4. Activities of Divisions and Centers

4.1 Division of Integrated Management of Disaster Risk

The Hanshin-Awaji (Kobe) Earthquake that occurred in 1995 showed us how vulnerable large modern cities are to extreme disasters. Modern cities consist of large complex systems, and the effects of a disaster also tend to be very complex and catastrophic. One of the most important lessons we learned from the experience of the Hanshin-Awaji Earthquake is that there is a need for comprehensive and integrated management methodologies to deal with the risks from catastrophic disasters. The aims of this research division are to develop methodologies for integrated disaster risk management. Our researches involve especially, the disaster risk evaluation, methodology of disaster prevention management (quality of safety), presentation of multifactorial infrastructure and logistics and its formation (quality of society), acquiring strategy of safety control of urban space and urban function (quality of life), and developing plan considering the disaster prevention measure with social development and environmental changes (quality of environment).

Regional Disaster Risk Management

To build up effective strategies for the disaster risk, it is necessary to carry our research forward based on the risk analysis of the strategy of disaster management. Hazards are brought about by the external force of nature and environment, but disasters are caused by hazards interacting with human activities. The interaction of such external force and activities makes the extent of disaster and recovering methods from the disaster different. This research section focuses on improvements in "Quality of Safety" (QOS). The structure of a region and city are examined by assessing potential risks involved in regional and urban activities. Effective remedies to reduce such risks are proposed from the viewpoint of integrated regional management. The current research tasks of this section are as follows,

1)Analysis and evaluation of disaster risks
2)Management-support information systems for urban diagnosis
3)Participatory disaster planning and adaptive management
4)Incorporation of disaster risk management into urban management
5)Disaster risk-oriented sustainable management

Infrastructure and logistics

Based on the analysis of urban disasters, the improvement of the quality of infrastructures are studied. The research is focused on reliable enhancements of infrastructure, such as lifeline systems, development of disaster response operation systems, and development of effective logistics. From this perspective, the current research topics are as follows,

1) Integrated Management for Infrastructure and Logistics
2) Quality Standard of infrastructure
3) Economic Analysis of Disaster Risk
4) Disaster Risk Communication
5) Policy Analysis of Disaster Mitigation
6) Disaster Response Analysis

Safety Control of Urban Space

Safety control of urban spaces is extensively studied to improve the Quality of Life. Our studies include development of risk evaluation methods for urban spaces, realization of high-quality living spaces with safety and amenities, development of optimal reliability design methods for constituent elements in urban spaces, and development of disaster risk management methods for urban living spaces. Our recent studies are focused on the following subjects,

1)Integrated management for disaster risk in urban space
2)Experimental and theoretical studies on structural control systems under earthquakes
3)Reliability analysis and reliability-based design of structures
4)Seismic risk management and performance design of living space for severe earthquakes
5)Damage prediction and disaster mitigation strategy for living space
6)Structural mechanics and seismic performance improvement of wooden buildings and houses

Environmental Disaster Management

For extended environmental subjects, we analyze the influences of natural (consisting of geo-systems and eco-systems) and social (socio-systems) environmental changes on disaster prevention and mitigation. Considering environmental preservation, disaster prevention plans in urban area are studied from these analyses. Specifically, a disaster is classified into four categories, "natural disasters", "environmental collapse disasters", "environmental pollution disasters", and "environmental culture disasters". Mutual relationships are analyzed from the viewpoint of disaster prevention and mitigation. Methodologies for planning, which combined natural sciences and social sciences, are systematized. Specific research subjects are as follows,

1)Analyses of processes of natural and social environmental changes
2)Planning for environmental disaster prevention in urban areas
3)Environmental disaster prevention investment in aging societies
4)Conflict analyses of development and environment concerns for consensus formation
5)Risk communication for disaster mitigation in regional community

International Disaster Research Collaboration (Inviting foreign scholars)

The mission of 21st century's research integration largely depends on international collaborations. Therefore, cooperating with the most ultramodern researchers in disaster science, elucidating the mechanism of disaster for different countries of different society and culture, utilizing the technology in disaster mitigation and international information, joint researches with the younger researchers and technician from those countries facing high levels of disaster risk, are of great importance. Our fifth research section, International Disaster Research Collaboration, serves this function by inviting research scholars from around the world. This research section focuses on,

1)Promotion of global collaborations of disaster research
2)Research on countermeasures against disasters, implementable in different socio-culture environments

4.2 Division of Earthquake Disaster Prevention

Theoretical and experimental studies are conducted with the aim of preventing and mitigating earthquake-induced disasters. Primary subjects of study include, mechanisms of earthquake sources, processes of seismic wave propagation, characteristics of ground motion inputs into structures, dynamics of foundation structures, and earthquake responses and seismic design of structures and structural components.

Strong Motion Seismology

For producing reliable strong ground motion predictions, earthquake source, propagation path, and site effects are studied. Observational and theoretical research is carried out to elucidate strong motion characteristics and to evaluate earthquake hazards during destructive earthquakes. Research topics are as follows,

1) Generation of seismic waves: Source inversion and characterization of earthquake sources; Dynamic seismic source modeling; Seismic source scaling; Near-source strong motions controlled by earthquake faulting
2) Seismic wave propagation: Surface geological effects on seismic motion; Subsurface structure modeling; Nonlinear characteristics of near-surface layers during strong ground motions
3) Strong motion prediction for scenario earthquakes: Development of theoretical and semi-empirical strong motion prediction methods; Strong motion estimation for historical earthquakes; Recipe for prediction of strong motions of scenario earthquakes

Dynamics of Foundation Structures

The aims of this section are to a) systematize the synthetic earthquake-resistant theory for foundation structures and underground structures; b) develop the foundation investigation method and earthquake-resistant technology; c) establish the reasonable earthquake-resistant design for underground structures. The research involves:

1)Identification and simulation of earthquake ground motions: We propose a model of phase characteristics of seismic ground motions. Our research scope also

includes development of real-time simulation method of earthquake ground motions from the strong motion records of array observations

2) Nonlinear soil-structure interaction: Behavior of structures during earthquakes is very complicated due to the soil-structure interaction. Our research is conducted using numerical computation methods of the nonlinear soil-structure system, which enable consideration of the effects of liquefaction and ground flow

3) Seismic damage estimation of lifeline systems: It is essential to assess the seismic safety of large-scale lifeline networks. We are working to develop reliability analysis methods based on various advanced theories, such as fuzzy theory and genetic algorithms

4) Seismic design methods for soil-structure systems: Limit state design methods, which can accommodate plastic deformation of slight damage during strong excitation, are essential for rational seismic design of civil structures, which are resistaned to destructive earthquakes, such as the 1995 Kobe earthquake. We propose new limit state design methods for soil-structure systems, such as underground structures and foundation structures

5) Identification of dynamic characteristics of structural systems: We are developing a new type of system identification methods, which are applicable to nonlinear and nonstationary systems, these include an adaptive robust Kalman filter, which is applicable to nonlinear dynamic systems, and a neuro-Kalman network, which is enabled by combining Kalman filters and a neural network

6) Health monitoring techniques: Our research scope covers development of a system to detect gradual deterioration of strengths of structures or damage due to earthquakes. Application of optical fiber sensors to the dynamic measurement of deformation of the ground is also under way

