitat diversity and flow/sediment continuity, and processes of sediment transport, riverbed topography, and biodiversity, 3) Understanding issues and explore solutions on flood mitigation, water resources for agriculture, and environmental conservations in arid regions and delta regions of major rivers overseas.

Upgrading dam operation rules and developing sediment management techniques

Our study keys are dam redevelopment, adaptations of operation rules to climate change, and measures against reservoir sedimentation. By focusing on particular dams and river basins with specific river management issues, we 1) explore flexible reservoir operation to optimize dam function and capacity and 2) develop flow and sediment monitoring systems to mitigate sedimentation in reservoirs and ecosystem degradation downstream of dams. We also pursue 3) extension of dam life, performance, and sustainability through asset management.

Fig. 1 Flexible dam operation and sediment management

River management based on sediment -bedform-ecosystem link and flow continuity

In order to conserve and restore the ecosystem functions of rivers, it is essential to control sediment transport, maintain the formation of riverbed topography and biological habitats, and maintain river continuity. We propose 1) elucidation of sediment and riverbed conditions necessary to optimize ecosystem functions such as biodiversity and self-cleaning, 2) evaluation of river ecosystems health and exploring suitable indicators (landscape, topography, organisms), and 3) reevaluation and development of technologies that enable proper sediment transport and river continuity), such as traditional river engineering structures using natural materials.

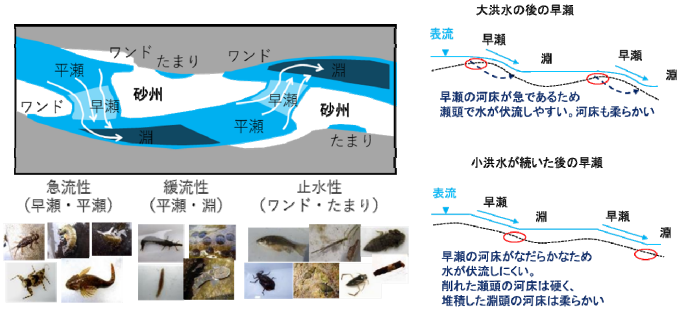


Fig. 2 Processes maintaining biodiversity in the river ecosystem

Dams, water resources, and sediment control in arid regions and large river deltas

International rivers always face water resource conflicts between countries and regions. In arid regions, both flood mitigation and water harvesting are required for sustainable societies. Dams are important, but their negative impacts on the ecosystem (sedimentation, reduced infiltration due to clogging, etc.) are also apparent. A Fertile delta region in the lower reaches of large rivers supports agriculture and river and coastal ecosystems. An intervention of water and sediment by dams in upstream countries significantly impact agriculture and fisheries by causing riverbank erosion, deterioration of the water cycle in floodplains, and saltwater intrusion.

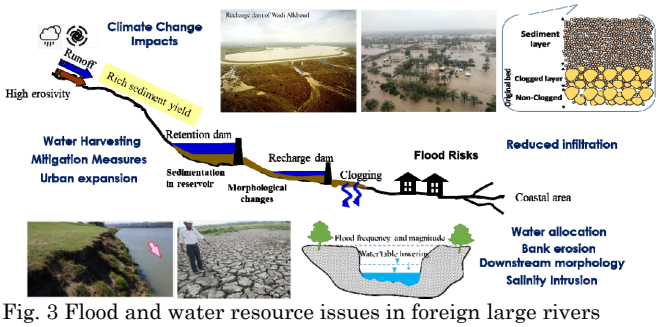


Fig. 3 Flood and water resource issues in foreign large rivers

G E O M E C H A N I C S

Professor
Yosuke HIGO

Associate Professor
Ryota HASHIMOTO

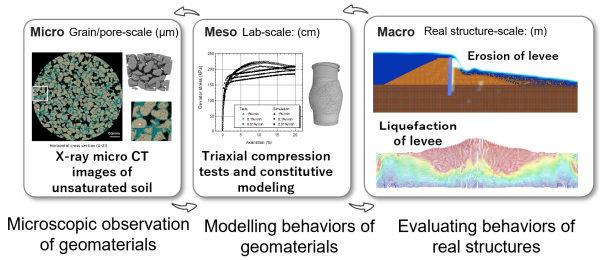
PS Assistant Professor
Zirui LU

Clarification of Mechanical Behaviors of Ground Supporting Civil Structures

Geomaterials support the civil structures and environments as a ground. It is important to clarify mechanical properties of geomaterials under different conditions such as water contents and confining pressure, deformation and failure mechanisms of geomaterials subjected to earthquakes and rainfall, and soil-structure interactions in order to build the safe civil structures. This laboratory studies these topics by conducting experiments and numerical analyses to develop reasonable design methods and new techniques for maintaining the civil structures and environment safety.

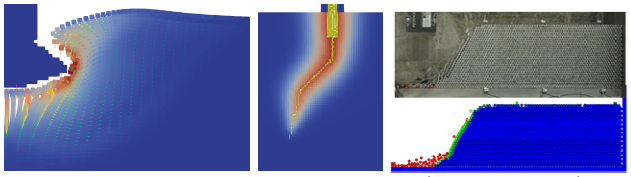
Clarification of multi-scale behaviors of geomaterials

Geomaterials are multiphase mixtures of soil, water, air and other materials, and hence the mechanical behaviour depends on the interactions between the phases. Accurate interpretation and representation of various behaviours of geomaterials require a focus on changes at the microscopic scale of the soil particle level. In current geotechnical engineering, the ground is treated as a continuum of averaged soil particle aggregates due to the significant difference in scale from the actual ground and the soil structure. In our laboratory, an X-ray micro-CT technology is used to reveal the structural changes of the individual phases of geomaterials from a microscopic point of view and to study their relationship with the deformation and strength characteristics of geomaterials at a macroscopic level. Furthermore, constitutive models and predictive simulation methods that can precisely represent the deformation and failure behaviour of geomaterials have been developed to analyse the behaviour of natural ground and earth structures such as roads and embankments, and to assess their stability during construction and disasters such as rainfall and earthquakes.



Development of mechanical simulation techniques for geomaterials

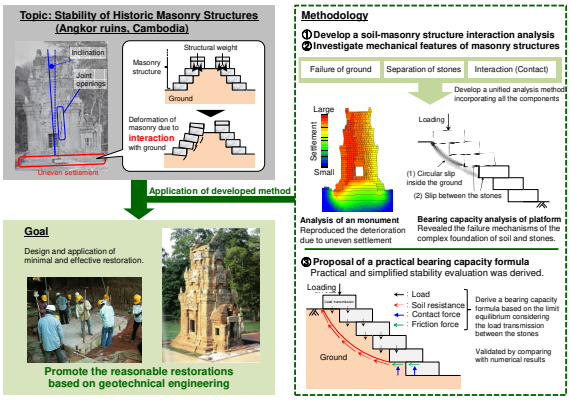
To gain insights into the mechanisms underlying geomechanical phenomena and enhance the design techniques of secure social infrastructures and resilience against geo-disasters, numerical simulation is a powerful tool. We are actively engaged in advancing numerical methods that tackle diverse challenges, including soil-fluid-structure interaction, fracture mechanics, and the seismic behavior of rock slopes. For example, we are developing a numerical method for analysing large deformation during offshore foundation installation (MPM: Material Point Method), formulating a novel approach to simulate hydraulic fracturing in porous solid (PD: Peridynamics), and also working on a new methodology to enhance accuracy and computational stability of seismic analysis of jointed rocks (DDA: Discontinuous Deformation Analysis).



Simulation techniques for geomaterials (MPM, PD, DDA)

Geotechnical conservation/restoration of historic masonry structures

We are developing a numerical analysis technique for discontinuities in order to clarify the mechanism of instability of masonry structures, which are cultural heritages, and to develop a stability evaluation method for them. One of the targets is the Angkor ruins, a World Heritage site in Cambodia. Many of the masonry structures at Angkor are in danger of collapsing due to deformation and failure of the foundation. We consider the deformation and failure of composite structures consisting of soil and masonry as a problem of mechanical interaction between a continuum and discontinua, and are conducting a series of research including (1) the development of an integrated mechanical analysis method for soil-masonry structures to (2) the investigation of mechanical properties of composite structures consisting of soil and masonry and (3) the proposal of a practical stability (bearing capacity) evaluation formula.



Geotechnical restoration of historic masonry structures

Dept. of Civil and Earth Resources Eng.,
Graduate School of Eng., Kyoto Univ., Japan

Infrastructure Innovation Engineering

Professor: **Chul-Woo KIM**

Manage Civil Infrastructure System Smartly!

Researches in International Management of Civil Infrastructure Lab aim to answer questions in managing civil infrastructure systems whose answers are not yet clarified: developing effective methods to identify change in bridge health condition even including decision making on the health condition; information fusion specialized for health monitoring of bridges.

Health monitoring of bridges

Effective management of bridges is one of the most important issues considering the large number of the bridge. A crucial issue in maintenance of those bridges, thus, is development of rapid and cost-effective tools for bridge health monitoring (BHM). The research covers developing novel damage- sensitive features, fault detection by means of statistical pattern recognition and Bayesian approach, drive-by inspection, digital twin for smart management of bridges, and image processing for bridge inspection.

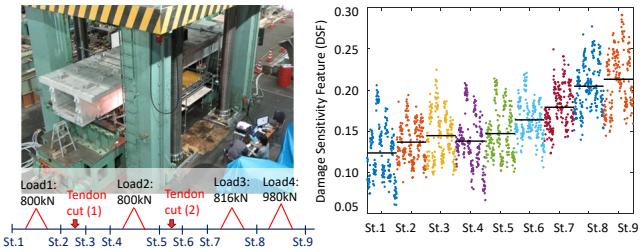


Fig. 1: Bridge damage experiment (left)/ damage detection using information on subspace (right).

Drive-by bridge inspection

This challenging research project aims to develop a smart way to monitoring bridges, esp. short and medium span bridges, utilizing vehicle vibrations when the vehicle passes on the bridge. The idea is that utilizing the inspection vehicle as an actuator, data acquisition and message carrier, and extract information about bridge behaviors.

