PREFACE

The Japanese Islands are located along the eastern side of the Asian Continent forming a transition zone joining the Continent and the Pacific Ocean. Location being in such a transitional situation, our lands have weak points in the crustal or tectonic structure and also lie in the frontal zone of air masses. Therefore our lands are frequently subjected to natural disasters due to earthquakes, volcanic activities as well as heavy storms accompanied by much rainfall and strong winds.

Moreover, our country is small and rather mountainous, accordingly, cities and industrial areas are mostly developed on the soft alluvial stratum. Therfore, with the developement of country districts and the extension of cities and industrial areas, various kinds of natural disasters due to topographical change increase year by year.

As stated above, there are a great number of natural disasters in Japan and it is therefore necessary to make every possible effort to solve the problems of disaster prevention.

The Disaster Prevention Research Institute was established and affiliated with Kyoto University, Kyoto, Japan in March 1951 in order to carry out scientific and engineering researches on various problems concerning the prevention of natural disasters. The Institute is located in Uji, Kyoto, about twelve kilometers south of the main campus of Kyoto University.

Starting with three research sections and sixteen research members, the Institute at the present time —on the 20th Anniversary— has the following sixteen research sections and eleven attached facilities including two laboratories as well as nine observatories. The research sections of Applied Geomorphology, Landslides, Subsidence and Failure of Soft Ground, Earthquake Resistant Foundation, Anti-Seismic Ground-Structure Systems, Earthquake Motions, Crustal Movement, Instrumentation for Earthquake Prediction, Earthquake Resistant Structures, Wind Resistant Structures, Applied Climatology, Applied Hydrology, Sedimentation and Debris Control, River Disaster Prevention, Drainage Engineering and Coastal Disaster Prevention.

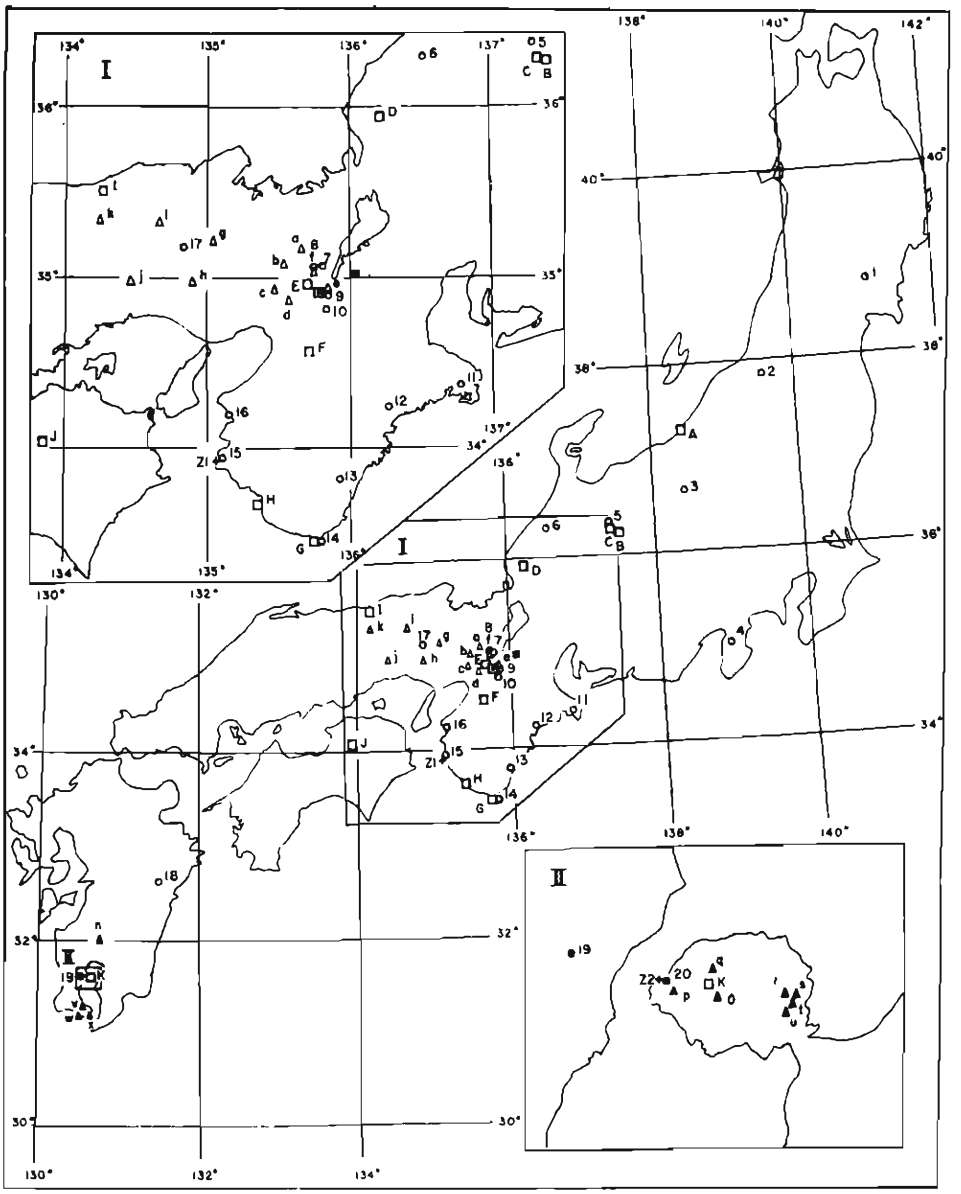
The Institute now has 213 staff members including 109 researchers. Moreover, a great number of post graduates and undergraduates of Kyoto University make researches together with the staff members of this institution.

On the 20th Anniversary the Disaster Prevention Research Institute herewith presents a publication which contains an introduction to its history and recent research activities.

September 1971

Sakuro Murayama

Sakuro MURAYAMA, Director



Locations of Facilities

◉ Disaster Prevention Research Institute

□ Attached Facilities

A: Ogata Wave Observatory
B: Hodaka Sedimentation Observatory
C: Kamitakara Crustal Movement Observatory
D: Hokuriku Microearthquake Observatory
E: Ujigawa Hydraulic Laboratory
F: Donzurubo Crustal Movement Observatory
G: Shionomisaki Wind Effect Laboratory
H: Shirahama Oceanographic Observatory
I: Tottori Microearthquake Observatory
J: Tokushima Landslide Observatory
K: Sakurajima Volcanological Observatory

■ Ara-kawa Research Basin of Runoff

△ Seismological Stations attached to Tottori Microearthquake Observatory

a: Kyohoku b: Yagi c: Myoken d: Takatsuki
e: Shizugawa f: Kamigamo g: Hikami h: Izumi
i: Oya j: Mikazuki k: Funaoka

▲ Seismological Stations attached to Sakurajima Volcanological Observatory

n: Yoshimatsu o: Hikinohira p: Koike q: Kitadake
r: Gongenyama s: Showa-yogan t: Kurokami
u: Nabeyama v: Ikeda w: Kaimon x: Unagi-ike

○ Crustal Movement Observation Stations attached to Kamitakara and Donzurubo Crustal Movement Observatories

1: Hosokura 2: Akatani 3: Kamatayama 4: Izu-Nagaoka
5: Kamioka 6: Ogoya 7: Iwakura 8: Kamigamo
9: Amagase 10: Ide 11: Shima 12: Nagashima
13: Kishu 14: Shionomisaki 15: Yura 16: Oura
17: Ikuno 18: Makimine

● Crustal Movement Observation Stations attached to Sakurajima Volcanological Observatory

19: Shimoishiki 20: Hakamagoshi

Z1 Yura Tide-Gauge Station

Z2 Hakamagoshi Tide-Gauge Station

Research Staffs

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Lecturer	Kazuo FUJITA*
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Assistants	Tatsuo MUROTA
	Yuzo YOSHIKAWA

Applied Climatology Research Section

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Assistant Professor	Haruo HIGUCHI
Assistants	Masaaki TANAKA
	Hisashi EDAGAWA

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	Kunio TOMOSUGI

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River Disaster Prevention Research Section

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Drainage Engineering Research Section

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Assistant	Yoshio HAYASE

Coastal Disaster Prevention Research Section

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	Yuichi IWAGAKI*
	Hideaki KUNISHI*
Lecturer	Tadao KAKINUMA*
Assistants	Shigehisa NAKAMURA
	Masataka YAMAGUCHI

Attached Facilities

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Director Prof.	Yasuo ISHIHARA
Assistant Professors	Masashi NAGAO
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Lecturer	Shoitiro YOKOSHI*
Assistants	Tadashi UTAMI
	Tetsuo UENO
	Teruo SHIBANO

Sakurajima Volcanological Observatory

Director Prof.	Keizo YOSHIKAWA
Professor	Akira KUBOTERA*
Assistant Professors	Kosuke KAMO
	Tatsuhiko WADA*
Assistants	Tsuneo ETO
	Kiyoshi NISHI
	Shigetomo KIKUCHI*
	Hiroyasu ONO*
	Yoshikazu TANAKA*
	Yasuaki SUDO*

Tottori Microearthquake Observatory

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Lecturer	Junichiro MIYAKOSHI*
Assistants	Ryohei NISHIDA
	Kazuo MINO
	Isamu HIRANO*
	Norihiko SUMITOMO*

Hokuriku Microearthquake Observatory

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Assistant	Kunihiko WATANABE

Kamitakara Crustal Movement Observatory

Director Prof.	Yoshimichi KISHIMOTO
Assistant	Hikaru DOI

Donzurubo Crustal Movement Observatory

Director Prof.	Michio TAKADA
Assistant	Kensuke ONOUE

Tokushima Landslide Observatory

Director Prof.	Soji YOSHIKAWA
Assistant	Takahiko FURUYA

Hodaka Sedimentation Observatory

Director Prof.	Kazuo ASHIDA
Assistant	Toyoaki SAWADA

Ogata Wave Observatory

Director Prof.	Yoshito TSUCHIYA
Assistant	Toru SHIRAI

Shirahama Oceanographic Observatory

Director Prof.	Yoshito TSUCHIYA
Assistant	Katsuya NISHI

Shionomisaki Wind Effect Laboratory

Director Prof.	Hatsuo ISHIZAKI
Assistant	Yukihiro MORI

* : concurrent

Research Activities

The Disaster Prevention Research Institute performs its research activities under sixteen research sections with eleven attached research laboratories. These are briefly outlined in the following:

(a) Research Sections

Applied geomorphology

This section was established in 1963 for the synthetic research of the exogenetic processes controlling the surface features of the Earth and for the fundamental development of preventive methods against various disasters resulting from these processes. In this section, active studies for the progress of physical geomorphology and its effective application to disaster prevention are being carried out with respect to the following problems:

(1) Slope geomorphology

Slopes are the basic constituents of the Earth's surface and the evolution of slopes caused by water and gravity has a close relation to various disasters in mountaneous regions in our country. Denudation process – the combined effect of rock weathering, loosening of surface material and the removal of loose pieces along slopes is being studied in order to clarify the mechanism of rill erosion, slope failure, land slide and mudflow and to prevent such disasters occuring. Hydrological and geochemical surveys are carried out at special mountain slopes where there is a danger of serious damage, taking into consideration experimental and analytical results.

