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)

Structural Dynamics (構造ダイナミクス分野)

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)

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

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)

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)

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

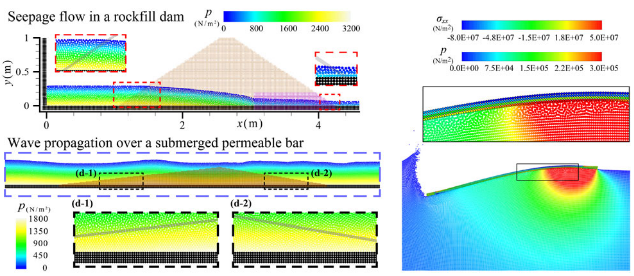


Fig. 1: Multi-physics simulations by particle methods (FPI and FSI) in coastal and ocean engineering

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.

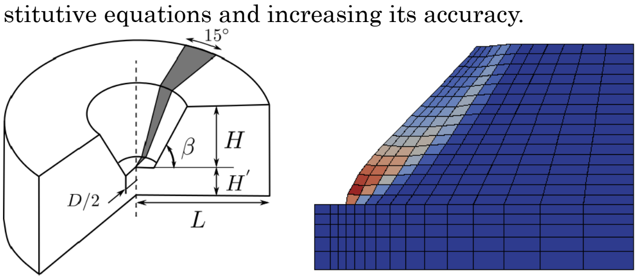


Fig. 2: Stability analysis of excavation

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.

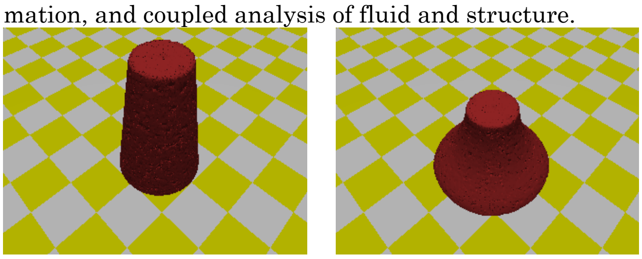


Fig. 3: Simulation of concrete slump test

Structural Materials Engineering

Professor
Takashi YAMAMOTO

Assistant 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 wavenumber 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.

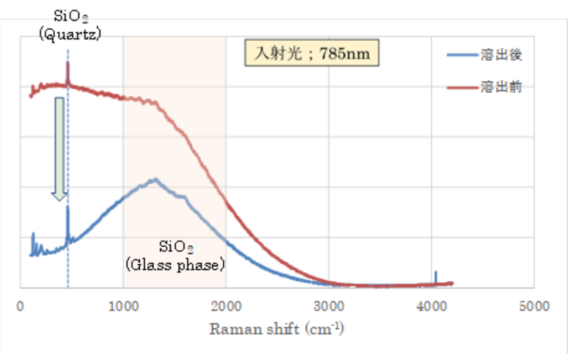


Fig.1 Comparison of Raman spectrum of aggregate before and after dissolution test

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.

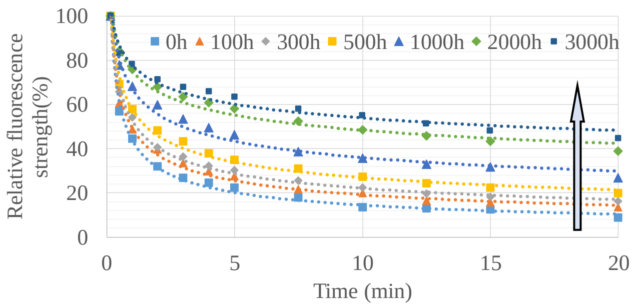


Fig.2 Change of photo breaching curve of an organic coating material due to deterioration propagation

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
Yasuo KITANE

Assistant Professor
Yoshinao GOI

Assistant Professor
Risa MATSUMOTO

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.

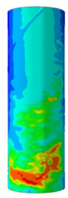
Research focuses on the load carrying and degrading mechanism, the performance evaluation, the rational and life-cycle design of steel, steel-concrete composite and FRP bridges. Fundamental characteristics of these structures are evaluated by advanced loading tests and versatile numerical simulations.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

New type of steel pier with steel pipes

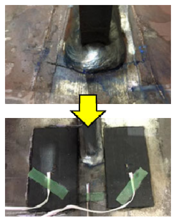
FRP pedestrian bridge

Remaining Load Carrying Capacity of Steel Structures and Repair Methods

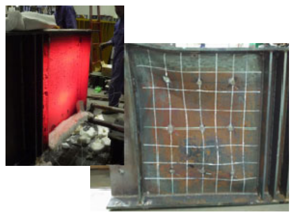
Steel structures will deteriorate over their service lives, and most frequent damages are corrosion and fatigue. Therefore, it is important to evaluate remaining load carrying capacity of steel structures based on periodical inspection results. Also, the evaluation of remaining load carrying capacity 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

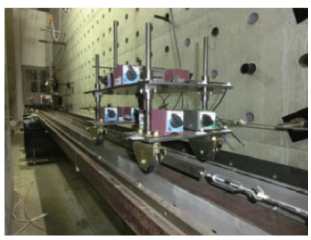


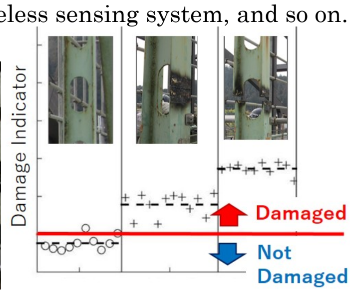
Heated steel girder after shear test

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 and symbiosis of urban space.

Research focuses on the analytical technique that can cope with the structural change such as corrosion and fatigue crack formation; that is the effective thickness evaluation of the corroded steel members and the fatigue crack extension of steel structures under repeated traffic loading. In addition, nondestructive evaluation of structural integrity, or limited destructive test methodology also have been undergoing; such as solving environmental vibration problems due to traffic-induced vibration of bridge structures; short- & long-term bridge health monitoring (BHM); and developing a novel wireless sensing system, and so on.





Bridge Engineering

Professor
Tomomi Yagi

Associate Professor
Hisato Matsumiya

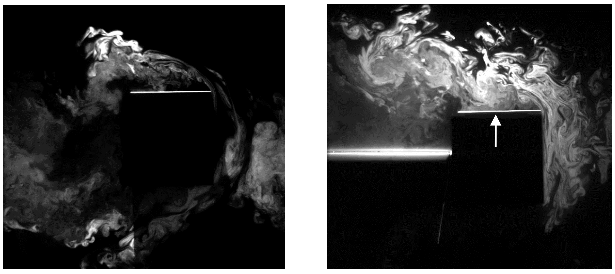
Assistant Professor
Kyohei Noguchi

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

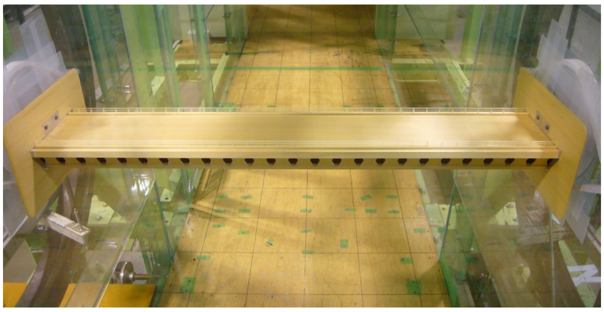
It is important to investigate the aerodynamics of fundamental cross sections such as circular and rectangular cylinders for advancing researches in the aerodynamics of actual bridges. The interactions between the vortex shedding and motion-induced forces are a very complex problem due to their unsteady 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

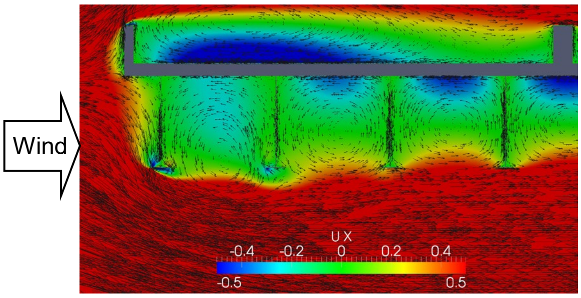
Wind-induced vibration of cable structures

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

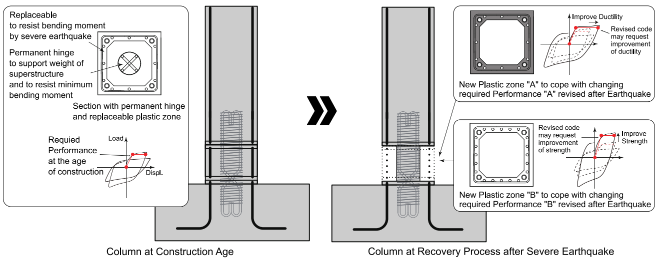
Earthquake Engineering and Structural Dynamics

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.

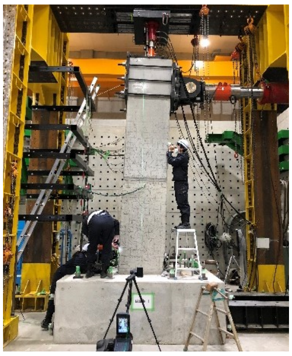
Seismic Performance of Infrastructures

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

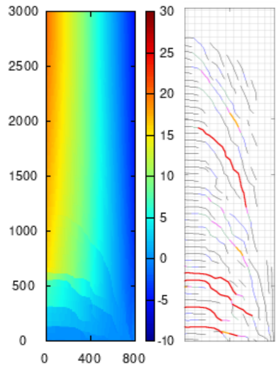


Loading test of a large RC column specimen

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

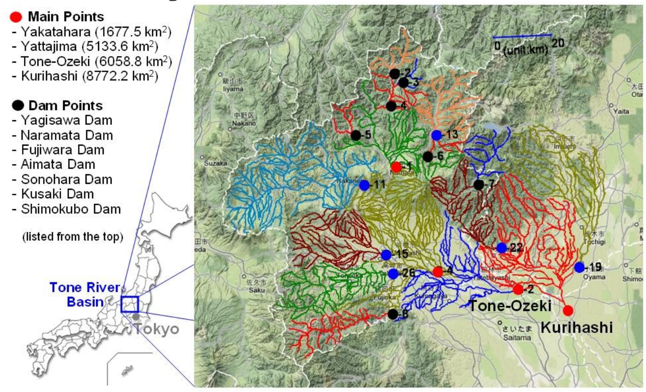
Jr. Associate Professor
Kai-Chun CHANG

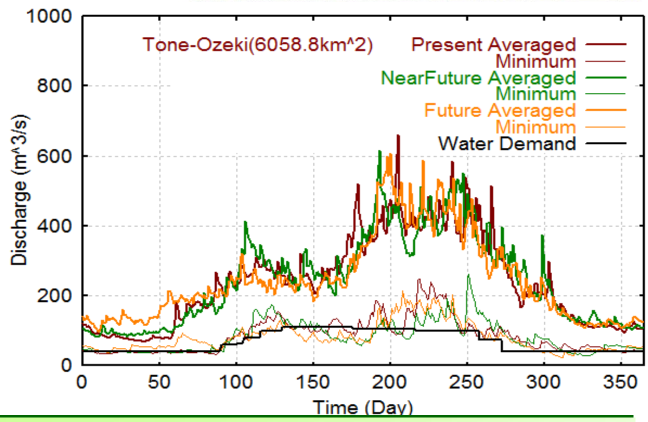
Climate Change Impact Analysis on Hydrologic System, And Health Monitoring of Bridge using Vehicle Vibrations

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).



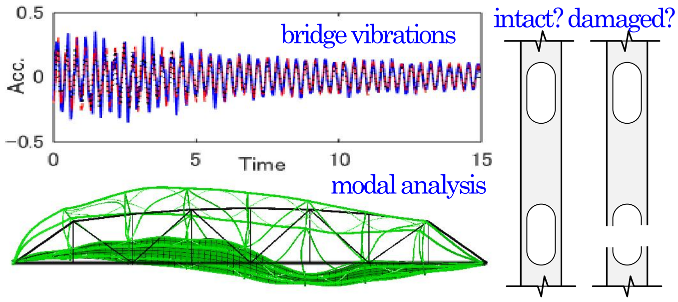


Realtime Flood Forecasting with Weather Radar Observation

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.

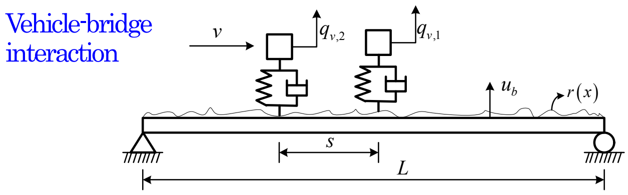
Bridge Modal Analysis & Damage Detection using Traffic-Induced Vibrations

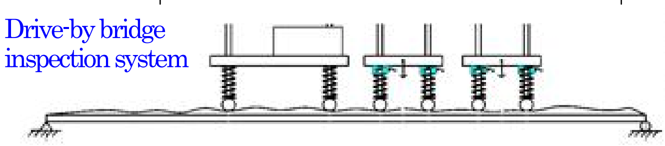
Bridge damage detection has become an important research and engineering issue in facing the pressing problems of aging bridges. Our study focuses on detecting potential damage in short- and medium-span bridges using their daily traffic induced vibrations. Effective indicators are extensively investigated, 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
Kunitomo SUGIURA

Associate Professor
Lin AN

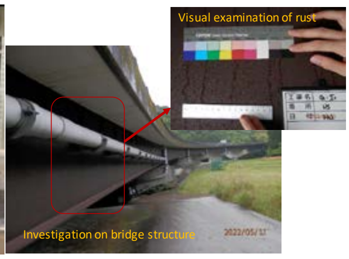
Development of New Structures Management

It is important to maintain performances and functions of our infrastructures to achieve their long service life and to reduce negative environmental impact in order to establish our social sustainability. With focusing on high performance materials as well as steel, concrete and other traditional construction materials combined together effectively, this laboratory works on developing rational design, durable service life, strategic maintenance and management under low negative environmental impact.

