Department of Architecture and Civil Engineering

Architecture and Urban Design

Urban and Regional Management

Earthquake Disaster Engineering Research Laboratory

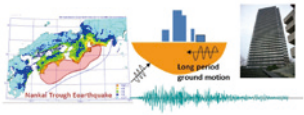
Staff	• Professor **Taiki SAITO** (E-mail：tsaito@ace.tut.ac.jp) • Assistant Professor **Kazuhiro HAYASHI** (E-mail：hayashi@ace.tut.ac.jp)
Laboratory URL	http://www.rc.ace.tut.ac.jp/saito/index.html
Key words	Long-period ground motion, high-rise buildings, response control techniques, earthquake response analysis, shaking table test, piles, health monitoring

Working toward the earthquake disaster mitigation of buildings and urban structures, and the promotion of international cooperation.

Faced with frequent earthquakes, everyone must have wondered at some point about whether the town and buildings in which they live are truly safe in regard to earthquakes and tsunami. In order to alleviate these concerns and reduce the impact of such disasters, there is a requirement for specialists such as ourselves to transmit accurate information out into society. Furthermore, enhancing the seismic safety of structures is extremely important work that demonstrably contributes to the saving of lives. This is true regardless of nation or race. The Earthquake Disaster Engineering Research Laboratory conducts research and development into the earthquake disaster mitigation of buildings and urban structures, and then relays these results out into society. We also promote international cooperation, aiming to conduct research that will aid in disaster mitigation both in Japan and around the world.

Theme 1 ▶ Seismic safety of high-rise buildings against long-period ground motions

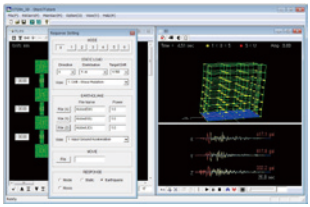
The Nankai Trough Earthquake is highly likely to occur by the middle of the 21st century, and threatens to cause extensive damage to those vital structures that perform core city functions. In particular, the high-rise buildings with long natural period have a quality to resonate with long-period ground motions. Therefore, the repeated shaking carries the risk of increased structural damage, movement & falling of interior furnishings, people becoming trapped in elevators, and ceiling panels falling. We are therefore conducting comprehensive investigations into the seismic safety of high-rise buildings against long-period ground motions.



The threat of long-period ground motion shaking high-rise buildings

Theme 2 ▶ Experiments and analysis concerning earthquake and tsunami safety of buildings

There is a requirement to enhance the seismic safety of cities and buildings in response to the threat of massive earthquakes or tsunami with an epicenter in the Nankai Trough. We are therefore conducting the experimental practice of structural engineering and the monitoring of strong earthquake observations of foundations and structures to clarify the actual phenomenon that occur. Moreover, we are using precise earthquake response analysis methods for the research to quantify the response and damage characteristics of buildings to large earthquakes and tsunami from the perspectives of safety, retention of function, and reparability.



Development of earthquake response analysis software

Theme 3 ▶ Development of post-earthquake health monitoring techniques for cast-in-place reinforced concrete piles

Any structure that experiences a major earthquake may still, at a glance, appear to be solid and sound, but could actually have suffered severe damage in locations that cannot be visually confirmed. In particular, the cast-in-place reinforced concrete piles used in the construction of large buildings have suffered severe damage in many cases, including crushing of the underground concrete, but current technology does not provide a way to evaluate their damage without excavating the surrounding ground and performing a direct visual inspection. We therefore focused our attention on the changes in the vibration characteristics of a building that accompany damage to its piles, and aim to exploit this to develop safety evaluation techniques that do not require any soil-foundation excavation.

A pile and foundations fracture experiment using a big shaking table

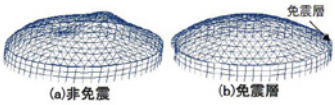
Structural Mechanics Laboratory

Staff	• Professor **Shoji NAKAZAWA** (E-mail：nakazawa@ace.tut.ac.jp)
Laboratory URL	http://www.st.ace.tut.ac.jp/~nakazawa/
Key words	Shell and spatial structure, steel structure, numerical analysis, vibration control, buckling, risk analysis

Spatial structures, such as the gyms for elementary and junior high schools, are often used as evacuation area or disaster prevention bases during a disaster, and so they have to be built to be resistant to seismic motions. These kinds of structure are easily accessed by the public, and needs to offer sufficient safety in regard to earthquakes, wind, and snow. The laboratory performs the following research themes; (1) analysis of seismic response characteristics of spatial structures subjected to severe seismic motion; (2) evaluation of seismic resistance capacity; (3) proposal of design methods with vibration control to reduce the damages; and recently (4) proposal of super light structures using low volume, recyclable materials and construction methods, and (5) a grid parallel computing system in order to provide effective analysis.

Theme 1 ▶ Evaluation of seismic performance of shell and spatial structures

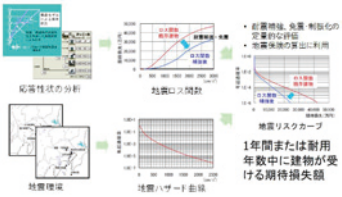
As spatial structures vibrate in a different way from high-rise buildings, it is necessary to analyze the response characteristic and seismic capacity of spatial structures. We therefore perform the following researches; (1) analysis of seismic responses and collapse characteristics; (2) proposal of the equivalent static seismic load; (3) research of evaluation method of seismic performance based on the pushover analysis; (4) research of vibration control methods to reduce the responses for spatial structures (fig.1).



Shaking of a mid-story isolation dome during an earthquake (When seismic isolation is not used, the dome shakes severely, but the use of seismic isolation greatly reduces the response of the dome)

Theme 2 ▶ Evaluation of buckling strength of shell and spatial structures

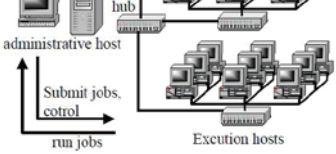
Shell and spatial structures can be realized using a lightweight construction, making their composite materials narrow and thin. This means that investigations into overall buckling and buckling for parts are important. We perform the following researches; (1) development of analysis programs that take buckling and turning into plastic of parts into account; (2) development of buckling design methods for spatial structures; (3) performing collaborative research of a visualization system with other Universities.



Outline of seismic risk analysis (allows for quantifiable evaluation of seismic retrofitting, base isolation and response control)

Theme 3 ▶ Development of seismic performance evaluation techniques based on seismic risk analysis

Seismic risk analysis is a stochastic method(fig.2). It is our aim to use seismic risk analysis to establish a method to quantifiably evaluate the seismic performance of a structure. Our research themes include; (1) a comparison of detached base isolation housing and seismic-resistant housing based on seismic risk analysis; (2) proposal of seismic retrofit method based on the minimum standard of lifecycle costs; (3) analysis of the capability to maintain functioning for school gyms and factories; (4) proposal of evaluation indexes for regional disaster prevention capabilities.



Outline of grid computing (A grid system connects multiple computers across a network, allowing them to perform parallel computations and achieving high speed operations. Applied to structural engineering)

Theme 4 ▶ Development of structural design approach using a grid computer system

Advanced structural analysis of large structures and seismic risk analysis requires faster computers. In order to realize high speed operations, we have therefore adopted a parallel grid computing system (grid system) as the foundation technology for the numerical analysis(fig.3), and research into how this would be used in the fields of architecture and civil engineering.

Earthquake Resistant Structures Laboratory

Staff	• Associate Professor **Tomoya MATSUI** (E-mail : matsui@ace.tut.ac.jp)
Laboratory URL	http://www.rc.ace.tut.ac.jp/matsui/index.html
Key words	Reinforced concrete structures, Steel concrete composite structures, Seismic performance evaluation, seismic retrofit

This laboratory conducts research into the reduction of damage caused to structures by earthquakes. Our principle goals are to increase the seismic resistance capacity of concrete structures (reinforced concrete structures, steel concrete composite structures) and establish methods for evaluating their seismic resistance capacity, and we are advancing our research from the approach of both experiments (static and dynamic testing) and analysis (earthquake response analysis and FEM analysis). Our research themes also branch out across a diverse range, including the development of new building structure systems, the seismic retrofitting of existing buildings, and methods for evaluating existing building's seismic resistance capacity.