(2) Soil physics

Soil water plays an important role on destructive phenomena concerning the pedosphere, i.e., slope failure due to the infiltration of water, mudflow caused by heavy rainfall, liquifaction of sand layers by the vibration and cracking associated with ground subsidence. It is clear that the research of physico-chemical properties of soil water may contribute to the establishment of criteria to soil failure. In this section, the problem is being studied theoretically. In connection with the above, studies on the deformation of frozen soil and its moisture movement in freezing are being carried out in order to elucidate the thermal effects on soil mechanical properties, with reference to solifluction, suface freezing and frost heaving. In coastal regions, salt intrusion into aquifer is being investigated taking into account soil property and geohydrological conditions.

(3) Physical sedimentology

The process of sedimentation, especially physical process relating to the transport and settling of small solid particles have a great influence upon subaquatic topography and some kinds of natural disasters through rapid change on micro-topography.

Delta evolution, turbidity current, filling up of reservoirs with sediments are investigated through field observations in various lakes and reservoirs, flume ex-

periments and numerical simulations taking account of dynamical and chemical conditions.

In addition to the above physical investigation, from a geological stand point, deep core sampling from lake bottoms and synthetic analysis of the samples are also being carried out in order to study the long term sedimentation phenomena in relation to the history of hydrological and depositional environments.

(4) Effective utilization of air-photography for field survey

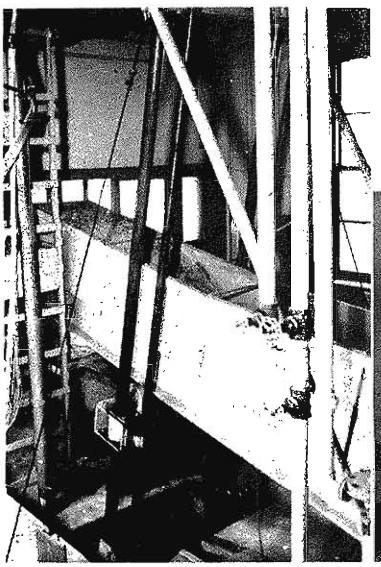
Air-photo interpretation and mapping are very useful methods for field survey, especially for rapid recording and analysis of disaster phenomena. Systematic utilization of air-photography with regard to digital processing, new techniques for special stereo-photographing and special classification of air-photos for disaster research are being carried out in cooperation with other branches.

Landslides

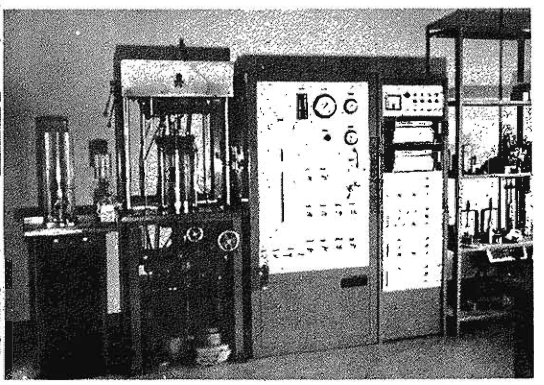
This section was established in 1959 for the geophysical study of landslides. The following projects have been conducted in order to clarify problems on landslide phenomena.

(1) Study on the basic factors and inducements of landslides

Landslides do not occur anywhere at any time, but at a fixed place and at a fixed time. It is therefore neccesary to determine the conditions for landslide occurrence. Conditions are divided into two parts; basic factor and inducement. In determining the basic factors and inducements, the neccesary conditions for landslide occurrence should be solved.



Equipment of model experiment for investigation of conditions of landslide.



Autographic triaxial compression apparatus for testing of soils in landslide area.

(2) Study on the movement mechanism of a landslide soil mass

In order to investigate the movement mechanism of a landslide soil mass, tilt-meters, extenso-meters, internal strain meters and other instruments are installed in the landslide area so that the movement conditions of the landslide soil mass may be seen three dimensionally.

(3) Study on the investigation methods of underground water and soil mass in a landslide area

Landslide movement occures through the loss of equilibrium between weathering rock material and underground water, therefore, it is neccesary to obtain correct information on the soil and water in a landslide area. To obtain this information, the electrical resistivity survey, seismic prospecting, natural radio and underground temperature surveies are conducted in landslide areas. The adaptability of these surveyes in landslide areas are then studied.

(4) Study on the techniques of prevention and control of landslides

To prevent and control landslide movement effective methods are studied, i.e., piles, drainage holes, underground water collecting wells, retaining walls etc.. The development of new prevention works are also being studied.

(5) Landslide forecasting

When a landslide movement occures, it always has some precursive phenomena. And by using geophysical instruments, it is possible to forecast the occurrence of a landslide movement.

Subsidence and Failure of Soft Ground

This section was established in 1962 for the intensive study on the prevention of soft ground disasters. As a fundamental research project, the mechanical properties of soil as well as soft rock are studied, and some field investigations have also been carried out. The main subjects being studied are as follows:

(1) Rheological properties of clays

The creep and stress relaxation characteristics of clays, the creep strength, the time effects and the temperature effects on the behavior of clays are studied from a rheological point of view, and the theoretical approach has been made by means of the linear visco-elasticity theory and the rate process theory.

(2) Mechanical properties of sands

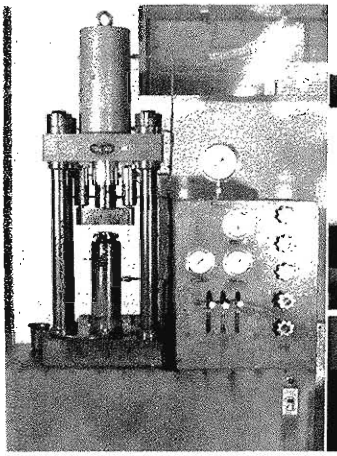
In order to obtain the general stress-strain relation of sands, theoretical and experimental researches founded on the micro-structure of sands have been carried out by assuming sandy soils as a random assembly of small particles and by applying a statistical consideration to it. As far as experimental studies are concerned, real sands, metal balls or metal rods are used in order to investigate the mobilizing behavior of the micro-structure of the cohesionless particles.

(3) Mechanical properties of rock and rock mass

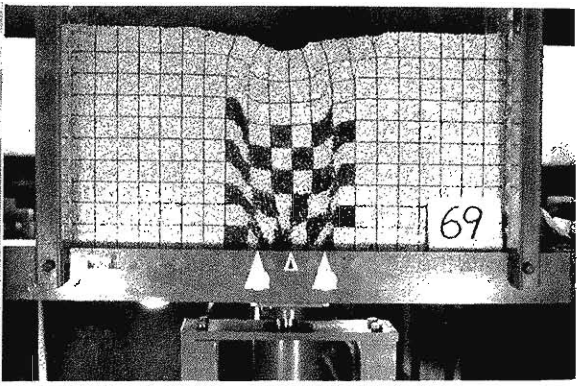
The study project consists of two parts. One is research on the mechanical characteristics of soft rock such as mudstone and weathered granite. The mutual relations

were found among elastic constants, the velocity of the ultrasonic wave especially in the case of transverse wave and the weathering degree.

The other study is an experimental research on the failure in stratified rock as for the case of the failure of rock slope and the local failure caused around excavated tunnel openings.



Triaxial high capacity compression apparatus.
(Max. value of axial load 50 t
Max. value of cell pressure 1000 kg/cm²)



Deformation pattern of a horizontal pile of aluminium rods due to lowering a "Trap-door".

(4) Dynamic behavior of soils

The dynamic behavior of clays are studied from various points of view by applying a statistical consideration and the rate process theory to the micro-structure of clay. Some results were obtained by a theoretical study on the effects of stress amplitude and frequency on the dynamic modulus of elasticity. Experimental studies on the flow behavior, the behavior of the pore water pressure, the fatigue character and the failure strength of clays under vibrating stresses were carried out by using a vibratory triaxial apparatus.

(5) Earth pressure on tunnels

The ground around tunnels may be divided into three types: Rocky, sandy and clayey types. In order to clarify the generating mechanism of the earth pressure on tunnels and predict the ultimate value of the earth pressure, experimental and theoretical studies were carried out for these different types of ground.

Besides such basic studies, a new method of measuring the earth pressure on steel supports in actual tunnels and some results measured by the method were presented.

Earthquake Resistant Foundations

This section was founded in 1967 in order to study the dynamic behavior of soils and foundations subjected to strong earthquakes, and to establish aseismic design

procedures. The main research projects are as follows:

(1) Liquefaction of Saturated Sand

One of the dynamic problems in soil mechanics is that of liquefaction of saturated sand. In part 1 of this project, the weight fluctuation of saturated sand is pointed out to be proportonal to the vertical gradient of dynamic pore water pressure and to the volume of the grain particles. In part 2, a theoretical treatment is made to establish the relationship between the following three factors: the number of stress cycles required to cause liquefaction, the magnitude of the cyclic shear stress, and the normal stress. Experiments are performed on saturated sand at different densities by the new-type dynamic triaxial apparatus.

(2) Elastic Wave Velocity in Soils

The propagation velocities of wave in soils depend not only on the elastic modulus and specific weight, but also on the porosity, moisture, stress, and strain level. In this research project, a model which represents the dependence of the elastic wave velocity on porosity is derived for a liquid-saturated porous solid. Laboratory tests using the ultra-sonic pulse method are carried out to measure the elastic wave velocity in specimens. The wave velocity of sandy soils is expressed as a function of the maximum porosity, the density of particles, the bulk modulus of water, and the elastic constants of sand for the minimum porosity.

(3) Strength of Dynamically Loaded Sand

The dynamic characteristics of soils under a vibrating load are usually different from the static one. In general, quicker loading or a higher frequency produces larger coefficients of elasticity and strength of soils. In this project, both the periodic axial and lateral confining pressures in the triaxial tests are controlled so that the angle between the normal stress and the resultant oscillating pressure is in accord with the mobilized internal friction. The internal frictions in terms of the effective stress of sand under the vibratory loading conditions decrease with the increase in the amplitude of lateral confining pressure and the frequency of vibration.

(4) Aseismic Design of Foundations

There are two different approaches to the design of structures for seismic loading. The first consists in the investigation of the response of structure to earthquake records and the second is based on the probability method. In this project, earthquake acceleration is represented as a nonstationary random process which is described as a product of a nonstationary deterministic function and stationary random process which has an arbitrary power spectrum. With the aid of numerical computation the response spectrum which contains a probabilistic quantity as a parameter is presented. From this spectrum the information related not only to the maximum vlaue of response but also the value of safety or risk is obtained.

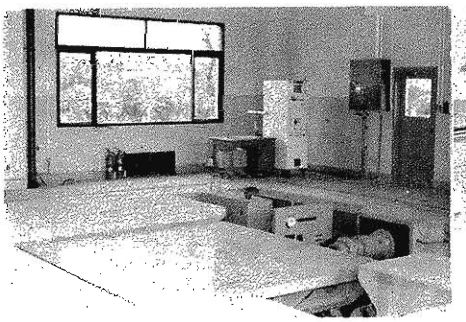
Anti-Seismic Ground-Structure Systems

This research section was established in April, 1964 in order to study the relationship between the earthquake damage sustained by structures and the dynamic

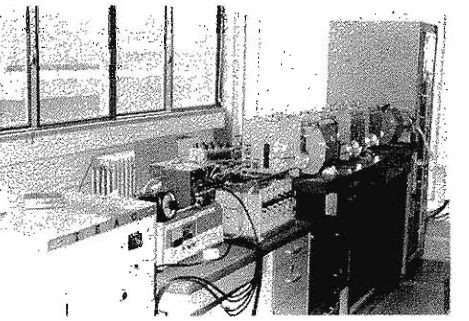
characteristics of soil-ground, and to find a reasonable method of preventing earthquake damage to ground-structure systems. The following is an outline of the research activities of this section:

(1) The dynamic characteristics of ground and earthquake excitations

Artificial earthquake excitations for dynamic response analysis of ground-structure systems, consistent with the wave transfer characteristics of ground, seismicity of the site and the randomness of excitation pattern, are being studied mainly by the theoretical approach.