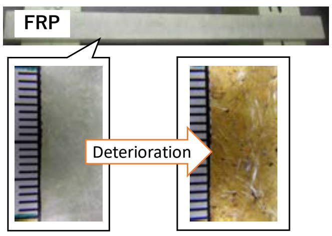
Mechanical behaviors, environmental impact and durability of structural materials

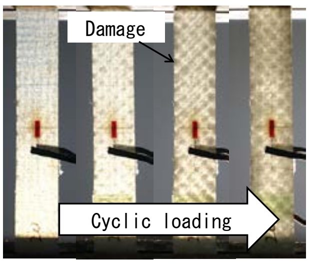
Mechanical behaviors, environmental impact and durability of high performance materials, recycled materials as well as traditional materials are investigated and evaluated.

Evaluate the performance of geopolymer concrete with low environmental impact



Examine the long-term performance of weathering steel without paint coats

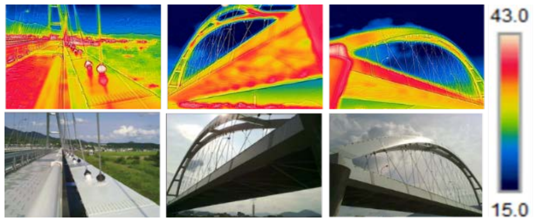




Evaluate aging and fatigue damage of fiber reinforced polymners (FRP) and reveal its effect on mechanical behavior

Inspection and deterioration prediction of existing infrastructures

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

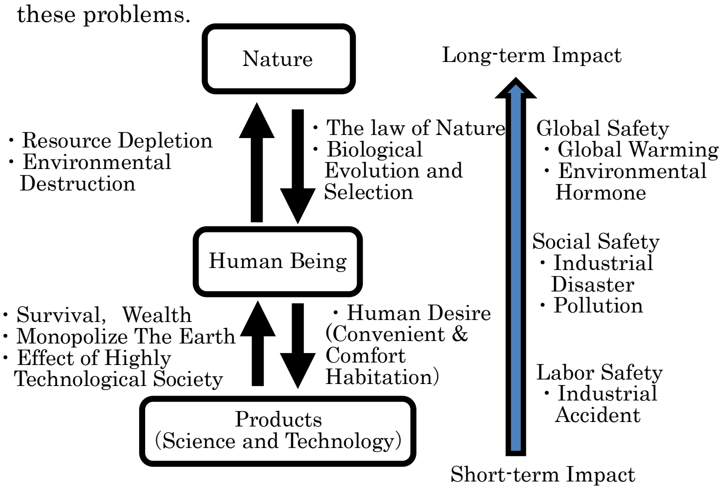


NDT technique for checking health condition of infrastructures by infrared camera

Check the health condition of the structure by deflection and 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

Associate Professor
Aiko FURUKAWA

Toward Effective Earthquake Disaster Mitigation Measures

Earthquakes cause damage to our built environment and disrupt out social systems. Infrastructure, such as water, gas, electricity, communications and transportation systems are not independent but rather complexly interact with each other. Therefore, even if only a part of the infrastructure is damaged, the urban community can sustain serious damage and functional disruption. Our laboratory covers a broad field, from the estimation of strong ground motion in the near fault zone, to the investigations of the mechanisms of structural damage, human injury and organizational disruption. Our goal is effective earthquake risk reduction, accomplished via analysis of the earthquake loss chain of causation, and development of effective mitigation measures for each link in that chain.

Evaluation of Ground Vibration Characteristics by Microtremor Observation

Earthquake damage is influenced by the vibration characteristics of the surface ground, which is dependent on the sediment conditions such as sediment thickness and soil profiles. Understanding the surface ground characteristics is very important form the point of view of the earthquake disaster mitigation. The microtremor observation is a promising tool to understand the surface ground in the non-destructive manner. We are investigating the effect of ground vibration characteristics on the earthquake damage by the on-site microtremor observation after the earthquakes.

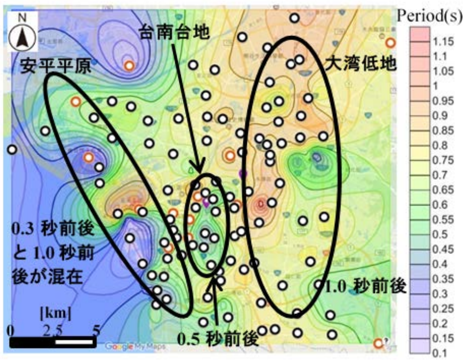


Fig. 1 : Predominant natural period distribution in Tainan city evaluated by microtremor observation

Analysis of Failure Phenomena of Masonry Buildings during Earthquakes

It has been reported that catastrophic earthquakes account for 60% of worldwide casualties associated with natural disasters. In most large-scale earthquake disasters, the principal cause of death is the collapse of buildings, and this has accounted for about 75% of earthquake fatalities over the last century. In addition, a large number of victims have died because of the collapse of masonry buildings. Therefore, it is necessary to improve the earthquake resistance of these primarily weak structures to reduce the number of casualties. With this background, a new numerical analysis method that enables the simulation of a series of seismic behaviors—from elastic to failure to collapse behaviors—is developed in order to clarify how the failure begins and proceeds, how the structures collapse, and how earthquake resistance can be improved effectively.

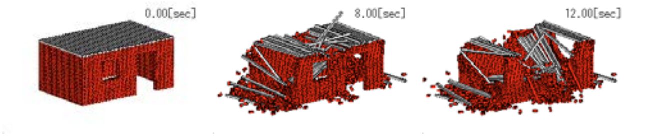


Fig. 2 : Failure process of masonry structures

Development of cable tension estimation methos based on vibration measurements

Cable-stayed bridges and other cable structures support loads by cable tension. Since each cable has its own load-bearing capacity, it is necessary to confirm that the tension of each cable does not exceed the load-bearing capacity in the maintenance. In practice, the higher-order vibration method is widely used to estimate the tension from the natural frequencies of the cables. However, the higher-order vibration method cannot be used directly for cables with dampers or crossed cables in the Nielsen-Lohse bridges. Therefore, we are developing tension estimation methods that can be applied to cables with dampers and crossed cables for the efficient maintenance of cable bridges.

Fig.3: CG image of cable-stayed bridge

Dynamics of Foundation Structures

Professor
Hiroyuki GOTO

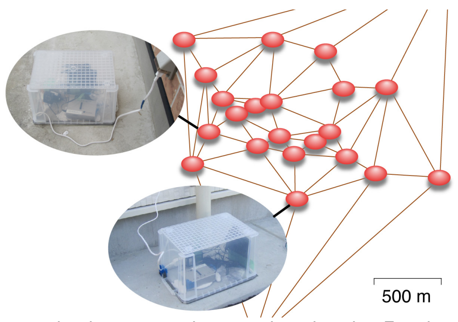
Pursuit of earthquake disaster science and development of next-generation technologies for earthquake disaster mitigation

In order 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.

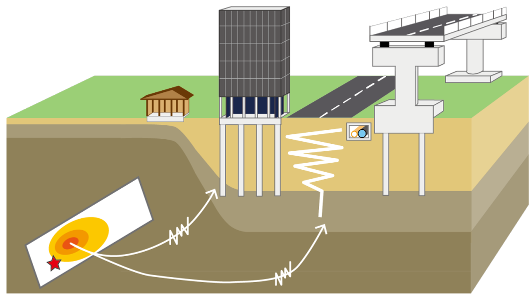
Theoretical investigation of earthquake disaster mechanism

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 as a whole. In order 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.



Super-dense seismic array observation in the Furukawa area.

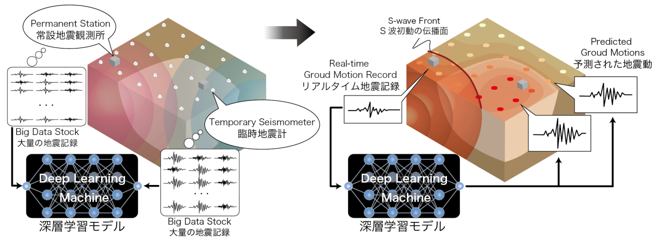


Conceptual diagram of research targets in the field of earthquake engineering

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 the 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

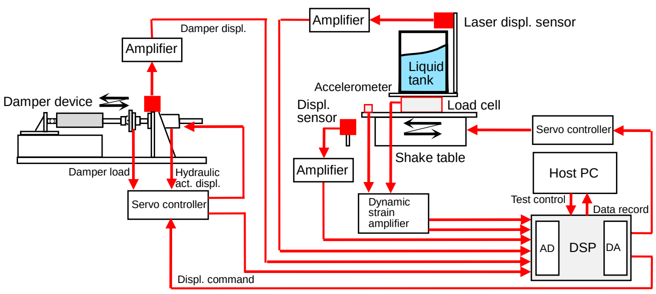
Associate Professor
Nozomu YONEYAMA

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

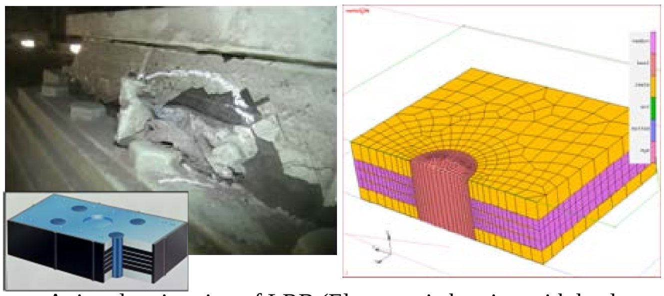
Implementation of advanced experimental systems based on the real-time hybrid simulation is investigated. In this unified testing-computing dynamic simulation, response calculation of the numerical substructure with computers and dynamic loading test of elements using shake tables or dynamic actuators, 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.



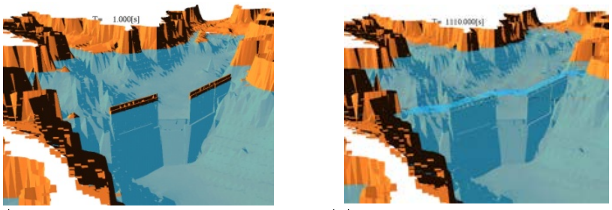
Aging deterioration of LRB (Elastomeric bearing with lead plugs) and numerical analysis

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.

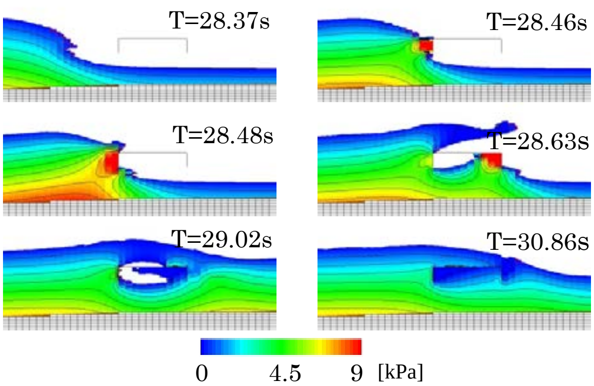


(a) Before tsunami attack (b) Time of tsunami attack

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

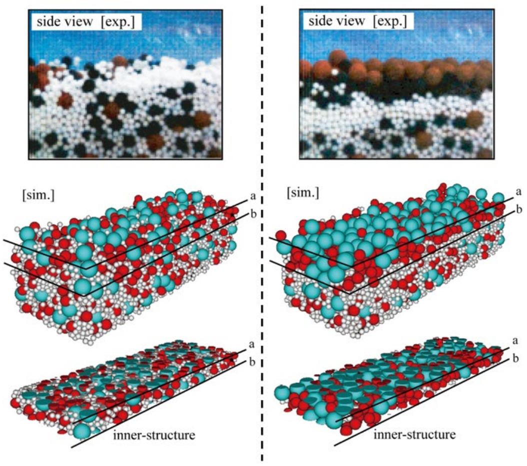
Professor
Eiji HARADA

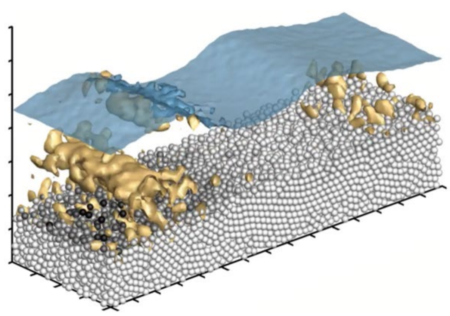
Investigation of movable bed dynamics using particle - fluid computations and multiphase turbulence measurements

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.

Computational Sediment Hydraulics by DEM-CFD

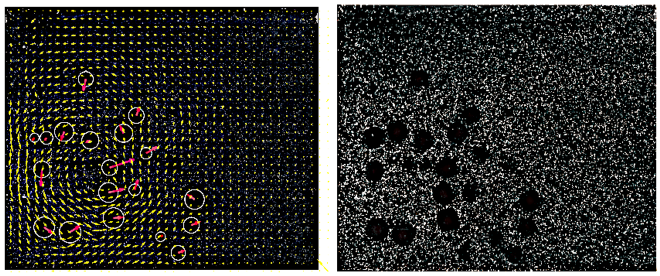
Sand particles on river and coastal bottoms are strongly influenced by the surrounding flow field, and a solid-liquid multiphase turbulent flow field with changes in particle configuration and porosity is formed on the moving bed surface. In order to investigate the flow mechanism of movable beds from 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 numerical movable bed simulation results using a granular material model: [upper] grading process under oscillatory flow conditions, [lower] vortex structure in the surface layer of a moving bed under resonance conditions.