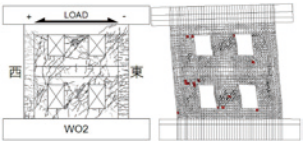
Theme 1 ▶ Development of composite concrete encased steel structural system

This research intends to develop a new structural system (CES structure), comprised of a steel frame and fiber reinforced concrete, offering excellent seismic resistance capacity. The current structural system of steel reinforced concrete is known for offering extremely good seismic resistance, but issues remain in terms of both construction and the length of time that construction takes due to the steel frame and rebar placing. In order to resolve these issues we are conducting ongoing research and development into a composite concrete encased steel structure that cuts out the rebar, with the ultimate aim of practical applications. As well as conducting parts testing in order to understand the structural capabilities of the CES structure, we also implement simulation analysis (FEM analysis), studying internal stresses that cannot be understood through just practical experiments.

Static loading test of CES beam-column joint

Theme 2 ▶ Structural performance of RC shear walls with multiple openings

This research intends to formulate a more logical structural performances evaluation method for reinforced concrete shear walls with multiple openings. Restrictions due to building plans etc. often result in shear walls having openings in them. Because those with openings display much more complex failure mechanism when compared to those with no openings, this makes them extremely hard to handle in regard to design. Therefore, in order to establish a more logical structural performances evaluation method we are implementing static loading test on RC shear walls with openings in different positions and of different sizes, investigating their structural performances. Alongside these tests we are also conducting numerical analysis, investigating the stress transfer mechanisms and numerical analysis models for RC shear walls with multiple openings.



FEM analysis of RC wall with multi openings : Crack situation (left ; experiment, right ; analysis)

Theme 3 ▶ Earthquake resistance seismic retrofitting via providing increased ductility to reinforced concrete walls using carbon fiber sheets

After the 2010 earthquake in Chile, much attention was drawn to the fact that concrete crushes due to bending and compression on multi-story shear walls without boundary columns in RC structures led to some buildings completely collapsing. Therefore, this research intends to develop a method for retrofitting these kinds of walls without columns against concrete flexural failure by using carbon fiber sheets. By conducting structural experiments on RC walls without boundary column retrofitted by being wrapped in carbon fiber sheets, we have confirmed a delay to the crush to the concrete at the bottom of the wall that occurs flexural failure, and an improvement in deformation capacity.

Static loading test of retrofitted wall using carbon fiber sheets

Structural Engineering Laboratory

Staff	• Associate Professor **Yukihiro MATSUMOTO** (E-mail：y-matsum@ace.tut.ac.jp)
Laboratory URL	http://sel.ace.tut.ac.jp
Key words	Shell, Spatial structures, Seismic design, Buckling, FRP, Hybrid structures, FBG, SHM

Research topics are as follows:
1) Seismic and Buckling Design Methodology of Shell & Spatial Structures
2) Structural Design of FRP Structures
3) Reinforcement and Strengthening for Steel Members using CFRP
4) Structural Health Monitoring using Fiber Bragg Grating Sensor

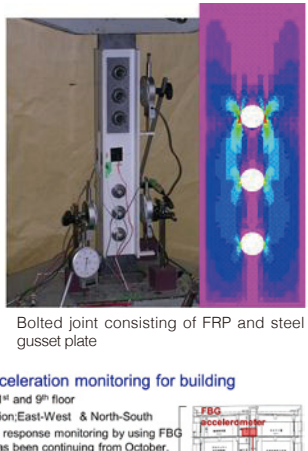
Theme 1 ▶ Buckling and seismic response behavior of shell and spatial structures

For the design of shell-like space frames located in seismic area, it is very important to give considerable attention to the dynamic and buckling behavior. However, for single layer latticed cylindrical roof structures, it has not been enough to make clear their dynamic responses during earthquake and to estimate the load carrying capacities. Also, it is well-known that metal shells and shell-like lattice frame structures have buckling behavior which is very sensitive to initial geometric imperfections. Our research interests are as follows.
1) Buckling behavior of thin-walled cylinders
2) Buckling behavior of latticed shell structures
3) Seismic response behavior of shell and spatial structures and its seismic design methodology

Single layer latticed cylindrical shell structure

Theme 2 ▶ Fundamental study on FRP material for building and civil structures

FRP material has good characteristics such as light-weight, high-strength and high-corrosion resistance. Light-weight structure possesses some advantages over the seismic load and rational constructing procedure. Our research interests are as follows.
1) Mechanical characteristics of bolted and adhesively bonded joint for FRP
2) Effects of reinforcement using CFRP
3) Design method of FRP structures
4) Long-term characteristics of FRP materials and FRP structures



Bolted joint consisting of FRP and steel gusset plate

Theme 3 ▶ Structural health monitoring

Structural health monitoring (SHM) is developed in order to detect the degradation of the structural mechanical performance.
We have been performing the vibration monitoring by using the recently developed fiber Bragg grating (FBG) sensors. Our research interests are as follows.
1) SHM using FBG accelerometers for buildings
2) SHM using FBG sensors for steel bridges
3) SHM using FBG sensor for adhesively bonded layer
4) SHM using wireless sensor system

SHM system using FBG accelerometer in Toyohashi Tech.

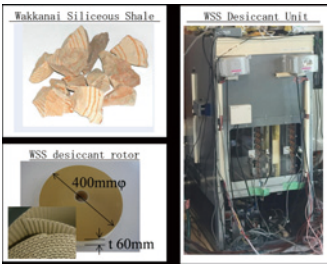
Building Environment Laboratory

Staff	• Professor **Kazuyo TSUZUKI** (E-mail : ktsuzuki@ace.tut.ac.jp)
Key words	Indoor air quality, indoor climate, desiccant ventilation system (dehumidification), sleep, thermoregulation, thermal comfort, energy saving, productivity, foliage, renovation

We conduct research on methods to achieve healthy and comfortable residential environments with a minimum burden on the natural environment. Current research themes include (1) indoor air pollution and ventilation systems; (2) sleep and thermal environments; (3) thermal comfort and productivity; (4) housing renovation and healthy effects for elderly people.

Theme 1 ▶ Development of Desiccant Ventilation System Using Natural Mesoporous Material

A highly efficient air-conditioning system for residential use is necessary to develop because energy consumption is increasing more and more in both the residential and commercial sectors. In Asian countries, with high temperatures and humid climates, dehumidification requires a large amount of energy to sustain a satisfactory level of thermal comfort. The desiccant ventilation system is expected to reduce energy consumption for the dehumidification process. We are focusing on a natural mesoporous material called Wakkanai Siliceous Shale (WSS) as a desiccant material. Our research aims to develop a new desiccant system using WSS. Currently, in order to evaluate energy saving performance, a demonstration test of a prototype WSS desiccant unit has started.



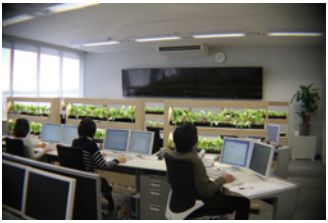
Pictures of WSS desiccant rotor and ventilation unit

Theme 2 ▶ The Effects of Thermal Environment on Human Sleep and Thermoregulation

Sleep is one of the most important behaviors for human health in the indoor environment. In order to investigate sleep quality and thermoregulation in an actual living environment, field surveys are performed to reveal the sleep quality and subjective sensations of the occupants as along with the surrounding air temperature, humidity, and air velocity in the bedroom. In a climatic chamber we set environmental conditions and measure EEG, ECG, or thermoregulatory responses such as skin temperature and sweat loss of the human subjects in order to investigate the effects of environmental factors on the human body during the sleep period. We consider the correlations between thermal factors and human responses in order to research a thermally comfortable environment for sleeping people. Further researches on elderly sleep quality and seasonal environmental effects on sleep are studied in residential houses and nursing homes.

