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AN OUTLINE OF THE HISTORY AND ACTIVITIES OF THE DISASTER PREVENTION RESEARCH INSTITUTE

ABSTRACTS OF PAPERS
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KYOTO UNIVERSITY, KYOTO, JAPAN

Publications of the Disaster Prevention Research Institute of Kyoto University

The Disaster Prevention Research Institute publishes the results of its research activities in annuals (in Japanese) and bulletins. The annual is published at the end of an academic year, April to March. One volume of the bulletin, corresponding to an academic year, is divided into four parts. Each of the first three parts includes several papers, and the fourth part comprises the abstracts of papers published by staff members of the Institute in the former calendar year. This particular part, Part 4 of Volume 16, includes also an outline of the history and activities of the Institute.

Discussions and the request for a copy of a paper should be addressed to the authors at Disaster Prevention Research Institute, Kyoto University, Kyoto, Japan.

CONTENTS

An Outline of the History and Activities of the Disaster Prevention Research Institute

1. Historical Sketch

The Disaster Prevention Research Institute was founded in March, 1951, affiliated with Kyoto University, Kyoto, Japan, in order to carry out scientific research on various problems concerning the prevention of natural disasters.

The Institute commenced its work at laboratories on the University campus and at Abuyama Seismological Observatory. The following is a list of its research sections and attached laboratories with the dates of their foundation:

March 31, 1951:	Earthquake Motions Research Section,
	River Disaster Prevention Research Section,
	Earthquake Resistant Structures Research Section
August 1, 1953:	Ujigawa Hydraulic Laboratory
April 1, 1958:	Crustal Movement Research Section
April 1, 1959:	Landslides Research Section
April 1, 1960:	Applied Hydrology Research Section
December 26, 1960:	Sakurajima Volcanological Observatory
March 25, 1961:	Shirahama Oceanographic Observatory
April 1, 1961:	Wind Resistant Structures Research Section,
	Coastal Disaster Prevention Research Section
March 31, 1962:	Shionomisaki Wind Effect Laboratory
April 1, 1962:	Soil Mechanics Research Section,
	Subsidence and Failure of Soft Ground Research Section
April 1, 1963:	Applied Geomorphology Research Section,
	Drainage Engineering Research Section
April 1, 1964:	Anti-Seismic Ground-Structure Systems Research Section,
	Tottori Microearthquake Observatory
April 1, 1965:	Sedimentation and Debris Control Research Section,
	Instrumentation for Earthquake Prediction Research Section,
	Kamitakara Crustal Movement Observatory
November 23, 1965:	Hodaka Sedimentation Observatory
April 1, 1966:	Applied Climatory Research Section
November 24, 1966:	Ogata Wave Observatory

2. General View (as of January 1, 1967)

Director: Prof. Tojiro Ishihara, Eng. Dr.

Location of the Administration Office: Kyoto University Campus, Sakyoku, Kyoto, Japan

Number of staff: 234

Number of research sections: 15
Number of attached research laboratories: 8
Square measures
Land: 238, 182 m²
Architecture: 8,624 m²
Annual Revenue: ¥233,488,070

3. Research Activities

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

(a) Research Sections

Earthquake Motions (Head: Prof. S. Yoshikawa)

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

(1) The generation and propagation of seismic waves

The origin mechanism of the natural earthquake, the vibrational characteristics of seismic waves artificially exerted and the propagation of the seismic wave in stratified media of the crust are being investigated.

(2) The relation between the earthquake motion and the ground structure

The vibrational characteristics of soft ground such as alluvium and reclaimed land and the vibrational trouble caused by artificial origins are being investigated from the viewpoint of applied seismology.

(3) The applied seismological study on the earthquake damage to ground foundations

The foundation of structures are surveyed by means of seismic explorations specially designed for engineering purposes and the relation between the method of the construction and the geological structure defined by the above method are investigated.

(4) The study on the micro-earthquake

Micro-earthquakes are observed in the Kinki district, and the seismicity in the area is being systematically investigated. The relation between the seismicity of micro-earthquakes and that of destructive earthquakes are being studied inclusively.