Artificial earthquake generating equipment—electro-hydraulic shaking table.



Measuring installation of earthquake response of the ground and building in the Uji Campus—central recording apparatus.

(2) The dynamic characteristics of foundations and ground-structure systems

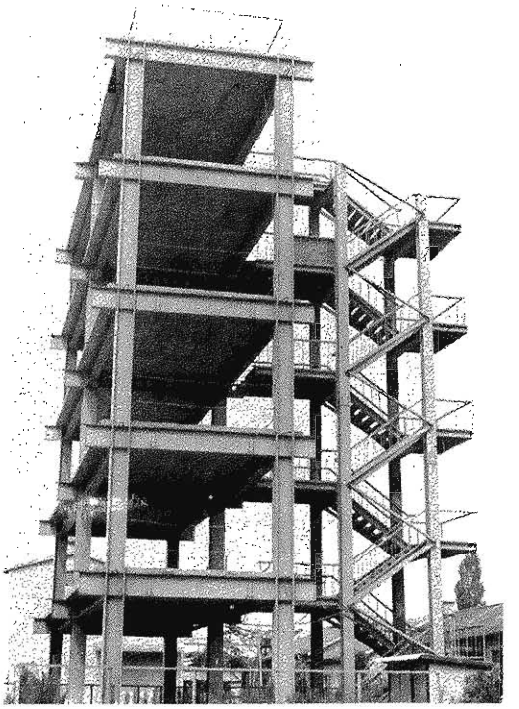
The dynamic force-displacement transfer characteristics of foundations, underground structures and of the neighbouring layered visco-elastic ground have been investigated by the theoretical methods. Based on these basic studies, the dynamic characteristics of a coupled ground-structure system as well as those of a group of such systems are being studied. Attention is being paid in particular, to the effects of the inelastic behaviour of the soil-ground on the interaction between ground and structures. Field experiments of the dynamic characteristics of actual foundations and ground-structure systems are also being made.

(3) The restoring-force characteristics of ground-structure systems and measures of their dynamic failure

The dynamic model of ground-structure systems and measures of dynamic failure of each part of the composite system, which are available for the elasto-plastic earthquake response analysis of such systems, are being studied mainly by the theoretical approach. Attention is now being paid to reasonable evaluation of the deteriorating restoring-force characteristics and also on finding the failure criterion under random cyclic excitations.

(4) Earthquake response analysis of ground-structure systems

The methods of elasto-plastic response analysis, including reliability analysis, of coupled ground-structure systems subjected to deterministic or stochastic excitations



Full-steel model framed structure.

have been studied. The elasto-plastic earthquake response characteristics of the coupled systems are being clarified through the numerical approach. Also, experimental studies on earthquake response characteristics of actual ground-structure systems are being continued.

(5) Anti-seismic design methods of ground-structure systems

Anti-seismic design methods of ground-structure systems based on their earthquake response characteristics have been studied. Emphasis is now on the establishment of the probabilistic optimal design method of elasto-plastic ground-structure systems, which guarantees a prescribed value of probability of anti-seismic safety together with maximum efficiency of the structural design.

Earthquake motions

This section was founded in 1951 for scientific and technological study of the basic problems of natural disasters. It was later given the present name. The fundamental theory of seismic waves and its application are being studied in order to elucidate some problems connected with earthquake damage, especially those related to ground. The substance of these studies can roughly be classified as follows:

(1) The generation and propagation of seismic waves

Physical property, the process giving rise to the generation of seismic waves in

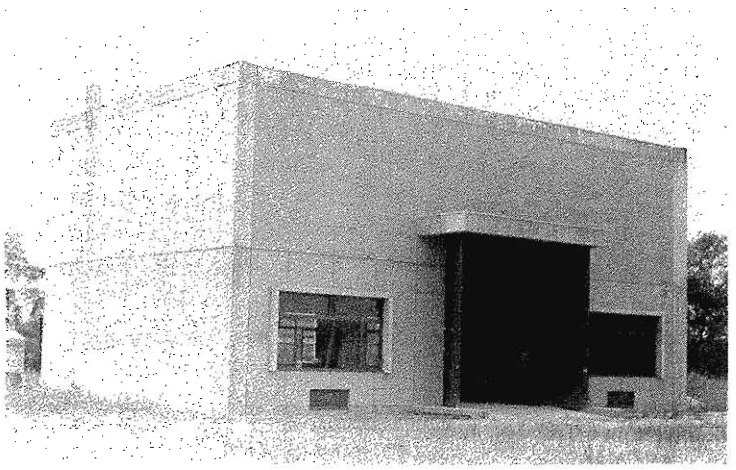
the source region and the modification of the waves during propagation through a media having a certain geological structure are being investigated by means of the observation of natural earthquakes and experiments on the artificial source of vibrations such as explosions. The main purpose of this investigation is to clarify the vibrational characteristics of the ground during destructive earthquakes. Observation of natural earthquakes have been carried out ranging from studies of micro-earthquakes to strong motion and the similarity law and its deviation due to the difference of strain amounts depending on the magnitude on the earthquake.

In cases of explosions the generation of waves are studied by the observation of waves near the origin using various kinds of explosives and charges, the mechanism of wave generation being investigated experimentally.

(2) Applied seismological study of grounds

The physical property of ground in relation to the behavior during earthquakes and of other disturbances are investigated by applied seismological methods. Seismic prospecting is used to obtain, in situ, physical constants of stratified geological structure comprising the foundation of the structure.

Various techniques of seismic prospecting such as the refraction method, veolcity



Artificial earthquake generating equipment—external view of the laboratory.

logging of P,S, and tube waves in boreholes, and three dimensional fan shooting are being developed.

The physical properties of the ground obtained are compared with those obtained by other methods such as the electrical method and formation of the media calculated from the analysis of test pieces. The relation between the geological structure and the distribution of earthquake damage is being studied.

(3) Relation between earthquake motion and ground structure

Basic study on the quantitative analysis of the effect of geological structure and

topography on earthquake motion are studied to obtain a microzoning map of urban areas such as Osaka and Kyoto.

Recent city developments have been extended in wide areas of made land and filled in land. Consequently, earthquake damage proper to soft land has tended to concentrated in these zones. In this section the vibrational damage of the ground is being investigated through the observation of natural earthquakes, vibration measurement and the clarification of ground structure by seismic prospecting.

(4) Local characteristics of earthquake motions

Input seismograms applied for dynamic analysis are being studied. Strong earthquake motions depend on the source mechanism, physical property of rocks in the neighbourhood of the source, the path of wave propagation, and the local geology.

On the other hand they can be regarded as stochastic process because of the complexity of the process of wave generation and the geology of the media of wave propagation. In order to determine the characteristics of strong motions, simulated earthquakes have been conducted considering the mechanism of wave propagation in each region based on the theoretical model of the earthquake. These are compared with observed strong earthquakes. As a result the methods of determining physical constants affecting strong motions are investigated.

Crustal Movement

This section was founded in 1958, originally as part of a large research project concerning crustal movements related to earthquake-occurrence. At present, the research activities in this section include not only work on crustal movement but also a variety of other work mainly in seismology, as described in detail below. The two main investigation programs in this section are, on one hand, to throw light on the nature of earthquakes and, on the other, to predict earthquake-occurrence.

(1) Investigation of crustal movement

Observations by tiltmeters and extensometers are being made at about 15 observation sites. The purpose of investigation in this field is to observe tilting motion and ground strain caused by the accumulation of strain energy in the focal domain of large earthquakes, and also to detect a possible relation between the mode of crustal deformation and earthquake-occurrence.

(2) Investigation of microearthquakes

Observation of microearthquake (magnitude less than 3) is being carried out at the network stations of the Tottori and the Hokuriku Microearthquake Observatories with the use of highly sensitive seismographs. Statistical study of microearthquakes is undertaken in order to clarify the nature of earthquake-occurrence as well as the relation between the generation of minor and major earthquakes.

(3) Investigation of earthquake mechanism

This investigation is, in a sense, the synthesis of all research projects in this section. The processes of accumulation and release of earthquake energy are investigated from various aspects, such as crustal movements, seismicity of microearthquakes,

and the wave-form analysis of seismic long-period waves observed by long-period seismographs. Also investigated is theoretical treatment of the source mechanism, and development of a new seismograph system for the purpose of clarifying earthquake-mechanism.

(4) Investigation into the predictability of earthquake-occurrence

This is one of the two main research projects in the section. Observations and investigations of crustal movements and microearthquakes are being intensified for this purpose.

(5) Investigation of the structures of the Earth's crust and mantle

Investigation of the structure of the Earth's interior, which is considered as the field of earthquake-generation, is important in determining the nature of earthquakes. Not only elastic properties of the crust and mantle but also anelastic behaviors are investigated mainly by seismological methods.

Instrumentation for Earthquake Prediction

This section was founded in 1965 for the purpose of investigating various phenomena relating to the occurrence of earthquakes and earthquake prediction. The following subjects have been studied.

(1) Crustal deformations and forerunning phenomena of earthquake occurrence

Since earthquakes result from stresses which accumulate within the crust and upper mantle, certain phenomena relating to the occurrence of earthquake should be observable on the earth's surface near their epicenters. Among them, crustal deformations are thought to give a promising clue for earthquake prediction at present, and much importance has been placed on the investigations of crustal deformations. Continuous observations are being made at the Amagase Crustal Deformation Observatory, Iwakura and Wakayama in cooporation with the Donzurubo Crustal Movement Observatory. Observations of crustal strains by the electro-optical measurement are also conducted at six base-line networks founded in western Japan. A model experiment of deformations and fractures of solids is now planned to investigate tectonic deformations and their relations to earthquake phenomena.

(2) The development of observation instrument

Instruments for observations of geophysical phenomena relating to earthquakes are being developed, especially with respect to telemetric and remote-controlled operations, for high-speed data processing. For the telemetric observations, a new digital recording system has been devised and successfully used to obtain digital records of crustal deformations. A long-term recorder for long period seismographs has recently been devised and test observations are now being carried out at the Amagase Crustal Deformation Observatory.

(3) Study on the source mechanism of earthquakes, seismicity and crustal structure

Source mechanism of earthquakes is being studied from observational results with the use of long-period and strain seismographs. Far-field residual strains caused

by large earthquakes and strain-steps associated with moderate earthquakes are studied in relation to focal mechanisms, magnitudes and seismic moments based on mathematical models from the dislocation theory.

Continuous observation of microearthquakes by short-period seismographs at the Amagase Crustal Deformation Observatory and temporal observations by a tripartite network have been carried out in order to investigate the source mechanism of microearthquakes, seismicity and small scale structure of the crust near Uji City. These investigations are intended especially for elucidation of the relation between the breaking strength of crustal rocks and the storage of earthquake generating stress.