Theme 3 ▶ The Effect of Foliage on Physiological & Psychological Responses and Productivity

Foliage plants such as benjamin and pothos seem to have a variety of beneficial ("green amenity") effects, including purification by removing chemical compounds from indoor air, recovery from fatigue, alleviation of stress, and an increase in productivity. The subject experiments were performed to investigate EEG, ECG, salivary amylase, subjective sensations, and productivity in a space including foliage plants in the experimental room. Moreover, further investigations were carried out to analyze office workers' productivity in actual offices.



Experiment on the effect of foliage plants on the office workers' productivity

Theme 4 ▶ The Housing Retrofit and its Health Effects on Human Occupants

Old houses without sufficient insulation material need to be renovated. We measured the blood pressure of the elderly occupants as well as thermal environments in the houses and compared them before and after renovation. The indoor air temperature increased with the addition of insulation material and improved air tightness in the older structures. Such an increase in indoor air temperature resulted in a good outcome by lowering the blood pressure of the elderly occupants.

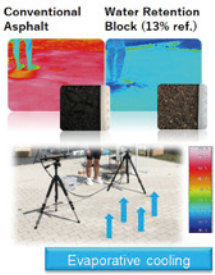
Building Environment Design Laboratory

Staff	• Associate Professor **Yasuhiro SHIMAZAKI** (E-mail : shimazaki@ace.tut.ac.jp)
Key words	Environmental Engineering, Ergonomics, Public Health, Thermo-physical property, Urban climate

Comfort or safety is an important concept in environment design. We are mainly investigating human thermal comfort or human-biometeorology under transient and un-uniform complex condition (space un-uniformity and human regional differences) and effect of environment components' thermal properties such as building materials and even clothing and bedding on heat transfer between human and environment with using field measurement and numerical simulation. Our research plans are to develop an accurate evaluation method for comfort issues to build both human and eco-friendly products and environments with engineering approach.

Theme 1 ▶ Evaluation for thermal comfort and environmental health

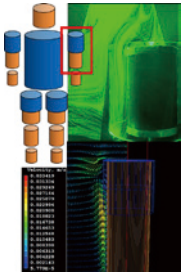
Traditional studies of thermal environments were performed indoors under uniform conditions. Because outdoor heat stresses people more severely than indoor heat, such extreme heat exposure is concerned about discomfort or risks of health. Since a thermal comfort index is a useful tool for understanding the experiencing environment, we proposed the human thermal load, which is a thermal comfort index based on the energy balance of the human body. In a steady state, and even in an unsteady state with its variations in weather and human factors, thermal comfort values can generally be obtained by using the overall human thermal load. The application for environmental planning is now examining with using human thermal load method. It has a lot of potentials by combining characteristics of material around living environment.



Field verification of pavement optimization for pedestrian comfort.

Theme 2 ▶ Measurement of material properties for comfortable living environment

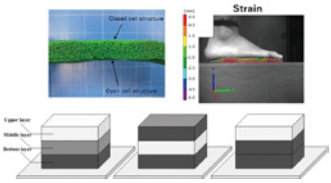
Our living environment is surrounded by various materials with various properties. They play an important role for formation of living environment and sense of user comfort. We are trying to assess the influences of materials properties around us on humans and the formation of the thermal environment. For example, covering the body such as clothing and footwear is a major contributor to the microclimate around the human body, which is the state of temperature formed by the combination of the environment, the human body, and materials. We are conducting measurements for the temperature, humidity and air behavior inside clothing microclimate contribute to the perception of thermal comfort, and commercial products have been developed based on the optimization of these parameters.



Clothing microclimate simulation

Theme 3 ▶ Ergonomics applications contributing to enhancing QOL (Quality Of Life)

Our research topics mainly include, but are not limited to thermal aspect of human comfort. Product designs have continued to advance in an effort to improve comfort and performance and reduce ergonomics risks. One of fundamental ergonomic principles is to reduce excessive force or stress. For example, we investigated the mechanical properties along with the viscoelastic behavior of laminated EVA foams and we provide a useful database for optimizing dynamic shock-absorption performance, which is applicable to footwear midsoles and paddings for preventing hip fractures.



Structure optimization for functionally-graded EVA foam

Architecture and Urban Design Laboratory

Staff	• Professor **Shiro MATSUSHIMA** (E-mail : shirom@ace.tut.ac.jp)
Laboratory URL	http://mlab.ace.tut.ac.jp/
Key words	Design technology, design robotics, digital fabrication, town development, management

The Architecture and Urban Design Laboratory conducts a wide variety of research relating to building design and practical design activities.

Theme 1 ▶ Theory in architectural design

We are conducting research into theories of design relating to what kind of philosophies is behind the background to an architect's designs and what kind of processes are used in designing. By reflecting the results of this research into actual design, we aim for the creation of comfortable and safe architectural environments.

A robot arm

Theme 2 ▶ Design technology & robotics

We are conducting research into application of CAD/CAM technology to architectural design, including 3D printers, laser cutters and CNC (Computer Numerical Control) devices by using a leading-edge architectural manufacturing lab, from such perspectives as; 1) the creation of complex architectural models that would have been impossible with existing design methods; 2) development of methods for gaining a practical understanding and investigating spaces at the planning stages using physical models; (3) new architectural manufacturing that involved collaboration with other industries, starting with manufacturers. We have introduced industrial robots ahead of other domestic architecture universities, and are working alongside overseas universities, including Harvard University , while taking progressive approach to realize a revolution in architectural design.

CloudLeft: Cast model project

Theme 3 ▶ Community Development and project management

We have been actively involved in community development by doing renovating the façades of the shops aligned in Toyokawa-Inari, Shrine promenade in Aichi. In order to improve the streetscape of the most popular venue to the prayers and tourist in Toyokawa City, students under the supervision of professor collaborated with local residents and have already renovated 15 shops. Other community-related projects include the creation of communion bases in order to promote proactive village development in hilly and mountainous areas. Management together with advancement of technology is another topic to investigate the keys to success in complex modern architectural projects; unlike the old projects where architect should only handle client, the knowledge and skills to undertake the tasks and coordination not only of a large number of participants but also of information. Instructor has a long practice experience and by combining real world situation and pedagogical methodologies, empirical research and education is provided.

The townscape improvement in Toyokawa Inari Monzen

Architectural Design and Information Technology Laboratory

Staff	• Lecturer **Akihiro MIZUTANI** (E-mail : mizutani@ace.tut.ac.jp)
Key words	Architectural Design, Architectural Planning, Building Information System, Digital Design

I am working extensively in the research and the practice related to architecture and urban design and planning. In particular, I am focusing on the research and the practice on "digital design" which is noted as a new design method in the field of architectural design.
My current main themes are the following three. I am trying to organize architectural design informatics from historical analysis of computational designs. In addition, I focus on the research which explores its possibilities through the practice of design activities and development of digital design method.
On the other hand, I am working on the research on redesign mainly for public buildings and public spaces. In addition to theoretical research about existing public buildings and public spaces, I am doing practical projects which perform from implementation design to renovation with my students.

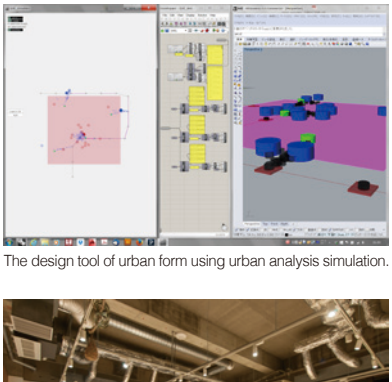
Theme 1 ▶ Study on "Architectural Design Informatics"

This research theme focuses on the arrangement of computer utilization projects which was introduced from the 1960s in the architectural design field. It also approaches to clarify its theoretical framework by analyzing it historically. Focusing especially on the philosophy of computer use in the early period, the research tackles to clarify the significance of its application today. By structuring them as "Architectural Design Informatics", we aim to make relativization of the development of computational design method that is becoming mainstream recently and to generalize it as an architectural design theory.