Structural Dynamics

The main theme of research is the improvement of seismic designs of buildings including foundations. Fundamental studies have been carried out to elucidate the dynamic characteristics of building structures with various types of foundations. The types of buildings studied are reinforced and pre-stressed concrete frame structures, shells and spatial structures. The main research subjects are as follows,

1) Earthquake damage field investigations: Damage of buildings and foundations were investigated by visiting the damage areas of the 1995 Kobe earthquake, 1999 Kocaeli, Turkey earthquake, 1999 Chichi, Taiwan earthquake, 2001 Gujarat, India, earthquake, etc. The causes of the building damage and problems of the seismic design criteria have been studied

2) Seismic design of reinforced concrete structures: Seismic performance of reinforced concrete frame structures has been studied using experiment and theory, to establish rigorous performance-based designs. The problems related to the scale effects have also been studied recently

3) Seismic response analyses of ground-building structure systems: Dynamic characteristics of coupled ground-structure systems are being studied, with special attention to the effects of the inelastic interaction between the ground and structures

4) Dynamics of shells and spatial structures: Free vibrations and earthquake response characteristics of shells and spatial structures have been investigated, including consideration of material and geometrical non-linearity

Earthquake Resistant Structures

The goal of research is to enhance technologies relevant to the functionality and safety of structures during earthquakes. Emphasis is also given on advancement of seismic design methods. Research, both theoretical and experimental, has been conducted for examining dynamic response properties and collapse mechanisms of structures subjected to strong ground motions. Current areas of research interest include:

1) Mechanical properties of structural components: Stability of structural members under cyclic loading; Plastic deformation capacity and fracture mechanisms of structural joints; Fracture toughness of structural materials as functions of plastic strains and temperature changes

2) Dynamic response properties and collapse mechanisms of structures: Seismic demand for structures subjected to near-fault earthquakes; Dynamic instability of braced frames

3) Simulation of seismic responses: Hybrid simulating systems combining structural experiments and numerical analyses; Seismic response simulations for large-scale structures using substructuring techniques; Dynamic loading tests controlled by real-time on-line mechanisms

4) Advancement of seismic design: Reliability-based seismic design considering uncertainties of seismic loads and structural properties; Seismic design of

structures equipped with hysteretic dampers; Construction techniques for weld-free structural systems; Effectiveness of base-isolation subjected to vertical motions; Rehabilitation and retrofit of existing structures; Quality assurance of structural connections

4.3 Research Division of Geo-disasters

4.3.1 Scope and objective

Interdisciplinary research to mitigate geotechnical and geological hazards is carried out by the research division of geo-disasters. The geo-disasters may be classified into two major categories. One is associated with seismic behavior and deformation of the soft ground in the urban areas highly developed over lowlands. The other is related to landslides, rock falls, debris flows and other mass movements threatening human life in mountainous areas and at slopes adjacent to the urban area.

A new professor and a research associate were appointed for research section of geomechanics in April, 2002; another new professor was appointed for research section of slope conservation in November, 2002. These new faculty members are expected to develop new research activities in the field of geo-disasters. Research Center for Landslides was established in April, 2003, and the acitivities of the former Research Section of Landslides was transferred to that research center.

4.3.2 Major Research Areas

(1) Research Section of Geomechanics

The urban areas highly developed over lowlands pose potential vulnerability to geotechnical and geological hazards. These hazards include earthquake induced geotechnical hazards such as liquefaction and landslides. Settlements and deformation of soft clayey ground are also serious hazards in lowlands. The research by the section of geomechanics is to identify the mechanisms of these geo-hazards and establish a strategy and engineering means to mitigate these hazards. The main research topics include

1) study on the large deformation problem of foundation based on large deformation theory
2) development and application of ground improvement methods
3) study on interaction between foundation and structure using geotechnical centrifuge model tests
4) study on mechanisms on and remedial measures for ground softening during earthquakes
5) prediction of deformation in the foundation-structure system and establishment of rational design method

(2) Research Section of Mountain Disaster

Disaster occurred in different processes on the large rolling mountain area. The mechanisms of slope processes, such as weathering, gravitational deformation, erosion, transport, and deposition of slope materials, are studied from the viewpoints of geology, geomorphology, geochemistry, and geophysics, to evaluate the potential of mountain hazards. On the basis of geological and geomorphological survey, remote sensing analysis, chemical analyses of minerals and groundwater, and surveying, mountainous disasters have been studied as long-term geological phenomena. The main subjects are as follows,

1) Gravitational deformation of slopes and landslides on large-scale
2) The mechanisms and rates of rock weathering as well as the long-term evaluation of slope stability
3) Field observations and model analyses on the rapid mass movements, such as debris flows etc.
4) Interaction between hydrological conditions and geological and geomorphological processes
5) Optimum land usage in mountainous areas for the prevention and mitigation of mountainous disasters

(3) Research Section of Slope Conservation

Due to the recent sprawling of urban areas, damage by the rapid mass movements has been increasing in residential areas, roads, energy lines, communication lines and other lifelines adjacent to steep slopes. While countermeasures have been successfully proceeding for the steep slopes adjacent to concentrated residential areas where high risk is officially acknowledged, risk is recently increasing on natural slopes, artificial slopes without reinforcement, and rocky slopes. Our laboratory is carrying out studies of the mechanisms and integrated countermeasures for such hazards.

1) Elucidation of the formation processes of unstable slopes and geomorphological and hydrological studies for anticipating sites of high risks,

2) Studies for exploring the characteristics of slope materials and GIS approaches for better recognition of stability of slopes,
3) Prediction and hazard mapping on landslide disaster in sloping urban residential areas,
4) Studies for the long-term maintenance, management, and repair of artificial slopes
5) Studies for better design of urban areas and better landuse on the basis of geoscientific and social conditions of slope hazards.

4.3.3 Major Experimental Facilities

A geotechnical centrifuge (with a radius of 2.5m, max. 200G) has been in operation since 1987 for scaled model tests of geotechnical works under static and dynamic loads. This facility has been fully in operation throughout year and open to the users in various research fields including disaster environment and construction engineering systems.

4.4 Research Division of Fluvial and Marine Disasters

The purpose of the division is to establish the scientific foundations to mitigate and prevent water-related disasters. The research activities are addressed to understand the physical mechanisms of extreme natural events such as floods, storm surges, tsunamis and debris flows; to predict the disaster-causing natural phenomena; to understand the mechanisms of water related disasters in view of human and social activities; and to establish countermeasures for mitigation of water related disasters. In order to achieve the above missions, the division promotes four major research areas comprised of sedimentation disaster, flood disaster, urban flood control, and coastal and offshore disaster. The followings are research activities conducted in the areas.