Crustal Movement (Head: Prof. Y. Kishimoto)

This section was founded in 1958, originally as part of a large research project concerning the 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. The two main purposes of investigation in this section are, on the one hand, to throw light on the nature of earthquakes and on the other to predict earthquake-occurrence. The research items are as follows:

(1) The investigation of crustal movement

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

(2) The investigation of microearthquakes

Observation of microearthquakes (magnitude less than 3) is being carried on at the network of the Tottori Microearthquake Observatory with the use of highly sensitive seismographs. Statistical study of microearthquakes is undertaken in order to make clear the nature of the problem of earthquake-occurrence as well as the relation between the generations of minor and larger earthquakes.

(3) The investigation of earthquake mechanism

This investigation is, in a sense, the synthesis of all the research projects in this section. The processes of accumulation and release of earthquake energy are investigated from various aspects, such as crustal movements, the seismicity of microearthquakes, and the wave-form analysis of seismic long period waves observed by long period seismographs.

(4) The 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.

Instrumentation for Earthquake Prediction (Head: Prof. M. Takada)

This section was founded in 1965, and the following subjects have been studied geophysically, in order to predict the occurrence of destructive earthquakes:

(1) The study on the forerunning phenomena of earthquakes

As earthquakes result from stresses which accumulate within the outer shell of the earth, so certain phenomena relating to the occurrence of earthquakes are expected to be observable on the surface near the epicenters. Observations for detection of these phenomena have been carried out at several points in Japan. An experimental study is now planned to investigate tectonic deformation and its relation to earthquake phenomena.

(2) The development of instruments

Instruments for observation of the forerunning phenomena of earthquake occurrences are being developed, especially with respect to telemetrical and remote-controlled operations, for high-speed data processing.

(3) The observation of seismic waves

Earthquake mechanism and crustal structure are being investigated from observational results with the use of long period and strain seismographs.

(4) The continuous observations of crustal movements

They have been carried out at Donzurubo, Iwakura, Wakayama and Amagase, in cooperation with Crustal Movement Research Section. In addition, ground movements in the fractured zone and on the landslide site are also being investigated.

Earthquake Resistant Structures (Head: Prof. M. Wakabayashi)

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 on the strength and deformation of structures. They include:

(1) The restoring-force characteristics of tall frames

Research here is to clarify the behavior of frames under the combined action of vertical constant loads and horizontal varying forces. Attention is paid, in particular, to the inelastic range of structural behavior.

(2) The inelastic behavior of frames under repeated loading

Experimental studies are being performed whose main emphasis is on the effect of the bracings and the energy absorption characteristics of rigid frames.

(3) The permanent deformation of structures due to large impact loads

Experiments are now being carried out to ascertain the plastic behavior of ductile frames under impulsive loading.

(4) The buckling strength of steel structures

Included are rigid-frames and structural members.

(5) Some basic problems in the experimental investigation of complex structures

This is the preparatory step toward the experimental stress analysis of shells.

(6) Some chemical studies on fire disasters

Experimental studies are also being made on fire-extinguishing techniques.

Anti-Seismic Ground-Structure Systems (Head: Prof. R. Minai)

This research section was established in April, 1964 in order to study the relationship between the earthquake damage sustained by strcutures and the dynamic characteristics of ground soil and to find a reasonable method of preventing the earthquake damage to the ground-structure system. The following is an outline of the research activities of this section:

(1) The earthquake excitation patterns which are consistent with the dynamic characteristics of the ground and the seismicity of the site of construction have mainly been studied by the statistical method.

(2) The dynamic model of the coupled ground-structure system and the measures of anti-seismic precaution of this system have been studied by both the theoretical and the experimental methods.

(3) The methods of earthquake response analyses of ground-structure systems subjected to deterministic or stochastic non-stationary excitiations have been studied. The properties of the earthquake responses of the coupled system have been clarified through the numerical approach.

(4) The anti-seismic design method of ground-structure systems has been studied. The statistical anti-seismic design method for moderately intense earthquake excitations and the ultimate anti-seismic design method for very intense earthquake excitations have been developed.

(5) Some experimental studies on the dynamic characteristics and earthquake responses of the actual coupled ground-structure systems have been continued.