A chair made through Digital Fabrication.

Theme 2 ▶ Study on Computational Design

In this research theme, we mainly develop the following digital design method. (1) Design proposal / consensus forming building tool using VR head mounted display (2) Using digital fabrication tool for manufacturing, (3) Design tool which can utilize various simulations such as structural analysis and urban forming. In addition to the development of design tools of such a new approach, we analyzes how the design and the result of planning changed through the process using these tools and we are discussing what effect it has in design proposals and forming consensus.



The design tool of urban form using urban analysis simulation.

Theme 3 ▶ Study on Redesign of Public Space

In this research theme, we analyze and examine how to redesign existing public buildings and spaces against anticipated social changes including population declines. Through the development of method that is not only complementing imperfections of existing spaces such as maintenance and renovation of facilities, it tries to optimize the gap between existing space or situation and future vision. In addition to the theoretical research approaches such as surveys on actual situation of public space use and analysis of refurbishment methods, we also focuses on the research through practical projects which perform from design to construction.

Recent work of redesign (Startup Garage).

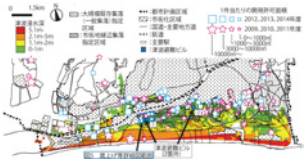
Urban Planning Laboratory

Staff	• Professor **Junichiro ASANO** (E-mail：asano@ace.tut.ac.jp) • Assistant Professor **Kazuki KARASHIMA** (E-mail：k-karashima@ace.tut.ac.jp) • Assistant Professor **Yichen LIU** (E-mail：liu@ace.tut.ac.jp)
Laboratory URL	http://urbandesign.web.fc2.com/MOTHER-hp/STU-hp/index.html
Key words	Land use planning, land use controls, urban design, history of modern urban planning, history of modern city making

"Urban Planning Research Declaration: Our method shall be urban design, our mentality shall be the doctrine of provincial cities, and our attitude shall be a complete appreciation of cities and architecture!" This is a riff on the famous city creation declaration of "Our method shall be readjustment, our mentality shall be the doctrine of small cities, and our attitude shall be a complete appreciation of cities." I include it here because it perfectly describes my research style and goals.

Theme 1 ▶ Study on land use planning and land use controls in Japan

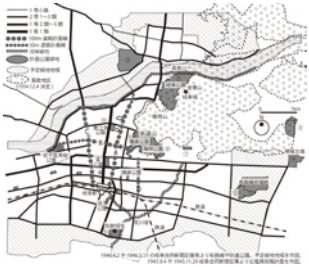
Entering an age of falling population and low economic growth, city planning needs to consider not only these factors but also effects upon the Earth's environment. In particular, provincial cities have a requirement to be compact and sustainable. One of the major factors that influences city planning is land use planning. This theme therefore focuses on suburban land use planning for provincial cities. While closely inspecting land use controls, including city planning areas, area division, the land development permission system, the district plan system and voluntary ordinances by local governments, we seek to highlight the issues between actual development and the systems & operations in place, and to inquire into issues relating to them. In the 2016-2017 academic years, it is our intention to advance our research into international comparative research into preventive measures for city shrinkage, research relating to formulation status of location optimization plans, etc.



Individual developments distribution in urbanization control area included of Tunami Hazard area : Hamamatsu City

Theme 2 ▶ Study on history of modern urban planning and city making in Japanese cities

Japanese research into the history of modern urban planning has been focused first and foremost on large cities and colonial cities from the world war period, but the development of domestic provincial cities has not yet been fully explained. This research targets major domestic provincial cities to which the old Urban Planning Act applied in a relatively early period, and seeks to make clear the ideals behind the planning and the planning techniques used in both the pre-war period and post-war reconstruction period. We also seek to make clear the meaning this history holds today, and how it is continued or discontinued in current urban planning. In the 2016-2017 academic year we intend to place our focus on the relationship between land use planning according to the war damage reconstruction plan, and land use planning in the period when the area division system was introduced.



Initial concept association diagram for the Gifu post-war reconstruction urban planning

Theme 3 ▶ Study on urban design methods

Some of the issues faced by urban design include three dimensional design, going beyond two dimensional land planning on a regional scale and allowing explorations of the form and design of buildings, processes that presume the participation of a variety of planning bodies, and the systems and income & expenditure management required in order to realize those plans, while research into urban design seeks to uncover new values and regional planning resources in order to create rich urban spaces. For the 2016-2017 academic year, we are placing our focus on the relationship between post-war reconstruction urban planning and modern downtown development policies.

Uncovering the riddle of the axis lines on the path leading to Zenkoji temple (left), A view of Ueda, as seen in the 1966 movie "The Inugami's family" (middle), The same location in the summer of 2002 (right)

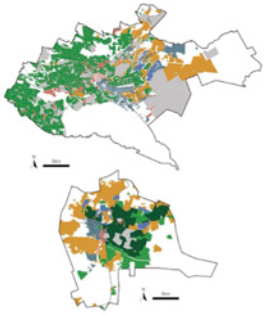
International Urban Planning Laboratory

Staff	• Lecturer **Haruka ONO** (ono.haruka@ace.tut.ac.jp)
Key words	Urban and Regional Planning, Territorial Design, Community Development, African Cities, Asian Cities

To realize sustainable cities, the mission of our laboratory is to explore the potential recommendations on what needs to change at policy, institutional and ground levels from a global perspective. Our research includes: international urban and regional planning; land tenure, planning and management; and territorial design. We encourage students to develop a sound theoretical knowledge as well as practical skills for enabling them to practice in all areas of urban planning and territorial design.

Theme 1 ▶ International urban and regional planning

In many of the rapidly growing cities, especially in Asian and African countries, modern urban planning and land management systems derived from western countries are not properly working. Urban development issues have become evident such as poverty, slums, environmental pollution and vulnerability to disaster. It is an urgent global issue to consider urban and regional planning based on the history and local resources of the city. Our work is to explore case studies on the process and actual situation of urbanization, as well as the institutional and political approaches, to develop sound theories for urban planning and regional development in developing countries.



Urban land use (Top: Nairobi, Bottom: Lusaka)

Theme 2 ▶ Land tenure, planning and management

Land issues gain increasing importance in view of accumulating problems related to vacant houses, little or unused land, utilization of public spaces faced by shrinking cities, housing shortages, squatters, environmental pollution faced by growing cities, and to issues relating to disaster reconstruction faced by both cities. Now it is essential to consider how to manage and make use of our land as a shared property for all humanity. Research is focused mainly in providing a highlight of the current situation regarding how land is owned, perceived, planned, used and managed in order to best contribute to the evolution of livable cities.

Before and after renewal of a parking lot in the Matsuyama city center

Theme 3 ▶ Territorial Design

Our laboratory explores ideal territorial design in the contexts of community, spatial and institutional design on multiple scales from neighborhood to regional. We develop both scientific research and practical territorial design work in the field with particular interests in proposing new design processes that lead to the creation of sustainable living environments.

Territorial design practice (Left: Community design, Right: Spatial design)

Japanese Literature and Culture Laboratory

Staff	• Professor **Yasuyuki NAKAMORI** (E-mail : nakamori@las.tut.ac.jp)
Laboratory URL	http://las.tut.ac.jp/~nakamori/
Key words	W.M. Vories, Isaku Nishimura, Basho, Haikai, Shiko

The appeal of the buildings by W.M. Vories and Isaku Nishimura are revealed from a perspective of cultural history, taking into account such clues as their ideas, their life philosophies, their value.