Sedimentation disaster

1. Sediment yield observation and modeling: Methods to estimate sediment yield are investigated. The characteristics of the parameters involved in sediment discharge models are examined using field data from various places.
2. Channel processes in mountain streams: Widening, meandering, and diverging processes of stream channels are studied in connection with the maintenance of the low water channel in a river course.
3. Debris flow: Fundamental mechanics and dynamic behaviors of stony, muddy and viscous debris flows are investigated. Simulation models to estimate the discharge hydrographs and other characteristics of debris flows are developed. Methods to delineate hazardous areas and to estimate the risks in these areas are studied. Flush floods resulting from the breach of natural dams are also investigated.
4. Sediment control: The functions of various types of debris dams are studied. The effective deployment of various structures to control the sediment budget in the watershed is investigated. The efficiency of some kinds of structures and the water release strategies of reservoirs for maintaining storage capacity of themselves as well as to keep the river bed and environments of the downstream river channel and the estuary are studied.
5. Volcanic hazards: Various aspects of volcanic hazards such as pyroclastic flows, volcanic debris flows, gigantic landslides, and so on are investigated mainly in respect to the construction of basic flow models.

Flood disaster

1. Flood runoff modeling: Physically-based distributed rainfall-runoff models are developed and applied to various catchments. Impact of human activities and social transition on hydrological cycle are taken into account in the modeling.
2. Stochastic and statistical analysis of hydrometeorological phenomena: Newly devised hydrologic frequency analysis models are applied to extreme events such as floods and storms. A stochastic simulation method to generate time and space rainfall distribution is constructed for water resources planning and management.
3. Real-time flood forecasting and control: A stochastic state-space runoff model coupled with control theory is developed to improve the accuracy of forecasting and reservoir operation. The method uses online hydrological observation including weather radar information.

4. Macro-scale hydrological modeling: Hydrologic cycle in regional scale river basins is modeled considering the interaction between runoff and meteorological processes. Effects of aggregation and disaggregation of hydrologic variables on simulation results are also discussed.
5. Remote sensing, GIS and hydroinformatics: State-of-the-art information and communication technologies are applied to develop improved methodologies of flood monitoring, prediction and control.

Urban flood control

1. Mechanism of urban flood and its prediction: The mechanism and characteristics of urban flood are studied which are caused by heavy rainfall, flood, storm surge and their combination. Also, the urban flood simulation model is developed which can express the flooding process by heavy rainfall in urban area. Through the simulation analysis, the potential of flood occurrence in urban area is discussed.
2. Inundation flow analysis considering the urban characteristics: Inundation phenomena in highly developed urban area with underground space are studied. A refined inundation flow model considering buildings, streets and sewerage system and an inundation flow model for underground mall and subway are developed. Hydraulic model tests are also executed by use of the large scaled urban surface area model and underground space model. The experimental results show the danger of underground space for inundation.
3. Study of flood defense system: Countermeasures against urban flood comprising both structural ones and non-structural ones are studied. As the structural measure, underground storage or tunnel system is taken, and as the non-structural measure, evacuation is taken. An evacuation activity model is developed which is linked with inundation flow analysis. And through the analysis by this model, suitable evacuation system is discussed. Also, the desirable flood control system is studied based on the simulation analysis by the urban flood model.

Costal and offshore disaster

1. Storm surges and tsunamis: The prediction of storm surges, tsunamis, and storm waves is carried out using numerical models. Methods for the reduction of damage caused are also investigated.
2. Mechanisms of wave transformation and sand sedimentation: Hybrid nonlinear transformation theory for random waves is being improved. Hydrodynamics analysis of wave breaking and coastal currents is carried out in relation to sand sedimentation.
3. Coastal preservation: Erosion control of sandy beaches and preservation of stable beaches are investigated by numerical and hydraulic experiments in relation to coastal observations carried out in collaboration with the Ogata Wave Observatory.
4. Coastal and offshore structures: The damages of coastal and offshore structures are characterized. Their safety design against storm waves and tsunamis is investigated.
5. Waterfront: Improved design for waterfront structures (regarded from the point of view of disaster prevention and community use) are investigated.
6. Water exchange in estuaries: The tidal exchange of sea water in estuaries is investigated using field data measured in collaboration with the Shirahama Oceanographic Observatory. Numerical experiments are also conducted.

4.5 Research Division of Atmospheric Disasters

The division of atmospheric disasters investigates a wide range of hazardous atmospheric phenomena using theoretical, observational, experimental, and numerical methods. Areas of research include typhoon and storm surge dynamics, wind interactions with urban environments, dynamics of severe storms, anomalous climate, air-sea interactions, turbulent transport processes of the planetary boundary layer (PBL), wind resistant structures and wind environment around buildings and structures .

Applied Climatology

In order to elucidate anomalous weather and climatic changes in relation to variations of the atmospheric minor constituents and the atmospheric and oceanic general circulation, we have investigated the following subjects:

1) Atmospheric minor constituents and their effects on global and regional climate, and their impact on

various disasters

2) Anomalous weather and climate due to changes of the atmospheric general circulation
3) Anomalous weather and climate in relation to the East Asian monsoon
4) Large scale air-sea and air-land interactions and their effects on climate
5) Regional and local circulations associated with disastrous local winds and heavy rains.

Severe Storms

This section specializes in the research on severe storms such as typhoon, tornadoes, heavy rainfall and others. It also covers observational study of the Planetary Boundary Layer (PBL). Meso- and regional-scale atmospheric environment and effects of human activity on it are also studied in the context of atmospheric disaster. Recent major research items are:

1) Dynamics and cloud physics associated with meso-scale severe storms and heavy rainfall
2) Dynamics of typhoons especially in its interaction with mid-latitude baroclinic environment
3) Observation of PBL turbulence and land surface-atmosphere interaction
4) Development of disaster prediction system integrating atmospheric, ocean/wave and land surface models
5) Physical processes of atmospheric turbulence, wave and vortex motions
6) Transport, transformation and deposition processes of photo-chemical oxidants, aerosols and acid rain.

Wind Resistant Structures

This section supports research on various subjects related to the wind resistance performance of structures and the wind environment around buildings and structures. These studies are carried out using wind induced hazards analyses, field observations, wind tunnel tests, numerical simulations and other methods. The research topics of the section are as follows:

1) Mechanisms of structural damage induced by strong winds
2) Wind induced pressure and its effects on buildings and structures
3) Scattering mechanism of tiles and panels in strong winds
4) Wind characteristics in cities and wind environment around buildings and structures
5) Generating unsteady flow fields for numerical simulation
6) Prediction of gale in cities and mechanism of disaster occurrence
7) Mechanism of the storms induced by typhoon and tornado, and the disaster prediction
8) Characteristics of high temperature plumes behind fires
9) Dynamic reliability analysis of hysteretic structures with uncertainty in strong winds

4.6 Research Center for Disaster Environment

The Research Center for Disaster Environment, which consists of four Research Sections, was established in 1996, with the aim of serving as an Open Laboratory. Its prime function is designed to promote interdisciplinary studies of complex natural process, such as air-sea and fluid-soil interactions, which frequently induce a wide spectrum of hazards and consequences. The Center's unique facilities include two experimental station (Ujigawa Hydraulics Laboratory; Shionomisaki stations (Ujigawa Hydraulics Laboratory; Sionomisaki Wind-Effect Laboratory) and four field observatories (Shirahama Oceanographic Observatory; Ogata Wave Observatory; Hodaka Sedimentation Observatory; Tokushima Landslide Observatory). With these facilities actively participating in collaborative research involving the nation's scientists and engineers, the academic staff at the Center has directed their research activities toward developing cutting-edge procedures for prediction geo-hydraulic processes, together with proposals for reducing their impact on society.