(4) Study on slow movements in fracture zones and landslide sites

Observations of ground movements in fracture zones and at landslide sites are carried out by extensometers in order to investigate the sliding mechanism of landslides and to predict their occurrence.

Earthquake Resistant Structures

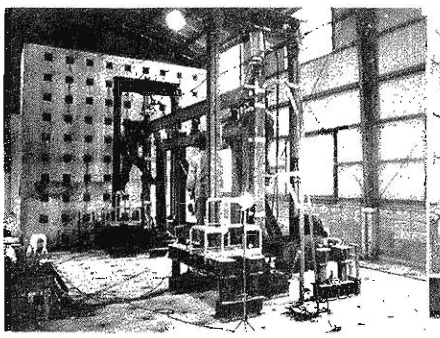
This section was founded in 1951 for the synthetic study on the prevention of earthquake and wind disasters, and later gained its present name. In order to find a reasonable design method for earthquake resistant structures, some fundamental problems are being investigated experimentally and theoretically on the strength and deformation of structures. They include:

(1) Elastic-plastic behavior of steel multi-storied frames

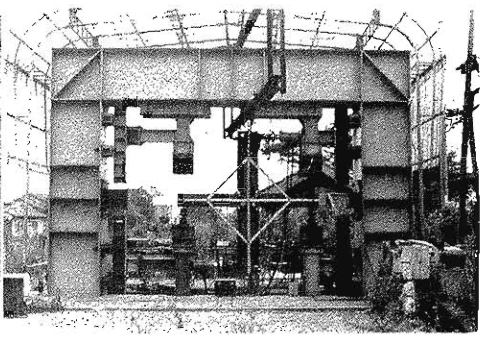
In order to investigate the ultimate state of steel multi-storied frames under earthquake or wind forces, models of steel frames are subjected to monotonously increased horizontal forces as well as constant vertical loads. Attention is paid, in particular, to the effect of the over-turning moments induced by the vertical loads and the change in geometry.

(2) Histeretic behavior of steel frames under repeated loading

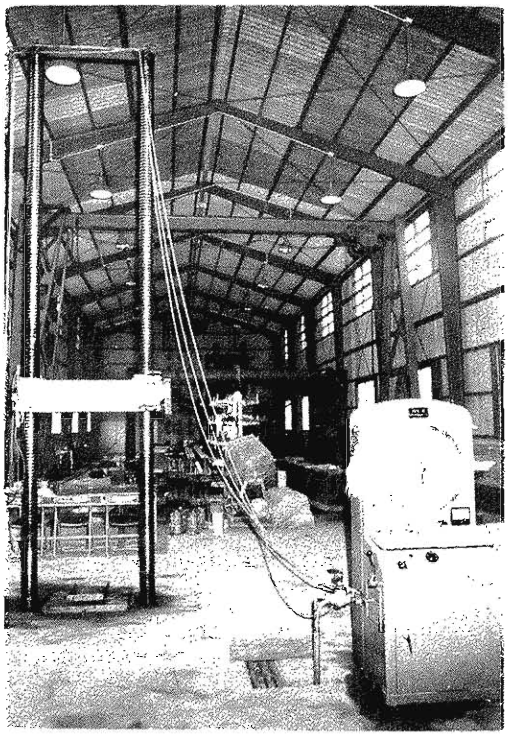
Research here is to clarify the elastic-plastic histeretic behavior of braced and unbraced steel frames due to the repeated action of horizontal loads such as earth-



Test bed for full-scale experiment.



Rectangular-shaped tesing frame.



Structure testing laboratory.

quake forces. Theoretical and experimental studies are now being carried out on bracing members which are repeatedly subjected to tension and compression.

(3) Permanent deformation of structures due to large impact loads

With the aim of clarifying the ultimate state of steel structures under destructive dynamic loads, models of portal frames are currently subjected to impulsive forces at the beam level and at the foot.

(4) Buckling strength of steel structures

This is to study the instability phenomena in a steel skeleton and its members, such as the buckling of plane- and space-rectangular portal frames, the lateral buckling of beams, unstable characteristics of columns due to biaxial bending, and the buckling of built-up columns.

(5) Earthquake resistant capabilities of reinforced and steel-framed reinforced concrete structures

Experimental studies are performed on the elastic-plastic behavior of structural members, joints and frames in reinforced and steel-framed reinforced concrete structures, for the purpose of determining their earthquake resistant capacities.

(6) Investigation of damaged structures

Investigations are conducted on the mechanism and cause of failure in damaged structures due to the action of earthquakes and winds.

(7) Studies on fire disasters and emergency evacuation

A variety of problems are investigated concerned with fire disasters and emergency evacuation in tall building structures.

Wind Resistant Structures

This section was founded in 1961 to carry out fundamental research into the prevention of wind damage on structures. The studies are divided into three main parts; one is the study of the characteristics of natural winds, i.e., environmental conditions including weather phenomena causing disastrous winds; the second is the interaction between wind field and structures, including the problems of aeroelastic phenomena, modifications of wind characteristics around structures etc.; the third is the response of structures to wind.

Three main methods of research are incorporated to obtain the final objectives; one is a theoretical method including numerical experiments, the second is experiments on full scale structures, the third is model experiments in wind tunnels or in the natural winds. Most of the field experiments are made outside the main campus. A wind tunnel for the experiment is of the Göttingen type with a working section of 1 m in diameter.

Subjects of recent research activities are as follows.

(1) Studies on typhoons and the characteristics of its severe wind.
(2) Studies on severe local storms and wind damage caused by them.
(3) Turbulent structure of strong winds.
(4) Modification of wind flow patterns around obstacles (small hills, high-rise buildings etc.)
(5) Distribution and fluctuation of wind pressure on structures in natural winds and those on model structures in wind tunnels.
(6) Theoretical and experimental studies on the vibration of structures in winds. The experiments are made on full scale structures in natural winds and on models in the wind tunnel.
(7) Mechanism of the destruction of structures by severe winds.
(8) Similarity between full scale flow and wind tunnel flow.
(9) Development of experimental techniques for wind studies, such as anemometering, pressure measurement and deflection measurement.

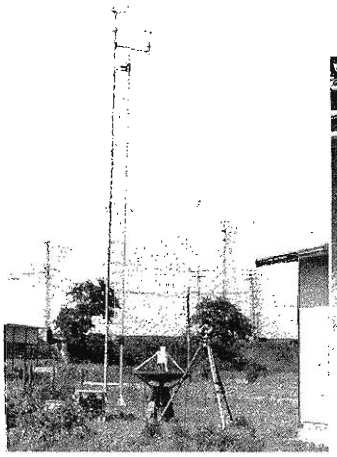
Applied Climatology

In this section, the relation between local climate and local disaster features is studied. Fundamemtal research on long-range weather forecasting for disaster prevention has also been conducted. The main subjects are as follows;

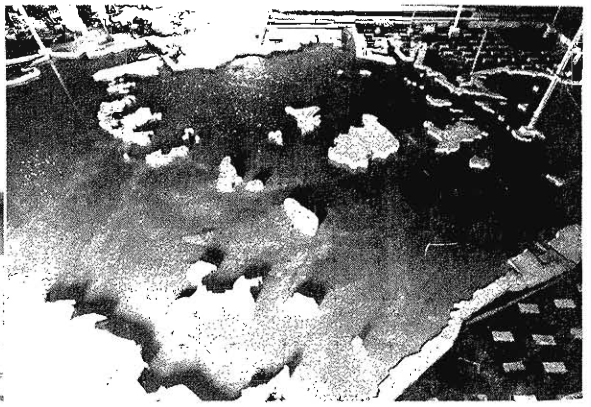
(1) Climatic Change.

The variation of the strength and position of the jet stream over the Far East and the prediction of climatic change in Japan are investigated. For this purpose, patterns of the jet stream relating to weather conditions in Japan have been classified.

The relation between the growth of glaciers and global climatic changes is also studied. Weather data in the Himalayan, Alaskan and Patagonian regions are being collected in order to understand the mechanism of heat and water balance under various weather conditions. It is intended to compare weather conditions of these regions.



Tracking and recording rawin set.



Model of the central part of the Seto Inland Sea for a hydraulic model experiment of the diffusion phenomena.

(2) Local Climate.

The topography of Japan is very complicated, and this is strongly connected with meso-scale weather phenomena.

1) Analysis of the differences between the inland and the coastal climate: Generally it is less rainy inland than in coastal areas. Sometimes heavy rains, however, do occur in regions where the topography is suitable for moist southerly winds to blow from the Pacific Ocean into these inland areas. The differences between the Pacific and the Japan Sea coast are also important. The local characteristics of lower atmosphere are investigated, using radio sonde and pilot balloons. 2) The study of air pollution: The study of local climatic conditions is very important for the prevention of air pollution. In Osaka, sea and land breeze is distinct, but Kyoto has a basin climate. Therefore in Kyoto, temperature inversion tends to develop rather than in Osaka. 3) The transportation of sea-salt particles from the sea to inland areas: Methods of measuring the concentration of salt particles in the air have been developed and the mechanism of the transportation is investigated in relation to the local climate.

(3) Heavy Rain

In Japan, we frequently have extraordinarily heavy rains, which tend to concentrate in certain small areas. It is intended to study why heavy rains concentrate in such areas. The main subjects are as follows.

1) The effects of synoptic, meso-scale weather phenomena on heavy rains and orographic effects: The central part of the Kinki district is a suitable experimental field for this purpose due to this district having a dense network of rainfall observation and radar stations. It is also one of the heavy rainfall regions. 2) The geographical and statistical distribution of heavy rains in Japan: The location, dimensions, frequency and duration of heavy rains are investigated. 3) The relation between the type of heavy rain and the type of flood: The phase differences between the peaks of heavy rain and high water are investigated for various types of heavy rains in the basin of the River Yodo.

(4) Diffusion Phenomena in Estuaries

A hydraulic model experiment has been carried out in order to approach the diffusion phenomena in a nearshore sea area. It is thought that the main factor controling diffusion is the tidal current in a nearshore sea area which does not directly face the open ocean. Only the tidal current is taken into account as the first approximation. Other factors such as density stratification, wind, waves, and so on, which may influence the diffusion in an estuary, are not considered.

Applied Hydrology

Extensive research has been carried out in order to elucidate hydrological phenomena with respect to disasters caused primarily by heavy rainfall and to establish engineering techniques against flood. The following specific fields of applied hydrology are now covered.

(1) Characteristics of heavy rainfall ; prediction of rainfall, spacial and time distributions of rainfall in the light of meso-meteorology, and influences of basin topography to distribution.

(2) The runoff process of rain-water ; water losses in relation to runoff, flood runoff from small watersheds, flood configuration in the net of stream channels, and simulation on hydraulic model basins in a laboratory with respect to runoff process.

(3) The hydrologic behavior of groundwater ; effects of influent and effluent on long-term runoff and relationship between the infiltration of rain-water and the height of the groundwater table.

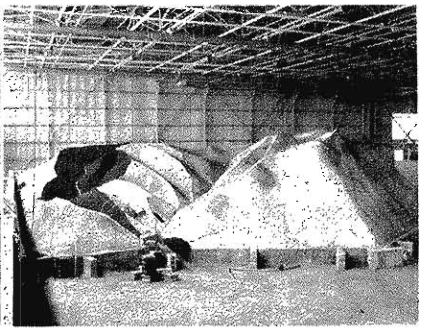
(4) Runoff analysis and flood prediction ; runoff analysis by distributed models, accuracy of prediction of heavy rainfall and flood runoff by the use of usual methods.