Theme 1 ▶ William Merrell Vories : personality and philosophy of Architecture

William Merrell Vories was a layman of Christianity, educator, architect, and founder of the Omi Mission. The appeal of the buildings by W.M. Vories are revealed from a perspective of cultural history, taking into account such clues as their ideas, their life philosophies, their values, the backdrop of the times and their interpersonal relationships.

Suikyuso

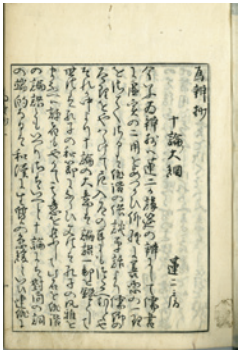
Theme 2 ▶ Isaku Nishimura : Education and philosophy of Architecture

Isaku Nishimura was an educator, architect, ceramist, painter, and founder of the Bunkagakuin. The appeal of the buildings by Isaku Nishimura are revealed from a perspective of cultural history, taking into account such clues as their ideas, their life philosophies, their values, the backdrop of the times and their interpersonal relationships.

Nishimurakinenkan

Theme 3 ▶ Theme3 History of Haikai : Basho, Shiko, Minoha

Haikai is a cultural movement from the Edo period. We seek to make clear the essence of Shiko-hairon, the poetic doctrine of Shiko, that reached the most notably conclusion among the Haikai poets. Moreover, we also seek to make clear the essence of the Minoha-Densyo written by Mino-ha poets based on the doctrine of Shiko and the history of Haikai. We are currently advancing research into a restructuring of the history of Haikai and literature.



"Zyuronibensyo"

Shishian

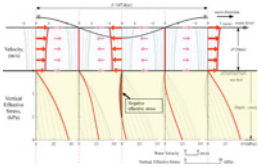
GeoMechanics Laboratory

Staff	• Professor **Kinya MIURA** (E-mail : k-miura@ace.tut.ac.jp) • Lecturer **Tatsuya MATSUDA** (E-mail : t.matsuda@ace.tut.ac.jp)
Laboratory URL	http://www.geomech.tutrp.tut.ac.jp/
Key words	Geotechnical engineering, seabed, structural foundations, stability analysis, seismic resistant design, wave resistant design

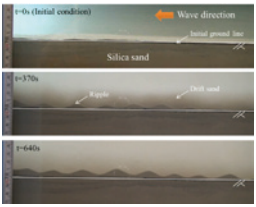
GeoMechanics Group Laboratory has studying the stability of soil structures and structural foundations, the disaster mitigation, and the geotechnical environment. The stability of structures that residential areas and public facilities such as roads, bridges and ports are important under severe external actions including earthquake, tsunami, heavy rain, and typhoon, is a pressing issue of civil structures for the safety and sustainability of residents lives. The geotechnical environment is also important for it, just as the atmosphere and the ocean. We are continue studying of geomechanics to resolve the issues related to these areas and propose new technologies.97

Theme 1 ▶ Scour mechanisms of seabed due to ocean waves and the stability of coastal structures

The study on the scour of seabed around coastal structure due to ocean wave has focusing on the tractive force by shear stress in surface seabed. On the other hand, the instability of seabed that is decreased of the vertical effective stress by acting the change of water pressure in the seabed during ocean wave is known. Our study clarify the mechanism of scour phenomenon with the synergy effect between the tractive force and a change in vertical effective stress due to ocean wave, and also is investigate for effect of stability of coastal structures.95



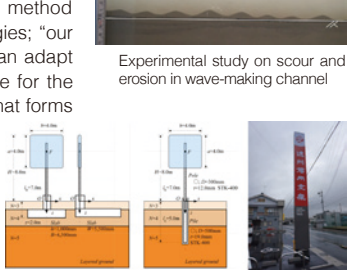
Investigation of scour phenomenon among interaction between tractive force and seepage force due to ocean wave by explicit solution



Experimental study on scour and erosion in wave-making channel

Theme 2 ▶ Design and construction method for economical pile foundations with short construction time for signs

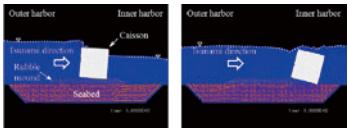
The foundations for signs and traffic signs are almost all gravity type, using a large volume of concrete. However, not only does concrete require considerable time for strength development, but construction processes include excavation, form construction, reinforcement work and water replacement. The results will be a number of potential problems, such as a prolonged work period or lack of skilled personnel. In order to resolve these issues, our laboratory has developed a design and construction method for pile foundations. This research is supported by three technologies; “our uniquely developed deflection analysis technique for a pile that can adapt to layered ground,” “our uniquely developed compound structure for the support pillar and the pile” and “a construction method for a pile that forms a soil improvement.”125



Design-construction method for economical piled foundations with short-term construction for signs

Theme 3 ▶ Stability of coastal structures against earthquake and tsunami

Coastal structures have occurred catastrophic damage from earthquakes and tsunami. However, the mechanism of the tsunami disaster for the coastal structure has not yet been completely revealed. Our laboratory is studying the seismic and tsunami disaster of coastal structure focusing to how the multi-scaling problems and multi-phase interactions among the soil and water affect structures, based on centrifuge tests and smoothed particle hydrodynamics simulations with external force-soil-structure interactions, and research the countermeasure and design methods based on the fracture control design.



Estimation of damage to caisson-type breakwater induced by tsunami with particle based method

Water Environment Conservation Laboratory

Staff	• Professor **Takanobu INOUE** (E-mail : inoue@ace.tut.ac.jp) • Research Associate **Makoto SAGA** (E-mail : makoto_saga@ace.tut.ac.jp)
Laboratory URL	http://www.wq.ace.tut.ac.jp/
Key words	Water environment, water quality, runoff loading, diffuse pollution, eutrophication, environment conservation

The main topics of this laboratory are quantification of pollution sources by monitoring and modelling, and development of approach for pollution control.

Theme 1 ▶ Development of the nutrients runoff model

The runoff of nutrients from drainage basins occurs not only from point sources such as factories and sewers, but also from plane sources such as forests and agricultural urban regions. There are a number of closed water areas, such as the Mikawa Bay, that have seen no improvement in water quality even with a reduction in runoff load from point sources, and therefore calculation of nutrient runoff load from plane sources is becoming more important. Based in actually observed data, we are working to create a model that can be used for high accuracy calculation of the nutrient runoff load in order to validate nutrient reduction effects etc.

Gold mining site

Theme 2 ▶ Survey on mercury contamination in the environment

In Indonesia and other regions in South-East Asia as well as Amazon basin, small-scale gold mining is common among the residents of the region. The mercury used for refining the gold is then released into the river without any processing. As a result of the biological concentration through the ecosystem of the river, the mercury contaminates the fish that the people living along the river eat, posing a threat to their health. In the regions where gold mining takes place actively, we are seeking to investigate the volumes of mercury contained in the river water and silt, and the effects this is having on fish and people to reveal the current state of mercury contamination.

Runoff from agricultural field

Theme 3 ▶ Development of measurement method for bio-available phosphorus and analysis of environmental fate

Phosphorus is a major cause of eutrophication, and a large volume of suspended phosphorus runs off in rainfall. This increases the ratio of suspended phosphorus, but as suspended phosphorus includes phosphorus derived from mineral, it is important to measure bio-available phosphorus. Along with the development of a method for testing a large number of samples in a short space of time, we will also make clear the runoff characteristics of bio-available phosphorus from a drainage basin.

Theme 4 ▶ Runoff analysis of contaminants from agricultural fields

A large amount of nitrogen and phosphorus applied through fertilizer are transported from agricultural fields to lakes and basins during rain events. We are investigating the loading and fate of contaminants in aquatic systems as well as the strategies for reduction of the contaminant loading.