Research Section for Hydroscience and Hydraulic Engineering

The research fields covered by this group are mostly water caused and water-related disasters, such as floodings of water and sediments, debris flows, storm surges and

tsunamis. Mechanisms of these disasters and their protection/mitigation schemes are studied both in laboratory experiments and in field observations. Fundamental research in hydroscience and hydraulic engineering are also conducted, particularly taking recent ecological/environmental issues into account. Experiment are carried out at the Ujigawa Hydraulics Laboratory, which was established in 1952. The site covers 68,700m^2, and includes flumes, basins and hydraulic models of various sizes and scales. Computational models are also developed and utilized for deter understanding and predictions of the phenomena.

The main topics are as follows:

1) Flood flows and river morpho-dynamics
2) Hydraulics in bays, estuaries and coastal areas
3)Hydraulic model tests and computational simulation
4) Hydraulic structures for disaster prevention /mitigation
5) Hydraulic structures for ecological management/ mitigation

Research Section for Sedimentation, Landslide and Waterfront Geohazards

This Research Section promotes studies of risks from geological hazards, which involve massive failure of sloping terrains, rapid debris flow, liquefaction of loosely packed soil deposits, and other soil movements. One strength of this Section is its unique observatories at Hodaka and Tokushima.

Another feature stems from its research focus on coastal and near-shore hazards involving dynamic fluidsoil interactions.

This Hodaka Sedimentation Observatory has facilitated extensive field studies of sediment yield, sediment transport and river channel variations. Also, sediment control by sabo works has been investigated in the Ashiaraidani creek on the active volcano, Mt.Yakedake.

The Tokushima Landslide Observatory is located in an area dominated by a large active fault, the Median Tectonic Line. This location and well designed research programs have facilitated extensive observational studies including, scale of landslides associated with fracture-zones; mountain deformation; landslide-related earth pressure changes; processes of mountain denudation; groundwater hydrology and mass movements in landslide areas.

Research Section for Meteorological and Coastal Hazard &Environment (MeCHE)

The Research Section for Meteorological and Coastal Hazard & Environment (MeCHE) has a mission to carry out observational investigations on meteorological, hydrodynamical, and ecological issues, which are related to disasters and environmental disruption in the land surface boundary layer and coastal ocean.

MeCHE has three observational facilities associated with other partner institutes around the world to advance studies of disaster prevention and environmental preservation in the atmospheric boundary layer through observatory (Wakayama), the Ogata Wave Observatory (Niigata) and the Shionomisaki Wind Effect Laboratory (Wakayama)

Our current major research themes are:

1) Typhoon and storm surge dynamics
2) Air-wave-current interaction systems
3) Wind field in the planetary boundary layer
4) Air-land surface energy exchange
5) Structure damage due to strong winds
6) Wind and wave-induced coastal current systems
7) Coastal ecosystems

Research Section for Seismic Hazards

The research activities of this section have been directed mainly toward assessing seismic risks of low-lying waterfront areas underlain by thick deposits of soil. The current research projects include the following:

1) Studies of seismic liquefaction and its consequences
2) Studies of seismic designs for water-defence facilities such as flood-control levees, sea dikes and breakwaters.
3) Performance of soil fills in hilly urban areas during strong ground motions

4.7 Research Center for Earthquake Prediction

4.7.1 Outline of Research Activities

The Research Center for Earthquake Prediction (RCEP) carries out many aspects of seismic research related to earthquake sources, seismic velocity structures, distributions of earthquakes in Southwest Japan, and laboratory investigations.These studies contribute to the long-term goals of earthquake prediction and mitigating earthquake damage. The Center was established in June 1990 as part of the Disaster Prevention Research Institute (DPRI) of Kyoto University.

The Center has 9 research sections (including a visiting researcher position) and 8 observatories. These sections closely cooperate with each other on research projects and observational activities. The Center is also involved in collaborative projects with other universities, especially since 1996 when DPRI was designated as a one of the centers for cooperative university research in Japan.

During the first half of this century, the probable occurrence of a great earthquake along the Nankai trough is reaching a peak, also large damaging earthquakes on onshore faults in southwest Japan appear to be occurring more frequently. In this active seismic period, the Center focuses its efforts into three main areas: (1) Prediction of the future Nankai earthquake, (2) Studies of onshore earthquakes in southwest Japan, (3) Efforts to provide earthquake information to other disciplines and the public.

4.7.2 Research Activity of Each Section

1. Seismotectonics

The target of the research in this group is to elucidate the mechanisms of earthquake generation in relation to the earth's internal structure and dynamics. The present main research topics are as follows

1) Deformation of the Japanese islands and motions of the regional tectonic plates
   - Estimates of strain rates in the Japanese islands using geodetic data
   - Observations and analyses of co- and postseismic deformations of large earthquakes
   - Modeling of the concentrated deformation zone and the deformation process in the lower crust

2) Preparation processes for great earthquakes along the Nankai trough
   - GPS traverse survey across the hinge line in Kii peninsula
   - Estimates of interplate coupling along the Nankai trough and modeling of the stress buildup process

3) Research on the activity of inland faults.
   - GPS traverse surveys around active faults
   -Estimate of the stress field utilizing focal mechanisms and stress drop data
   -Modeling of deeper extensions of seismogenic faults in the lower crust

2. Earthquake Source Mechanisms

Our goal is to understand earthquake nucleation processes from the quasi-static phase, accelerating phase to earthquake faulting, by incorporating seismic and geodetic data. One aspect of this research is searching for silent earthquakes that occur in the brittle-ductile transition zone on subduction interface along the Nankai and the Sagami troughs. We have already identified and analyzed several silent events that have occurred throughout Japan and are currently studying the conditions under which they occur and their possible relationship to large earthquakes. To understand what kind of links there may be between the silent earthquakes and nucleation of large damaging earthquakes that occur within the seismogenic zone, we are carrying out continuing efforts to increase observations of crustal deformations along with poroelastic measurements of crustal rocks to refine observations of the crustal strains and tilts.

We are also carrying out characterization studies of rock properties in borehole field investigations and laboratory experiments to understand the mechanisms of rock fracture. High frequency (kHz) seismic observations in boreholes have been used to record earthquakes in the Yamazaki fault zone to study the occurrence of the tiniest earthquakes.

3. Crustal Movements

Stress gradually accumulating within the earth causes crustal movements and it is sometimes released suddenly as earthquakes. Accordingly, it is essential for long- and short-term predictions of earthquakes to understand the state of earthquake generating stress within the crust by monitoring crustal movements. Accordingly, the center maintains observation tunnels with sensitive crustal instruments at locations across western Japan.

The well water observations on the Pacific coast from Kii peninsula to Shikoku showed interesting decrease and dried wells before the Showa Nankai earthquake (1946). The phenomenon were explained by the large regression of the boundary between sea and fresh water, which was caused by a small uplift of the land that may be attributed to pre-slip before the earthquake. The drying up of the well water was also confirmed at the time of the Ansei Nankai earthquake (1854).