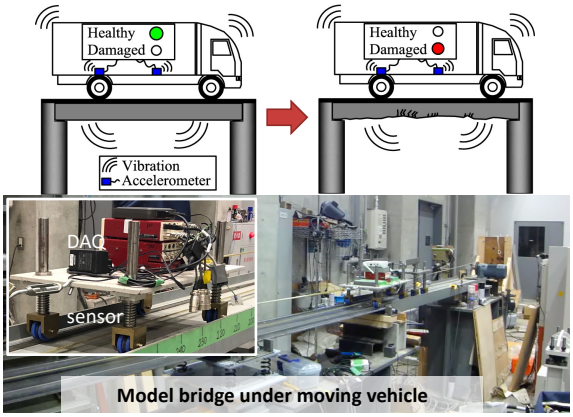


Fig. 2: Drive-by Bridge inspection systems.

Long-term monitoring of infrastructure

In long-term monitoring of infrastructure, the target monitoring feature is fluctuated caused by the changing environmental and operational variables (EOVs), which makes the damage effect blurred and undetectable. Proper methods for addressing the issue caused by variability are required. Fig.3 shows a predicted bridge frequency considering seasonal variation utilizing a deep learning. In addition, development of a remote edge computing system for long-term scour detection is under investigation.

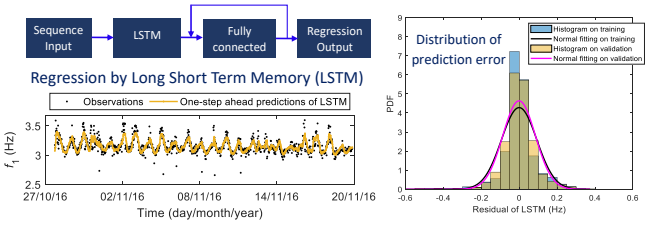


Fig. 3: Predicted frequency of a bridge under changing environment and error distribution of the prediction.

Advancing vehicle-bridge interaction

Vibration serviceability/ seismic behavior under traffic

The low frequency sound radiated from bridges under traffic is one of the environmental problems especially in land scarce major cities of Japan, since the low frequency sound can shake houses near the sound source and also can cause psychological and physiological influences to residents. The research aims to develop a general platform simulating traffic-induced vibrations that can even apply to assess the low frequency sound radiated from a viaduct and to simulate the nonlinear dynamic response analysis under seismic and traffic. Fig.4 shows simulated propagation of bridge born low-frequency vibration under traffic.

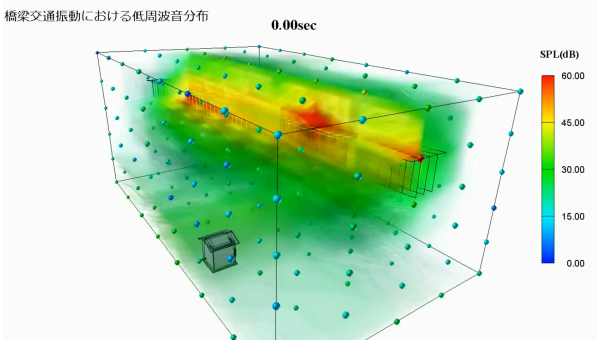


Fig. 4: Propagation of bridge born low-frequency vibration under traffic by simulation.

Construction Engineering and Management

Professor
Kiyoshi KISHIDA

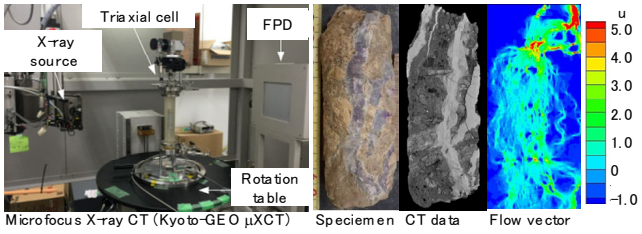
Associate Professor
Yasuo SAWAMURA

Development of Infrastructures toward Carbon Neutral Society with Harmony of Environments

In overcrowded urban areas, the developments of new infrastructures, such as railways, rapid transport systems, and energy facilities, is being adjusted in order to employ underground space. Underground space is useful as a solution for the Geo sequestration of by-products after energy generation, and to achieve carbon neutral society. In order to develop new geofronts, the mechanical and hydro-mechanical properties of soils and rock are being studied and their application to tunnel and underground excavations, dam foundations, slope stability are being researched based on the geotechnical engineering, rock mechanics, and fluid mechanics.

Mechanical and hydro-mechanical behaviors of fractured rockmasses

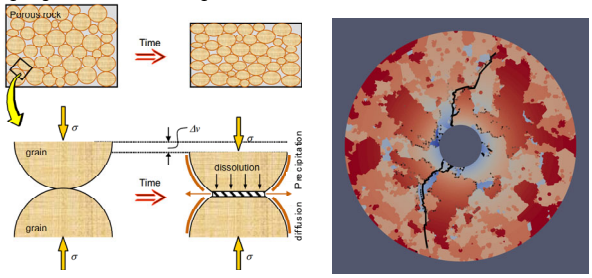
When discussing the construction and the maintenance of tunnels and underground caverns and the slope stability, the mechanical and hydro-mechanical behaviors of fractured rock masses should be clarified. The mechanical and hydro mechanical behaviors of fractured rock masses are strongly affected by those of the rock joints and/or fractures. Through experimental works on single joints and/or fractures, the mechanical and hydro-mechanical behaviors of single joints are studied.



Analysis on discontinuous rock by microfocus X-ray CT

Advanced approach for geological isolation of by-products after energy generation

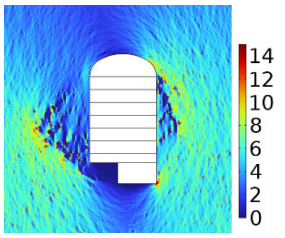
When considering the geological isolation of high-level radioactive waste and CO_2 geological storage, the integration of various types of information through geomechanics, rock mechanics, fluid mechanics, thermal dynamics, and geochemistry is required. The mechanical and hydro-mechanical properties of jointed rock masses are clarified through an advanced approach and fundamental experiments with iPSACC (interface for Pressure Solution Analysis under Coupled Conditions) coupling the thermal (T), hydro-mechanical (H), mechanical (M), and chemical (C) properties is developed.



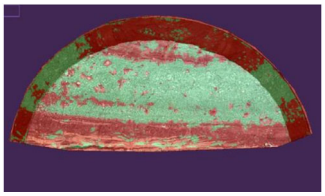
THMC concept and simulation example under fracturing

Design, construction, and maintenance of geo-infrastructures and rock infrastructures

The stability of rock masses during the excavation of underground caverns and deep tunnel are studied through numerical simulation works. The numerical simulation is conducted to study the stability of underground cavern considering the ground profile and the excavation steps of the actual site. The tunnel face data obtained during the deep tunnel excavation are analyzed through machine learning to predict the convergence of the tunnel face ahead.



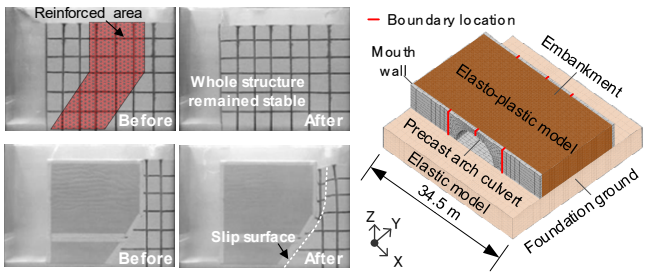
Excavation analysis of an underground cavern



Analysis of a tunnel face with machine learning

Clarification of seismic performance of reinforced earth wall and precast arch culvert

In order to realize the labor saving of the earthworks, the reinforced earth wall and the precast arch culvert have been positively applied in the domestic road structures. Through the dynamic centrifuge tests and the numerical analyses, these unknown seismic behaviors due to dynamic soil structure interaction are being investigated. Based on these approaches, we aim to clarify the limit state and required performance of road structures during earthquakes.



Investigations by geotechnical centrifuge and 3D FEM

GEOFRONT SYSTEM ENGINEERING

Professor
Hideaki Yasuhara

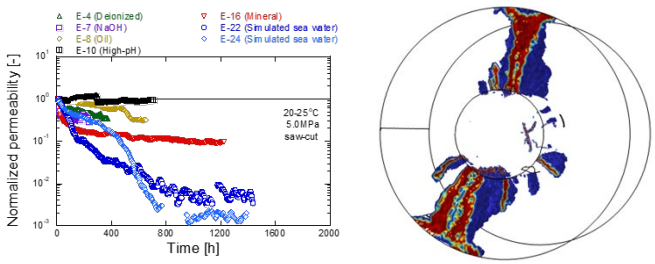
Associate Professor
Hiromasa Iwai

To create, conserve and maintain underground space considering Geofornt environment

A grate deal of attention is attracted to utilize underground space (Geofront) as the new space in order to preserve environment of geo-surface and urban surroundings. Considering environment and creating, conserving and maintaining underground space, we are educating students and researching on complex problems combined above to solve complicated behavior of soil, rock and water.

Mechanical and hydraulic behavior of subsurface rock mass in a coupled field

We model coupled thermal, hydraulic, mechanical, and chemical phenomena in rock. For the utilization of underground space for geological disposal of radioactive waste, carbon capture and storage (CCS), underground fuel storage, and geothermal power generation, it is essential to fully understand the characteristics of the underground rock mass and to ensure its long-term safety. This study aims to properly evaluate the mechanical and hydraulic properties of underground rock masses through laboratory experiments such as permeability tests and hydraulic fracturing tests, and their reproducible analyses.