(5) Flood control ; optimal operation of a group of reservoirs for flood control by a method of operations research such as dynamic programming, objective function of flood control and the relation between the operation of flood control and that of water use.

(6) Water balance ; water balance among surface runoff, sub-surface runoff, groundwater runoff and water losses in mountainous areas, and water balance in the area of Lake Biwa.

(7) The stochastic analysis of hydrological data and its engineering applications ; probability of embankment breaks in a system of river channels, probable distri-

River Ara experimental basin for examining the runoff process.



1/100 scale model of the experimental basin for study of simulation technique.

bution of rainfall in time sequence, and design floods at various points in a river basin.

As one of the projects of the International Hydrological Decade proposed by UNESCO, a variety of field observations, such as the experimental basin and plot for examining rain-water runoff and sediment yield processes, in the drainage area of Lake Biwa have been carried out since 1966. This work is being performed with the cooperation of research members belonging to other research sections of the Institute and the Faculties of Science, Engineering and Agriculture.

Sedimentation and Debris Control

The purpose of this section is to clarify the mechanism of sediment yield, transportation and deposition, in order to prevent flood disasters relating to sediment problems.

The main subjects being studied are as follows :

(1) Sediment yield

A method to estimate the sediment yield from hydrological factors such as rainfall intensity and discharge for a given geological condition has been investigated in both field and experimental studies. Field studies are carried out in various basins such as Kurobe River, Arita River and Hodaka sedimentation observatory.

An experimental study for the erosion of a land slope by overland flow is being conducted in a facility with artificial rainfall.

(2) Sediment transportation

The mechanism of bed load and suspended load transportation for non-uniform sediment is being investigated theoretically and experimentally. On the basis of this result, river bed variations occuring in a non-equilibrium state of sediment transportation are being studied for various boundary conditions. Measuring techniques for sediment transportation have been developed.

(3) Mud flow

Mud flow with a property of non Newtonian fluid occurs in a steep slope of 20

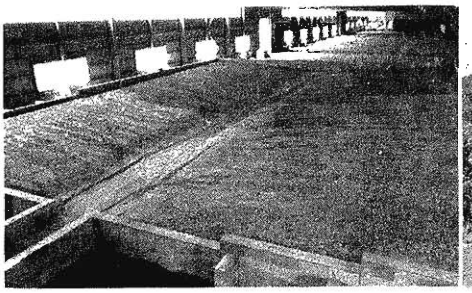
~30°, and the material transported by mud flow finally is deposited at a place with a mild slope causing severe disaster.

The mechanism for the occurence of mud flow, characteristics of non Newtonian fluid, and properties of deposition are being clarified in experimental studies.

Field observations for mud flow are being conducted.

(4) Flood propagation

Characteristics of flood propagation in both regular and irregular channels are clarified under various boundary conditions by theoretical and experimental studies. Flood behavior on movable beds and sediment transportation during flood are also being studied.



Experimental facility for surface erosion. Width: 15 cm, Length: 20 m, Intensity of rain: 0-125 mm/hr

RI Tracer-Experimental Facility to investigate sand transport phenomena. Flume: Width and Depth: 50 cm, Length 20 m, Slope: 0-1/50, Laboratory: 66 m^2

(5) Sedimentation in reservoirs

Dispersion and sedimentation process of suspended sediment in reservoirs are investigated in order to clarify a trap efficiency by using a reservoir model.

(6) Sediment control

The debris dam is considered to have a function of sediment control which means a temporal storage of part of the sediment transported during a high flood.

This function is investigated for various types of over flow structure.

River Disaster Prevention

This section was founded in 1951 for synthetic study on the prevention of water disasters in rivers and seacoasts, and later gained the present name. Extensive laboratory studies and field observation have been carried out, i.e., studies on meteorological "Tsunamis" traveling up rivers, washed timbers due to floods, percolation of river embankments, river meandering, hydraulic resistance of artificial roughness and its application to river models, sedimentation in reservoirs and river stabilization, flood flows under various boundary conditions, movable bed configuration and flow resistance, sediment transport of uniform and graded sediment, local flows and scours at bends, channel expansion, etc.. In addition to these basic studies,

reconnaissance studies of a number of river disasters due to heavy rainfall and floods have been carried out in cooperation with other research sections of the institute.

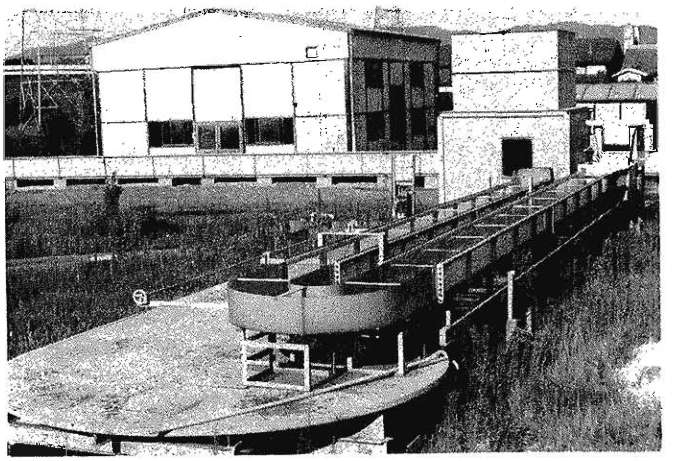
An outline of the present research activity is as follows:

(1) Some basic studies on flood disaster due to river morphology

In order to elucidate flood disaster due to the macroscopic river morphology, hydrological conditions and the geometrical properties of the drainage basin and stream channel in the major rivers of Japan have been investigated by the use of survey maps and flood records of the past.

(2) The study on fluvial processes of stream channels

The fundamental laboratory study on river channel processes with bank erosion has been conducted in a large alluvial channel 110 m in length and 7.5 m in width and under various boundary and steady flow conditions. Some theoretical considerations on the process of channel widening and the self-formed stable channel profile have been made on the basis of fluvial hydraulics. Influence of sediment mixture and unsteady flow conditions on the channel process and mechanics of channel meandering and braiding are being carried out.



Curved flume of variable angle and radius.

(3) Studies on hydraulic models of run off and river bed variation

The approach of simulation to interception, infiltration and other various run off components have been tested by the use of 1/100 scale models of the experimental basin in the River Ara, in which detailed observation on hydrologic factors have been made by the Applied Hydrology Research Section. The basic model experiments on river bed variation have been conducted in 1/500 and 1/100 scale models of the lower reach of the River Daido in order to investigate river bed configuration and the effects of river structures under various flow conditions. The criteria of similarity in the design of the hydraulic models and the precise methods of flow mesurement in hydraulic models are being examined.

(4) Field observation of flood flow and sediment transportation

Observation of water stages, flow rates, the structure of turbulence and the sediment concentration in flood flows have been conducted in the River Daido in order to elucidate the transport mechanism of sediment yielded in the mountain-side and the characteristics of flood propagation in the river channel.

Drainage Engineering

In this section, fundamental research and field investigations have been carried out in order to develop a method for planning drainage systems. The main subjects are summarized as follows:

(1) Quantitative representation of runoff characteristics: Relation between the occurrence condition of overland flow and soil moisture content, the distribution pattern of which is governed by a process of infiltration-evaporation, is studied experimentally using lysimeter equipment in order to obtain information for runoff analysis. Characteristics of rainfall excess and storm runoff in a drainage basin are also examined using the data obtained in experimental basins, each of which is composed mainly of a forest, agricultural or an urban area. After the method of runoff analysis applicable to such a drainage basin is examined, the method of quantitative representation of runoff characteristics in each sub-basin is investigated in relation to the simplification of a model for the sub-basin.

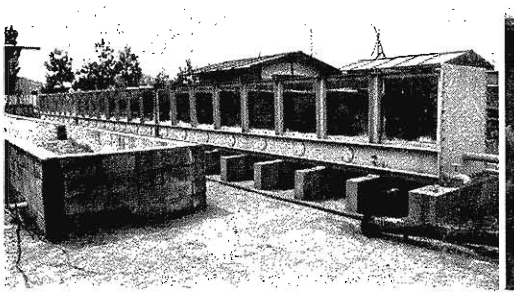
(2) The hydraulic problems of drainage systems: The resistance law of a flow with very mild hydraulic gradient, sediment hydraulics in a drainage channel and the method of hydraulic calculation in channel networks are investigated experimentally and theoretically.

(3) The seepage problems in earth structures : The two and three-dimensional problems of steady and unsteady seepage flow through porous media are studied using analog and digital models to analyze the flow through such structures as an earth embankment.

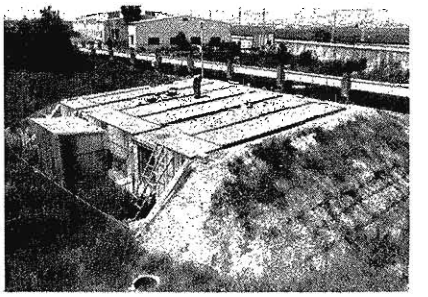
(4) Behaviour of groundwater in an alluvial fan : Field surveys on the groundwater movement are carried out in experimental basins, and the possibility of simulating their behaviour is examined by solving the fundamental equations of the confined and unconfined groundwater flow using a digital computer.

(5) The change of damage potential according to the urbanization of a drainage basin : Urbanization of a drainage basin causes delicate changes in hydrographs at the outlet and therefore in the damage potential of the basin. In order to develop methodology for predicting such changes, the changes in area of urban, forest and agricultural lands, and in the roughness of ground surface and their effects on runoff characteristics in the basin, are studied using the data obtained in experimental basins.

(6) Design of drainage systems : Flood control by channel and culvert networks, allocation of flood water by the choice of temporary floodable areas, decision of optimal locations for pump stations are investigated from the view point of engineering economics. The optimal capacities of pump and pond are also investigated



Tank for groundwater experiments.



Lysimeter equipment.

by using the sequence of rainfall generated by the stochastic technique. Developing statistical and stochastic techniques, therefore, to analyze hydrological data are also an important subject for the optimal design of drainage systems.

Coastal Disaster Prevention

This section was founded in 1961 in order to carry out basic and applied research into coastal disasters. Extensive research has been carried out at the Ujigawa Hydraulic Laboratory in order to solve various hydraulic problems in shallow water. In addition, field investigations to prevent coastal disasters due to wave action have been made at several coastal points in Japan in close cooperation with both the Shirahama Oceanographic Observatory and the Ogata Wave Observatory. The main subjects are as follows:

(1) Characteristics of shallow water ocean waves and their estimation

In order to elucidate the transformation characteristics of wind waves in shallow water, the development process of wind waves and transformation of finite amplitude wind waves have been investigated by the use of a recirculating wind wave tank. Applied the power and directional spectrum method, characteristics of wind waves in shallow water have also been investigated using data obtained at the observatories described above. Applicability of various methods of estimation of wind waves has been considered and stochastic characteristics of shallow water ocean waves have been analyzed using wave data.