4. Seismic activity studies

We are investigating the source processes of all size earthquakes, including micorearthquakes, small and moderate events, and the largest plate boundary earthquakes. For plate boundary seismicty, we are studying the relationship of seismicity to the structure of subduction zones (including the recently discovered low-frequency tremor). For the onshore seismicity, we study the relationship of the earthquakes to the character and behavior of active faults. We use an integration of a variety of geophysical observations to study and explain the earthquake source process in terms of the build-up and release of stress.

Research Objectives

1. Understanding of the regional earthquake activity
2. Evaluation of intermediate term prediction of large onshore earthquakes
3. Statistical analyses of earthquakes hazards Specific Projects

1. Analyses of Rupture Processes of Large Earthquakes

   We analyze recordings of large earthquakes to study the characteristics of the source properties and to evaluate strong ground motion effects. Studies of the strong-motion records of the 1999 Chichi, Taiwan earthquake have provided detailed information about the rupture process and source dynamics for the earthquake

2. Quantitative Evaluation of Regional Seismic Activity

   We are studying the spatial and temporal dependence of earthquake activity over the entire country to understand the seismicity, as related to intermediate and short term changes of earthquake occurrence. Using hypocentral information and GIS techniques, we are evaluating the seismic activity, especially in regards to seismic gaps on active faults and the build-up of stress during an earthquake cycle build up of stress.

3. Integrated Observations of Active Inland Active Faults

   We maintain observations of seismicity, crustal deformation, water levels, along with GPS, gravity, and electric resisitivity surveys, to study the large earthquake potential of several prominent faults in Japan. Recently we have focused on the Yamazaki fault, where high sensitivity earthquake observations, crustal deformation instruments in underground tunnels (including a new strainmeter at Ozawa), and water well monitors are operated.

5. Earthquake Prediction Observations

In this research section which focuses on “earthquake preparation processes”, various kinds of basic research are being undertaken, using methods based on seismology, geo-electromagnetism and geodesy. In particular, the ‘Nojima Fault-zone Probe’ is a multidisciplinary research project studying the recovery process of the Nojima fault on Awaji Island, which was the source of the 1995 Kobe earthquake.. Main research topics are as follows.

(1) Studies on fault recovery processes.

(2) Research on fault structure of fracture zones using fault zone-trapped waves.

(3) Investigation of deep crustal resistivity structures.

(4) Theoretical research on geodynamical data analyses and modeling.

6. Earthquake Prediction Information Processing

Methods for the detection of precursors have been studied from a variety of observational data collected for earthquake prediction. New systems of data acquisition and automated data processing have been developed for the detailed analyses of geophysical data, such as precursory changes in crustal strain fields, spatial and temporal variations in seismic activities. Databases for information retrieval are constructed on the basis of multivariable time series analyses of observational data sets. For the purpose of finding earthquake prediction indicators, estimation is made from various kinds of observations for the M7.2 1995 Southern Hyogo Prefecture (Kobe) earthquake. Many kinds of geophysical data are collected for the basic research of the earthquake prediction. These data include crustal velocity structures derived from seismic surveys, gravity anomalies, heat flow, as well as seismicity and crustal strain from continuous monitoring and processing.

7. Data Processing and Analysis

The on-line seismic data from 5 DPRI observatories

(Tottori, Abuyama, Tokushima, Hokuriku, and Kamitakara) along with JMA (Japan Meteorological Agency) data are received through a satellite station. The hypocenters and origin times of earthquakes along with the digitized wave data are stored. Seismic data recorded from temporary stations following large earthquakes, such as the 1995 Hyogoken-nambu (Kobe) Earthquake (M7.2) and 2000 Western Tottori Earthquake (M7.3), are also recorded and studied.Recently low-frequency earthquakes occurring below 20 km depth have been found and studied in detail. The acquired data from seismic exploration experiments for studying crustal structure in Japan are also stored and used.

8. Real Time Seismology

When possible precursory phenomena are detected for a large earthquakes, it is necessary to quickly carry out various geophysical observations in the affected area. Also, the center often conducts dense temporary observations of local seismicity and crustal structure to obtain basic data for future earthquake prediction.The center is equipped with various instrumentation, including telemetered and stand-alone seismic data acquisition system . We also have precise gravimeters and electric resistivity equipment for for studies of monitoring possible precursory phenomena and subsurface geophysical structures . In addition, we have GPS receivers for monitoring crustal deformations.In 2002-2003, the joint university group carried out temporary large-scale observations in southwest Japan. Many seismic stations were installed across the Chugoku-Shikoku district to study the seismicity and crustal structure of this area. One of the main targets was the detection of the aseismic slab of the Philippine-sea plate beneath this region . This joint observation project was mainly organized by our center.

9. Observatories

Since recurrence intervals of large earthquakes on active onshore faults are generally more than 1000 years, to understand of the seismic cycle, it is important to monitor seismic data over long periods of time. The Center maintains field observatories at Tottori, Abuyama, Hokuriku, Kamitakara, Osakayama Donzurubo, Miyzasaki, and Tokushima across western Japan. These observatories act as local centers for collection of seismic and crustal deformation data, which is then forwarded to the Uji Campus. Some of these observatories have been collecting geophysical data for decades and have played an important role in the historical development of seismology in Japan. The observatories continue to develope networks for recording microearthquakes and continuous recording of crustal movements in western Japan, which is now part of a nationwide system for monitoring seismic activity.

4.7.3 Outreach

Center now considers that, along with carrying out research on earthquake prediction, it is equally important to inform the public about current seismic activity and recent research results Since realistic earthquake prediction is currently difficult, it is important to provide available earthquake information to the public, especially about the possibility of future large earthquakes. These efforts can promote earthquake mitigation activity of the public and government agencies. Information about current earthquake activity are regularly distributed through a website, public lectures, and newspaper columns.

4.8 Sakurajima Volcano Research Center

Sakurajima Volcano Research Center (SVRC) is located at Sakurajima volcano in southern Kyushu, where several active volcanoes are aligned along the Kirishima Volcanic Zone. The main subjects are mechanism of volcanic eruptions and prediction of volcanic eruptions, and SVRC has carried out continuous observation and repeated field surveys at several volcanoes during the past 42 years. The items of observation and measurements are (1) seismic observation, (2) monitoring of ground deformation by tiltmeter, strainmeter, tidal gauge, GPS, EDM., leveling survey and so on, (3) gravity, geomagnetic and geomagnetic measurements, (4) geochemical and geothermal observation, and (5) monitoring of eruptive phenomena by video camera and infrasonic microphones. SVRC has offered facilities, data and samples to many researchers as a field laboratory in Japan and promoted collaborative studies on volcanic activity and mitigation of volcanic hazards.

Volcanic processes from magma storage under the Aira caldera to eruptions at Sakurajima are fairly well

monitored with seismic and ground deformation monitoring, and an automated warning system for explosive eruptions is in operation. The system and data have been offered in real-time to Meteorological Observatory and Volcanic Sabo-engineering Office.