Continuous permeability tests and crack propagation analysis of hydraulic fracturing experiments

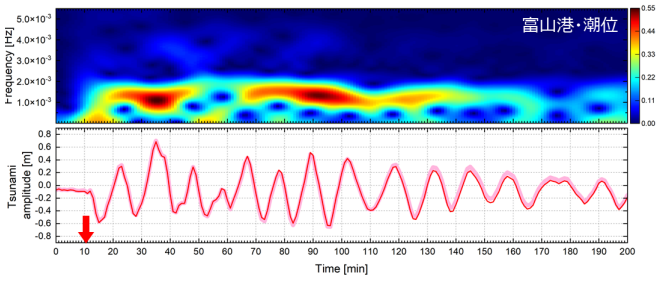
Development of slope disaster observation system using wireless network

Slope monitoring using LPWA (Low Power Wide Area) wireless communication technology is attracting attention as a method of slope monitoring for landslide prevention. The collected information is processed on the cloud and displayed in real time, enabling rapid response in the event of a landslide. In this research, we are developing various sensors and monitoring systems that can be applied to actual slopes.

Overview of slope monitoring using LPWA with lab test

Relationships between submarine landslide motion and generated tsunami

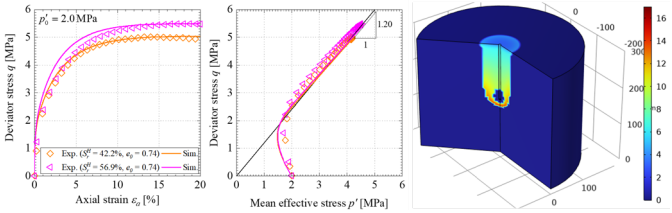
Submarine landslide can generate unexpected tsunamis. It will magnify the tsunami amplitude, larger than that predicted by seismic motions, and will strike coastal areas. In this research field, we focus on the ground-fluid interaction, and investigate the relationship between kinematics of submarine slide motions and characteristics of the generated tsunami through model experiments and theoretical analysis.



Tsunami characteristics of Toyama Bay observed during the 2024 Noto Peninsula earthquake

Development of constitutive models for CO_2 hydrate-bearing soils

CO_2 hydrate sequestration in seabed ground is one of the most promising negative emission technologies to reduce the net amount of CO_2 emitted to the atmosphere. To clarify how CO_2 hydrate will be stored in the seabed is an important issue to be considered in order to achieve highly efficient CO_2 hydrate storage. In this study, we are developing a constitutive equation that can describe the strength and deformation characteristics of the seabed soils based on mechanical tests such as triaxial compression tests.



Left: Elasto-plastic constitutive equation fo CO_2 hydrate soils
Right: Formation behavior of CO_2 hydarte in deep-sea sediment

International Urban Development

Associate Professor
Ali Gul QURESHI

Associate Professor
Fan ZHU

Studying International Urban Development Problems from a Multidisciplinary Perspective

Modern Cities are considered living organisms due to the complex interrelations between their various systems and sub-systems. Their management requires multidisciplinary knowledge and holistic methodologies to avoid the problems that encircle most reductionist solutions. This laboratory focuses on issues related to urban development from planning and numerical modeling viewpoints; working closely with the International Management of Civil Infrastructure Laboratory to incorporate concepts related to structural and water resource engineering.

Urban Logistics Systems and Humanitarian Logistics

Transportation and logistics networks make the backbone of the economy of any country. Within cities, they have enormous impact on sustainability and livability of a city. Planning for efficient urban logistics opens up a wide range of research opportunities, such as in policy making, management, operations research, environment, etc. One of the focus of this laboratory is on optimization of strategic and tactical logistics issues such as facility location problem and vehicle routing problem. Research is conducted in modeling various variations (such as considering land uses (Fig.1)) of these problems and in development of both exact and heuristics optimization methods. Integration of these methods in more comprehensive frameworks such as with multi-agent system or micro/macro traffic simulation, is also studied for evaluation of logistics policies. Humanitarian logistics is also an active and expanding area of research of this laboratory.

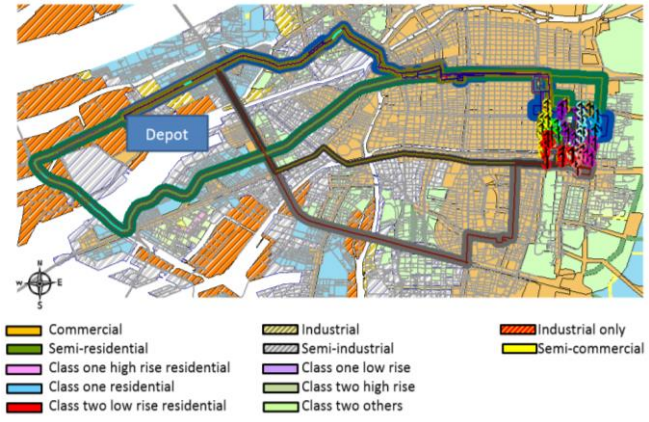


Fig. 1: Vehicle routing and land use

Multiscale and Multiphysics Modeling of Geomaterials

The geomaterials are multiscale in nature, with both discrete and continuum material behaviors at different length scales. The material behaviors may also be subject to combined effect of mechanical, thermal, hydraulic, and chemical loads. To model and predict geomaterial behaviors, application of multiscale and multiphysics approach is inevitable. In this laboratory, we develop innovative and advanced numerical approaches for modeling behaviors of geomaterials with a focus on physics related to material fractures. We aim to build the next-generation computational toolkit that can facilitate relevant geophysical studies and engineering activities such as oil exploitation, geological carbon sequestration, mining, and rock excavation where assessment of rock fractures (Fig. 2) and granular material fragmentation is required (Fig. 3). The laboratory also works on application of high-performance computing techniques in numerical modeling. The laboratory promotes research works for inter-discipline collaborations and applications.

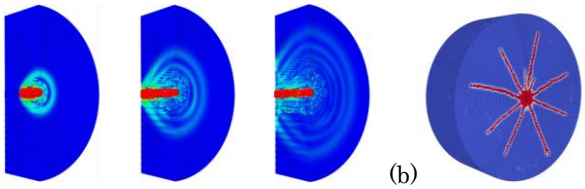


Fig. 2: Modeling fracturing of rock due to blasting: (a) stress wave propagation; (b) fracture pattern.

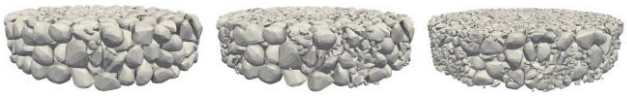


Fig. 3: Modeling fragmentation of granular materials.

A Multidisciplinary Perspective

In addition to working with topics directly related to Urban Logistics Systems and Humanitarian Logistics, and modeling of geomaterials, the International Urban Development Laboratory works closely with the International Management of Civil Infrastructure Laboratory to incorporate concepts related to structural and water resource engineering, so as to include a complete multidisciplinary perspective in the study of international urban development problems.

Geotechnics for Hazard Mitigation

Professor
Ryosuke UZUOKA

Associate Professor
Kyohei UEDA

Geo-hazard mitigation for disaster-resilient societies

Rapid development of urban areas originated from plains and lowlands towards hills in the suburbs poses increasing risks in geohazards. The potential geohazards include soil liquefaction during earthquakes, settlement of reclaimed lands, collapse of artificial cut-and-fill, and instability of natural slopes. A series of strategic measures are required for mitigating these geohazards and establishing higher performance of geotechnical works.

Damage mechanism of geotechnical structures during combined disaster

Many geotechnical structures were damaged by ground shaking and/or tsunamis during the 2011 Tohoku, Japan, earthquake. In the Tohoku region, the offshore tsunami breakwaters, coastal levees and river levees were found to be severely damaged by the tsunami after the earthquake. In the Kanto region, fill ground around the Tokyo bay severely liquefied during not only the main shock but aftershocks. The 2016 Kumamoto earthquake caused severe damage of geotechnical structures with multiple shocks. In addition, many slope failures were caused by heavy rainfall in June two months after the earthquakes. These recent earthquakes teach us that some natural disasters very often did not come alone, and the sequential multi external forces caused worse situations of geotechnical structures, which is known as combined disasters.

To clarify the damage process and the mechanism of geotechnical structures during combined disasters, we have assessed the residual performance of geotechnical structures after earthquake motions by using centrifuge model tests (Fig. 1) and numerical simulations.

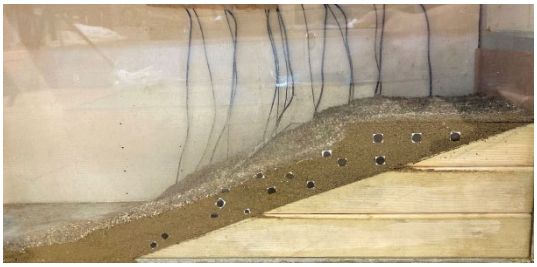


Fig. 1 Centrifuge experiments of post-shaking rainfall

Centrifuge aided data driven real time prediction of geohazards

Although numerical methods are available for predicting geohazards, the uncertainty of input geotechnical information remains an issue. We develop a centrifuge aided data-driven real-time geohazards prediction method by combining two types of statistical information (referred to as double data-driven): experimental data obtained from centrifugal model experiments and observation data routinely obtained in the field.

Various ground softening mechanisms during earthquakes and their remedies

To address ground damage challenges in recent earthquakes, we are utilizing centrifuge experiments and numerical analyses to investigate various ground softening mechanisms under seismic activity. We have examined clayey soil, multi-layered ground with impermeable layers, and unsaturated ground below the water table. One key focus is understanding the impact of inherent (or fabric) anisotropy (Fig. 2) on soil behavior during earthquakes. We have conducted shaking tests in a centrifugal field using a model ground with inherent anisotropy and updated a constitutive model to incorporate this effect in numerical analyses.

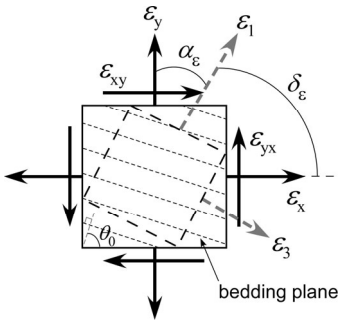


Fig. 2 Multi-directional shear with different bedding-planes

International research project on liquefaction (LEAP)

LEAP (Liquefaction Experiments and Analysis Projects) is an international project aimed at overcoming the constraints of traditional individual projects and improving prediction accuracy by ensuring the universality and objectivity of results. To date, collaborative round-robin centrifuge experiments and numerical simulations focusing on the seismic behavior of gently sloping ground and sheet pile revetments have been conducted in collaboration with domestic and international research institutes (Fig. 3). These efforts seek to quantify variability and analyze factors influencing prediction accuracy.