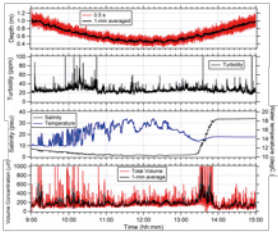
Coastal Engineering Laboratory

Staff	• Professor **Shigeru KATO** (E-mail : s-kato@ace.tut.ac.jp)
Laboratory URL	http://www.umi.ace.tut.ac.jp
Key words	Sediment dynamics, Coastal disaster mechanism, Coastal management, Beach change

Researches on coastal environment and disaster mitigation are conducted from the viewpoint of Coastal Engineering. We are trying to solve problems and to make clear phenomena in coastal region using field observation, data analysis and numerical simulation. We hope to create useful results for our life and community.

Theme 1 ▶ Sediment dynamics and topographic change in coastal zone

Sediment transport in coastal zone has a great influence on coastal erosion, topographic changes and coastal environment. We are conducting the researches on the generation of the sediment transport in coastal zones (sea and river mouths), their spatial and temporal characteristics, the relationship among coastal waves and currents, volumes of the sediment transport and coastal topographic changes, to aim for the protection of coastal erosion and the preservation of coastal environment Various approaches, such as field observation, laboratory experiment and numerical simulation, are used for the elucidation of related phenomena and the investigation of countermeasures. We are also conducting XRF (X-Ray Fluorescence) analysis to investigate the sediment transport using chemical elements of a sand as a tracer, and coastal survey using UAV (Unmanned Aerial Vehicle) to estimate the topographic changes of tidal flat and beach.

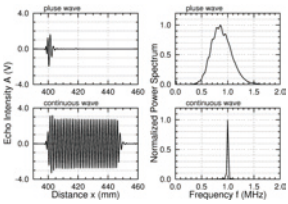


Results of field observation of sediment transport at a river mouth.

Theme 2 ▶ Development of measurement method for coastal sediment using ultrasonic waves

In order to understand the characteristics of sediment transport in water areas, such as rivers and coastal areas, we are attempting to develop a new technique for quantitative measurement of sediment concentration using ultrasonic waves. The goal of this research is to establish a new measurement method of sediment transport using ultrasonic waves. We are also developing a data analysis algorithm to estimate the particle size distribution of sand grains from the acquired ultrasonic echo data.

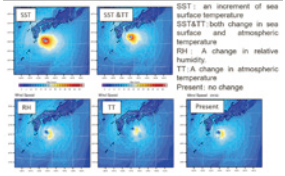
Aerial photography of Maeshima-Tonboro at Higashi-hazu taken by UAV.



Differences of transmitting wave profiles and their frequency spectrum between pulse wave (top) and continuous wave (bottom).

Theme 3 ▶ Evaluation of Coastal Disaster Mechanism and Future Coastal Hazards

It is reported that coastal hazard will be more severe under climate change in the future. We try to evaluate future possible and past occurred coastal hazards based on numerical simulations and field surveys. As a recent research, numerical simulations are conducted for future possible typhoons and storm surges under RCP8.5 scenarios of IPCC (2013). Furthermore, numerical simulations and field surveys are carried out for storm surge disasters associated with Typhoon Haiyan (2013) and rapid intensified extra-tropical cyclone over Nemuro (2014). One of the goal of our studies is to investigate coastal hazard and mitigation for regional social community in order to contribute to next-generation disaster prevention society.



Results of future possible typhoons under different atmospheric and oceanic environments of RCP 8.5 scenario.

Water Environment Engineering Laboratory

Staff	• Associate Professor **Kuriko YOKOTA** (E-mail : yokota@ace.tut.ac.jp)
Laboratory URL	http://www.wq.ace.tut.ac.jp/
Key words	Water environment, diffuse pollution, nutrients, Mercury

The main topics of this laboratory are quantification of pollution sources by monitoring, and elucidation of runoff mechanism from forest stream to urban area rivers.

Theme 1 ▶ Runoff analysis of contaminations from agricultural fields

Runoff from agricultural fields includes nitrogen and phosphorus from fertilizers, and can be considered to contribute a large volume of the runoff load to closed water bodies such as lakes and estuaries. Runoff containing a particularly large volume of pollutants is generated when it rains. Targeting runoff during rainfall, we are seeking to understand and evaluate the volume of contaminants in runoff from agricultural fields and the characteristics of that runoff, and consider ways to reduce the resulting load.

Runoff from agricultural field

Theme 2 ▶ Study on water quality of the Umeda River

The eastern, interior part of Mikawa Bay (Atsumi Bay) suffers from chronic eutrophication, with damage to the finishing industry already being reported, including massive damage to the population of juvenile littleneck clams. The reason is through to be excessive nutrients being supplied from continental areas, but much remains unknown about the actual situation. Looking at the Umeda River, the second largest river in the region behind the Toyo River, as the subject of our survey, we are seeking to obtain an understanding of the characteristics of the pollutants in the drainage basin and consider ways to reduce the pollutant load.

Mikawa Bay

Theme 3 ▶ Survey on mercury contamination in the environment

The Minamata Convention on Mercury, ratified in October 2013, has brought further attention to problems relating to mercury. Mercury is easy to spread worldwide via atmospheric long-range transport. Some mercury compounds are removed from the atmosphere as a dry/wet deposition. Mercury ion in the water is readily methylated by both abiotic and biotic pathways. There are still many unknown elements in relation to the movement of mercury through the environment in Japan, however. We are continuously monitoring the input of contaminants from non-point sources at investigating sites.

Forest Stream Survey

Atmospheric observation

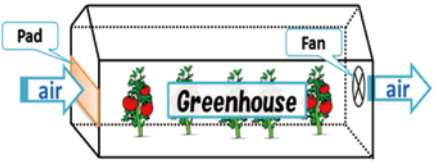
Atmosphere and Thermal Environment System Laboratory

Staff	• Lecturer **Takayuki TOKAIRIN** (E-mail：tokairin@ens.tut.ac.jp)
Laboratory URL	http://www.ace.tut.ac.jp/
Key words	plant factory, micro meteorology, computational fluid dynamics, environmental control

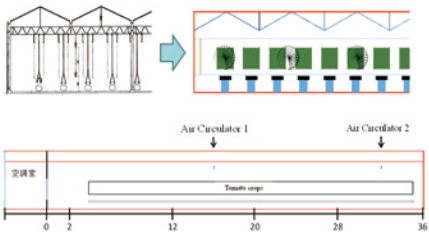
This laboratory mainly researches atmospheric and thermal environment inside a plant factory (greenhouse) using various sensors and computational fluid dynamics model (CFD model) to clarify the appropriate environment for plant growth. Details are described below.

Theme 1 ▶ Evaluation of environment for various types of plant factory (green house) using a computational fluid dynamic model.

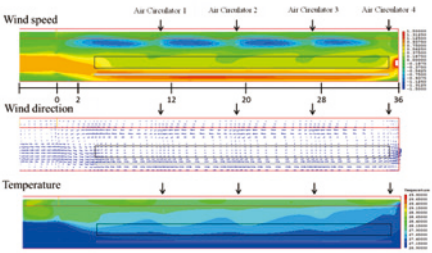
Atmospheric and thermal environment inside a plant factory (greenhouse) have been evaluated mostly based on empirical method, therefore it is difficult to know the detailed distribution of air temperature, humidity, airflow and CO2 concentration and their control. The objective of this study is to evaluate and predict the detailed distribution of environmental components mentioned above in a plant factory for contribution to the environmental control to maximize crop yield. In future, photosynthesis model will be considered for modeled crop in CFD to clarify the effect of CO2 application on crop yield.



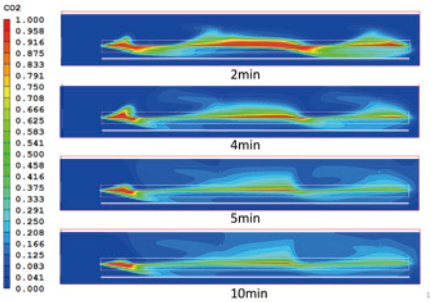
Plant factory equipped with a pad and fan evaporative cooling system



Modeled plant factory.