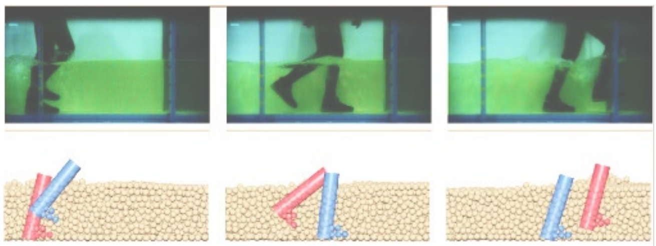
PIV Measurement of Multiphase Turbulent Flow by RIM-PIV

Understanding solid-liquid multiphase turbulent transport in movable bed physics requires information on the turbulent field in the vicinity of the moving bed, and multiphase turbulence measurements using PIV require laser sheet light to be transmitted into the movable bed. The figure below shows an example of the sedimentation process of a group of beads in water using refractive-index-matched PIV. This type of information is expected to be useful as the basic data for the development of multiphase turbulence models for movable bed simulations.



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 [upper] an image of an underwater walking experiment and [lower] an example of coupling between a walking model considering a below-knee posture and fluid calculation using the particle method.



Hydrology and Water Resources Research

Professor
Yasuto TACHIKAWA

Assistant Professor
Tomohiro TANAKA

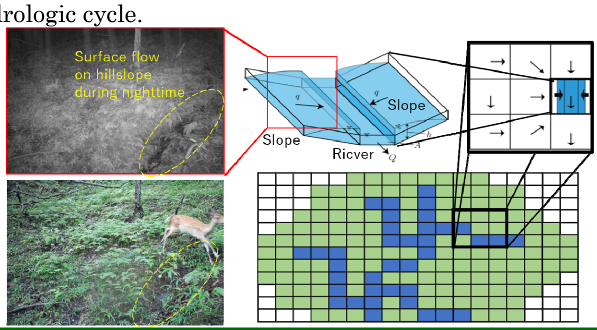
Assistant Professor
Aulia TINUMBANG

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.

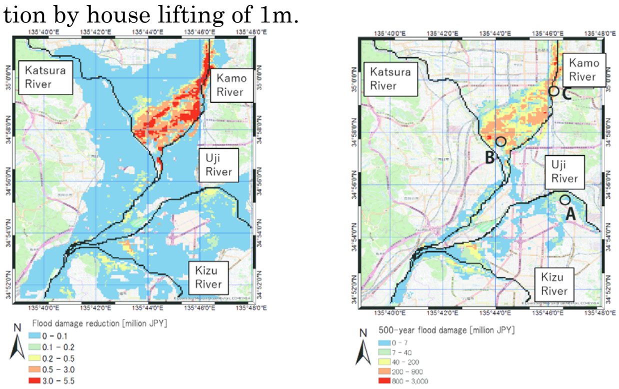
Analysis and numerical modeling of hydrologic processes

Understanding the hydrologic cycle is the basis for river planning and mitigation measures against water-related disasters. We analyze hydrologic phenomena in various aspects and improve our understanding of the hydrologic cycle.



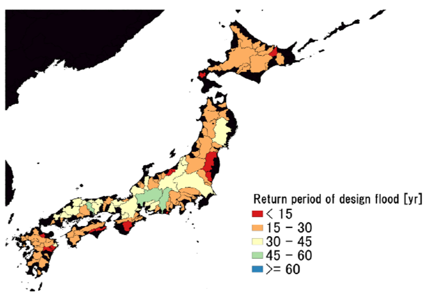
Flood risk assessment for local-scale integrated flood risk management

We develop a framework of local flood risk assessment with probabilistic modelling of various types of extreme rainfall, a large number of flood-inundation simulations and flood damage estimation. In the Kyoto Basin, we evaluate on-site flood risk (e.g. 500-year flood damage in the left bottom panel), based on which integrated flood risk management including urban planning is analyzed (e.g. the right bottom panel shows annual flood damage reduction by house lifting of 1m.



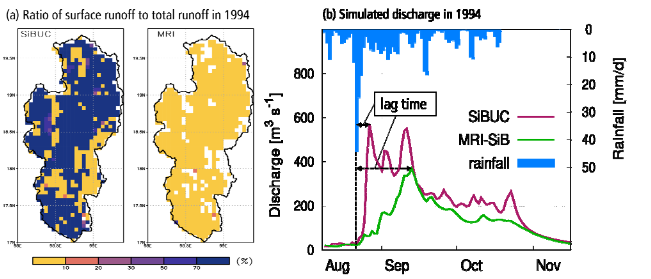
Climate change impacts on floods and water resources

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. In particular, 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.



Land surface modeling for water resources assessment

We develop a sophisticated land surface model (LSM) which can consider human activities to predict future change in water resources. We conduct model intercomparison to improve our understanding in modeling hydrological process and enhance the model's prediction. The bottom figures present intercomparison results showing the difference in estimated runoff (left) and streamflow (right) between our model and the LSM developed by Meteorological Institute in a catchment in Thailand.



Urban Coast Design

Professor
Hitoshi Gotoh

Assistant Professor
Hiroyuki Ikari

Assistant Professor
Yuma Shimizu

Simulation engineering by Lagrangian particle method

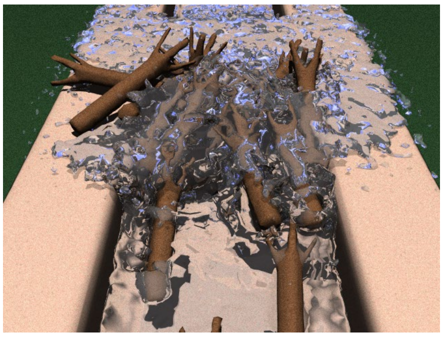
A leading technology in computational science of fluid flow (solid-gas-liquid multiphase flow) by using particle method is developed for dynamics of violent flow. We aim for establishment of the methodology of computational science and engineering, to describe various phenomena in civil engineering by 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 flooding in a girder bridge across a mountain stream due to drift woods.

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.

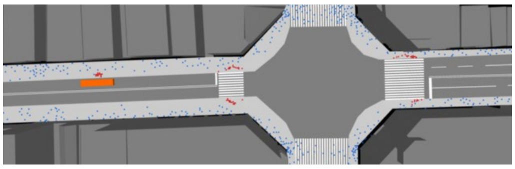


Computational Sediment Hydraulics by Multiphase Flow Model

Understanding of the dynamics of the movable bed is indispensable for both river and coastal engineering. In our laboratory, to address phenomena regarding the movable bed from computational point of view, 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

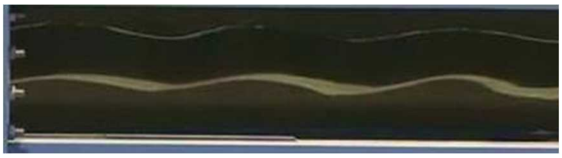
Associate Professor
Shinichiro ONDA

Towards Building a Sustainable Society

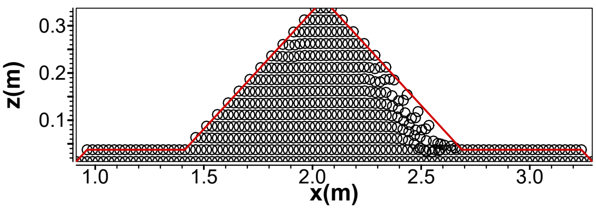
To address various water issues in river basins and cities, it is necessary to consider complicated interactions between nature systems and socio-economic activities. Towards building a sustainable society maintaining a favorable natural environment, we study river flow dynamics including bed deformation, hydrological processes in river basins, hydraulic/hydrological simulations and their applications for river basin management.

Modeling River Dynamics and its Application to Channel Management

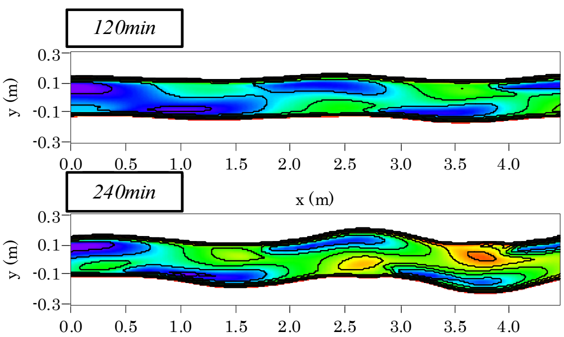
It is of great importance to develop a numerical model of river flows and sediment transport, to predict water stage during floods and river bed deformation and to design a stable channel as well as ecological issues. We have been developing various kinds of computational models for a prediction method. Various sand waves are formed over a river bed in response to hydraulic conditions. The experiments are carried out, to examine a formation process of sand waves, and antidunes are observed in the following photo.



This figure shows the simulated soil deformation on the back side with reduction of effective stress due to seepage flows.



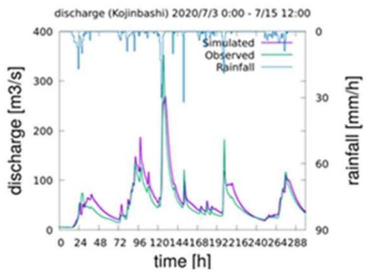
This figure shows the simulated results on the initiation of river channel meandering caused by the generation of alternative bars and flow meandering with bank erosion.



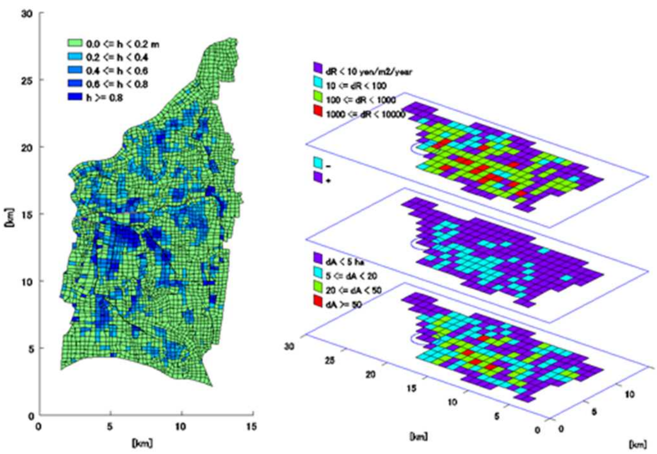
Modeling Hydrological Processes and its Application to River Basin Management

Rainwater flows through a variety of pathways in a basin. Water flows out quickly from an urbanized catchment, while groundwater flows slowly. Exploring and modeling various water flows in river basins are critical keys to investigate countermeasures for water issues.

Many factors influence hydrological processes in river basins, including topography, geology, and land use. We develop computer models which incorporate the above factors. The right figure shows a river discharge simulation of the Kamo river in Kyoto city. The simulated discharge (the purple line) is in relatively good agreement with the observed one (the green line).



These models are used to investigate countermeasures for preventing and mitigating water problems. The lower left figure shows a maximum inundation depth map for a 40-year rainfall input, obtained by flooding simulations for Neyagawa river basin in Osaka. The lower right figure shows simulated changes of household location pattern assuming that land use regulations were implemented relevant to flood disaster risk. These results were used to investigate the validity of the regulations.



EROSION AND SEDIMENT RUNOFF CONTROL ENGINEERING

Professor
Kana Nakatani

Associate Professor
Syusuke Miyata

United research to produce safe sound sediment environment in river basin

In a sediment transport system from mountainous area through river area to coastal area, 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.

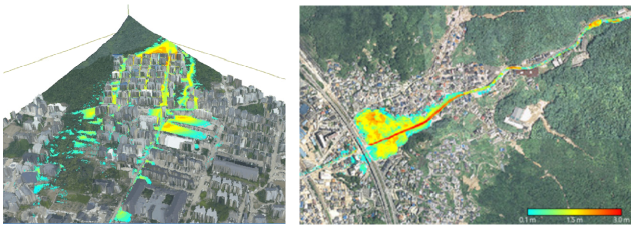


Fig. 1 : Debris flow simulation result(left) and sediment and flood damage simulation result (right).

The debris flows mechanism is not fully understood due to the severe phenomena. We conduct field observations of fine sediment contents within debris flows, which contribute to elucidating the debris flow mechanism and simulation models improvement.

Fig. 2: Observation equipment in debris flow-prone stream to observe the fine sediment content rate in debris flow.

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

Considering Safe Sediment Runoff Through Sediment Transport System

Capturing all the sediment runoff from mountainous area to coastal area through rivers with structures is difficult. Therefore, land use considering safe sediment runoff is required. Such as to capture large boulders and woody debris with sabo dams, control density and grain size and transport safely into bypasses and channels, and use some parks for sedimentation area.
Applying field surveys, observations, and simulations, we aim to consider safe urban development in cooperation with not only erosion control section but also rivers and reservoir sections.