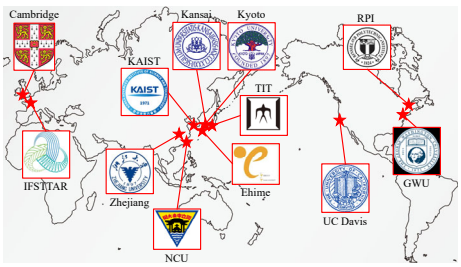


Fig. 3 Institutions participating in the LEAP-Asia-2019

Environmental Infrastructure Engineering

Professor **Takeshi KATSUMI**
Associate Professor **Atsushi TAKAI**
Assistant Professor **Tomohiro Kato**

Sustainable Geoenvironmental Engineering

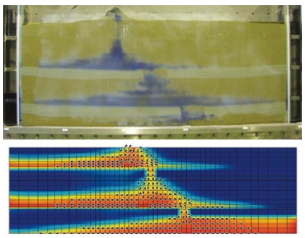
Environmental sustainability of the subsurface should be maintained for a long period of time since it is crucial for life and society. This laboratory mainly focuses on the study of recycling technologies of various wastes as geo-materials, remediation technologies for contaminated lands, and lowering environmental impact of infrastructure development. The main research topics are detailed below.

Geotechnics for Material Recycling Contributing to Carbon Neutrality

Huge amounts of excavated soils and rocks are generated, because many infrastructures are developed. Therefore, the recycling of excavated earthen materials is a crucial issue. Since Japan has a wide range of geological formations with low concentrations of heavy metals and metalloids (geogenic contaminants) such as arsenic and lead, geogenic contaminants are often leached from the excavated earthen materials in concentrations that slightly exceed environmental standards. Therefore, precisely understanding the behavior of geogenic contaminants leached from the excavated soils and rocks and designing the proper countermeasures are required to utilize the excavated earthen materials. In addition, various by-products are generated due to industrial activities, such as steel slag produced during the steel manufacturing process and incineration ash derived from waste treatment. Promoting the recycling of these products is essential. Our laboratory aims to contribute to a recycling-oriented society and create a new social system by evaluating the environmental safety of using construction by-products as geomaterials for constructing infrastructure and proposing infrastructure development with low environmental impact.


Smart Management of Soil and Groundwater

When soil-groundwater contamination is confirmed, excavating the soil at the site and replacing it with clean soil is often applied. If the reliability of a contain method using natural clay with low permeability or techniques of in-situ remediation is increased, these countermeasures can be applied. As a result, since the amount of soil disposed at landfills can be reduced, a low social cost and eco-friendly countermeasures against soil-groundwater contamination can be established. Our laboratory conducts experiments and numerical analysis to predict the behavior of chemicals in the ground and investigate countermeasures against soil-ground water contamination with low environmental impact. Recently, our laboratory has also been researching the migration characteristics of organic fluorine compounds (PFAS) in the ground.




Environmental Geotechnics for Disaster Recovery

Large-scale disasters such as earthquakes, tsunamis, and torrential rains frequently occur widely in Japan. Since many soils are included in disaster waste, it is important to recover and utilize soils from disaster waste. As shown in the photo, since various wastes such as plastic and wood chips are often mixed, the soils recovered after separation also contain many fine impurities. Suppose soil containing wood chips is reused as a geomaterial. In that case, achieving high-accuracy processing at high speed is essential because the biodegradation of organic matter over time can create voids in the ground and lose its stability. Therefore, the establishment of a processing method is essential. In our laboratory, the effective separation method of soil and waste mixture was investigated through laboratory experiments and full-scale sieve sorting tests. Recently, the plasticity index of the mixture or sieving type is considered the parameter. The research is conducted from legal and technical aspects to prepare for future mega-disasters such as earthquakes, tsunamis, and volcanic eruptions and contribute to the establishment of post-disaster systems.


COMPUTATIONAL SCIENCE

Professor

Mamoru KIKUMOTO

Modeling and High-Performance Computing for Scientific Applications

Many problems in civil engineering are governed by complex multiphysics processes, involving the interaction of solid, liquid, and gas mechanics, as well as mass and heat transport and chemical reactions. Our laboratory addresses these challenges through a comprehensive approach: from the development of constitutive models, to the formulation of governing equations, and their implementation in high-performance numerical simulations. Our goal is to build predictive tools capable of solving actual scientific problems.

Modeling of Geomaterials

Geomaterials are mixtures of solids, liquids, and gases, and exhibit unique, complex behavior. We aim to overcome the limitations of conventional geomechanics by developing theoretical models that can reliably predict such behavior. Our research philosophy follows Occam's Razor: the problem-solving principle that recommends searching for explanations constructed with the smallest possible set of elements. Based on this principle, we are developing rational models that capture the responses of geomaterials with a minimal number of simplified assumptions.

Micro-Macro Transition of Granular Media

To develop rational models, it is essential to understand how micro-level interactions between particles govern macro-scale mechanical response. We are investigating the micro–macro linkage by combining laboratory testing with granular mechanics simulations, aiming to uncover the intrinsic mechanical properties of granular materials.

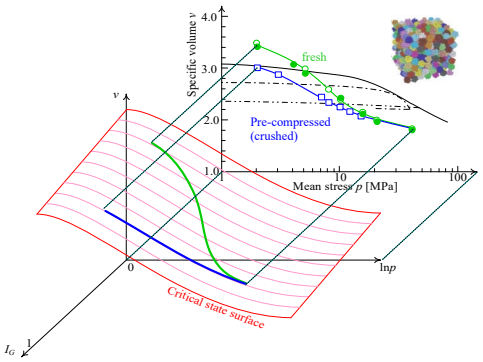


Fig. 1 : 3D state boundary surface capturing evolving grading.

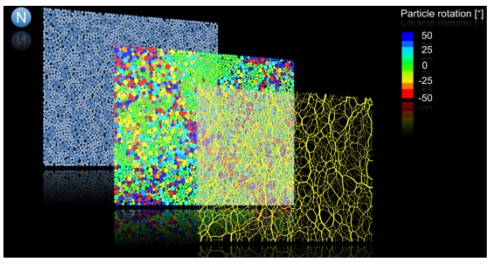


Fig. 2 : Simulation of micro-macroscopic granular behavior

From Empirical Knowledge to Rational Science

Our objective is to transform mechanical understanding from empirical knowledge into theory-based science. We focus on earth structures such as tunnels and cut slopes, integrating lab tests, field surveys, modeling, and simulations. In particular, we are developing a method to predict rock weathering and assess the long-term stability.

Geoenvironmental Geotechnics and Interdisciplinary Research

We work on environmental geotechnics, focusing on soil contamination caused by oil and heavy metals. This includes the development of fundamental physical models and advanced simulations. In addition, we actively engage in interdisciplinary research, collaborating with experts in cultural heritage preservation and other fields.

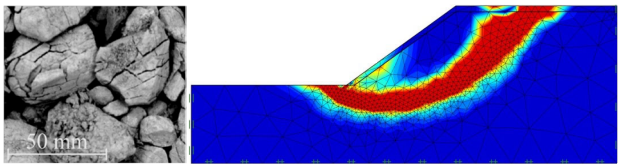


Fig. 3 : Weathering of weak rocks and simulation of instability of cut slope.

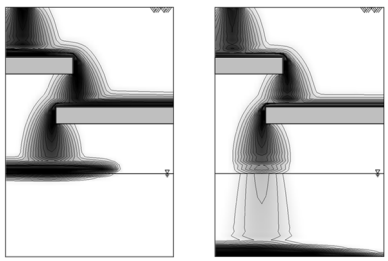


Fig. 4 : Simulation of soil contamination using oil–water–air multiphase flow analysis.

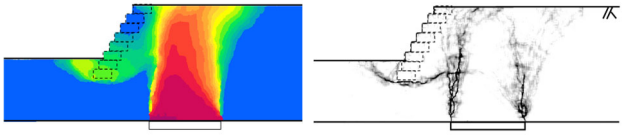


Fig. 5 : Laboratory investigation of tunnel-masonry interaction.

Geoinformatics

Professor
Junichi SUSAKI

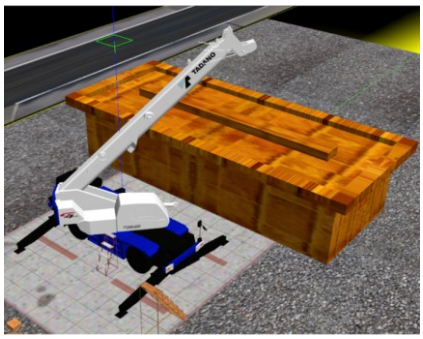
Assistant Professor
Yoshie ISHII

Analysis and Utilization of Spatial Information

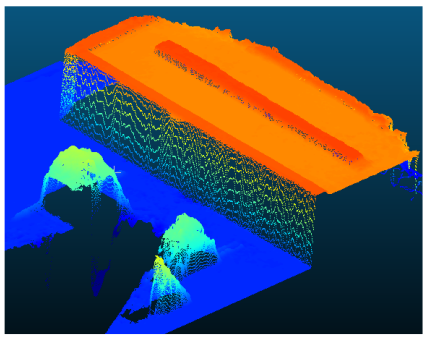
We analyze and utilize spatial information for disaster prevention, environmental protection and urban planning. In particular, we focus on satellite remote sensing, 3-D digital photogrammetry, laser surveying, geographic information systems, and location identification using mobile phone and SNS data for monitoring, modeling, and management of urban and natural environment and human behavior.

Rapid 3D mapping and detecting moving objects around a crane from video images

We are now developing methods for rapid 3D mapping around a crane from video images in actual construction sites and simulated video images. In addition, we are also developing method for detecting moving objects, e.g. workers, vehicles and hook.