Calculated wind and temperature fields using a computational fluid dynamics model.



Calculated CO_2 distributions due to CO_2 application in a modeled crop.

Coastal Environmental Research Laboratory

Staff	• Assistant Professor **Takumi OKABE** (E-mail : okabe@ace.tut.ac.jp)
Laboratory URL	http://www.umi.ace.tut.ac.jp/
Key words	Coastal sediment management, coastal morphology, estuarine environment, rip curnents

Theme 1 ▶ Monitoring coastal morphology for regional sediment management

A large number of technical hurdles remain before we can achieve a measurement method for understanding sediment transport in water areas such as rivers and coasts. In particular, long-term coastal management requires a monitoring method providing continuous and highly-frequent topographical information on shallow sea areas. This research theme concentrates on small vessels for whitebait fishing in which fishermen operate in shallow sea areas. By recording and analyzing position and water depth during the operation of these fishing vessels, we are undertaking research to develop a low-cost monitoring method that can provide highly-frequent and continuous region-wide bathymetry data. Moreover, we are also using this data to research into analytical methods to calculate bathymetric changes and volume of sediment transport, along with methods of data assimilation.

Small fishing vessels in the Enshu-Nada coast

Theme 2 ▶ Material transport and ecosystems in an estuarine tidal flat

Ecosystems and environment in coastal zones are heavily influenced by economic activities, such as deterioration of water quality and man-made changes to coasts. Fisheries are no exception. Because reducing the numbers of fish catches is a critical issue, water resource management and environmental conservation are thus vital in order to maintain sustainable fishing. This research theme targets abundance of juvenile littleneck clams in Rokujo tidal flat, a primarily setting site for juvenile of manila clam in Japan, seeking to make clear their generation mechanism by investigating relationship between mechanisms and material transport in the tidal flat. We are especially focused on the relationship between waves, currents and sediment transport and juvenile littleneck clams setting and movement. Unlocking the sediment transport mechanisms around estuaries and tidal flats will allow us to present the optimal sediment environment for the development of juvenile clams, intending to point the way to the recovery of clam resources.

Japanese littleneck clam juveniles on Rokujo tidal flat

Theme 3 ▶ Water quality variations in an estuary

Interest in water environment has increased significantly in recent years, and a variety of regulations intended to conserve water quality have served to improve water quality in rivers and estuaries. On the other hand, hypoxia has a large impact on aquatic ecosystems and water quality in estuaries, coastal waters and freshwater lakes, and its formation and movement is related to hydrology. In order to protect waters from the hypoxia and to improve methods of water quality management, therefore, there is a requirement to understand the movement of these water masses based in the hydraulic characteristics. This research theme is focused on a estuary lagoon, Hamana Lake, intending to make clear the mechanism by which the hypoxia is formed and moves, upwells, and influences the water quality of shallow water areas in the lake. In order to make clear the mechanism, we are also taking into account a variety of other elements, including weather, tides and currents.

Field measurements in Hamana Lake

Socio-Economic System Engineering Laboratory

Staff	• Associate Professor **Hiroyuki SHIBUSAWA** (E-mail：hiro-shibu@tut.jp)
Laboratory URL	http://www.pm.ace.tut.ac.jp
Key words	Urban and regional economics, industrial policy, simulation

The studies in my office are classified into two fields. One is about socio-economic system analysis for city, region and industry and another is about evaluation methodology for policy and project.

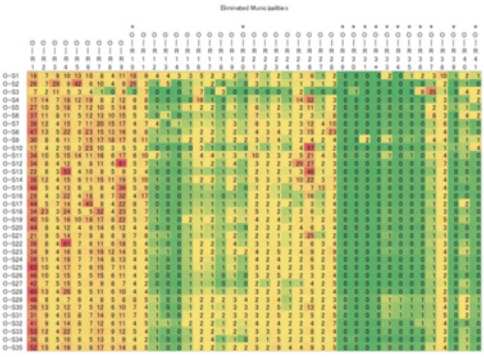
Theme 1 ▶ Socio-Economic System Analysis for City, Region and Industry

In order to understand socio-economic structures and to be able to predict the future, there is a vital requirement to fuse the accumulation of academic data with analysis methods. We are pursuing the construction of economic systems in urban and regional areas and industrial clusters, although with their analysis and application. Based in approach of economics and simulation methods, we are developing a methodology for analyzing the variety of issues that can arise in urban and regional areas and industrial clusters, and conducting analysis that targets urban and regional areas and industrial clusters. Some of the themes we are working with include the economic effect of large risks such as earthquakes, the regional economic effect of the innovation of next generation automobile technology, the economic effect of ports, and the economic effect of the formation of compact cities.

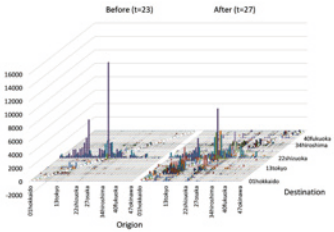
Modeling for Regions

Theme 2 ▶ Evaluation methodology for policy and project

We are pursuing the formulation of basic scientific theories required in order to support spatial policies for urban and regional areas, and the application of these theories. Based in economics, regional science, inter-industry analysis and econometrics, we implement analysis and simulations on a variety of socio-economic phenomena and policy issues that have a spatial dimension. Some of the themes we are working with include the development of an econometric model for urban and regional areas, calculation of the economic effects provided by technological revolutions in industry clusters, analysis of inter-organizational learning in an intellectual society and quantitative analysis that makes use of GIS and spatial economic data.



Modeling for Industries



Modeling for Transportation

Urban and Transportation Systems Laboratory

Staff	• Associate Professor **Nao SUGIKI** (E-mail：sugiki@ace.tut.ac.jp) • Assistant Professor **Kojiro MATSUO** (E-mail：k-matsuo@ace.tut.ac.jp)
Laboratory URL	http://www.tr.ace.tut.ac.jp
Key words	Road traffic management, public transport network, traffic big data, intelligent transport systems (ITS), travel behavior analysis, public service demand, urban model, microsimulation

This laboratory researches the following themes in the pursuit of the ideal state for a safe, convenient, comfortable, and environmentally-friendly urban structure and transport systems that is in unison with regional society, and how it might be realized.

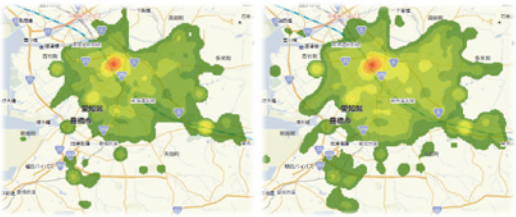
Theme 1 ▶ Traffic safety management methods that make use of traffic big data

The effective and efficient realization of traffic safety management that lies at the center of improving the road traffic environment demands a scientific understanding of the risks posed by traffic accidents. Our laboratory is aiming to construct a traffic safety management method that uses not only traffic accident statistical data, but also traffic big data such as drive recorder data, vehicle probe data, and three dimensional road space data. Our approach is focused on Aichi Prefecture and Toyohashi City, and includes the construction of an accident risk statistical model, the evaluation of accident risks by location and type of accident and an analysis of their causes, the observational survey, analysis and construction of a simulation model for detailed traffic flows at specific accident risk points, and the proposal and evaluation of traffic safety measures based on all of this information.

Extraction of rat-run traffic from car probe data

Theme 2 ▶ Local public transport network planning considering taxi mode

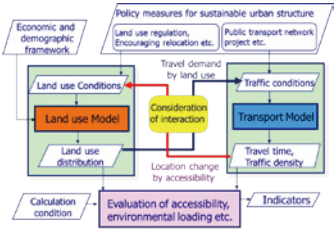
It is important to consider ideas that make use of taxi mode in local public transport network. Taxi mode is an individual and door to door transport system and has the advantage of being able to meet the diverse needs which mass transit systems such as railways and buses could not meet. Our laboratory analyses the actual situation and of taxi trips and the mechanisms of the use taxi mode based on digital daily log data and evaluates several policies that make use of taxi mode as a local public transport network through simulations and so on.