Hydroscience and Hydraulic Engineering

Professor
Kenji KAWAIKE

Associate Professor
Hiroshi TAKEBAYASHI

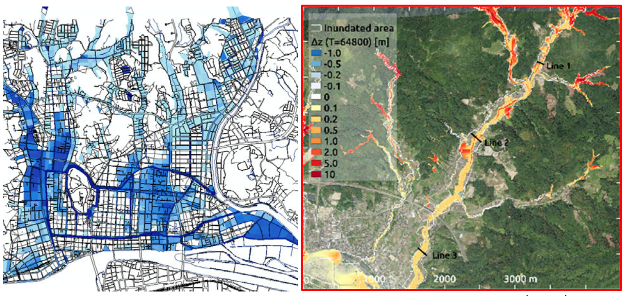
Assistant Professor
Kazuki YAMANOI
Takahiro KOSHIBA

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

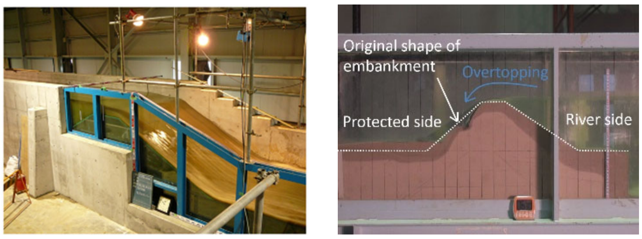
In our laboratory, to enhance hydraulic understandings of flood and sediment disasters, we have been trying to obtain data from observations and field survey. Also, we have been trying to develop more accurate numerical models to predict those phenomena of disasters using the data obtained. Those models would enable us to get significant information to evaluate the effect of flood prevention/mitigation measures such as evacuation systems. Furthermore, sediment produced by landslides during huge rainfall event cause topographical variation and increase the flood risk. We are trying to develop the simulation method of such series of phenomena, and applying to the disaster prediction and risk evaluation.



Simulation results on the inundation depth (left) and topological deformation (right).

Strength Evaluation and Maintenance Method of River Embankment

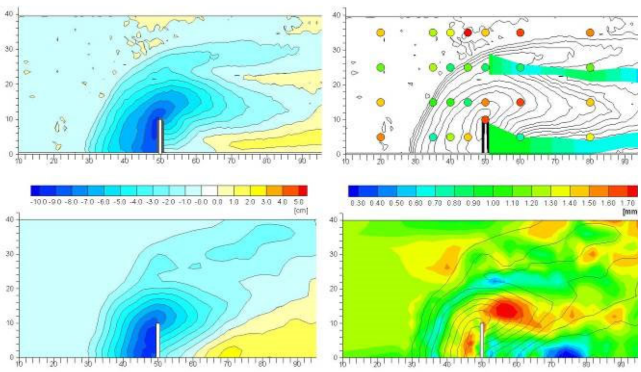
Recently, extreme floods frequently cause dyke breaches in rivers managed by central or local governments. As an urgent requirement, river dykes should be strengthened all over the country. We study the mechanisms of river dyke breach due to flood water overflow by carrying out model experiments. Based 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.



Experimental flumes for the river dyke breach (left) and landslide dam (right) in Ujigawa Open Laboratory

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.


Variations of bed topography (left) and particle size of bed material (right); experiment (above) simulation (below).

Hydrometeorological Disasters Engineering

Professor
Eiichi NAKAKITA

Associate Professor
Kosei YAMAGUCHI

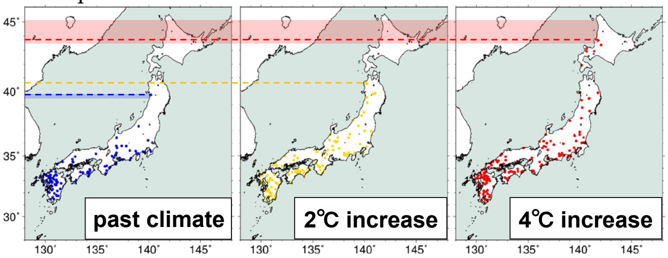
Assistant Professor
Yukari NAKA

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

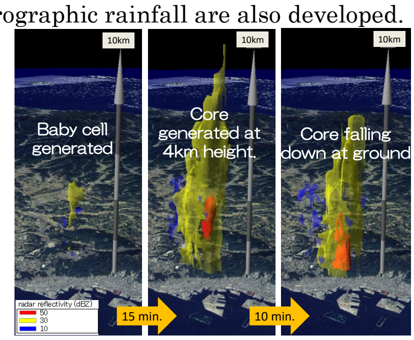
Multi-sensors observation toward the understanding of storm-genesis and its development is carried out at Keihanshin region and Okinawa. We have identified the structure of pairs of positive/negative vertical vortex tubes at the storm-genesis, and discovered a developing storm possesses a hierarchical 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.

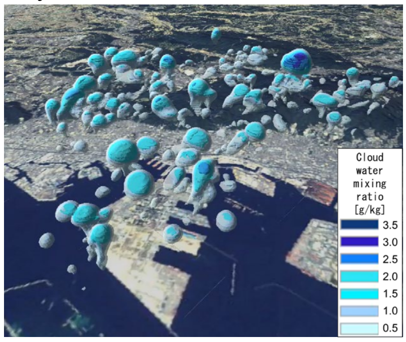
Flash flood at Toga river.



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
Nobuhito MORI

Associate Professor
Tomoya SHIMURA

Assistant Professor
Takuya MIYASHITA

Reduction of Coastal Disaster Risk

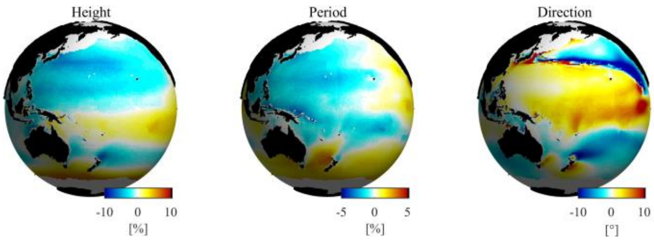
Modeling and Long-Term Assessment of Coastal Disaster Risk

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.

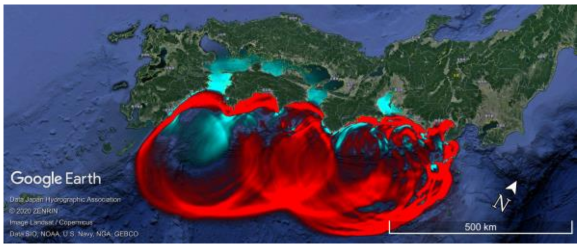


Future projected changes in ocean wave climate.

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.

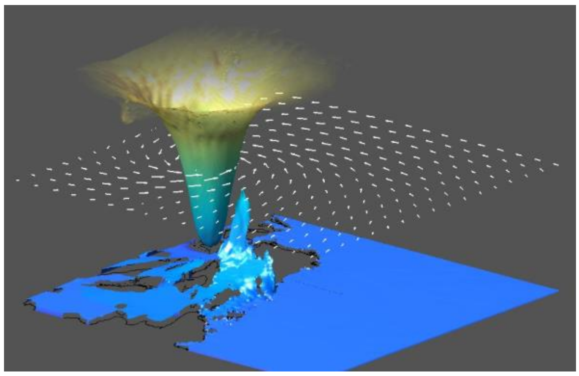
We have developed long-term assessment tools of megathrust earthquake tsunami, probabilistic tsunami hazard assessment model, and engineering technology for urban area inundation for tsunami disaster risk reduction based on the knowledge of the 2011 Tohoku Earthquake Tsunami.



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

Junior Associate Professor
Florence LAHOURNAT

Assistant Professor
Eva YAMAMOTO

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

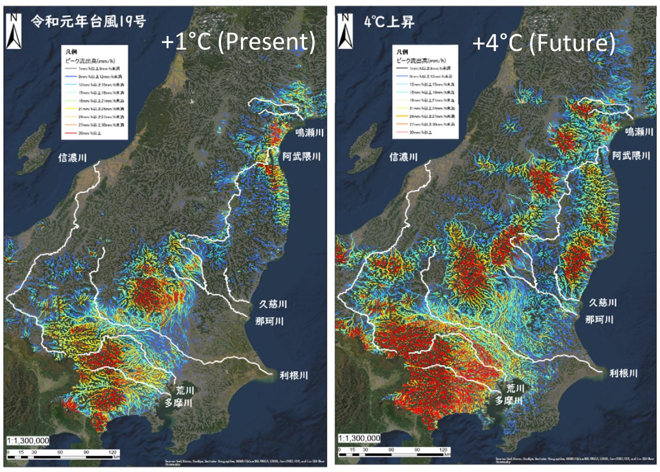
Climate change has been causing an increase in the severity and frequency of water-related disasters. Socio-environmental changes in turn affect disaster risks. In order to prevent and mitigate such disasters, it is indispensable to understand hazard mechanisms, improve the accuracy of monitoring and 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 study new technologies and policies to prevent and mitigate disasters, particularly by analyzing the frequency and intensity of floods and sediment-related disasters caused by extreme cyclones and heavy rainfall.

We develop and apply distributed hydrologic models simulating both rainfall-runoff and flood inundation, particularly the RRI model. Our core focus is hydrology, especially rainfall runoff processes. Field surveys and mathematical analyses are also used to understand how heavy rainfall flow in catchments, and how soil and geological settings play a role in basins.

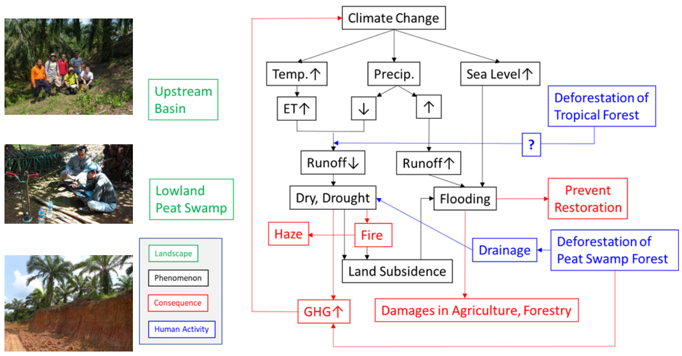
The main applications of the nationwide RRI model are real-time flood forecasting and climate change impact assessments. Our objective is to develop more precise flood inundation and damage predictions, with longer lead-time. In addition, we conduct research on climate change impact assessments of multi-hazards, integrating droughts, storm surges and ocean waves.



Pseudo global warming experiment for 2019 Typhoon Hagibis

Social and Climate Changes in South-east Asian River Basins

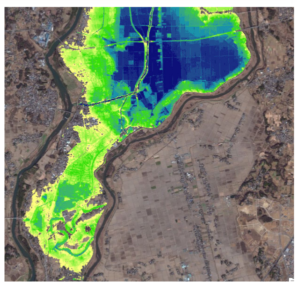
Field investigations and experiments allow us to identify the socio-environmental characteristics of study sites. Based on this understanding, we propose new technology and policy for better water resources management and water disaster mitigation relevant to each region. In particular, we have been conducting field studies in Sumatra Island, Indonesia, focused on compound disasters (flood and fire) in tropical peatland. International collaborative research activities are implemented under the UNESCO-IHP framework.



Flood and fire disaster study in humid tropical region

Real-time predictions on flooding with ICT

We develop distributed hydrologic models for real-time flood predictions, particularly focusing on flood runoff and inundation, notably using Information and Communication Technology (ICT).



WATERFRONT AND MARINE GEOHAZARDS

Professor
Michio SANJOU

Associate Professor
Yasuyuki BABA
(Shirahama Obs.)

PS Assistant Professor
Che-Wei CHANG

Assistant Professor
Yuki IMAI
(Shirahama Obs.)

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.

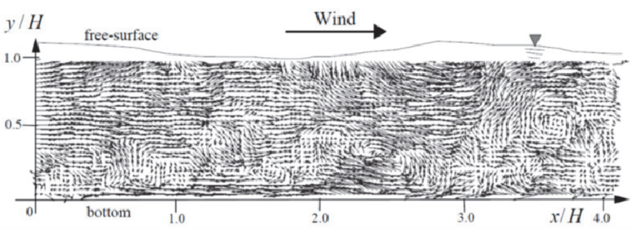
Investigation of Disaster Mechanism in Riverine and Coastal Regions

Comprehensive sediment management from mountainous to seashore areas requires expert knowledge covering coastal, estuary and riverine hydraulics. We study the mechanics of sediment-related water disaster, and aim to contribute to the realization of a safe / secure disaster prevention society and the local implementation of disaster mitigation technology.

Sedimentation in the estuary induces a risk of clogging rivers, but also plays an important role in preventing salt water invasion and maintaining sandy beaches.

With the main topic of elucidating the dynamic mechanism of current-induced sediment transport, we are proceeding with integrated research on rivers and costal arears based on turbulence hydraulics.

Furthermore, we are also working on the development of cutting-edge observation system and new water disaster prevention technology like a robot boat and drone-type float. Collaborative researches are conducted among industry, government and academia for the practical application of academic achievement.



Turbulence structure of wind-induced waves observed in laboratory experiment

Autonomous robot boat measuring velocity and bottom sedimentation

Field Measurements on Oceanographical and Meteorological Phenomena

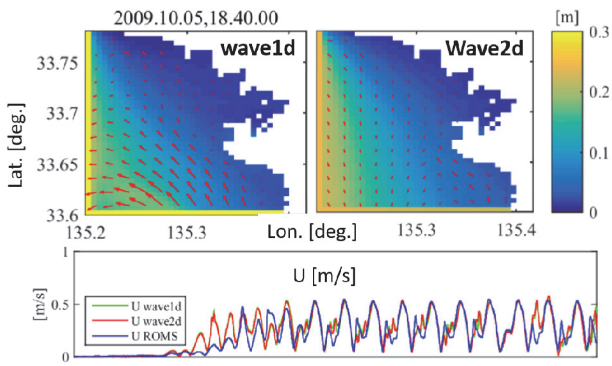
The offshore observation platform has great advantages for research activities of oceanographical and meteorological phenomena.

One of the great advantages is measurement operation under severe conditions such as high wave and strong wind because field observation under severe conditions is very difficult to carry out and therefore the amount of observed data under severe conditions is inadequate.

Development of a Coupled Ocean-Wave Model and Coastal Current Simulation

In coastal area, waves and current (forcing) is dominant in sedimentary environment, and temperature and salinity distribution (physical environment) hugely effects the ecosystem. In order to estimate them, it is important to adequately parameterize physical variables in the ocean surface of the ocean-wave model interface.