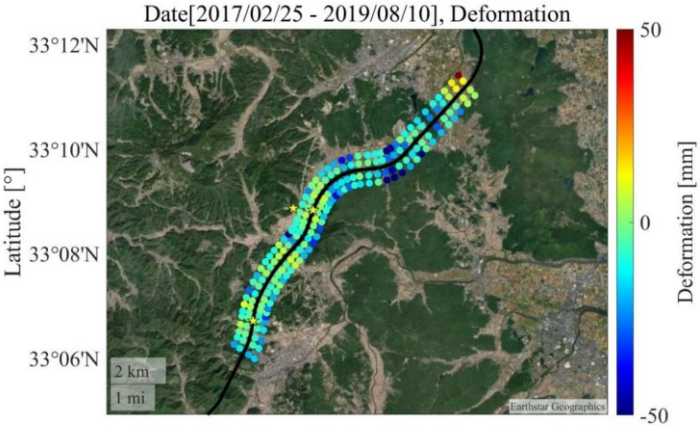
Simulator in a virtual construction site. A video camera is attached at the tip of the boom of the crane.



Reconstructed 3D map of the construction site in the above simulator. The achieved accuracy of objects is less than 10 cm.

Monitoring of displacement of ground and civil infrastructure from satellite SAR images

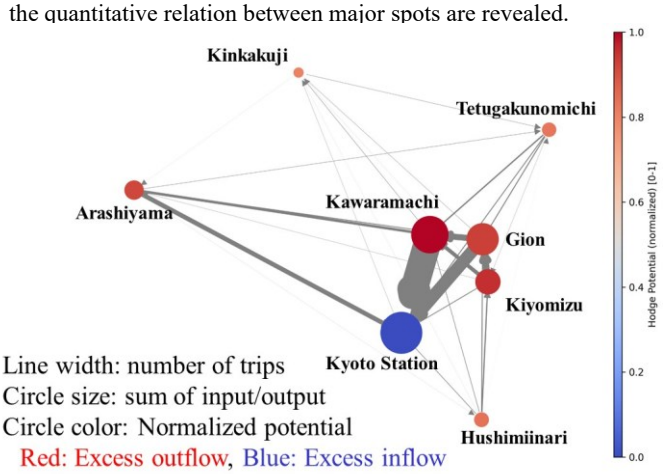
We can estimate the displacement by using multi-temporal satellite-borne synthetic aperture radar (SAR) data. Radar measures the amplitude and phase of the signal reflected by scatter(s). We estimate 3D displacement velocity as follows. First, we estimate two displacement vectors along the radar line-of-sight (LOS) from images acquired on ascending and descending orbits, respectively. Then, we apply an interpolation technique, e.g. Kriging, to the global navigation satellite system (GNSS) data measured by Geospatial Information Authority of Japan (GSI).



Multi-temporal satellite synthetic aperture radar (SAR) image analysis provides land displacement along a highway. In this area, a significant landslide near the highway occurred on August 28, 2019, and the highway was severely damaged. The blue plots indicate significantly large subsidence after heavy rain.

Analysis of spatial relation between tourist spots in a tourist city from people flow data

Major tourist cities are suffering from an overtourism issue where excessive tourists gather and cause traffic congestion. We are trying to quantitatively analyze the relation between major tourist spots from people flow data. Following is an example of Kyoto city and the quantitative relation between major spots are revealed.



Line width: number of trips
Circle size: sum of input/output
Circle color: Normalized potential
Red: Excess outflow, Blue: Excess inflow

Urban and Landscape Design

Professor	Associate Professor	Assistant Professor
Masashi KAWASAKI	**Keita YAMAGUCHI**	**Riku TANIGAWA**

To integrate creatively the beautiful landscape and cultural environment based on rich water, green and land

Landscape refers to a geographic and cultural region encompassing various landscape experiences, ranging from natural to cultural environments. This lab aims to understand its spatial and temporal structure and transformation through topographic and landscape analysis, design surveys, and historical studies. Based on these insights, it seeks to develop practical proposals for creating urban infrastructure, public spaces, and human activities that harmonize with the landscape and methodologies for sustainable management.

Design for Public Spaces and Urban Infrastructure

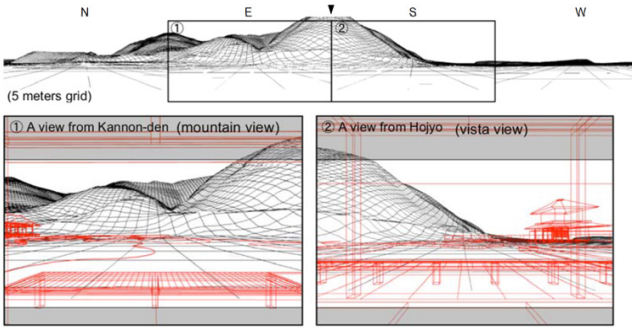
This research explores the design of roads, parks, waterfronts, bridges, and other urban facilities to create public spaces that are both environmentally harmonious and culturally engaging. By studying leading domestic and international cases, it examines design methods, processes, and institutional frameworks. It also develops practical and theoretical approaches for setting clear design goals, predicting user behavior, and evaluating spatial quality—focusing on design concepts, scale, color, texture, and overall management.

Before Redevelopment (Left) and Landscape Conceptual Plan (Right) of the Nakanoshima Area, Osaka

Research on Landscape Structure, Formation Processes, and Planning

Landscape areas emerge by layering diverse social systems shaped by unique climates and natural geography. This research analyzes the long-term urban and landscape formation mechanisms, focusing on high-quality waterside and mountain-edge environments. Using tools such as GIS and 3D simulations, we examine topography, viewsheds, and the impact of landscape regulations to identify normative design approaches and explore sustainable landscape creation and management.

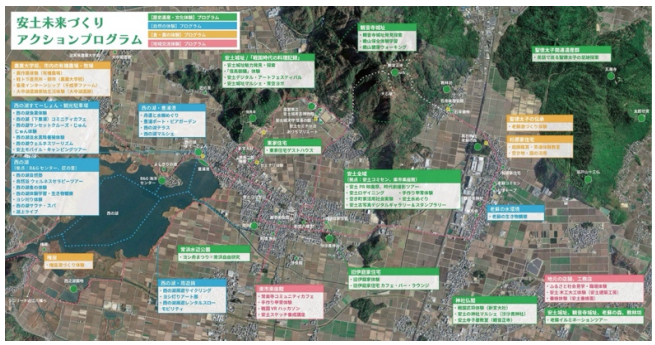
We investigate the cultural and scenic values of modern heritage sites and traditional scenic places through historical documents, literature, and media analysis, aiming to redefine their appreciation and use. By proposing new goals and methodologies, the study contributes to urban design, regeneration, and tourism planning.



Landscape Analysis of a historic site of scenic beauty

Practice-Based Research on Community Development and Co-Creation

We explore methods for utilizing underused public land and facilities, vacant houses, and regional natural and historical resources for community development. We investigate approaches for transforming existing infrastructure and public spaces through public-private partnership (PPP) project design and the reorganization of urban and regional spaces. We focus on building sustainable and efficient systems for managing public spaces and facilities, emphasizing the roles of local stakeholders. Through fieldwork and design proposals, we aim to develop regional strategies, new planning methods for improving urban hubs and infrastructure landscapes, and participatory techniques for spatial management, advancing both technical and theoretical frameworks.



Examples of Action Programs Utilizing Local Resources

PLANNING AND MANAGEMENT SYSTEMS

Professor
Masamitsu ONISHI

Associate Professor
Satoshi Nakao

Pioneering a Practical Science Rooted in the Real World

Civil engineering has a mission to contribute to the development of society. To unravel complex social problems and gradually lead society toward a desirable society, it is necessary for experts with scientific knowledge in a variety of fields to work with society. In this laboratory, we are researching management techniques for creating, supporting, and making good use of the infrastructural systems that support our daily lives, while interacting with the real world.

Management of infrastructure construction, maintenance, and operation

Our research focuses on the social infrastructure that supports people's lives and socioeconomic activities, namely, infrastructure, and the overall social systems that contribute to the improvement of the value of infrastructure, the efficiency of its construction, maintenance, and management, and its sustainability. While many of the services provided by infrastructure are of a public nature, not only the public sector but also the private sector is involved in their construction, maintenance, and operation. The various public and private players involved in infrastructure are shaped by institutions such as laws, contracts, administrative rules, and various business practices. In recent years, we face a situation in which the stability of infrastructure service supply is threatened by climate change issues, declining birthrates, an aging population, and the concentration of population in urban areas. In this laboratory, we are analyzing various issues surrounding infrastructure from the perspective of "institutions" and practically examining ways to improve them.

Specifically, we are studying the desirable application of Public Private Partnership (PPP), a system in which a single private company provides infrastructure services throughout the entire infrastructure lifecycle, from design to operation and maintenance, as well as construction, project systems, and contracts. PPPs are becoming popular worldwide, and since private financial institutions finance the construction of infrastructure, we are conducting research in cooperation with financial institutions and international development agencies.

In addition, while disaster risk is increasing due to climate change, the number of construction workers responsible for post-disaster infrastructure restoration is decreasing every year. If this trend continues, disasters could become a fatal risk to local economies due to the lack of progress in post-disaster recovery. We are continuing our search for a sustainable social framework that will allow communities to recover strongly after disasters, while engaging with actual communities.

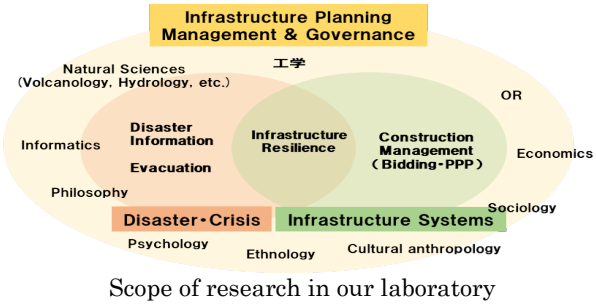
Furthermore, we are analyzing the movement of goods and people, such as marine and air transportation, and studying various management issues, including port and airport planning and crisis management, as well as measures to promote the development of remote islands supported by marine and air transportation.