(2) Transformation of storm surge and tsunamis in estuaries

Due to the main factors in coastal disasters, the transformation characteristics of storm surges accompanied by typhoons and tsunamis caused by earthquakes in estuaries should be investigated. Behaviour of storm surges and tsunamis in estuaries have been studied using hydraulic models. Based on the spectral characteristics of tsunamis in an estuary, the transformation and resonance characteristics have been investigated in connection with the evaluation of the effects of tsunami breakwaters. In future investigations, further problems, such as the mathematical simulation of transformation of storm surges and tsunamis, the shoaling wave pressure and reflection of tsunamis and the currents accompanied by storm surges and tsunamis should be investigated.

(3) Characteristics of coastal currents and tidal currents

In order to clarify the changes of currents in coastal water due to the development of littoral districts and to investigate the longshore currents by wind waves, extensive investigations have been carried out. In the former, the mixing and diffusion characteristics of coastal water in estuaries have been studied by the use of hydraulic models in cooperation with the Research Section of Applied Climatology. In the later, basic observation of longshore currents at Ogata coast and theoretical approaches to longshore currents taking into account radiation stresses, horizontal mixing and bottom friction have been developed.

Recirculating wind wave tank. (Shallow water ocean wave simulator)

(4) Hydraulic characteristics of sea walls and sea dikes

Although investigations have been carried out in order to clarify the effects of wind on the wave overtopping of sea walls and the wave run-up on slopes, the wave overtopping of obliquely incident waves and some problems on the effects of the irregularity of waves on wave overtopping and wave run-up on beaches have been investigated in order to establish a complete design method for sea walls and dikes.

(5) Hydraulic characteristics of shore and offshore structures

In order to investigate the wave forces on shore and offshore structures and to establish a complete design method, extensive studies on the wave pressure and wave force in shallow water have been carried out by measuring them on horizontal and vertical circular cylinders and spheres in wide conditions of wave characteristics and the dimensions of structures. A theoretical analysis for wave forces on a large cylindrical pile, the diameter of which is comparable to the wave length, is carried out on the basis of wave diffraction theories. Further investigations of wave forces on shore structures and the dynamic response of structures due to wind waves are investigated.

(6) Beach processes, sediment transport by waves, currents and winds

Although much research has been done in order to elucidate beach processes, basic research on bar formation and the mass transport of wind waves have also been performed. Beach processes by wind waves and shore processes due to sand drifts have been investigated using a newly designed recirculating wind wave tank and a fan shaped wave basin.

(b) Attached Facilities

Ujigawa Hydraulic Laboratory

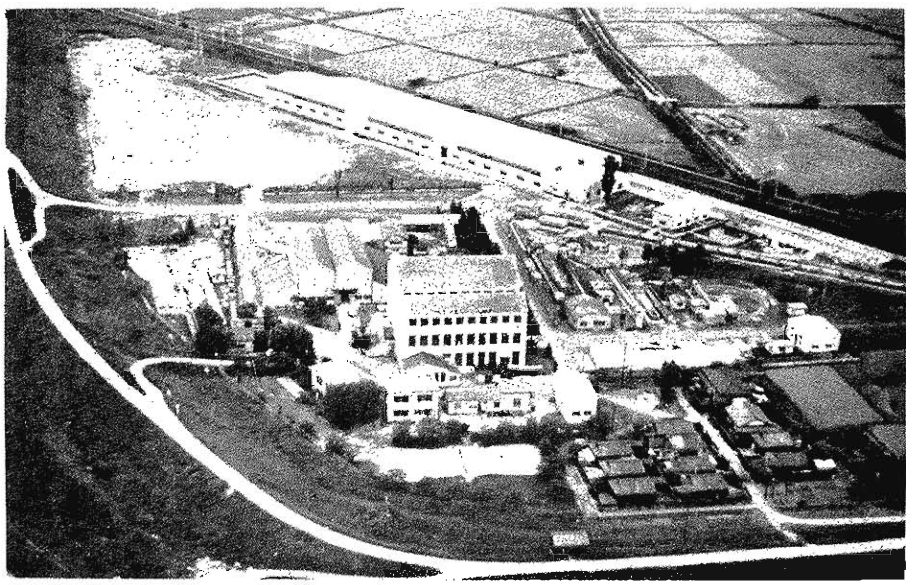
The Ujigawa Hydraulic Laboratory was established in 1952 in order to conduct research into methods of preventing disaster caused by water and soil. The laboratory is located beside the levee of the downstream of Uji River (Ujigawa), about twelve kilometers south of the main campus of the university. The site covers an area of 61,000 m^2.

In this laboratory, theoretical and experimental studies, together with field observations, have been conducted to elucidate some scientific problems concerning water and soil. In addition to the research staff assigned to the laboratory, other members of the following research sections, that is, Applied Climatology, Applied Hydrology, Sedimentation and Debris Control, River Disaster Prevention, Drainage Engineering, Coastal Disaster Prevention, Subsidence and Failure of Soft Ground, and Earthquake Resistant Foundations, are working in cooperation with the members in this laboratory.

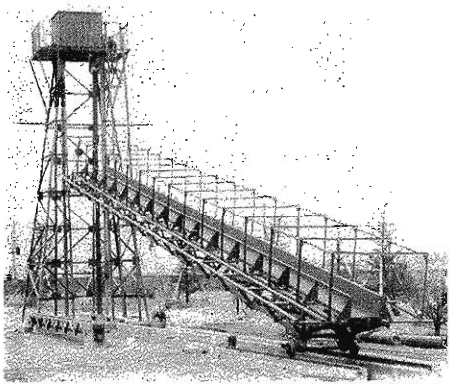
Numerous facilities for experimental research in hydraulics, i.e., straight and curved flumes, channels with fixed and movable bottom, wind wave tanks, and model basins, are installed here. The experimental facility for research on river disasters was completed in 1968, with the object of systematically studying disastrous phenomena caused by heavy storm rainfalls in a river basin.

The main research programs conducted by assigned staffs are as follows;

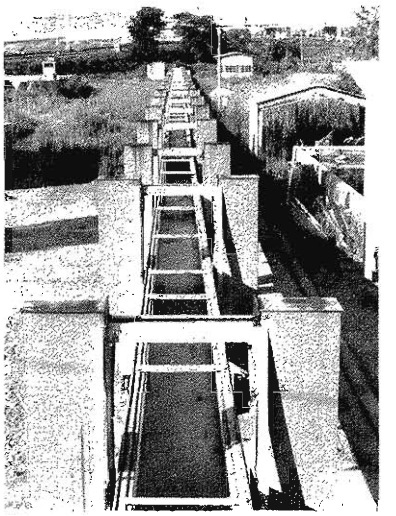
(1) Theoretical and experimental studies on the characteristics of turbulent structure in free surface shear flow.



General view of Ujigawa Hydraulic Laboratory.

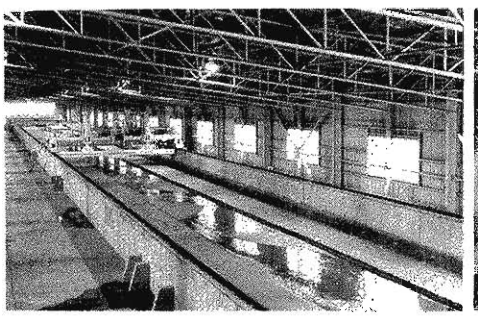


Steel flume with artificial rainfall.

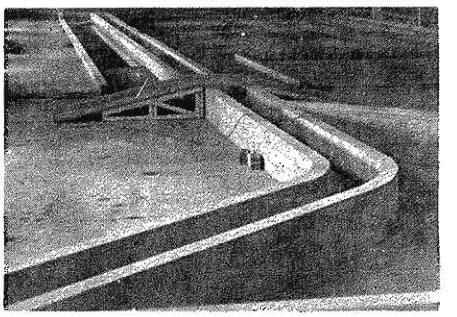


Steel flume for unsteady flow.

(2) Experimental study of the micro-structure of river flow.
(3) Study on local structure of open channel flow, for use in the hydraulic design of river structures and development of more rational design procedures.
(4) Study on the simulation techniques of hydraulic phenomena, that is, similitude of the flow in fluvial channels, digital and analog simulations of the flow around structures.
(5) Developments of measurement techniques for hydraulic phenomena; flow visualization technique, automatic measurement of water surface and bottom, flowmeter of fluctuating velocity, and so on.
(6) Study on the method of hydraulic data processing.
(7) Theoretical study on two-variate hydrological distribution and its engineering application in the design of systems of flood control and water resources.



Concrete channel in the experimental facility for research on river disasters. Experiment of free meandering is shown.



Concrete channel for the experiment of floods behaviour at junctions.
Width: 60 cm, Length: main channel 90 m, Slope 1/500, tributary 43 m.

(8) Study on the evaluation of the probability of water-shortage and the rule for releasing water in a system of reservoirs in relation to the flow regulation through reservoirs.

Sakurajima Volcanological Observatory

Sakurajima Volcanological Observatory was established in 1960, for the purpose of undertaking fundamental research on the mechanism of volcanic eruptions, and for predictions on the explosion of Sakurajima Volcano which is one of the most active volcanoes in Japan.

At present, this observatory has two branches at Kurokami and Yoshimatsu, two underground vaults at Hakamagoshi and Shimoishiki, and a tide gauge room at Hakamagoshi. Moreover it has 12 sub-stations for seismic observation everywhere on the Kirishima volcanic belt.

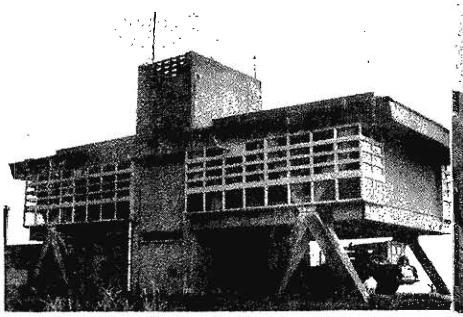
Routine and temporary works in this observatory are as follows.

(1) Seismic observation

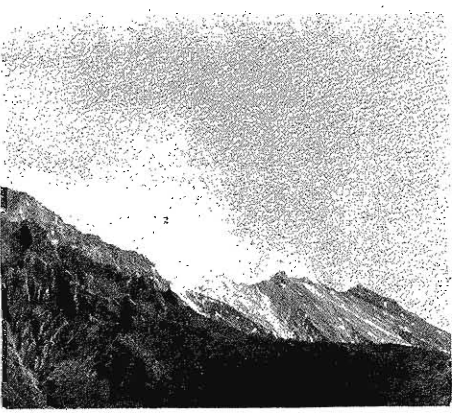
Sakurajima: In studying the epicenter distribution, the nature and the occurrence mechanism of volcanic earthquakes, two networks of 3 seismograph sub-stations were established around the active crater, operated by tele-recording systems at the observatory and Kurokami Branch. Also, at the observatory and Kurokami Branch, different kinds of mechanical seismographs are set up to observe the felt-earthquakes occurring in and near Sakurajima.

Yoshimatsu: In studying earthquake occurrence in the Kakuto caldera on the borders of Kagoshima and Miyazaki prefs., a network of 3 seismograph sub-stations has been established and is operated by tele-recording system at Yoshimatsu Branch.

Kaimon: In studying earthquake occurrence in the Ata caldera at the southern end of Satsuma Peninsula where the Kaimon Volcano is the central cone, sensitive seismic observations are carried out at Kaimon, Ikeda and Unagi-ike sub-stations.



Sakurajima Volcanological Observatory.



Explosion of Sakurajima Volcano in mid-night.

Besides the above routine observations, high sensitive seismic observation is occasionally carried out everywhere on the kirishima volcanic belt.