4.8.1. Members

(Prediction of Volcanic Eruptions)
Professor: Kazuhiro Ishihara, Dr. Sc.(Kyoto Univ.) Volcano geophysics
Associate Professor: Masato Iguchi, Dr. Sc.(Kyoto Univ.) Volcano Geophysics
Research Associate: Daisuke Miki, M.Sc. (Toyama Univ.) Paleomagnetism
Keigo Yamamoto, Dr.Sc.(Univ.Tokyo) Volcano geodesy
Wataru Kanda, Dr.Sc.(Univ.Tokyo) Geomagnetism
Takeshi Tameguri, Dr.Sc.(Kyoto Univ.) Volcano Seismology

4.8.2. Recent research activity and main results

The following subjects have been studied.
(1) Process of volcanic explosion at Sakurajima volcano (Tameguri, Iguchi, Ishihara)

From a waveform analysis of explosion earthquakes, it was revealed that Rayleigh waves of large amplitude are excited by the outbreak of gas pocket at a shallow part of magma conduit.
(2) Research on the source region of phreato-magmatic explosions (all the staff in collaboration with Tokyo Institute of Technology)

It was inferred from seismic, geodetic, geothermal, geochemical and geomagnetic observations that storage of eruption energy at Kuchinoerabujima volcano is located about 1 km beneath the summit crater.
(3) Process of magma intrusion and storage under the Aira caldera and Sakurajima volcano (Yamamoto, Ishihara, Iguchi, Miki in collaboration with University of Tokyo)

It was revealed that magma supply rate to the Aira caldera is changed with time from GPS data, and that the effect of ocean tides on microgravity change is exactly evaluated using data of absolute gravimeters.
(4) Analysis of underground structure of volcanoes (Yamamoto, Iguchi, Nishi)

Three-dimensional seismic velocity structure at some volcanoes is estimated by experimental seismic explosion data.
(5) Geomagnetic and geoelectric study on shallow part of volcanoes and volcanic fluids (Kanda in collaboration with the Graduate School of Science, Kyoto University)

Zone of hydrothermal activity beneath volcanoes was located at Sakurajima, Satsuma-Iwojima, Suwanosejima and Kaimondake from survey of self potential. Demagnetization of rock under the summit of Kuchinoerabujima volcano has been detected with magnetometers.
(6) Re-construction of volcanic activity in southern Kyushu by geological and paleomagnetic methods (Miki, Ishihara in collaboration with Geological Survey of Japan and the Graduate School of Human and Environment Sceince, Kyoto University)

Several of pre-historic lava flows around the Aira caldera, at Sakurajima and Kuchinoerabujima volcanoes were newly dated by K-Ar dating and paleomagnetic method.
(7) Comparative study on eruption mechanism of island-arc volcanoes (Iguchi, Ishihara, Tameguri in collaboration with Volcanological Survey of Indonesia)
(8) Comprehensive Joint Volcano Observation and Joint Experiment on Subsurface Structure of Volcanoes (all the staff in collaboration with other universities)

4.8.3. Users of facilities, instruments, data and samples

SVRC has offered sources for research and education to universities, institution, mass media, autonomies, and so on. The offered items are videotapes and photographs of volcanic activity, rock samples, data on volcanic activity, and so on. The number of applicants was 21 and 23 in 2000 and 2001, respectively (university and institutions 31, education and publish

4.9 Water Resources Research Center

4.9.1 Brief introduction of WRRC

The aim of this center to understand the natural and social phenomena associated with water resource problems on the scale ranging from global to regional. We study the total management system, including conservation and development of water resources, as integrated elements of geo-systems, socio-systems, and eco-systems. Members of the Center are actively participating in international research projects, such as GAME (GEWEX Asian Monsoon Experiment), and UNESCO-IHP (International Hydrological Program). This center consists of three research laboratories and other cooperative research networks:

Global Hydrology studies the development of prediction methodology on hydrological cycles on a global scale. Research involves analysis of long-term hydrological events, and interdisciplinary studies of energy and water cycles.

Urban and Regional Hydrology studies runoff characteristics affected by urbanization, quantitative evaluations of water and energy budgets for comprehensive estimation of water environments, and development, conservation and sustainable utilization of water resources in urban areas (especially where water is scarce).

Water Resources Systems Planning studies management of water utilization systems including conservation and improvement of water environments on a regional scale.

There are other research projects carried out cooperatively with researchers from other institutes and universities. Currently, the following research subjects are given as emphasized research.

(1) Evaluation of water resources considering climate change and basin water resources management
(2) Development of methodology for comprehensive water environment assessment and river basin management system including interaction between water quantity, water quality, ecosystem, and human activity
(3) Development of short, medium, and long range rainfall prediction system and support system for real-time operation of water resources system
(4) Development of global water resources system dynamics model for international water conflict and water trade

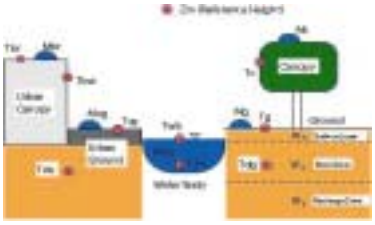
4.9.2 Introduction of research area

I. Global Hydrology

Professor: Shuichi IKEBUCHI
Associate Professor: Yasuhiro TAKEMON
Research Associate: Kenji TANAKA

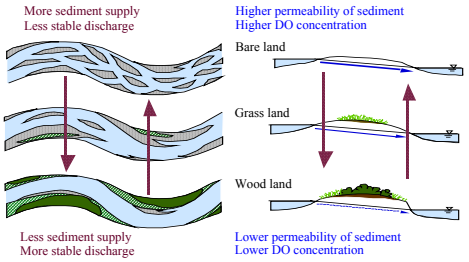
(1) Development of the land surface scheme (SiBUC) and its coupling into mesoscale Numerical Weather Prediction model

LSS (Land-Surface Scheme) calculate the energy/ water/ radiation budget of the land surface to provide the lower boundary condition for the atmospheric model. The SiBUC (Simple Biosphere including Urban Canopy) model uses "mosaic" approach to incorporate all kind of land-use into LSS. In the SiBUC model, surface of each grid area is divided into three landuse categories and five components. Owing to the field experiments such as the Lake Biwa Project, GEWEX/GAME Project, paddy field and farmland irrigation and drainage scheme is developed. Which enables us to treat not only the natural water cycle, but also artificial water cycle caused by human activity. In order to improve the description of the land surface hydrological processes together with the data assimilation for land surface and atmospheric variables, SiBUC has been coupled into various mesoscale numerical weather prediction models such as JSM, ARPS, CReSS.



(2) Ecological functions of stream geomorphology

Human impact of habitat alterations of rivers, such as dam construction and Sabo works on river ecosystems are investigated via field works on stream geomorphology, physico-chemical environmental factors such as water quality, species diversity and composition of benthos and fish communities. Japanese river ecosystems are now under conditions of less sediment supply and more stable discharge because of dam construction, Sabo works, channel works and afforestation works which hinder sediment erosion from the basin and channels and decrease sediment transport through rivers. Following four topics are investigated for clarifying suitable stream geomorphology from ecosystem aspects: relations of bar structure and habitat preference of aquatic biota, ecological function of tree canopies for stream invertebrates, function of sandy bar on organic matter budgets, and benthic community structure in a spring-fed river.