Emergency response management for disaster risks

It is important to have the infrastructure in place in advance to be able to respond effectively when a disaster strikes, as well as plans, drills, and social relationships in place to be able to implement a response before a disaster strikes. It is also important to plan, train, and build social relationships before a disaster strikes. Our research engages in bottom-up initiatives that involve working collaboratively with residents, with a particular focus on indigenous knowledge rooted in the community.

Specifically, to create a system for large-scale, wide-area evacuation at the stage when a large-scale volcanic eruption is imminent, various experts in volcanology, traffic engineering, psychology, sociology, informatics, and other fields will work together with residents, step by step, to examine the issues to be addressed and their solutions. We are also working with residents to discuss the issues to be addressed and how to resolve them. This approach values narratives from residents, their relationships with the land, and emphasizes processes grounded in the everyday lives and social contexts of local communities. If a large-scale volcanic eruption were to occur at Sakurajima, the ash would spread to the Kanto and Tohoku regions, which is expected to have a very large impact both in Japan and abroad. We are studying disaster crisis response for air traffic, since operations to move aircraft out of the area where ash fall is expected will be necessary when a large-scale volcanic eruption is imminent, and this will require coordination at the national level.

We are also engaged in research to utilize real-time traffic data provided by private companies in order to make decisions regarding road operations, such as road closures, as quickly as possible in the event of abnormal events such as earthquakes, floods, and heavy snowfall.



Scope of research in our laboratory

Urban and Regional Planning

Professor	Associate Professor	Assistant Professor
Nobuhiro UNO	**Ryoji MATSUNAKA**	**Tomoki NISHIGAKI**

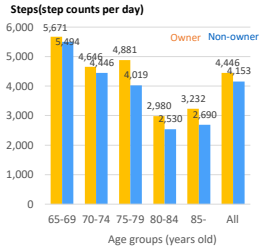
Empirical research to realize the appeal and vitality of cities

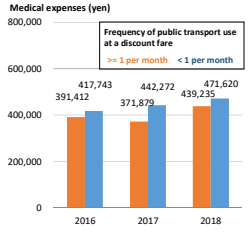
While cities play a role in people's daily activities in work, leisure, and peace of mind, they also introduce many issues such as in environment, energy, transportation, landscape, and land use. In our laboratory, in order to bring about the appeal and vitality of cities, the basic theoretical structure for solving these issues is applied to real cities and real problems in our research applications. Our goal is to observe and analyze cities, and to make use of the results of our research in greater society.

Evaluating the impact of public transport promotion on health improvement

In recent years, the role of public transportation has been attracting attention for its health-promoting effects. Step counts and travel behavior were obtained using mobile phone GPS data and medical expenses data were also analyzed. The figure (left) compares step counts per day between older citizens who participated in the "Odekake" commuting pass project to those who did not. Pass owners walked 293 steps more than non-owners in all age groups.

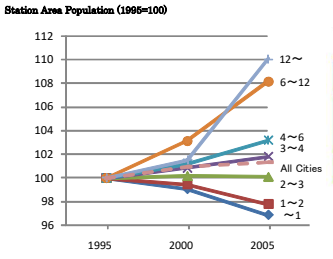
The figure (right) shows that medical expenses were lower for older citizens whose frequency of public transport use at the discounted fare was greater than once a month.

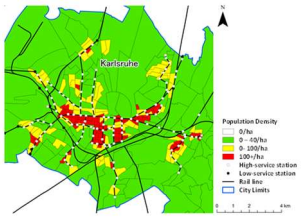




An international comparison of rail service level and urban structure

It is said that to move toward compact cities, the realization of highly-convenient public transportation is important. We analyze how differences in rail convenience can bring about differences in service area population changes using real-world data. The figure below (left) shows that at stations whose service level is 3 or more trains per hour, station area population increases, but where the service level is less than 3 per hour, population decreases. The same method of analysis is used for local cities in England, France, and Germany. The figure below (right) shows the population distribution around stations in German cities. It is clear that population concentrates in areas around rail stations.





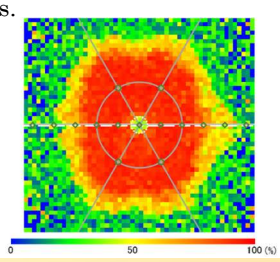
Experimental analysis of driving behavior using driving simulator

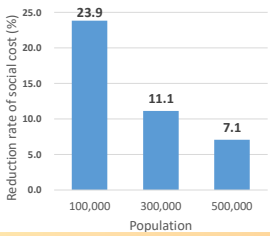
Analysis of driving behavior using a driving simulator, which can safely observe the behavior of subjects under various road and traffic conditions, can be useful in understanding the causes of traffic accidents and congestion and in studying solutions. Major research topics so far include behavior analysis when providing merging support information on urban highways, and analysis of the effect of behavioral norm recognition on vehicle speed during an earthquake. In the future, we plan to continue our research focusing on the analysis of driving behavior in a mixed situation of autonomous and manual vehicles.

Driving simulator equipped with 6-axis motion

Estimating social benefits obtained from the spread of Shared Autonomous Vehicle

With the recent development of autonomous driving, conventional transportation system will be changed radically. Shared Autonomous Vehicles (SAVs) will be key to driving this change. We analyzed social benefits obtained from shifting from private cars to SAVs. Under several assumptions, including the complete penetration of SAVs, results show that benefits amount to 24.6 million yen per day, fleet requirements to meet trip demand is decreased by 84% and parking requirements are decrease by 71%. The figure below (left) shows reduced parking requirements in the city by percent. The opposite figure (right) shows the reduction rate of social costs simulated on different population settings.





Urban Management Systems

Professor
Tetsuharu OBA

Assistant Professor
Yutaro KAMADA

Contributing to the creation of sustainable and resilient cities and nations of the future

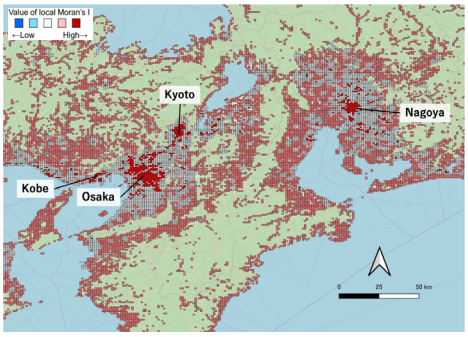
It is essential to develop cities, nations, and infrastructure as robust systems and to manage them efficiently to support current and future socio-economic activities. Our laboratory conducts empirical research using urban data and practical field studies to explore planning theories, policy theories, and methodologies, aiming to achieve sustainable and resilient urban and national development.

Research on Addressing Contemporary Urban Challenges through Inclusive Urban and National Planning, and Infrastructure Development and Management

This research aims to envision a sustainable and inclusive future for urban and national territories and contribute to the development of better urban infrastructure. We conduct empirical studies on planning theory, policy and institutional design, and infrastructure development related to urban and national planning. In the field of national and regional planning, we aim to realize a polycentric national spatial structure and a sustainable interregional balance through regional collaboration and the development of wide-area transportation networks. In urban planning and community development, we explore the flexible and strategic reconstruction of urban spaces to address contemporary challenges such as motorization, urban sprawl, and the intensification of land use. In transport and mobility planning, we pursue the realization of transportation systems and mobility that are accessible to all, efficient, and environmentally conscious.

Research Contributing to the Creation of a Sustainable Urban Society through Urban Regeneration and Conservation

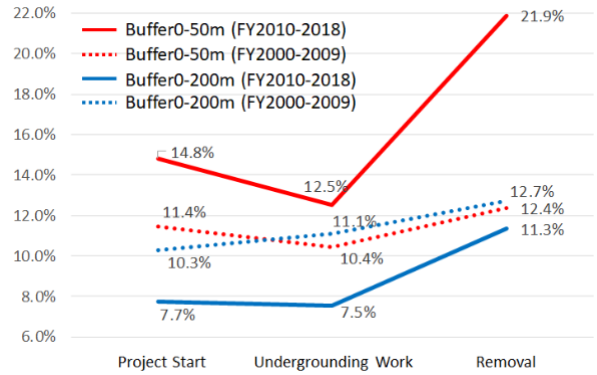
Our research on urban regeneration and conservation seeks to rediscover and reconstruct regional assets to enhance the sustainability of urban society by fostering innovation and creating new value. Specifically, we approach urban and regional regeneration from various perspectives, including local revitalization and urban management, focusing on the renewal of central urban areas and station-front districts, urban redevelopment aimed at rational land use and the updating of urban functions, and the conservation of historical environments that emphasize the inheritance and utilization of cultural heritage and landscapes in historic cities such as Kyoto. One example involves analyzing the spatial distribution of innovation driven by corporate research and development in urban areas using the number of domestic patent applications as a proxy indicator, and empirically examining its relationship with infrastructure development and urban planning.



Analysis results of spatial autocorrelation of domestic patent applications (2010s).

Empirical Research for Enhancing the Resilience of Cities and Nations, and Utilization of Digital Urban Infrastructure

Enhancing the resilience of cities and nations requires a comprehensive approach that includes not only physical and economic infrastructure development but also social connectivity and environmental preservation. Collaboration among stakeholders, as well as evidence-based policy and information dissemination, is essential. As an example, we estimate the causal effect of undergrounding and utility pole removal projects on nearby land prices by utilizing geospatial data on the track records. Moreover, we consider how to improve these projects in the near future.



Comparison of the increase rate in land prices by under-grounding and utility pole removal projects considering the timing of the project start, underground work, and removal.

In addition, we are developing and applying methodologies that contribute to smart urban development and infrastructure management by utilizing digital urban infrastructure, such as technologies for data collection, analysis, and visualization.

Example visualizations: 3D city model of Kyoto City using the Ministry of Land, Infrastructure, Transport and Tourism's 'PLATEAU' project (left), and road space representation using point cloud data provided by Shizuoka Prefecture's 'VIRTUAL SHIZUOKA' (right).