Distribution of departure and arrival points of taxi trips in Toyohashi (Left: Departure, Right: Arrival)

Theme 3 ▶ Future public service demand estimation for sustainable urban structure

It is concerned in the local government it becoming severe to offer public service at the same level now by annual revenue decrease under a population decline and aging society. Emerging pressures for more efficient and effective public management require more rational approach in forecasting future demand for public services before such problems will be actualized. Our laboratory develops the method to estimate the future distribution of population or households and grasp the change of urban service demand including transportation using urban model considering interaction between land use and transportation, in particular, microsimulation model. And we evaluate policy measures for sustainable urban structure, such as encouraging relocation policy to , improving or rebuilding of public transport network.



Analysis framework of urban model considering interaction between land use and transportation

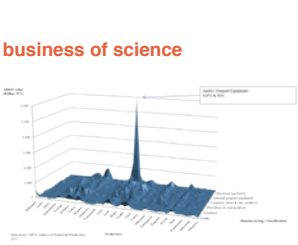
Business Risk Management Laboratory

Staff	• Professor **Takao FUJIWARA** (E-mail：fujiwara@las.tut.ac.jp)
Key words	Management of technology (MOT), business of science, real options, option games theory, timing options

This laboratory is studying the following topics as Studies on Industrial clusters, Valuation of start-ups at death-valley, Option-games analysis, and Timing option.

Theme 1 ▶ Study on open innovation and industrial clusters: MOT, business of science

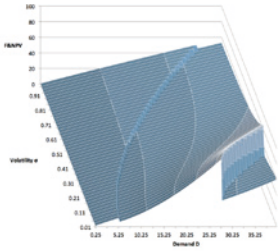
Regardless of advances in information and communication technology, the world has not flattened out but is rather showing a tendency to form up into industrial clusters. While heavily concentrated industrial clusters display selective and concentrated economy, they are also vulnerable weak to uncertainty. This creates a necessary condition for a business or and financial engineering model that can achieve a return on investment from even high birth and high death rate projects from basic research. Our laboratory is conducting research on the investment strategy of the business portfolio that can respond to uncertainty as MOT (Management of Technology) and the business of science.



Japan's 3Dminesional Industrial Structure

Theme 2 ▶ Study into valuation of start-up's early negative profits period: Real options

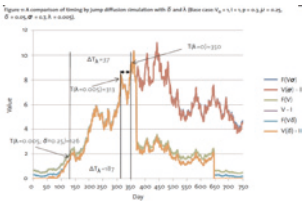
When it comes to rapid conversion from projects of basic research, start-ups have superiority over major large companies from the perspectives of combing revolutionary technology and niche markets. However, start-ups also have a tendency to collapse in after a short time due to lack of funding. This creates a requirement for an optimal valuation and implementation method that will allow revolutionary ideas to be implemented during their negative profits period. Our laboratory is performing research into the investment potential of revolutionary but high risk projects by using real options to convert the negative NPV (Net Present Value) into the positive ENPV (Expended Net Present Value) of the project.



Option-games Model

Theme 3 ▶ Study on strategic partnership in the trade-off between flexibility and commitment: Option games

Real options are reliant on flexible values that wait until uncertainty has been reduced. There is also a requirement, however, to evaluate a commitment value - limiting the risk of being overtaken by a rival company - from game theory and then striking an overall balance. Therefore, during strategic alliances under uncertainty, there is a demand for the proposal of scenarios in which the information sharing strategy can shift Nash equilibrium from the Prisoner's Dilemma to Pareto optimality. Our laboratory is using an option games approach to a conduct research into the optimization of the tradeoff between these two values.



Timing Option

Theme 4 ▶ Study on optimal timing of irreversible investment under uncertainty: Timing option

In the development of technology and products, future profits are an uncertain and investment should become an irreversible sunk cost. At this severe condition, the optimum timing is decided by waiting to invest until the present value of total return on investment can exceed the investment value with the value of waiting option. Of course, it is also possible to instead quickly make a withdrawal investment in order to limit downside risk as the negative profits of project or calculate the potential value of expanding an R&D investment as a growth option in order to create an upside opportunity for the future new market. Our laboratory team is conducting research into the timing option of investment decision by developing a model of underlying asset behaviors under uncertainty.

Advanced Agricultural Engineering Laboratory

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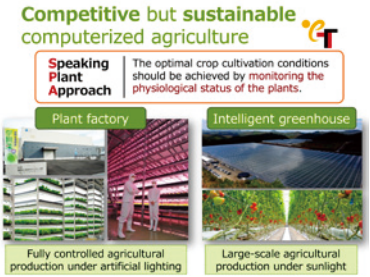
Laboratory URL	http://www.recab.tut.ac.jp/index.html
Key words	intelligent greenhouse, plant diagnosis, plant factory, photosynthesis, sensor, smart agriculture

The main research and development of this laboratory are relating to environmental control and optimum design of intelligent greenhouse and plant factory, plant diagnosis/monitoring for agricultural production.

Theme 1 ▶ Optimum design of intelligent greenhouse and plant factory for sustainable food production

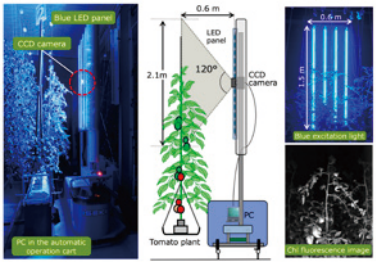
The intelligent greenhouse is an advanced greenhouse equipped with an automated environmental control system and conducting year-round plant production of various plants including vegetables and ornamental foliage plants under the sun. And, the plant factory is a facility achieving an extremely steady plant production under fully controlled environmental condition without sunlight. Currently, the computerized plant production based on the concept of Speaking Plant Approach (SPA) attracts attentions as an implementable key technology to achieve a significant productivity improvement in intelligent greenhouse and plant factory. The concept of SPA defines that the optimization of cultivation conditions should be based on measurements of the plant biological and physiological information and it is getting feasible according to a recent development of information technology, i.e. artificial intelligence and bioinformatics symbolized by omics.



Plant factory and intelligent greenhouse

Theme 2 ▶ Plant diagnosis robot and precise plant data for agricultural production

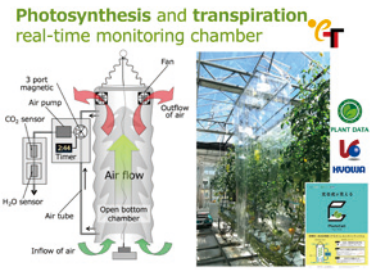
Chlorophyll fluorescence (CF) imaging technique is useful to evaluate the photosynthetic functions. CF is red light emission from plant leaves, which is generated by residual light energy that is not used for photosynthetic reactions. So, the precise measurement of CF allows us to evaluate the status of photosynthetic functions without touching the plants. The figure shows a CF imaging robot, which was developed in our previous studies and come onto the market in 2015. The CF imaging robot proved an apparent heterogeneous distribution of photosynthetic functions across the cultivation area (> 1 ha). Such information is probably useful to optimize the environmental control and crop maintenance strategies.



Chlorophyll fluorescence imaging robot for plant health diagnosis

Theme 3 ▶ Real-time monitoring of photosynthesis and transpiration

A variety of instrumentations for environmental control such as CO2 enrichment, supplemental lighting and air circulation have been installed in commercial greenhouses and utilized to increase the net photosynthesis. However, the extent of the contribution of each environmental control instrumentation to the crop photosynthesis is not clear. We developed a real-time photosynthesis and transpiration monitoring system that is able to be installed in commercial greenhouses and applied to obtain the time course of photosynthesis and transpiration of full-size tomato plant grown in a semi-commercial greenhouse. This system is going to be commercially available until 2020.



Photosynthesis and transpiration real-time monitoring chamber