(3) Development of a satellite data assimilation system for short to medium-range weather prediction

(4) Systems approach to planning and management for droughts(5) Hydrology/meteorology collaborative field experiments for the understanding of land-atmosphere interactions in regional and global water cycles (Lake Biwa Project)

. Urban and Regional Hydrology

Professor: Taro OKA

Associate Professor: Yoshinobu KIDO

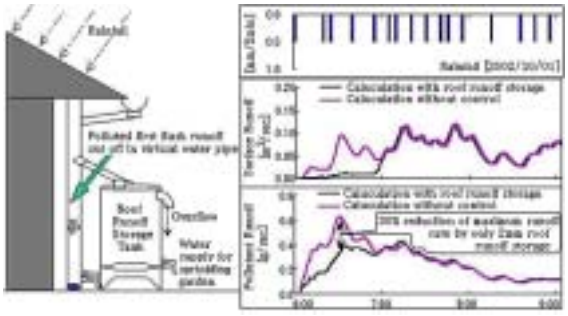
Research Associate: Toshio HAMAGUCHI

(1) Water Balance during Plants Growth Using Weighing Lysimeter

In order to investigate the water balance, rainfall infiltration, runoff, evapotranspiration and solute transport during plant growth, a weighing lysimeter was constructed in 1998. Hydrological observation have been carried on under the condition of planted crops; corn, cauliflower and broccoli. The simulation models of evapotranspiration and soil moisture movement have been discussed by using the growth curve of corn by Kimball and the relationships between the evapotranspiration and soil moisture content in root zone.

(2) Analysis of pollutant runoff mechanisms and estimation of impact to water resources in urban and rural area

Water and material cycle and urbanization effects were analyzed and estimated by model building of storm and pollutant runoff. Rainfall runoff observations were continuously carried out in Yasu River basin and Koyama Lake Basin. Pollutant load inflow was evaluated and its impact to water quality of enclosed lake was forecasted. This study shows that effects of non-point source pollutants were gradually increased more than point source and that reduction measures for non-point source pollutants were estimated.



(3) Collaborative research on mitigation of flood disaster in Bangladesh

(4) Study on the development and conservation of groundwater

(5) Geostatistical estimation of hydrological structures and groundwater management

(6) Conservation and restoration of water environment in urban area

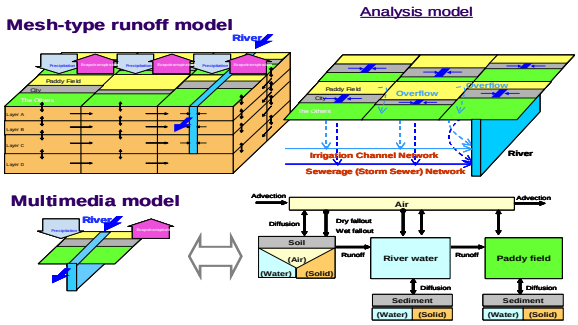
. Water Resources Systems Planning

Professor: Toshiharu KOJIRI

Associate Professor: Kunio TOMOSUGI

(1) Development of GIS-based river basin environment assessment model (Hydro-BEAM)

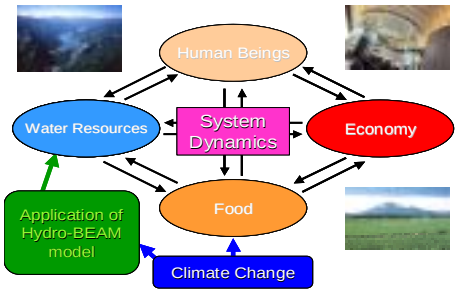
The river basin is modeled with multi-mesh and multi-layer-typed runoff model combined with GIS data. Hydro-BEAM (Basin Environment Assessment Model) treats three dimensional structure from atmosphere to under ground as for the space and runoff process from flood to low discharge as for the time scale. It has prognostic and diagnostic variables such as water stage, discharge, water temperature, pollutant, chemical materials, turbidity etc. to evaluate the impact of climate change on river basin quantitatively. Also agricultural and industrial water use and water treatment are considered.



(2) Development of global water resources system dynamics model

Global water cycle depends not only on meteorological

and hydrological processes (natural phenomena) but also on regional water use and human activities (social phenomena). Thus, the interaction between social / industrial activities, such as population variation, social activities, agricultural productivities, and hydrological cycles should be included in the system dynamics model for global water resources assessment. As a result, the transition (variation) of the global water resources distribution due to human activities and climate change will be estimated, and it will be utilized in water resources management policy toward sound basin water system and sustainable development.



(3) Support systems for water resources management by Artificial Intelligent Technology

(4) Characteristics and prediction of abnormally low precipitation phenomena

(5) Long-term forecasting of water resources using Pattern Recognition Technology

4.10 Research Center for Disaster Reduction Systems

The Research Center for Disaster Reduction Systems, (DRS) was established in 1993, and expanded in 1996. It was created within the Disaster Prevention Research Institute, Kyoto University as a center of excellence for the promotion and integration of various fields of research dealing with catastrophic urban disasters which hit mega-cites. The purpose of the Center is to minimize the direct and indirect losses and to reduce the human suffering which results from this type of natural disaster.

An Integrated Approach to Disaster Loss Reduction

DRS focuses on the following four domains of disaster management: Hazard Mitigation, Urban Design and Planning, Preparedness and Societal Reactions, and Information and Intelligence. The goal of the Center is the development of an integrated program for loss reduction which encompasses all phases of the disaster management cycle, including mitigation, preparedness, response, and recovery.

Hazard Mitigation: Reducing Direct Loss

Bringing natural scientists, engineers, and social scientists together.

■Predicting Hazards for Disaster Management

The center connects the efforts of scientists to predict hazards with the efforts of engineers to reduce vulnerabilities, along with the efforts of social scientists to develop integrated programs for disaster management.

■Predicting Losses for Disaster Management

The center develops strategies for estimating various kinds of losses, such as human loss, direct physical loss, and indirect socio-economic losses, in order to arrive at the best mixture of mitigation and preparedness measures.

Preparedness and Societal Reactions: Reducing Indirect Loss

Having a better understanding of human reations following disasters is the basis for effective disaster management.

■Studying Disaster Ethnology

The center emphasizes the necessity of helping victims, as well as disaster workers, to understand what they have experienced, as the basis for establishing any disaster management measures.

■Studying Reconstruction and Rebuilding Processes

The center also emphasizes the necessity of promoting the study of reconstruction and rebuilding processes following urban catastrophic disasters. It is a long, complex, and difficult process to which little attention has thus far been paid.

Urban Design and Planning:
Avoiding Direct and Indirect Loss

Long-term effort and a holistic perspective for reducing vulnerability is the key for avoiding urban disasters.

■Designing Safer Cities

The center helps cities to better protect themselves from catastrophic disasters by recommending urban design and planning measures which will make them safer.

■Providing Better Disaster Management Plans

The center helps disaster management agencies formulate more effective and rational plans for disaster management.

Information and Intelligence:

Reducing Human Loss and Suffering

A better understanding of hazards and potential damage is the first step in reducing vulnerability.

■Understanding Disaster Processes

The center strives to focus both on the similarities and differences among various urban catastrophic disasters and seeks to make the unpredictable and unforeseeable predictable and foreseeable.