Intelligent Transport Systems

Professor **Tadashi YAMADA**

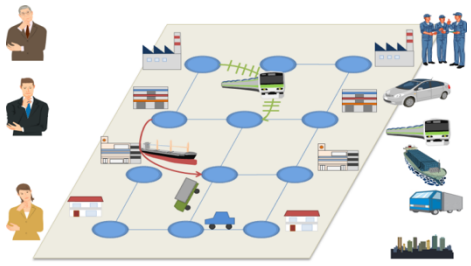
Assistant Professor **Kosuke TANAKA**

Creating smart transport and logistics systems
— Intelligence and Optimization —

Utilizing information technologies and analytical techniques on transportation and logistics, we have been developing efficient procedures to settle transport and logistics problems in urban areas. We are dealing with various research topics; including traffic flow modeling, transport and supply chain network design, effective operation, management and control of transport systems, and behavior analysis on transportation and logistics.

Utilizing Big Data to understand travel patterns

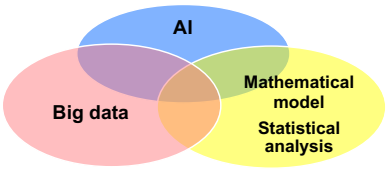
Passengers and freight move on a transport network (TN). Designing optimal TNs is therefore efficient for alleviating or settling urban and regional transport problems.
In the case of designing an optimal TN in terms of logistics, we need to take into account the decisions on logistics typically made looking over an entire supply chain network (SCN). Therefore, accurate comprehension of what happens on the SCN, namely, precisely describing the behavior of economic entities in the SCN and the resulting flow of products (and of raw materials as well) is necessary to understand the mechanism of the generation of freight movement.



We are developing mathematical models to represent the behavior of manufacturers, wholesalers, retailers, consumers and freight carriers. The behavior of passengers is also incorporated within the models as well as the behavioral interaction between passenger and freight traffic. This approach is a sort of super network modeling. We are also tackling the development of AI-based optimization techniques capable of solving large-sized problems.

Modelling network flows for public and shared transport systems

Data often build the basis for subsequent network flow models. In other cases we start from theoretical models to gain general insights into efficiencies of networks. The figure on the left shows a model of a bus stop to reflect that only some of the newly boarding passengers will be able to find a seat. Extending this model to a network helps us understanding the effect of, for example, service frequency changes. We create multimodal network flow models especially considering the growing importance of car sharing, cycle sharing, cooperative freight transport systems, and other technological developments that influence network flows such as autonomous vehicles.

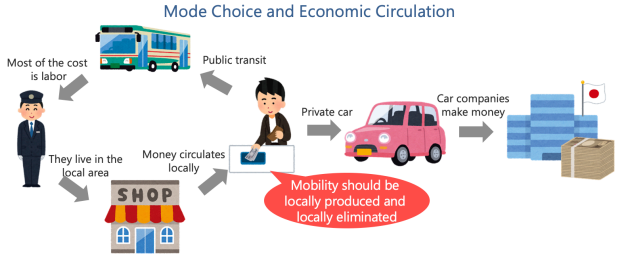


Analysis of the multifaceted impact of transport behavior

Transportation is a physical phenomenon in which people and goods come and go, and its optimization and efficiency are indispensable for realizing a prosperous society. On the other hand, it is more than just a physical phenomenon. In addition to the fact that economic activities are stimulated by the revitalization of transportation, transportation behavior itself influences the local economy, as shown in the figure below.

The economic impact also differs depending on whether people visit a national chain store or a local store, for example, and such differences in behavior also affect the formation of cities and societies. In addition, contact with people and scenery during transportation also affects people's psychology, and may influence their attachment to the city and the formation of their personalities.

Thus, our research is not limited to mere efficiency improvement, but also includes a multifaceted analysis of the effects of transportation on transportation, cities, and society.



Travel Behavior Analysis

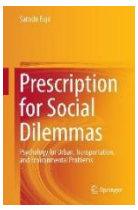
Professor	Associate Professor	Associate Professor	Assistant Professor
Satoshi FUJII	**Jan-Dirk Schmöcker**	**Yuichiro KAWABATA**	**Toshiya OBATA**

Pragmatic Social Science Studies for Solving Problems in Urban Planning, Travel Behavior and National Resilience

Social science was originally a field of integrative and pragmatic studies to address various social issues that arose during modernization. However, over 200 years since the dawn of the modern age, the "siloing" (deep specialization) of social sciences has made applying those findings to actual problem-solving difficult. In the real world, social problems exist as multidimensional phenomena and are not split to fit a researcher's specialty. Our lab has been working on pragmatic social science research to address problems in urban planning, travel behavior management, and building national resilience based on the understanding of the multidimensional nature of humans and society.

Comprehensive Approach to Resolve 'Social Dilemmas' in Urban &Transportation Contexts

Various social issues such as environmental pollution, deterioration of urban landscape, traffic congestion, and overtourism are caused by 'social dilemmas' where individual interests like seeking convenience or personal preferences conflict with collective societal benefits. Our laboratory investigates the social and psychological mechanisms behind these problems, as well as the structural challenges within transportation networks, urban systems, and institutional frameworks, aiming to overcome these social dilemmas while exploring more desirable urban and transportation systems. Specifically, we work on establishing attitude and behavior change methods based on social psychology, modeling transportation and tourism demand using crowdsourced data, and proposing effective use of shared mobility and micro-mobility solutions. Our methodology incorporates diverse techniques beyond statistical data analysis and mathematical modelling, including fieldwork, case studies, and institutional analysis to approach these issues comprehensively.



Prescription for Social Dilemmas (Fujii, 2017)

A case study of “resident-led” regional mobility management

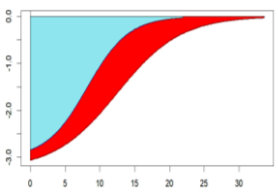
Social Psychological Research on the Mindset Necessary for the Maintenance and Development of Civil Society

In tackling problems at the urban, regional, national, and even global levels, people's 'sound mindsets' is often indispensable. Regardless of well-established legal systems, sufficient funding, or new technologies, desirable outcomes may not be achieved without citizen's morality, ethics, problem-solving vitality, and a calm sense of balance. Of course, defining a good mentality, attitude, or sense is not an easy task, nor are the ways to cultivate these mindsets straightforward. Thus, our research focuses on fundamental analyses, using empirical data, to examine whether factors such as regional attachment or religious sentiments can foster problem-solving in society and to understand the psychological mechanisms underlying issues such as political apathy, excessive pursuit of political correctness, and the naive acceptance of conspiracy theories.

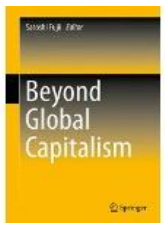
A field study on the vitality for maintaining traditional community and local landscape

Macroeconomic Policies and Land Planning Strategies for Enhancing 'National Resilience'

Enjoying satisfying cultural lives in urban and regional societies largely depends on the overall economic growth and crisis management capabilities of our nation. Especially in the current context, securing "National Resilience" is an urgent task in preparation for large-scale natural disasters, financial crises, geopolitical conflicts, and the declining birthrate and aging population. For this purpose, this lab focuses on disaster prevention, macroeconomic policies to enhance growth measures to mitigate the "over-concentration in Tokyo" for balanced land use, and the integration of land planning and defense strategy. We are also actively working on proposing policy suggestions to national and local governments and sharing the key findings through journalism and public symposiums.



An estimation of the economic damage from an earthquake and the recovering process



Beyond Global Capitalism (Fujii, 2015)

DISASTER RISK MANAGEMENT

Associate Professor
Yoko MATSUDA

Research on better communication among diverse stakeholders for effective disaster risk management

The laboratory is interested in the dialogue among citizens, experts, policy makers, NPOs, and other diverse actors in order to create a city that is comfortable for people to live in and that is resilient to disasters. Part of this research falls within the field of infrastructure planning, and part within the specialized field of disaster risk communication. While our research approach emphasizes field research and field experience, we also value an international research environment.

Research on resilient communities based on human independency

Evacuation and mitigation behaviours are not solely recalled by his/her individual intention, but is also care-oriented, based on concern for others, interdependence, and response. We conduct research on evacuation policies and community planning based on the assumption that all human beings are vulnerable and need to depend on others. For example, rather than establishing a vertical relationship between experts and citizens, the experts provide information on flood risks through dialogue between the two, while the experts carefully learn about the process by which residents decide to evacuate and apply this information to their own reflections. This is called a process of mutual social learning.

Figure 1. A concept of social co learning

Local knowledge adaptation and knowledge management for disaster risk reduction

It is essential to adapt local knowledge for disaster risk reduction and reconstruction processes from disasters. However, local knowledge exists as tacit knowledge or people are unaware of its existence and value, so that it is challenging to manage them intentionally.

On the other hand, expert knowledge accumulated through past experiences is also indispensable for recovery from disasters and reconstruction of people's lives. It is also necessary to consider how to communicate this knowledge in an easy-to-understand manner to citizens who rarely experience disasters.

The lab pursues on the design to communicate such local and specialized knowledge in disaster risk reduction that can be truly implemented in our society, as well as ways to involve local residents in the process.

Recent research results include the development of a new tool for risk communication by reorganizing the specialized knowledge necessary for flood victims to rebuild their lives from the perspective of the affected citizens (Figure 2), and the finding that conversations among residents on social networking services (SNS) that encourage evacuation can be as effective as official evacuation information in influencing people's willingness to evacuate.(Figure 3).

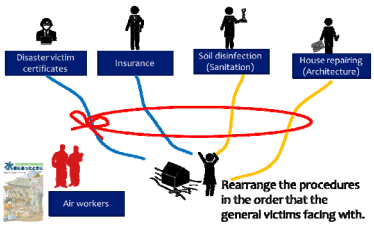


Figure 2. Concept of a risk communication tools through reorganization of experts' knowledge

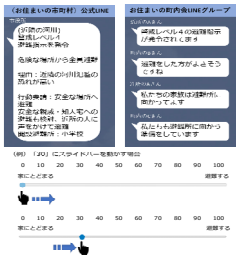


Figure 3. A survey of willingness to evacuate

Improving Resilience to Natech Risks

Given the potential severity of Natech accidents, a way to systematically rate improvements towards risk reduction goals, while strengthening business continuity and territory resilience is needed. We propose an area-wide comprehensive Natech risk management framework to assess and manage risks, protect residents, and ensure business continuity leading to an increase in territorial resilience.