This study develops a coupled ocean-wave model to consider wave-current interaction on random waves with parameterized thermal flux, wave-induced current, and insert spatial resolution enhancement into it with nesting. Moreover, after implementing validation on the simulated results compared with obs. data of Shirahama Oceanographic Observatory, it can contribute climate change impact assessment by future projection as well.



Upper: wave (contour) , current (vector), left: Ocean model, right: Coupled model, Lower: time-series: current (Ocean, semi-Coupled model, Coupled model)

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.

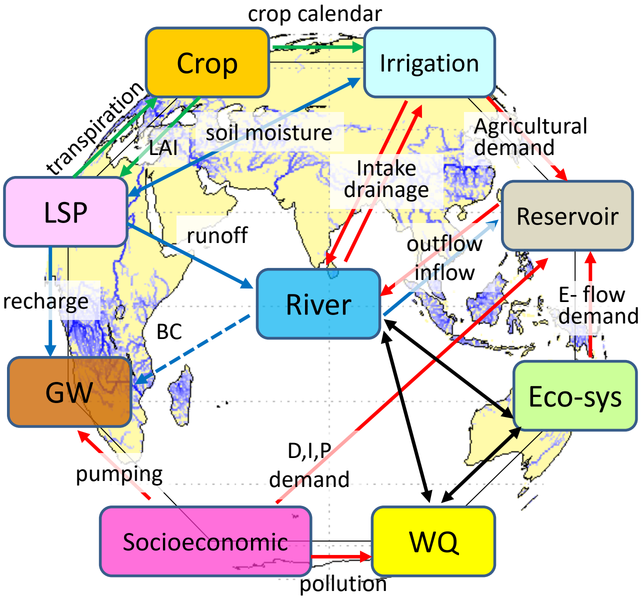


Figure: Structure of integrated water resources management model.

Current (On-going) Research Topics

- Understanding of snow/ice hydrological processes

Glaciers function as natural water towers that supply water to downstream areas, storing water in winter and gradually releasing it as snow and ice melt water in summer. Due to global warming, glaciers, which are the source of water, are disappearing. We are conducting meteorological observations on glaciers, as shown in the photo below, to better understand the snow/ice hydrological processes, and are developing models to predict how long glaciers will last and when melt water volume will start to decrease.

- Climate Change Impacts on Water Resources

Global warming may change the amount and patterns of precipitation. Future changes in the available water resources of the major rivers in Japan and the world are assessed considering the water demand under expected socioeconomic scenarios.

- Groundwater Management

Depletion of groundwater resources has become obvious in many parts of the world. Land surface model has been upgraded to monitor groundwater storage change through recharge and groundwater withdrawal processes. The strategy for land and groundwater utilization toward sustainable water resources management is investigated.

Photo: Meteorological observation on glacier in Kyrgyz.

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.

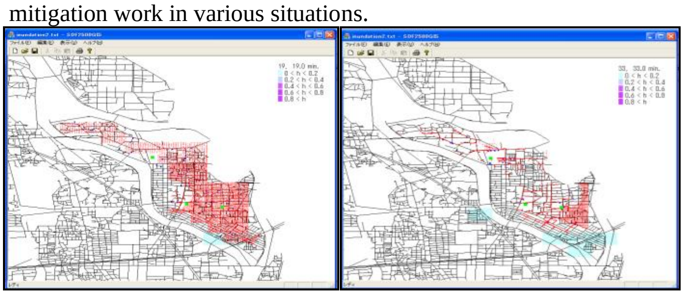


Fig. 1: Flood evacuation simulation with detailed road network

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.

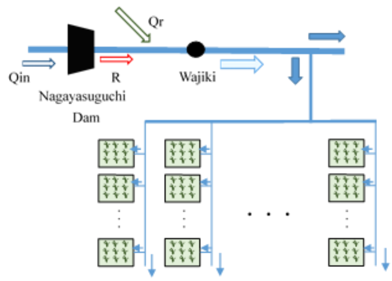


Fig. 2 Crop growth and optimum reservoir operation

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.

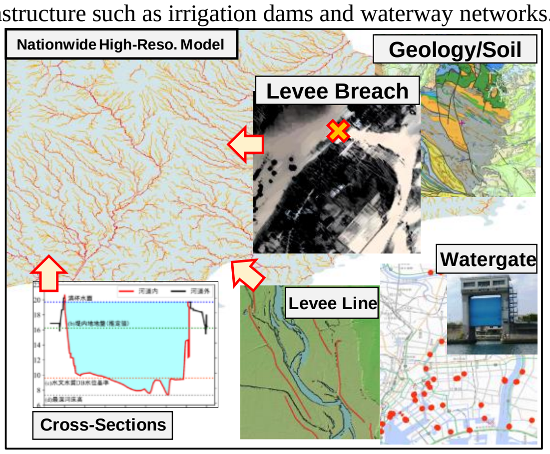


Fig. 3: Integrated Water Dynamics Model

Socio and Eco Environment Risk Management

Professor Tetsuya SUMI
Associate Professor Sameh Ahmed KANTOUSH

For planning of risk management of water resources systems and integrated river basin management

In order to realize environmental disaster mitigation and to solve environmental problems in the water resources issues, measures for integrated river basin management for flood control, water use and environmental conservation are investigated aiming at enjoyment of ecosystem services in a sustainable manner. We focus on subjects such as 1) asset management of dams and development of reservoir sediment management methods, 2) development of riverbed management methods for habitat creation and maintenance, 3) restoration of sustainable interactions between human use and ecosystem responses in water front environments and 4) water resources management in trans boundary river basins ex. the Nile and the Mekong River Basin.

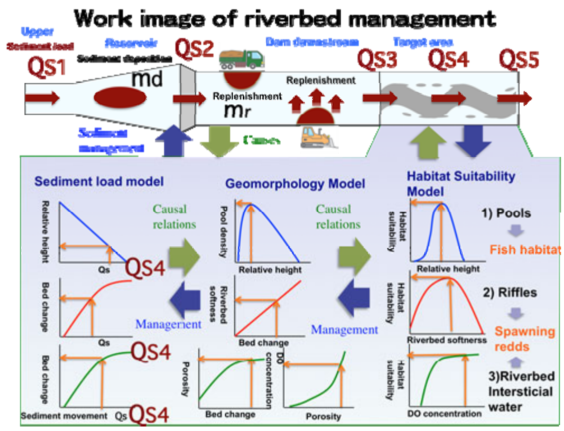
Asset management of dams and development of reservoir sediment management methods

In order to achieve sustainable use of water resources and integrated sediment management in a basin scale, countermeasures for reservoir sedimentation will be a key subject. Aiming at technical support of cooperative sediment flushing of the Kurobe River dams, sediment bypass tunnel at the Miwa Dam, etc., we investigate on 1) applicability of methods for reservoir sedimentation management, 2) prediction of sediment transport during drawdown flushing operation, 3) fine-sediment and turbidity management in a reservoir at flood events and 4) sediment resources management for recycling, using both numerical simulation and field measurement methods. In addition, researches for reservoir sustainability through the asset management of sedimentation based on a life cycle management approach are conducted.

Fig. 1 : Reservoir sedimentation management in Japan.

Development riverbed management methods for habitat creation and maintenance

Riverbed management is essential for conservation and restoration of ecological functions in river ecosystems. We investigate on following subjects for developing the riverbed management methods: 1) elucidation of habitat conditions required for facilitating biodiversity and material cycling in rivers, 2) estimation and prediction of potential distribution of organisms based on the habitat structure, 3) estimation boundary conditions of sediment load and flow regimes for creating suitable habitat structure geomorphology, 4) assessment of human impacts on river ecosystems from the aspects of habitat dynamism and 5) proposal of countermeasures for riverbed management.



Restoration of sustainable interactions between human use and ecosystem responses

Ecosystem and social system are mutually interactive, and thus, for realizing a sustainable system of water resources, basin ecosystem structure, function and mechanisms for maintenance should be investigated in relation to human life styles and utilization patterns of natural resources. Our researches focus on the interactive nature of the system to propose a truly sustainable society.

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

Associate Professor
Ryota HASHIMOTO

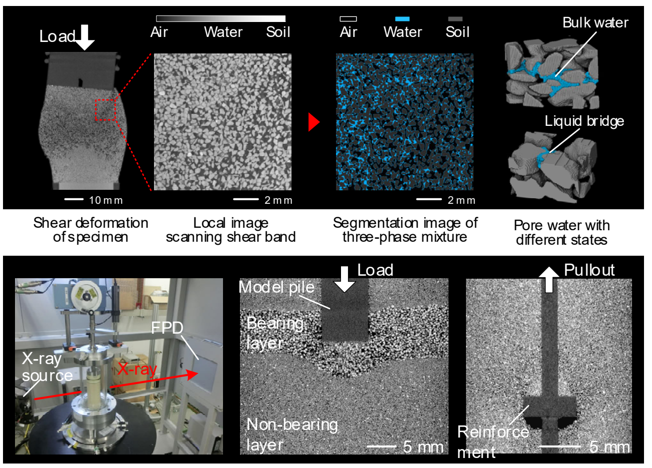
Assistant Professor
Ryunosuke KIDO

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

Since the ground is composed of soil particles, water, and air, it is important to understand the microscopic behavior at the soil particle scale in order to understand its macroscopic mechanical behavior. We use an X-ray micro-CT apparatus and CT image analysis to understand the failure mechanism of sands and evaluate the microscopic characteristics of pore fluids. We also apply X-ray CT to model experiments of, for example, reinforcement and piles. The interaction between soil and structure from a microscopic viewpoint and its relationship with the macroscopic mechanical behavior are investigated.

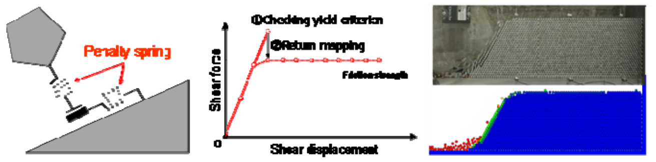


Shear deformation of specimen | Local image scanning shear band | Segmentation image of three-phase mixture | Pore water with different states

Pile penetration test with X-ray CT apparatus | Density change of bearing layer due to loading of pile | Density change of ground due to pullouting reinforcement

Development of mechanical simulation techniques for geomaterials

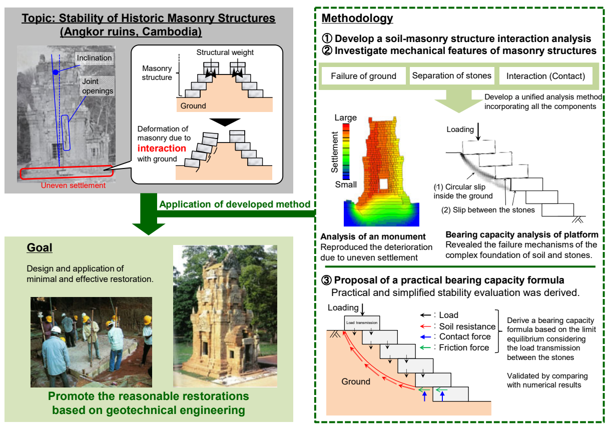
To gain insights into the mechanisms underlying geomechanical phenomena and enhance the design techniques of secure social infrastructures and resilience against geo-disasters, numerical simulation is a powerful tool. We are actively engaged in advancing numerical methods that tackle diverse challenges, including soil-structure interaction, soil-fluid interaction, and the seismic behavior of rock slopes. For example, we developed an improved Discontinuous Deformation Analysis (DDA) that enhances accuracy and computational stability issues aiming to establish a seismic response analysis of jointed rock slopes. We are also working on the development of large deformation analysis technique for earth structures using the Material Point Method.



Simulation of seismic behaviors of rock slope using 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

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.

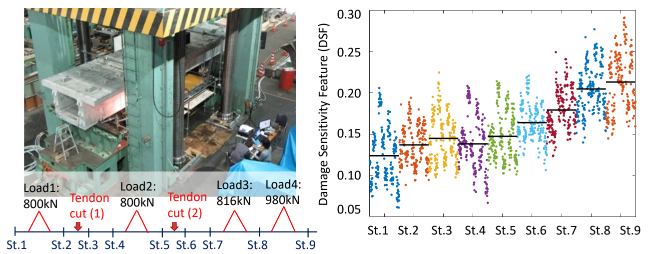


Fig. 1: Bridge damage experiment (left)/ damage detection using information on subspace (right).

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.

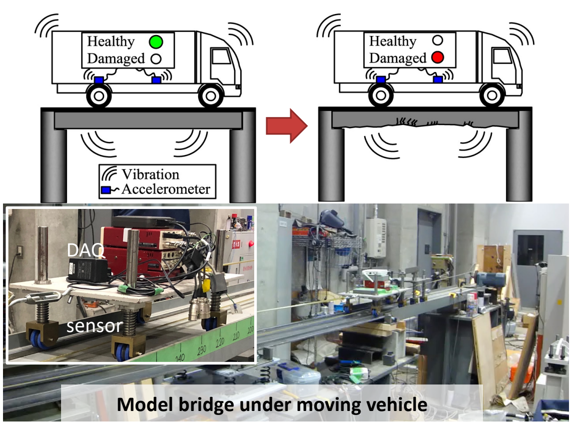


Fig. 2: Drive-by Bridge inspection systems.

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.

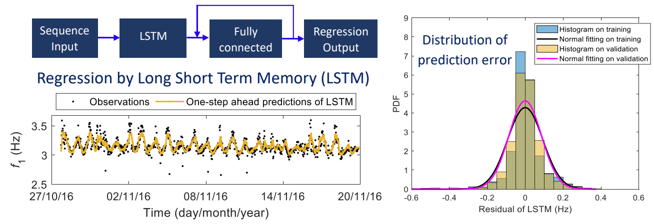


Fig. 3: Predicted frequency of a bridge under changing environment and error distribution of the prediction.