(2) Geodesic observation

In studying crustal deformation caused by volcanic activity, continuous observations are carried out by the Sassa-type extensometer, the bar-type extensometer, the pendulum-type tiltmeter and the water-tube tiltmeter at two underground vaults situated at Hakamagoshi in Sakurajima and at Shimoishiki in Kagoshima city. Tide observation too is conducted at the Hakamagoshi tide gauge room.

Besides the above continuous observations, precise levellings and surveys with a geodimeter are repeated to find the crustal deformation associated with volcanic and seismic activity.

In order to investigate the crustal structure under the volcano and the change in the physical nature of the magma reservoir with time, gravimetric and geomagnetic surveys are conducted.

(3) Further observations

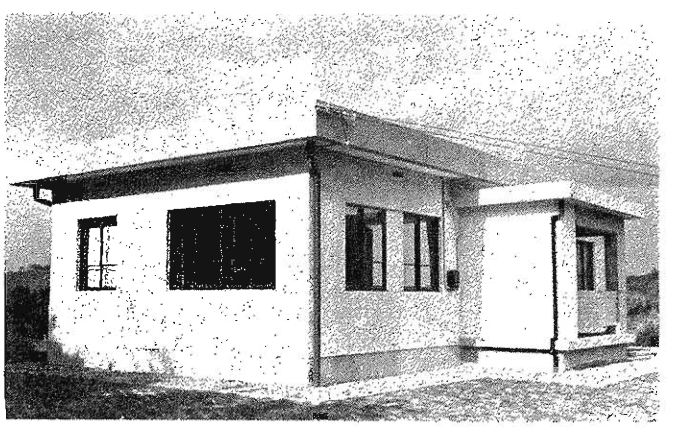
The measurement of sound waves accompanying volcanic explosions is continuously carried out by the Shida-type microbarograph to obtain information on the pressure and mechanism of explosions.

Underground temperature is measured in order to examine its relation to volcanic activity.

Meteorological observations are being conducted to examine meteorological conditions relating to volcanic phenomena.

Tottori Microearthquake Observatory

Tottori Microearthquake Observatory planned by the "Earthquake Prediction Research Group in Japan", was established in 1964, as one of a network of observatories covering the whole of Japan for the observation of microearthquakes. At present, this observatory has 11 sub-stations mainly in the northern part of the Kinki



Tottori Microearthquake Observatory.

Equipped instruments of the Tottori Microearthquake Observatory and sub-stations.

	Station	Location	Seismograph			Time
			Type	Comp.	Mag.	
I	Tottori Microearthq. Obs.	Tottori City	Electro-magnetic with amplifier and pen-galvanometer	NS, EW, V	150,000	Crystal clock accuracy: 1/20 s
			Press-Ewing long period	NS, EW, V	2,000	
k	Sub-station Funaoka	Tottori Pref.	Electro-magnetic with amplifier and pen-galvanometer	V	150,000	"
j	Mikazuki	"	"	NS, EW, V	"	"
g	Hikami	"	"	"	"	"
i	Oya	"	"	"	"	"
h	Izumi	Hyogo Pref.	"	V	"	"
d	Takatsuki	Osaka Pref.	"	NS, EW, V	20,000	"
c	Myoken	"	"	V	25,000	"
b	Yagi	Kyoto Pref.	"	"	"	"
a	Kyohoku	"	"	"	"	"
f	Kamigamo	"	"	"	"	"
e	Shizugawa	"	"	"	"	"

District. The names of sub-stations and equipped instruments are shown in the Table, including those of the Tottori Observatory.

The main research project is to discover the nature of microearthquakes directly related to the occurrence of large earthquakes. Up to the present time, the distribution of earthquake foci, distribution of earthquake magnitude, variations of microseismicity with time and region, and the mechanism of microearthquakes as well as large earthquakes, have been worked out. At present, some new research works are under way such as tectonophysical consideration of microearthquakes, and wave-form analysis of microearthquakes to examine in more detail the focal mechanism of those minor earthquakes.

A mobile station equipped with an ultra-sensitive seismograph system was attached to this Observatory in 1971, for the purpose of investigating ultra-microearthquakes mainly in the northern Kinki and Hokuriku Districts.

The observation of geomagnetic intensity is carried on by use of a proton magnetometer mainly in the Chugoku District, in order to investigate the relation between the earthquake-occurrence and variation of geomagnetic intensity.

Hokuriku Microearthquake Observatory

Hokuriku Microearthquake Observatory was established in 1970, on the basis of the "Research Project for Earthquake Prediction", for the purpose of investigating microearthquake activity in relation to the generation of large earthquakes in the Hokuriku District. The Hokuriku District, extending over Ishikawa, Fukui, Gifu, Shiga and Kyoto Prefectures, is known as a tectonically and seismically active region, where destructive earthquakes have frequently occurred including the great Fukui earthquake in 1948.

The Observatory building will be constructed in Sabae City, Fukui Pref.. Here, observations not only of microearthquakes but also of larger earthquakes and crustal movement will be carried out synthetically in an observation tunnel adjacent to the Observatory building. The tunnel is grid-shape, total length of which is about 560 m. All instruments will be installed in the tunnel, and recordings will be made electrically in the Observatory building. A new seismograph system, which covers an extremely wide band of frequency, from 10 Hz of microearthquake to static range of crustal deformation, will be manufactured by the end of 1971, and installed in this Observatory. Such a synthetic observation is considered especially important in the Hokuriku area for the reasons described above.

Four sub-stations are now in operation at Azai (Shiga Pref.), Tsuruga (Fukui Pref.), Imazu (Shiga Pref.) and Maizuru (Kyoto Pref.), in order to obtain basic data on microseismicity in the southern part of Hokuriku District. In the near future more sub-stations will be established in the northern part of the District.

Kamitakara Crustal Movement Observatory

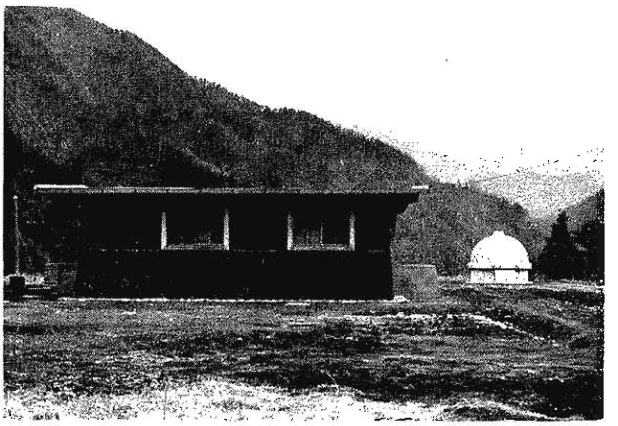
The Kamitakara Crustal Movement Observatory was established on April 1, 1965, for the purpose of investigating relations between crustal movement and earthquake-occurrence and finding some clues for earthquake prediction. The Observatory consists of two parts, the main building and an observation tunnel at Kurabashira. Also, 8 sub-stations mainly in Chubu District are attached to this Observatory, making a network for crustal movement observation. Details of this network are shown in the Figure on page 2.

The main subjects carried out in this Observatory and its network are as follows:

(1) Measurements of crustal movement by means of geodetic methods, especially with a geodimeter, are repeated in the neighbourhood of the Observatory and the Atotsugawa Fault area.

(2) Continuous observation of crustal movement is made in the Kurabashira observation tunnel by super-invar tiltmeters of the horizontal pendulum type, fused quartz extensometers of thed ifferential transformer type, water tube tiltmeters of the automatic recording type, and others.

(3) The seismic activity around the Observatory is continuously watched by an electro-magnetic high sensitive seismograph.



Kamitakara Crustal Movement Observatory.

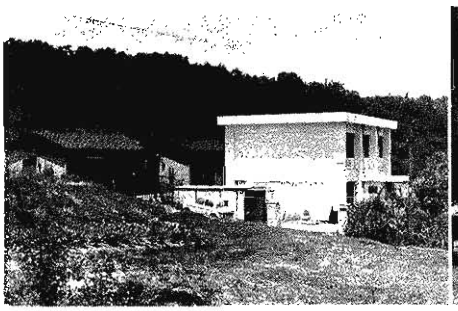
(4) Continuous observation of large and/or distant earthquakes is made by Press-Ewing long period seismographs and strain seismographs of the differential transformer type at Kurabashira.
(5) At each of the 8 sub-stations, continuous observation of crustal movement is made mainly by super-invar tiltmeters of the horizontal pendulum type and super-invar extensometers of the optical recording type.
(6) The records of crustal movement and earthquakes are digitized and analysed by various methods, including an automatic tracer in the Observatory.

Donzurubo Crustal Movement Observatory

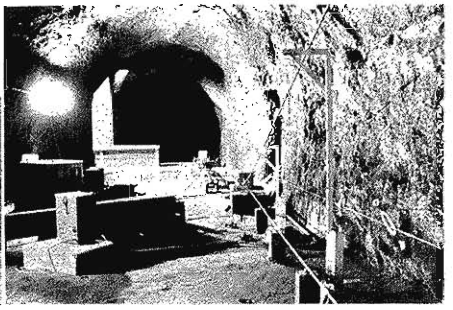
The Donzurubo Crustal Movement Observatory planned by the earthquake prediction research project in Japan, was established on June 1st, 1967, for the purpose of investigating the relations between crustal movement and earthquake occurrence and finding some clues for earthquake prediction. The observatory consists of two parts, a main building and an observation vault, the locations of which are as follows:

Main building : $\lambda=135°\ 40'\ 34''$ E, $\phi=34°\ 32'\ 28''$ N, h=125m,
Observation vault : $\lambda=135°\ 39'\ 57''$ E, $\phi=34°\ 32'\ 22''$ N, h=115m
(Anamushi, Kashiba-cho, Kitakatsuragi-gun, Nara Prefecture).

Observation vaults are adapted air-raid shelters which were excavated by the military at the end of the 2nd World War some 27 years ago. A cross-section of these vaults is about 4.0m in width and about 3.2m in height. The observation room is some of the vaults divided by partition walls made from concrete blocks and little affected by the open-air temperature. The observation of the crustal deformation in this observation room was begun in 1966. The neighbouring formation is formed by the Donzurubo beds, which belong to the Nijo Groups made from lava and volcanic ash thrown up by volcanic activity in the Late Miocene of the Tertiary period and



Main building of the Donzurubo Crustal Movement Observatory.



Underground observation room. Several extensometers, tiltmeters of horizontal pendulum type and a water vessel of the water-tube tiltmeter are seen.

the surrounding rocks are chiefly tuff and tuff breccia. In this observation room, a super-invar-bar extensometer, six super-invar-bar extensometers (6 components type), two super-invar-wire extensometers (Sassa type), three silica-tube extensometers, ten tiltmeters with horizontal pendulum of the Zöllner suspension type, two tiltmeters of the water-tube type and three strain seismographs were set up and, using these various instruments, observations of ground strain and groundtilt have been carried out. In the neighbourhood of this observatory, the base-line networks for electro-optical measurements using the Geodimeter (AGA, Model-6) were constructed for detecting tectonic movements.

In this observatory, the main program of present research is as follows:

(1) The continuous observation of crustal movements by means of extensometers, tiltmeters and the like.
(2) The measurements of crustal movements by means of geodetic methods.
(3) The synthetic investigation of the methods for earthquake prediction.
(4) The development of instruments for the observation of crustal movements.