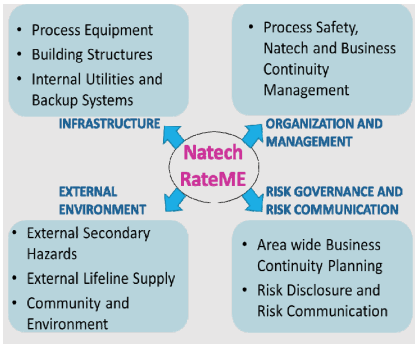


Figure 4. Area-wide Natech risk management framework.

Integrated Disaster Risk Management Systems

Professor
Hirokazu TATANO

Associate Professor
Subhajyoti SAMADDAR

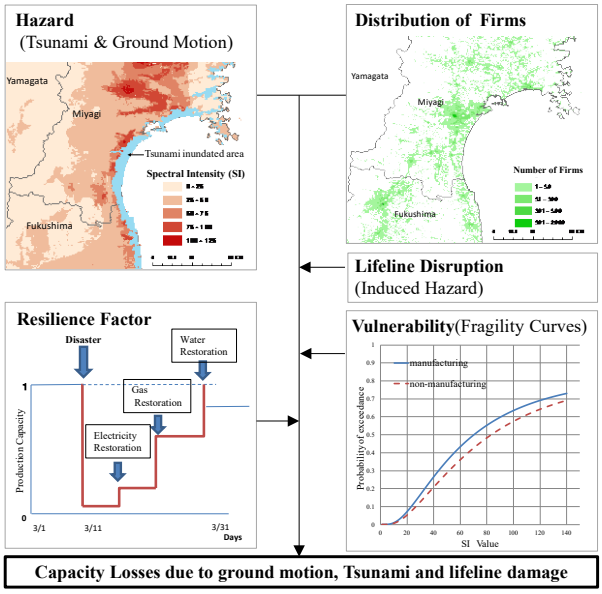
Associate Professor
Toshio FUJIMI

Social Systems for Disaster Risk Governance

To realize a safe and secure society, integrated disaster risk governance is a key infrastructure which supports design and implementation of management policies consisting of risk control and financing. Considering disaster risk governance and/or management, public involvement and participatory approach to planning are essential frameworks. Our laboratory focuses on human behavior before/during/after disasters and aims at constructing original methodologies for efficient integrated management of disaster risk. It also aims at establishing a comprehensive mechanism for successful implementation of disaster risk reduction strategies through better risk communication.

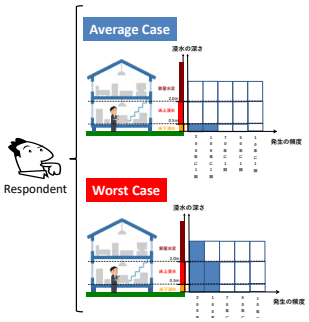
Economic Impact Assessment of Natural Disaster

In order to enhance social resiliency against natural disaster, it is necessary to introduce integrated disaster risk management measures effectively. Establishment of methodology for design and estimation of effective alternatives against disaster is requested. In our laboratory, consistent measurement of economic losses of a natural disaster considering the problem of double counting is promoted. For evaluation of the overall economic impact of a natural disaster considering the recovery process, attention needs to be paid to the problem of double counting of economic losses. For this purpose, it is necessary to answer the following research questions: (1) how does a natural disaster impact the economy at each phase of the disaster and recovery, and (2) how do you consistently evaluate overall economic losses of all stakeholders during the recovery process. Methods for avoiding double counting of losses are referred to as “consistent measurement” of economic losses and have been increasingly studied recently.



Economic Evaluation on Risk Mitigation Measure under Uncertainty

Scientific prediction of natural disaster risk includes uncertainty due to insufficient knowledge or the relevant data. Our research aims to develop a method to estimate economic value of risk reduction measure under uncertainty. For an example, we estimated a decision model under uncertainty by using household choices data on hypothetical insurance with average and worst predictions of disaster risk.



Risk Communication and Community Based Disaster Risk Management

Community preparedness and community participation in disaster management are considered cornerstones to realize the vision for disaster resilient community. In practice, however, local community are left unsolicited and their preparedness remains unrealized. This calls for better risk communication and risk governance.

Our research endeavors, therefore, encompass in following areas: (i) Household Preparedness and Risk Communication (ii) Evaluating Community Participation in Disaster Risk Governance.

Integrated Disaster Reduction Systems

Professor
Katsuya YAMORI

Associate Professor
Genta NAKANO

Interdisciplinary approach to disaster reduction

We commit to contributing to disaster risk reduction by implementing various policy approaches from the both of social and natural scientific point of view. Particularly, we emphasize the aspect of social psychology to establish information system, education methodology and culture for disaster risk reduction. In addition, we are also oriented to develop the effective inter-local transfer approaches of disaster risk reduction.

Building Implementation Science of Disaster Reduction

Implementation science should be developed and implemented in a scientific manner. Because implementation deals with how well scientific knowledge is implemented in an arena in which more diverse stakeholders rather than only limited number of scientists join, knowledge of implementation science by itself should be developed in a more dialogical and more discursive way. In other words, implementation science is a process to (re-)co-construct knowledge networks in which multiple locally and/or temporarily "viable solutions" co-exist and are mutually interlinked, rather than a process to identify universally "correct solutions" exclusively by scientists.

Thus, we need to create a new-type of communication medium by which people can see a society, not as a world where a single "correct solution" is specified by privileged persons, such as a professional scientist, an influential politician, or an talented administrative government officer, for example, but as a debatable, conflicting, and dilemmatic world, and thus, a world where multiple "viable solutions" can coexist.

Concrete Research Targets

The followings are seven major research targets:

1) Promoting citizens' participatory disaster management system in a local community.
2) Developing disaster education tools and methods to be used at a school and in a local community.
3) Developing countermeasures to reduce damages caused by big and complicated disasters like the Nankai Trough earthquake and tsunami, the earthquake in Tokyo Metropolitan Area and large-scale eruption of Mt. Sakurajima.
4) Building a crisis management system for catastrophic natural and man-made disasters.
5) Analyzing disaster information from the viewpoint of social sciences such as mass media studies, risk communication studies, and narrative theory.
6) Creating theoretical foundation of implementation science in disaster reduction studies.
7) Developing computer simulations to estimate damages caused by the Nankai Trough Earthquake and Tsunami
8) Building effective strategies for inter-local development of disaster risk reduction practices

Fig.1 Examples of disaster education materials, "Cross road," and "Nige-tore," developed in the laboratory

Fig. 2 Examples of field studies implemented by the laboratory.

Crisis Information Management Systems

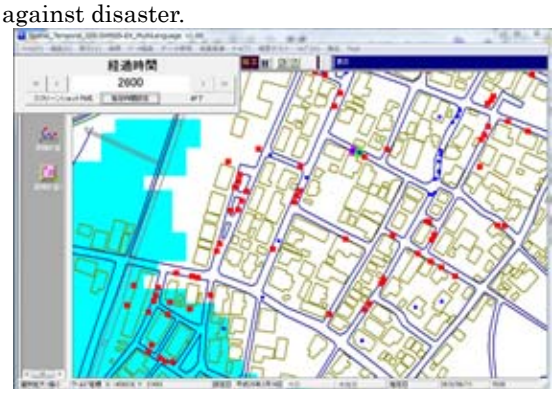
Professor **Michinori HATAYAMA**
Associate Professor **Kei HIROI**

Disaster Information Systems with Information Technology

After Great Hanshin-Awaji Earthquake in 1995, Rapid and remarkable advances have been made in Information Technology (IT). A number of advanced information systems were proposed, but most of them didn't work sufficiently as we expected under disasters. Our goal is to establish design methodologies for development of effective disaster management systems against various types of disaster for National/Local Government, local communities in affected areas and disaster relief organizations. One of the most important key technology is spatial temporal database to record, visualize and analyze current/near future status in affected areas. In addition, our laboratory focuses on human behavior before/during/after disasters as targets to supply valuable services

Disaster Management / Response Support System based on Advanced IT

Our goal is to submit efficient information system considering human behavior for disaster prevention and mitigation. In our laboratory, we have been developed several disaster management systems such as evaluation of regional disaster response plan and Tsunami evacuation plan and IoT based Early Warning System for sediment disaster and tried to implement them to local governments and regional communities to improve their coping capacities against disaster.



Tsunami Evacuation Evaluation System
as a disaster risk communication tool

Development of Spatial Temporal and Parallel world Shared Information Platform to realize RARMIS Concept

Through the experience with disaster and recovery support activities obtained as a result of Great Hanshin Earthquake, our research group have been developing an information system that can use after immediately a disaster in local governments and their surroundings, such as regional communities, and studying implementation processes to them. RARMIS (Risk-Adaptive Regional Management Information System) concept is an output of these activities. In the concept for disaster risk management we proposed an information system which has these three features; (1) continuity between emergency and routine use, (2) independence and decentralization, and (3) integrated space and time information.

We have already implemented database management system for routine and emergency work in local government. However, fundamental technology is evolving day by day. We try to submit a next generation system which replace system which we have developed.

Cutting-edge Data Analysis Methods / Data Federation Platforms that are Compatible with the Real World

AI, big data, and IoT have come to be common in every situation. However, it is difficult to use such convenient technology in an emergency. The data that can be collected in a disaster is limited. This research proposes a system that enables stable data collection even in a disaster, and an analysis method for precisely predicting damage from limited data using the cutting-edge IT. Another goal is to research and develop superior IT that is compatible with real world and IT development. Another goal is to research and develop superior IT that is compatible with real world and IT development. It is important that the system or technology can actually be used. We are carrying out technical and social development of system architecture that enables high-speed/performance calculation processing even in an environment with many restrictions, network protocols and cyber-physical systems that realize data federation of various systems and simulations.

Data Federation Result of Simulator in Flood Situation