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.

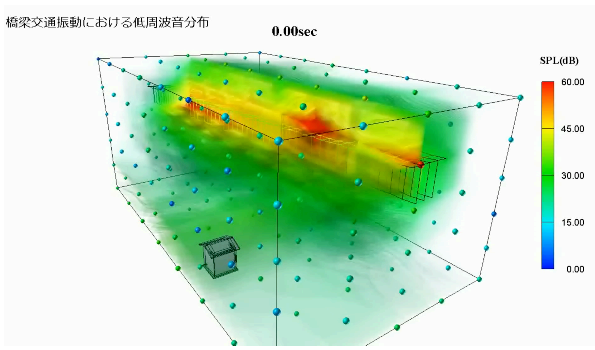


Fig. 4: Propagation of bridge born low-frequency vibration under traffic by simulation.

Construction Engineering and Management

Professor
Yosuke Higo

Associate Professor
Thirapong Pipatpongsa

Geotechnical engineering research for creation, maintenance and management of the social infrastructures

Our missions contribute to modeling behaviors of geomaterials from micro to macro; design, construction, and maintenance of earth structures; safety assessment of earth structures against natural hazards; innovation of stress sensing technologies.

Outlines of research

Modeling behaviors of geomaterial from micro to macro

Geomaterial is a multi-phase mixture composed of soil, water, and air. It is important, therefore, to study microscopic changes in soil structures and phase interactions. We aim to clarify a link between the microscopic and macroscopic behaviors through experiments. Furthermore, we are developing analytical methods based on the physical origins to predict macroscopic geotechnical issues such as geohazards induced by rainfalls and earthquakes.

Designing “robustness” of earth structures

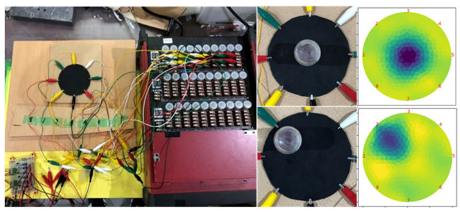
It is important for earth structures to have “robustness” to avoid catastrophic damage against accidental natural hazards such as large earthquakes and floods caused by heavy rainfalls. We are developing a numerical method that accurately describes the progressive failure of river levees during earthquakes and overtopping flows such as surface erosion and liquefaction-induced large deformation. Then, alternative models for these simulation methods based on reliability analysis theory are developed and applied to establish a design scheme of “robust” earth structures.

Evaluation of stability of soil structures against natural disasters

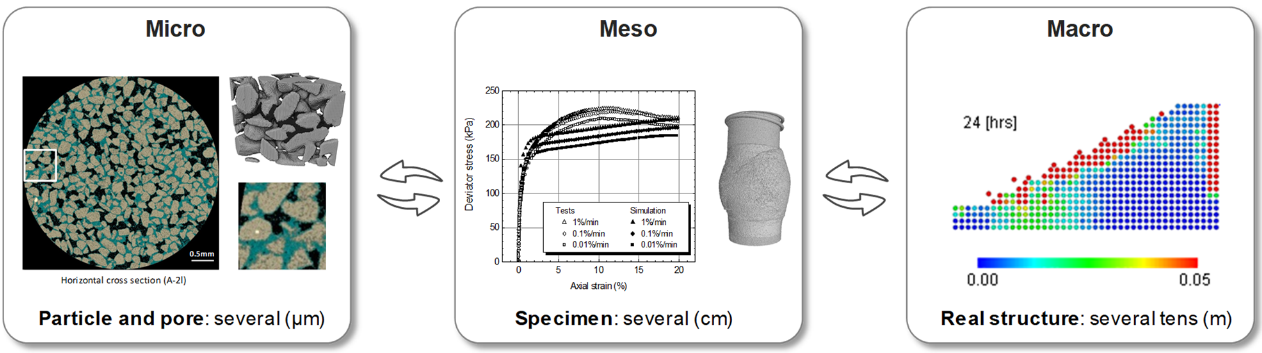
Embankments stability against earthquakes are investigated by highlighting that initial stress states influenced by passive arch action across a basal deflection play a dominant role in the mechanisms of weakening resistance against liquefaction.

Innovation in geo-sensing technology

Measurement of three-dimensional state of stress can reduce risks in geotechnical engineering, thus this research aims to enhance high-value specific applications of pressure-sensitive conductive granules for developing the device enabling to measure 3D stress tensors in which the existing techniques cannot work well.



Electrical resistivity tomography of conductive rubber



Pore-scale observation of granular assembly using **x-ray micro tomography**

Laboratory-scale investigation of geotematerial behaviours and their **modelling**

Real-scale evaluation of behaviours of geomateirals by **numerical analysis**

GEOFRONT SYSTEM ENGINEERING

Professor
Hideaki Yasuhara

Associate Professor
Hiromasa Iwai

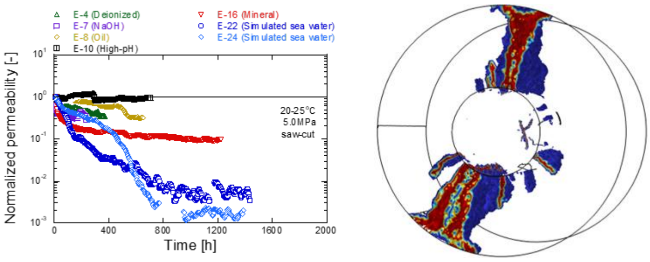
Assistant Professor
Yuusuke Miyazaki

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

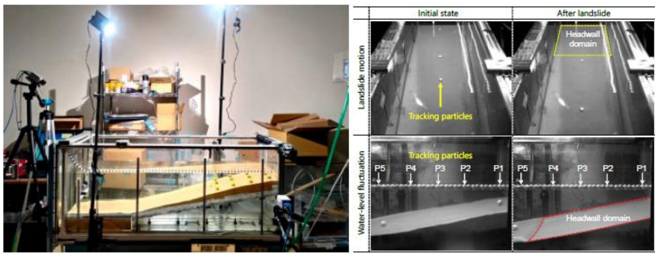
Development of slope disaster observation system using wireless network

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 land-slide motion and generated tsunami

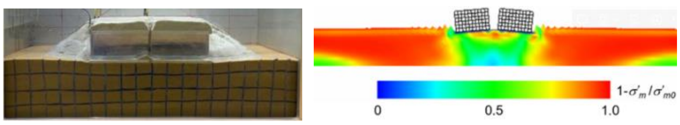
Submarine landslide can generate unexpected tsunamis. It will magnify the tsunami amplitude, larger than that predicted by seismic motions, and will strike coastal areas. In this research field, we focus on the ground-fluid interaction, and investigate the relationship between kinematics of submarine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



Model experiments on submarine landslide motion and tsunami

Study on “Seismic-followability ” of underground structure

Many cases of loss of serviceability of underground structures have been reported in past earthquakes in Japan. In this laboratory, research is being conducted especially on backfilled tunnels used as underpasses. Geological and topographical features in the foundation ground are considered to be important factors in both types of damage. We are conducting model experiments and numerical analyses to clarify the question of what kind of geological and topographical features can impair the serviceability of underpasses (i.e., loss of "seismic followability").



Joint opening phenomenon on liquefied soil

Urban Management Systems

Professor
Kiyoshi KISHIDA

Associate Professor
Yasuo SAWAMURA

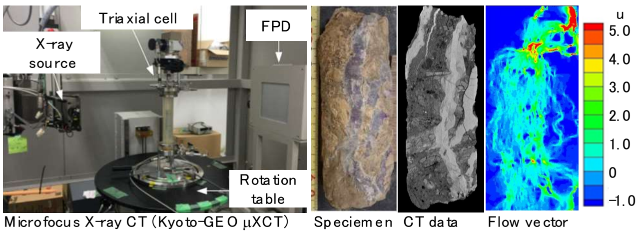
PS Assistant Professor
Takako MIYOSHI

Development of Infrastructures toward Sustainable Human 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 geosequestration of by-products after energy generation. 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, and safe and trusted road network are being researched based on the geotechnical engineering, rock mechanics, and fluid mechanics.

Mechanical and hydro-mechanical behaviors of fractured rock masses

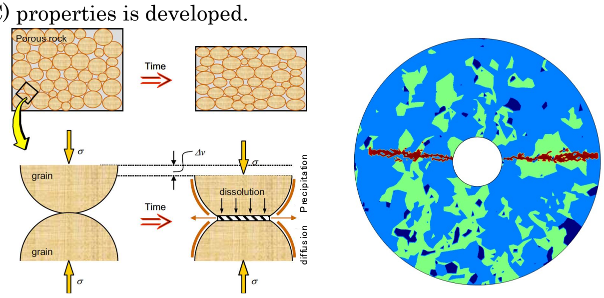
When discussing the construction and the maintenance of tunnels and underground caverns and the slope stability, the mechanical and hydro-mechanical behaviors of fractured rock masses should be clarified. The mechanical and hydro mechanical behaviors of fractured rock masses are strongly affected by 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.

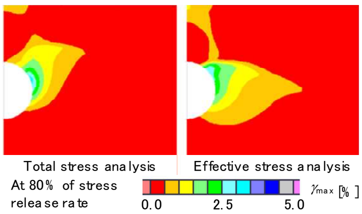


THMC concept and simulation example under fracturing

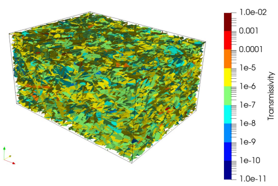
Hydraulic Fracturing Simulation

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

The effective design, safety construction, and smart maintenance of geo-infrastructures and rock infrastructures are studied here. For examples, when shallow overburden tunnel is to be excavated in an urban area, the auxiliary method that will be applied should be considered. When an area is to be excavated in deep underground, seepage and the huge earth pressure that will be encountered should be considered. Also, to improve the rock strength and prevent the water leakage of rock mass, grouting is studied. Through numerical simulation, the mechanism of grouting into single fracture and fracture network is investigated.



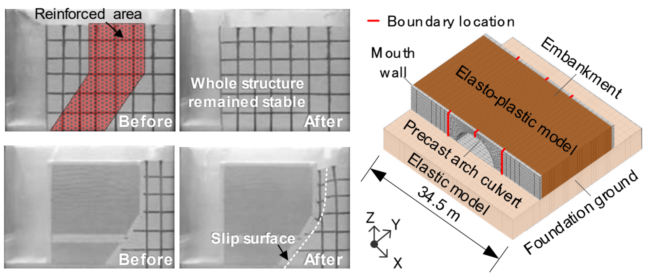
Examples of excavation analysis on tunnels



Example of Discrete fracture network model

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 seismic performance.



Investigations by geotechnical centrifuge and 3D FEM

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.

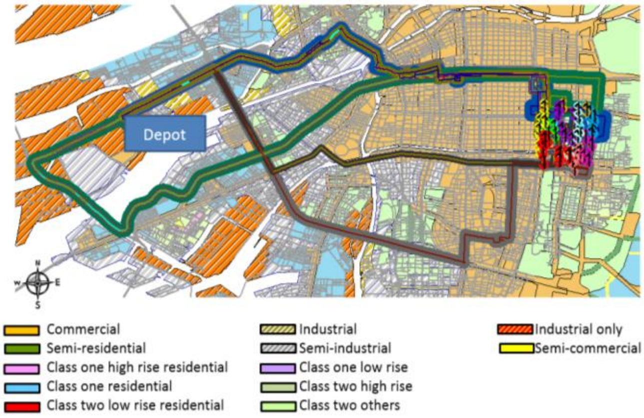
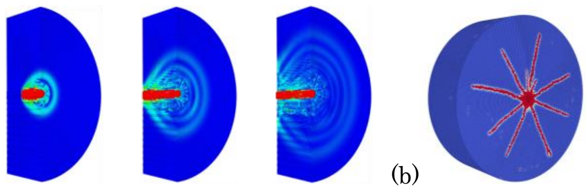


Fig. 1: Vehicle routing and land use

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.



(a) (b)

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.

Simulation of dynamic soil-structure systems under large earthquakes

The 1995 Kobe, Japan, earthquake caused loss of more than 6,000 lives and catastrophic damages on civil infrastructures, such as lifelines, bridges, highways, and port/harbor structures. Among them, geotechnical structures along waterfront areas were also severely damaged due to liquefaction and lost their function after the earthquake. Tremendous costs for their reconstruction made a demand for reliable and practical methodologies for damage assessment and structure design with higher performance.

A broad extent of Tohoku and Kanto region was affected by strong shaking, and tsunami took nearly 20,000 lives after the 2011 Tohoku, Japan, earthquake. Liquefaction caused not only failures of geotechnical structures, but serious settlements and tilting on residential houses in Tokyo bay area. Also, a combined effect of long duration earthquake and tsunami created severe damage on civil structures located along the coastline. Again, development of methodologies for damage assessment against such a devastating earthquake and tsunami is urgent needs, especially, under the current situation that the Great Nankai Trough earthquake is expected with high rate.

To provide reliable and practical tool, we have been developing numerical simulation programs in which state-of-the-art constitutive models for saturated and partially saturated soils are implemented.

Centrifuge modeling on dynamic behavior of geotechnical structures

Due to concentration of population in urban areas, surrounding residential areas have been rapidly expanding by land reclamation. After recent large earthquakes, a number of reports on failure of such reclaimed land have been increasing (e.g., 2003 Niigata-ken Chuetsu and 2007 Notohanto earthquakes). Dynamic behavior of soil structure is highly nonlinear and its deformation is quite large compared to other materials, such as metals.