Tokushima Landslide Observatory

Landslides in Japan are classified into three types, (1) a shattered zone type of landslide, (2) a Tertiary type of landslide, (3) a volcanic or hot spring type of landslide.

The Tokushima Landslide Observatory has been established for scientific research of the central part of Shikoku. Observation and communication of field survey and the geographical conditions there are well suited to the study of field phenomena of the shattered zone type of landslide.

This observatory, part of which was founded in November 1966, amalgamated with the government organized Disaster Prevention Research Institute of Kyoto University in April 1, 1969.

The key subjects of the shattered zone type landslide are divided into four parts, (1) the genesis of a shattered zone type landslide, (2) the sliding mechanism of a shattered zone type landslide, (3) prediction of the sliding activity of a shattered

zone type and (4), the control and correction of a shattered zone type landslide. As extensive problems, the following subjects at the Tokushima Landslide Observatory are studied in and out of the laboratory.

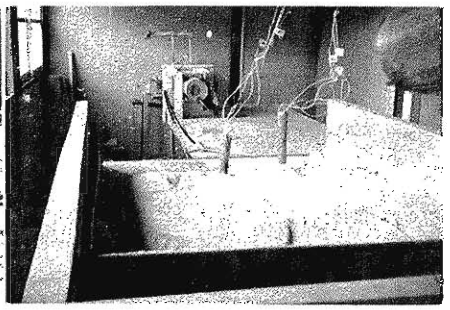
(1) Study of the basic factors of the shattered zone type landslide.

Basic data of topography and geology which form the genesis and sliding mechanism of the shattered zone type landslide are collected along the Yoshinogawa river basin and the Niyodogawa river basin, the main distribution areas of the shattered zone type landslide.

(2) Study of the sliding mechanism of the shattered zone type landslide.

The sliding mechanism is measured with a internal strainmeter, extensometer, tiltmeter, a water level gauge, pluviograph etc. around the Kuraishi and Sakura landslide areas in the basin of the Inouchidanigawa river, the tributary of the Yoshinogawa river.

Tokushima Landslide Observatory.



Test apparatus of the technological method of pile driving.

(3) Study of the trigger factors of the shattered zone type landslide.

The outbreak of the shattered zone type landslide is mainly due to process of trigger factors. The main trigger factors are rainfall and groundwater, and the amount of rainfall and level change in groundwater are directly connected with these trigger factors. Therefore, the influence of rainfall and a level change in groundwater on a landslide are measured with pluviograph and water level gauge at the above-mentioned areas.

(4) Study of the prevention and control of the shattered zone type landslide.

Piling is adopted for a study of methods for control and correction. The earth pressure of pile and condition of metamorphosis of the soil mass around the pile are measured with a strainmeter, and the technological method of pile driving is being studied. These studies are through a model landslide capable of changing the soil mass artificialy.

Hodaka Sedimentation Observatory

This observatory was established in 1965 in order to perform organic observation of run-off and sediment yield during floods in the Gamata River basin, located in

Observation house at the Hodaka Sedimentation Observatory.

the North Japan Alps at an altitude of approximately 1,000m to 3,000m. This observatory is composed of an observation house, covering $68m^2$ in area, and a soil testing house, covering $40m^2$ in area. Observation is conducted at the Hiru-dani Experimental Watershed, located at 1,200m to 2,000m above sea level. the basin area being $0.85Km^2$ and at the Ashiaraidani Experimental Watershed, located at 1,000m to 2,400m above sea level, the basin area being $7.5Km^2$.

The following research studies are being conduted in cooperation with the section of sedimentation and debris control.

(1) Observation of rainfall and run-off process in a basin with high altitude

Rainfall and discharge in several gauging stations are observed by the telemeter system in the experimental watersheds, Hirudani and Ashiaraidani, both of which are tributary of the Jinzu River in Gifu Prefecture.

The variation of rainfall intensity with the altitude and slope direction, run-off characteristics, relation between rainfall and run-off are analyzed.

(2) Observation of sediment yield and transportation

Soil characteristics, rate of sediment yield, transport and change in water qualities during floods are observed at Hirudani and Ashiaraidani.

Measuring devices for sediment transportation in Ashiaraidani are developed in this observatory in order to automatically obtain a continuous record of sediment transportation during floods.

Suspended sediment is measured by using a γ ray probe, on the other hand, bed load can be measured automatically by a loadcell probe connected to a reversibe bucket which captures the bed load sediment.

(3) Relation between geochemical features and land slides.

Temporal and spacial variation of the chemical composition of ground water such as temperature, PH, conductivity values and chemical constituents are measured in

the experimental watershed. Relations between geochemical features of ground water and land slides are investigated.

(4) Relation between the weathering of rocks and land slides.

Compressive strength and density of joint net in the granitic rocks are measured in the experimental watershed. Relations between these physical values and land slides are investigated.

Stream flow and sediment measuring station at Hirudani Experimental Watershed, Hodaka Sedimentation Observatory. Knife-edged weir for measuring stream flow and sediment load sampler.

Ogata Wave Observatory

This observatory was established in 1969 on the Ogata Coast facing the Japan Sea. Near the observatory, there are a pier, 314 m long, 3.3 m wide and 15 m high above the mean sea level off the coast and a tower located 2.5 km off the coast, constructed by the Teikoku-Sekyu Oil Co. Ltd.

The purpose of the observatory is to carry out synthetic observations of the transformation of wind waves in shallow water, longshore currents, sand drift and the variation of beach profiles, etc., by using the facilities and equipment installed in the pier and tower. At present, continuous records of shoaling waves are being measured by one and six-resistance type wave meters installed in the tower and the pier respectively, and a Delta array of ultrasonic wave meters has been newly installed in the tower. Temporary observations have been carried out to investigate the relation between the transformation characteristics of wind waves and the sand drift and

variation of beach profiles during storms and typhoons. The main subjects of investigation carried out in this observatory are as follows:

(1) Development and transformation of shallow water ocean waves

In order to establish a method for the estimation of shallow water ocean waves, a series of records obtained by seven wave meters and by a Delta array have been analyzed by the power and directional spectrum method. Shoaling characteristics of wind waves involved wave breaking have been investigated.

(2) Coastal processes

A series of routine and temporary observations of the sand drift, longshore currents, changes of beach profiles during storms have been carried out. The data obtained have been collected and analyzed with the aid of hydrodynamics of wave transformation and sand drift.

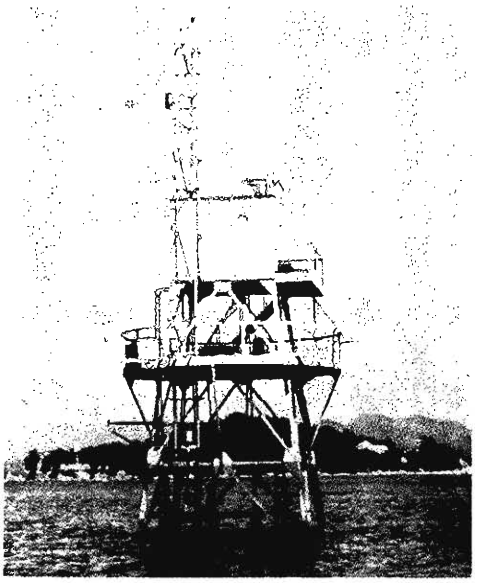
Observation pier on the Ogata Coast.

(3) Wave forces on shore structures and dynamic response characteristics

In order to investigate the wave force on a pile of the tower and the pier, continuous observations will be carried out although some observations of wave run-up on a pile of the pier have already be made.

Shirahama Oceanographic Observatory

This observatory was established in 1966 for investigating quantitatively the correlation between air and sea using continuous records of physical quantities; atmospheric pressure, precipitation, radiation, air temperature, humidity, wind direction, wind speed, water temperature, salinity and waves and tides which were obtained at the oceanographic tower station constructed in Tanabe Bay. Accordingly, to understand the phenomena obtained at the tower station more clearly, oceanographic observations are carried out by Shirafuji, the observation boat which is 7m in length, and has a maximum speed of 22 knots. A thermister thermometer, salinograph and a Servonious type current meter are installed in the boat. The tower stands



Tower station at the Shirahama Oceanographic Observatory.

on a submerged rock where the mean water depth is 5.5m, and the top of the tower is 12.7 m above the mean sea level.

Records obtained at the tower station are exchanged once a month, all instruments are powered by batteries which are charged twice a month.

The main subjects of investigation carried out in this observatory are as follows:

(1) The characteristics of waves under high speed wind, especially that of storm surges caused by typhoons: a series of wave records obtained at the tower and other offices at the same time have been analysed in the power spectrum, and the relation between the peak of the period of the wave and the scale of the typhoon has been studied.

Survey boat belonging to the Shirahama Oceanographic Observatory.

(2) The exchanges of sea water inside and outside Tanabe Bay

From the continuous records of water temperature at the tower and observations by the observation boat, it has been almost precisely shown that the water in Tanabe Bay constitutes water masses and their variation is explained as the density current.

(3) The characteristics of the seich caused on the kii coast continental shelf

Long waves of about 42 minute periods which are often seen on the records of tides have been investigated.

(4) The air-sea interaction

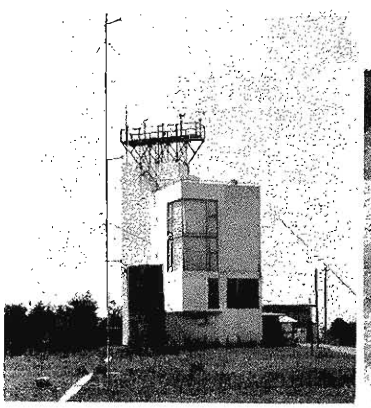
The mass transport from air to water on the sea surface, the evaporation from sea surface and the heat budget are being studied.

Shionomisaki Wind Effect Laboratory

Shionomisaki Wind Effect Laboratory, which was founded in 1966, is the first and only establishment for permanent and systematic study of wind effect in Japan. It is located at the southern end of the Shionomisaki peninsula on the Pacific coast of the main island of Japan where strong typhoon winds and other storms blow so frequently that the site is ideally suited for making experiments in strong wind. The observatory has a 2000m^2 test field, three full-scale houses for the use of experiments and two office buildings. On the roof of the main 4-storied building, a wind tower 17m above the ground has been erected and instruments for routine wind observation and new experimental devices are installed on it.

Observations are carried out in the test field or on test buildings to investigate the structure of wind turbulence and its effects on structures in stormy conditions. General study of atmospheric turbulence and of turbulent transport is also being conducted. For these studies of wind turbulence, sonic anemometers and other high-response anemometers are used.

Measurements of wind pressure distribution are being made on walls of the test buildings as well as on a main four story building which has many pressure inlet holes



Main building of the Shionomisaki Wind Effect Laboratory.

Medium scale topographic model in the test field.

and on model structures built in the test field. The measurement of correlation between wind pressure fluctuation and displacement of structure or its members is also in progress. Wind pressure is measured by wind pressure gauges of the Pitot tube type. For the measurement of the vibration of structures, wire strain gauges and differential transformers are used.

The study of topographical air flow modification which is also important for disaster prevention is under preparation on the Shionomisaki peninsula which has several types of characteristic topography. The model experiments of topographic modifications of wind characteristics have already started in the test field of the laboratory using a medium scale model of typical topography in natural wind.