■Simulating Mega-scale Disaster

The center has developed a multi-media disaster simulation system which utilizes the information we have gained from urban catastrophic disasters at the community level, at the regional level, and at the national level.

Networking

■Database "SAIGAI"

DRS has succeeded in developing and expanding the DATABASE "SAIGAI" PROGRAM, which is the most intensive bibliographical database on Japanese disaster research. This database was begun in 1975.

■International Adjunct Research Professorship

DRS has five adjunct research professorship positions for the promotion of interdisciplinary studies and global research networking.

For More Information

http://www.drs.dpri.kyoto-u.ac.jp

4.11 Research Centre on Landslides

The Research Centre on Landslides (RCL) was established in April 2003. RCL aims to pursue research for protecting human lives, properties, and cultural and natural heritages from landslides. RCL conducts research on the mechanisms of initiation and motion of landslides triggered by earthquakes and rainstorms. Efforts are made for the development of precise monitoring systems of landslides from a local scale to a global scale, and new techniques of landslide field investigation and instrumentation. Education and capacity building for landslide risk mitigation is also an important task of RCL. As the core centre of global landslide research network, RCL is coordinating the following two international programmes cooperating with UNESCO,

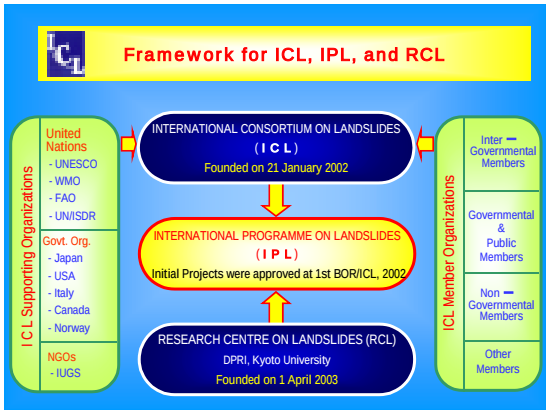
1) UNITWIN Cooperation Programme

"**Landslide Risk Mitigation for Society and the Environment Cooperation Programme**" between UNESCO, Kyoto University and the International Consortium on Landslides (ICL)

On 19 March 2003, UNESCO represented by its Director-General, Mr Koichiro Matsuura, Kyoto University represented by its President Makoto Nagao, and the International Consortium on Landslides represented by president Kyoji Sassa exchanged the agreement concerning concerning the establishment of a UNITWIN Cooperation Programme on Landslide Risk Mitigation for Society and the Environment Cooperation in the framework of the UNITWIN/ UNESCO Chairs Programme, at Kyoto University President Room. In this signing ceremony, two from UNESCO, two from Ministry of Education, Culture, Sports, Science and Technology, three vice presidents of ICL joined and exchanged opinions. Detail of this programme is accessible through :

http://landslide.dpri.kyoto-u.ac.jp/unitwin.htm. The principal objectives of the Cooperation Programme are to ;

(1) promote an integrated system of research, training, information and documentation activities in the field of



Landslides for the benefit of society and the environment and as a key contribution to sustainable development and the protection of the environment on a global scale;

(2) provide advice and expertise to all countries, particularly the least developed, with a view to:

(i) establishing landslide research and education for landslide risk mitigation;

(ii) facilitating exchange of scientists and engineers;

(iii) helping members of the Consortium in developing methods of global landslide monitoring;

(iv) enhancing landslide experiments;

(v) permitting development of a landslide database and digital library as well as of a world digital inventory.

2) International Programme on Landslides (IPL) under the initiative of ICL ,UNESCO, et al.

The International Consortium on Landslides (ICL) created at the Kyoto Symposium in January 2002 is an International non-governmental and non-profit scientific organization, which is supported by UNESCO, WMO, FAO, UN/ISDR, and intergovernmental programmes such as the IHP of UNESCO; the IUGS; the Government of Japan; and other governmental bodies.

The objectives of the Consortium are to:

a) promote landslide research for the benefit of society and the environment, and capacity building, including education, notably in developing countries;

b) integrate geosciences and technology within the appropriate cultural and social contexts in order to evaluate landslide risk in urban, rural and developing areas including cultural and natural heritage sites, as well as contribute to the protection of the natural environment and sites of high societal value;

c) combine and coordinate international expertise in landslide risk assessment and mitigation studies, thereby resulting in an effective international organization which will act as a partner in various international and national projects; and

d) promote a global, multidisciplinary programme on landslides.

The central activity is the International Programme on Landslides (IPL). Other activities planned include international co-ordination, exchange of information and dissemination of research activities and capacity building through various meetings, dispatch of experts, landslide database, and publication of "Landslides": Journal of the International Consortium on Landslides.

The figure of "Framework for ICL, IPL and RCL" shows the relationship of ICL, IPL and the Research Centre on Landslides (RCL). ICL consists of four categories of Members and receives support from UNESCO, WMO, FAO, UN/ISDR, IUGS and governmental bodies such as Japan, USA, Italy, Canada and Norway. The Research Centre on Landslides was established in the Disaster Prevention Research Institute, Kyoto University, Japan, with possible satellite centers elsewhere.

Research Section for Landslide Dynamics

Rapid and long traveling landslides triggered by earthquakes and rainstorms, especially those in urban area, have caused catastrophic disasters. To promote science and technology for landslide risk evaluation and mitigation, new geotechnical testing apparatuses including dynamic loading ring shear apparatuses have been developed. Techniques for landslide hazard mitigation are also studied. Current major research topics include:

1. Studies of Mechanisms

- Initiation and run-out mechanisms of fluidized landslides triggered by earthquakes and heavy rains
- Mechanism of landslide-triggered debris flows and state-shift from slide to flow
- Mechanism of creep movement of crystalline schist landslides

2. Development of Testing, Remote Sensing and Exploration Techniques

- Geotechnical testing apparatus for landslide studies (undrained dynamic loading ring shear apparatus, field geotechnical testing apparatus, etc.)
- Satellite and air-borne remote sensing and data-transfer
- Geophysical exploration for underground water

3. Mitigation of Landslide Hazards

- Cultural and natural heritages at landslide risk
- Evaluation and management of landslide risk
- Prediction of landslide occurrence time

Research Section for Landslide Monitoring (including the Tokushima Landslide Observatory)

The section includes the Tokushima Landslide Observatory located in Ikeda-cho, Tokushima Prefecture, one of most landslide prone area in Japan as a field base. Technologies for the monitoring of landslide movement and triggering factors, the measurement of mechanical and physical landslide parameters are developed. Field investigation of various types of landslides occurring in Japan and foreign countries, education and capacity building for students and researchers from foreign countries are conducted. The activities contribute to UNITWIN Cooperation Programme. Current major research topics include:

1. Observational Studies

- Movement of crystalline-schist landslides associated

with fracture-zones

- Earth pressure change due to landslide activities
- Groundwater hydrology and hydrogeology

2. Field Investigation and Instrumentation

- Field investigation of precursor stage of rock slides such as Machu Picchu, Peru
- Field investigation of rapid landslides and debris flows in volcanic deposits
- Development of field instrumentation

3. Education and Capacity Building for Landslide Risk Mitigation Especially in Developing Countries.