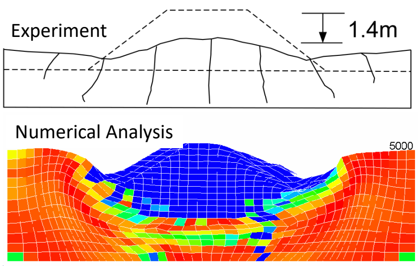


Fig. 1. Deformation of an embankment resting on liquefiable ground (Centrifuge experiment and numerical analysis)

Applicability of the numerical models developed by our laboratory is verified through comparison with a centrifuge test result (Fig. 1).

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. 2) and numerical simulations.

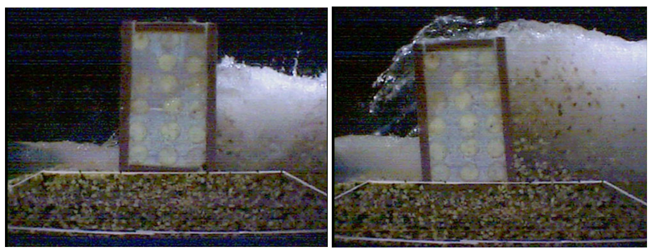

(a) Tsunami arrival (b) Caisson deformation

Fig. 2. Centrifuge experiment for stability of the tsunami breakwater

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 Waste Landfills

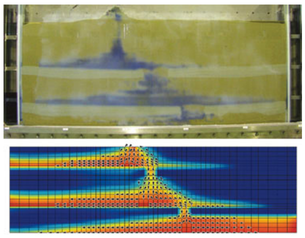
In order to build a recycling-based society, the 3R principle should be a strong driver of our life. Unfortunately, certain amount of wastes that are technically and economically difficult to recycle is going to be generated. Hence, to properly dispose such wastes to landfill sites so that we can use the land after post-closure is a reasonable solution. In this laboratory, a series of studies related to the construction, management, and utilization of waste landfill sites are performed including the geotechnical evaluation of construction materials, the mobility assessment of toxic elements in the sites, and the risk assessment of the utilization of closed landfill sites.

Environmental Geotechnics for Disaster Recovery

Treatment of disaster wastes is one of key issues to be addressed immediately after a huge disaster occurs. This laboratory contributes to geotechnical characterizations and utilization of recovered materials, including tsunami deposits, based on lessons learned through the 2011 Great East Japan Earthquake.

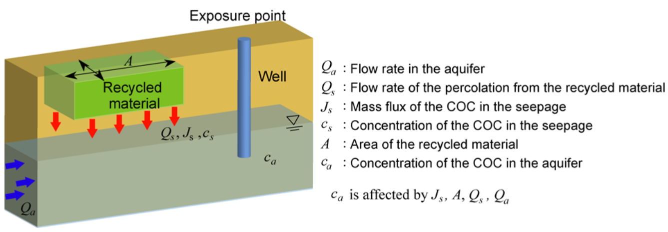
Subsurface Contamination and its Remediation

When selecting adequate techniques to solve soil and/or groundwater contamination problems, the mobility of the contaminants, their mechanisms, and the reliability of the countermeasures should be scientifically clarified. In this laboratory, the mobility of heavy metals and PFASs and their effective countermeasures, such as remediation and containment techniques, are experimentally and analytically studied. In addition, the quantification of the environmental impacts and that of the effectiveness of the countermeasures are calculated using the environmental risk assessment method to contribute to the adequate communication of risks.



Construction and Demolition Waste (CDW) Management and Utilization

The social and economic system is now shifting to promote further resource recycling and the maintenance of existing infrastructures, in order to attain a sustainable development. Furthermore, environmental problems are being exacerbated by climate change, which can also trigger various ground disasters. In this laboratory, new concepts for infrastructure improvement are studied considering such global environmental problems as the application of recycled wastes as geo-materials, the development of the more environmentally-friendly construction, and methods for foundation maintenance.



Geoinformatics

Professor
Junichi SUSAKI

Associate Professor
Tetsuharu OBA

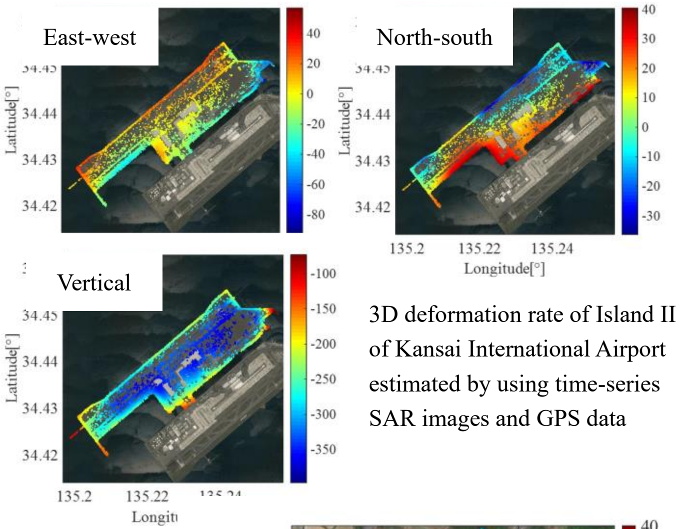
Assistant Professor
Yoshie ISHII

Analysis and Utilization of Spatial Information

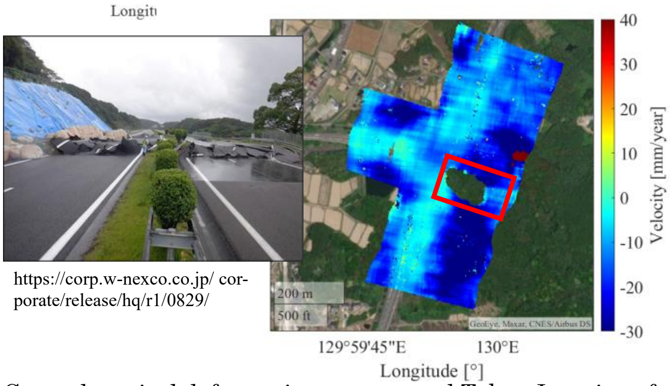
We analyze and utilize spatial information for disaster prevention, environmental protection and urban planning. In particular, we focus on satellite remote sensing, 3-D digital photogrammetry, laser surveying, geographic information systems, and location identification using mobile phone and SNS data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

Assessment of disaster damage and environmental changes by remote sensing

Satellite or airborne sensors can regularly observe temporal changes of land and environment on a large scale. We are developing methodologies for observing the current state and changes of Earth's surface using optical and radar sensors, especially synthetic aperture radar (SAR), for disaster prevention and environmental protection.



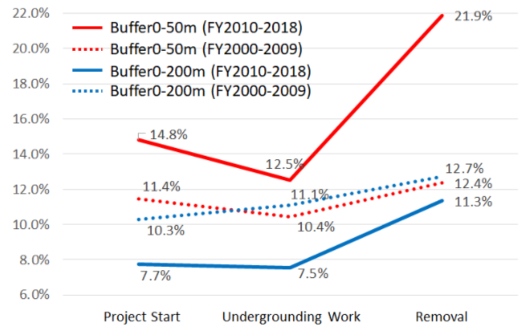
3D deformation rate of Island II of Kansai International Airport estimated by using time-series SAR images and GPS data



Ground vertical deformation rate around Takeo Junction of Nagasaki Expressway where a large landslide occurred in Aug. 2019. The red rectangle denotes the landslide area. The results were obtained by using SAR images of period from 2017 to heavy rain in 2018. This indicates a significant deformation started after the heavy rain in 2018 because a big hole is observed due to the large deformation.

Urban / regional analysis utilizing geospatial information for policy management

We are not only grasping the current situation and issues of cities / regions, but also considering how to formulate and manage policies based on evidence from urban / regional analysis utilizing geospatial information. 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.

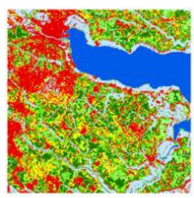


Comparison of the increase rate in land prices by undergrounding and utility pole removal projects considering the timing of the project start, underground work, and removal

Research on improving the accuracy of land cover classification

The land cover classification map created from satellite images has various potential applications, such as assessing the impact of climate change and monitoring disaster situations. However, the process of creating this map involves uncertainty, which can result in insufficient degrees of accuracy. In order to enhance the precision of land cover classification, we are conducting research on the development of a new classification method based on set theory, as well as methods for ensuring the quality of validation data used for evaluating map accuracy.

Satellite image (Landsat 8)



Land cover map of Southern Ibaraki created using the proposed method

Urban and Landscape Design

Professor
Masashi KAWASAKI

Associate Professor
Keita YAMAGUCHI

Assistant Professor
Riku TANIGAWA

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

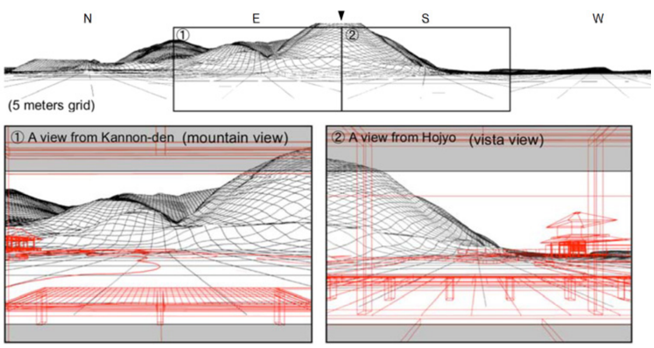
Landscape involves habitat, cultural climate and geographical field. It means integration of natural and cultural environment of mankind. This lab aims to study on the structure of the landscape based on landscape engineering, cultural climate analysis, and regional planning. It also aims to develop the methods and theory of urban and landscape planning and design to sustain and create the proper landscape and the natural & cultural environment.

Landscape Planning and Design for Public Spaces and Urban Infrastructure

By way of actual planning and design practices on Infrastructure such as roads, parks, waterfront and terminal facilities, We study on the construction of the concept for design and methods for spatial structuring, and consider making drawings and the visual simulation for the project. On the other hand, we research on the Design Methodology on making colors and texture of Infrastructure. And we aim to harmonize artificial environment with natural environment and human activities, to create spaces and facilities of inducing cultural activities.

Research on Landscape Structure and Development in Historic Districts

We aim to find the concept and methods of practical landscape design using the natural or nature-origin water ways or environment characterized by the surrounding landform, by focusing on the historical area of hillside and riverfront. And we aim to clarify the cultural trials to make connections between nature and human in the name of "sustainable development". Lastly we try to make sure the method and theory of regional landscape design for the proper, natural, and cultural environment.



Landscape Analysis of a historic site of scenic beauty

Research on Cultural and Climatological Environment

It is necessary to understand the mechanism of physical structure to evaluate the quality of the space since there is deep relationships between the structure and the space. We cannot design appropriate structures unless we consider the physical structure and the quality of space simultaneously. On such a theme of integration of engineering and architecture, we aim to develop the method of integrated design of infrastructures and design management, with studying fundamental principles underlying the structures, systematizing the design methodology, and developing the knowledge management in design.

Research on Methodology for Making Livable Cities

In order to deal with the increasing number of urban problems such as disasters, medical care, communities and environment etc., the study aims to establish the theory and methodology to make cities liveable. Our research focuses on the perception of space and environment, especially the perception of landscape, its cognitive process and a sense of place (physical realm). The results of our studies will provide the theories and methods to manage the sense of a place and redesign our environment and increase civic engagement.

Comprehensive Strategy Plan of Omihachiman City

PLANNING AND MANAGEMENT SYSTEMS

Professor
Masamitsu ONISHI

Assistant Professor
Hitomu KOTANI

Pioneering a Practical Science Rooted in the Real World

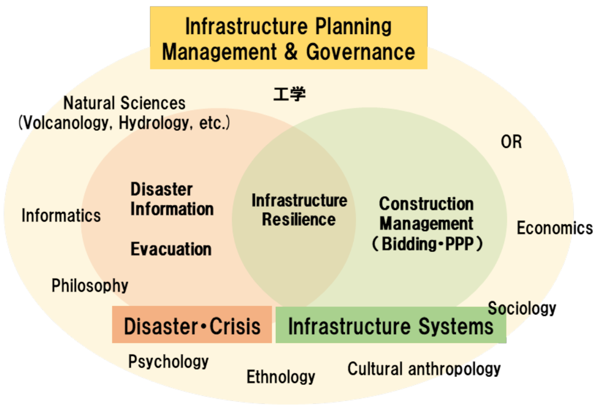
Civil engineering has a mission to contribute to the development of society. To unravel complex social problems and gradually lead society toward a desirable society, it is necessary for experts with scientific knowledge in a variety of fields to work with society. In this laboratory, we are researching 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

Most of the services provided by infrastructure are public, but in the process of construction, maintenance, and operation, not only public organizations but also various private companies are involved. How can we ensure a social structure that allows each of these various public and private organizations to fulfill their responsibilities and function as expected throughout the entire lifecycle? These social mechanisms are shaped by laws, contracts, administrative rules, and various business practices that have existed for a long time. This laboratory conducts research on desirable social mechanisms to support infrastructures.

Specifically, we are studying the desirable application of Public Private Partnership (PPP) schemes, in which the private sector has greater discretion in providing infrastructure services, as well as project institutions and contracts. We also conduct research on infrastructure financing in collaboration with financial institutions and international development agencies.

In addition, while climate change is increasing the risk of disasters, 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.



Scope of research in our laboratory

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.

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. 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 also analyze the formation and function of social networks, which are the connections between people in a community, during a disaster. Specifically, we theoretically and empirically study the content and sources of information that contribute to disaster risk reduction and recovery actions, as well as the emergency activities of communities with strong social networks (e.g., minority communities), and the long-term effects of short-term mutual help immediately after disasters on the long-term expansion of networks.

Interview with people in a minority community

Urban and Regional Planning

Professor
Nobuhiro UNO

Associate Professor
Ryoji MATSUNAKA

Assistant Professor
Tomoki NISHIGAKI

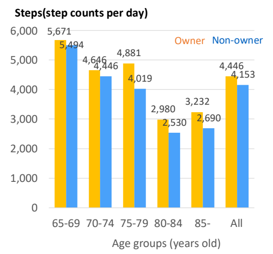
Empirical research to realize the appeal and vitality of cities

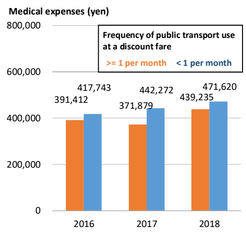
While cities play a role in people's daily activities in work, leisure, and peace of mind, they also introduce many issues such as in environment, energy, transportation, landscape, and land use. In our laboratory, in order to bring about the appeal and vitality of cities, the basic theoretical structure 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.

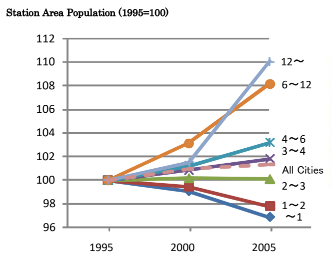
The figure (right) shows that medical expenses were lower for older citizens whose frequency of public transport use at the discounted fare was greater than once a month.

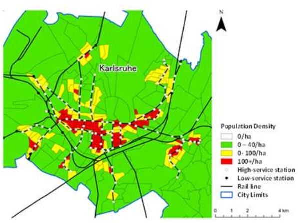




An international comparison of rail service level and urban structure

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.





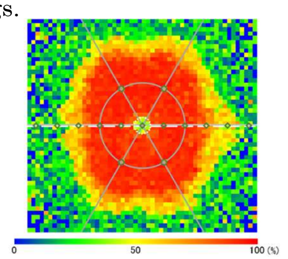
Experimental analysis of driving behavior using driving simulator

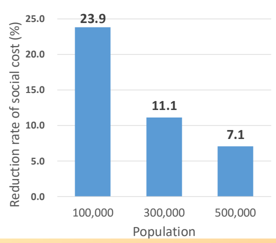
Analysis of driving behavior using a driving simulator, which can safely observe the behavior of subjects under various road and traffic conditions, can be useful in understanding the causes of traffic accidents and congestion and in studying solutions. Major research topics so far include behavior analysis 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.





INTELLIGENT TRANSPORT SYSTEMS

Professor
Tadashi YAMADA

Associate Professor
Jan-Dirk SCHMÖCKER

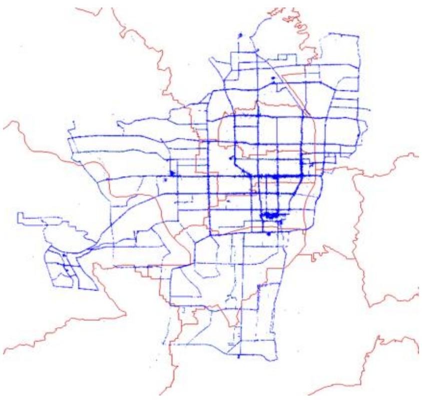
Assistant Professor
Satoshi NAKAO

Creating smart transport and logistics systems
ー Intelligence and Optimization ー

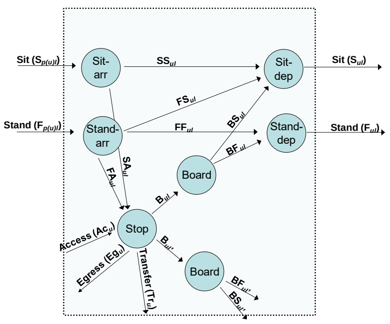
Utilizing information technologies like ITS (Intelligent Transport Systems), we have been developing efficient procedures to settle transport and logistics problems in urban areas. We are dealing with various research topics; including traffic flow modeling, transport and supply chain network design, effective operation, management and control of transport systems, and behavior analysis on private car users, public transport users and tourism.

Utilizing Big Data to understand travel patterns

Nowadays a large amount of data have become available to the transport analyst. IC card data tell us the boarding and alighting points of passengers. ETC data provide us with information for car drivers. Mobile phone data can be used to understand how many people are where during different time periods. GPS bus data give us information about bus locations and service regularity (the figure on the left shows Kyoto's bus lines obtained from GPS data). Truck data obtained via GPS or digital tachograph can indicate truck routing and scheduling. Other sensors installed within the city can help us understanding the walking pattern of people. We aim to utilise such data in an efficient way with novel analysis methodologies.



Modelling network flows for public and shared transport systems



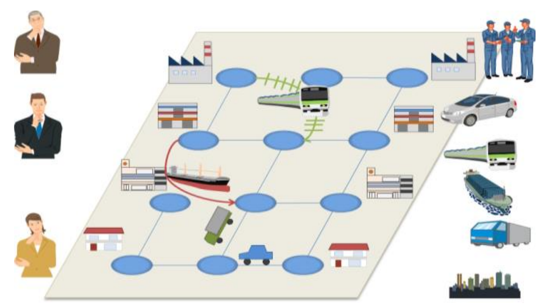
Data often build the basis for subsequent network flow models. In other cases we start from theoretical models to gain general insights into efficiencies of networks. The figure on the left shows a model of a bus stop to reflect that only some of the newly boarding passengers will be able to find a seat. 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.

Network design for transport and supply chain

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 supernetwork modeling. We are also tackling the development of AI-based optimization techniques capable of solving large-sized problems.



Travel Behavior Analysis

Professor
Satoshi FUJII

Associate Professor
Yuichiro KAWABATA

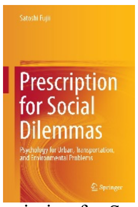
Assistant Professor
Kosuke TANAKA

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 the urban landscape, traffic congestion, and disorderly overdevelopment, are prompted by individual egoistic attitudes. For instance, when everyone drives their own car for convenience, it results in significant CO_2 emissions and traffic congestion. Social psychology refers to this conflict between public and private interests as a 'social dilemma.' In this lab, we analyze the social and psychological mechanisms causing problems in urban and transportation contexts. Furthermore, we study measures to mitigate or resolve the underlying social dilemmas and propose solutions to the public. Our methodology incorporates diverse techniques, including psychological surveys, statistical data analysis, fieldwork and case studies, and institutional analysis.



Prescription for Social Dilemmas (Fujii, 2017)

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

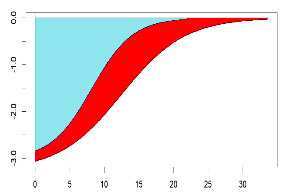
Social Psychological Research on the Mindset Necessary for the Maintenance and Development of Civil Society

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

Professor
Ana Maria CRUZ

Natural and Technological Disasters: Building Resilience

Growing urban populations and industrialization have resulted in more people and property at risk from natural disasters and so called Natechs (conjoint natural and technological disasters). We evaluate physical and socio-economic impacts of these complex disasters and their mitigation in an effort to promote sustainable development, reduce overall disaster losses and increase societal resilience. Our lab is multidisciplinary integrating skills and knowledge from a variety of disciplines such as engineering, sociology, economics, and disaster risk management (DRM). The lab benefits from synergistic association with local, national and international researchers and faculty. A sample of some of the ongoing research projects follows. For more details please visit our website at: www.natech.dpri.kyoto-u.ac.jp

Improving Resilience to Natech Risks

Despite efforts to consider natural hazard loads in the design and construction of industrial facilities and to ensure industrial safety, natural hazards are not part of process hazard and risk assessments resulting in inadequate assumptions concerning safety barriers as well as gaps in emergency planning. 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. See Figure 1.

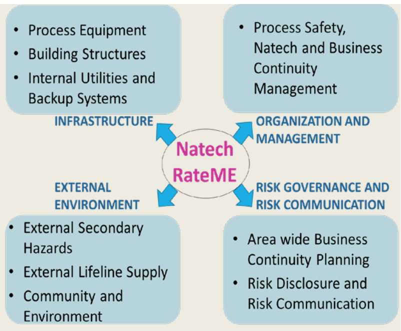


Figure 1. Area-wide Natech risk management framework

Dynamic risk assessment of Natech hazards: The case of domino effects

Domino effects are secondary chemical accidents caused by a primary chemical accident. See Figure 2. Domino effects make Natechs dangerous and complex. Japan has many potential earthquakes like the one expected along the Nankai Trough. Thus, Natech risk assessment is needed to prevent Natech accidents and domino effects in the future.

In this study, we use dynamic Bayesian Network to analyze Natech spe-cific domino effects to determine the likelihood of propagation using probit functions.
Furthermore, we propose and test a Natech specific domino effect analysis methodology using the Cosmo Oil Refinery fires during the Great East Japan Earthquake in 2011 as a case study.

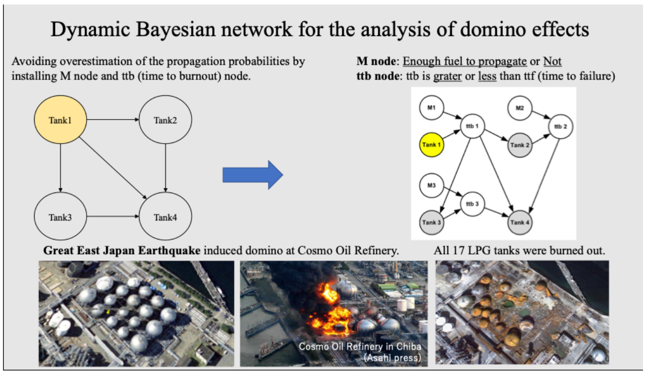


Figure 2. Dynamic Bayesian network for the analysis of domino effects at a storage tank farm following earthquakes.

Appetite for Natech Risk Information and Citizen's Communicative Behaviour

In Japan and elsewhere, there still limited to no information provided to local governments and citizens regarding the potential for chemical accidents. In areas where there is the threat of Natech accidents, the risk to nearby residential areas is even greater. In this study, we use the Situational Theory of Problem Solving (STOPS)(Kim & Grunig, 2011) to identify factors of community appetite for Natech risk information disclosure and formulate policy guidelines for effective risk communication. Figure 2 presents the STOPS model and hypothesis being tested through a household survey to residents living near industrial parks in Osaka Bay, Japan.

Figure 3. Application example of STOPS model

Integrated Disaster Risk Management Systems

Professor
Hirokazu TATANO

Associate Professor
Subhajyoti SAMADDAR

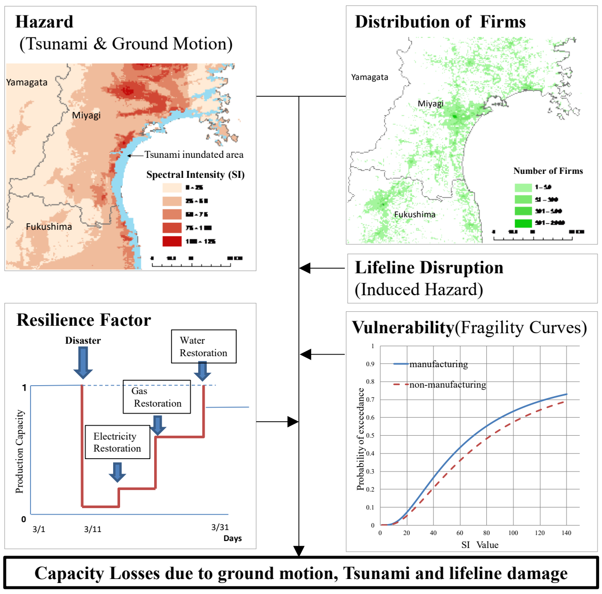
Associate Professor
Toshio FUJIMI

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.

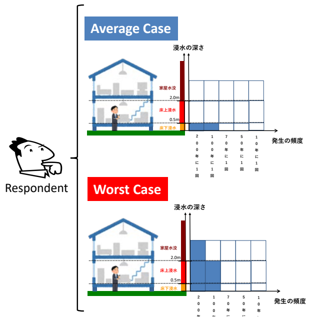
Economic Impact Assessment of Natural Disaster

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

Assistant 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

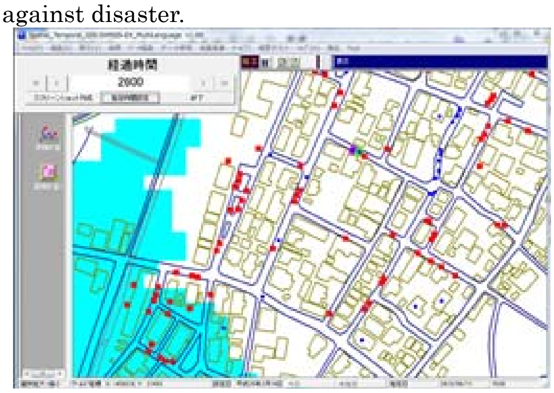
Associate Professor
Kei HIROI

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

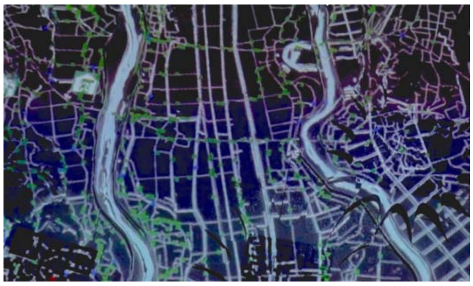
Development of Spatial Temporal and Parallel world Shared Information Platform to realize RARMIS Concept

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