Applied Hydrology (Head: Prof. Y. Ishihara)

Extensive research has been carried on in order to elucidate the hydrological phenomena with respect to disaster caused primarily by storm rainfall and to establish engineering techniques for disaster prevention. The following specific fields are covered:

(1) The characteristics of rainfall in relation to runoff

(2) The runoff phenomena on the surface of a river-basin and the flood flow through a stream channel

(3) The hydrologic behavior of ground-water and its runoff into streams

(4) The runoff analysis and the flood prediction

(5) The flood control

(6) The water balance

(7) The statistical analysis of hydrological data and its engineering application

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 now under construction in the drainage area of Lake Biwa, for examining the runoff process and the water balance, are being conducted. This work is being performed with the the cooperation of research members belonging to the other Research Sections and the Faculties of Science, Engineering and Agriculture.

Sedimentation and Debris Control (Head: Prof. K. Yano)

Basic and applied research has been carried out to ascertain the mechanism of the sediment yield in a mountain basin together with its transportation and to establish a method for preventing flood disasters caused by anomalous sediment yields. With regard to field investigations, basic observations on run-off characteristics in a high altitude mountain basin, the sediment yield and transportation, and characteristics of mud flows are being conducted at the Hodaka Sedimentation Observatory established in 1965. The Main subjects now being studied are as follows:

(1) The sediment yields and the run-off in a mountain basin

(2) The mechanics of the sediment transport in a stream

(3) The hydraulics of the mud flow

(4) The local scour downstream of hydraulic structures
(5) The hydraulic design of debris control structures

River Disaster Prevention (Head: Prof. K. Ashida)

This section was founded in 1951 for the synthetic study of water disaster prevention, and later gained the present name. In order to establish the engineering basis for disaster prevention and the utilization of water in rivers, fundamental laboratory studies and field investigations have been carried out in this section. The main subjects being studied are as follows:

(1) Some basic studies on sedimentation in reservoirs and river stabilization
(2) The behavior of unsteady flow in an open channel under various boundary conditions
(3) The stochastic analysis of bed forms and the resistance law in open channel
(4) The flow structure of curved open channels
(5) Basic studies on river meandering and local scouring at bends
(6) Field observation of river floods and sedimentation

Drainage Engineering (Head: Prof. M. Kadoya)

In this section, fundamental research and some field investigations have been carried on in order to ascertain the mechanism of floods in low-lying areas and to elucidate problems of drainage engineering. The chief data respecting present research activities are as follows:

(1) The runoff characteristics in the basin were conditioned by a small mountain, hill, urban land and agricultural land.
(2) The mechanism of the flood in low-lying land and the establishment of the drainage method.
(3) The hydraulic problems of the drainage system: for example, the resistance law of the flow where there is a very mild hydraulic gradient, the sediment hydraulics in the drainage channel, the flow characteristics of the drainage culvert, and so on.
(4) The behavior of the ground water and its control.
(5) The economical planning of water-works.

Coastal Disaster Prevention (Head: Prof. Y. Iwagaki)

Fundamental studies on coastal engineering have 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 carried out at several coastal points in Japan. The main subjects of study are as follows:

(1) Some basic studies on the wave damping due to bottom friction.
(2) The field observations and characteristics of shallow water wave spectra.
(3) The overtopping and run-up of waves against shore structures.
(4) The air-sea boundary process.

(5) The beach processes and sediment transport by waves and currents.
(6) The resonance effect in storm surges.

Subsidence and Failure of Soft Ground (Head: Prof. S. Murayama)

In this section, as a fundamental research project, the mechanical properties of soil as well as soft rock are studied. Among these, the present subjects are the creep and stress relaxation of clay, the effect of the intermediate principal stress on the deformation and strength of soils, the effect of the structure of clay particles on its mechanical behavior, the dilatancy of soils and the expansion of soft rock due to the sucking of water, etc..

As extensive problems, the following subjects are investigated theoretically and experimentally:

(1) The land subsidence
(2) The bearing capacity
(3) The ground pressure on undergound structures

Beside these static problems, the mechanical behavior of soil in a dynamic state is investigated to improve the asysmic analysis of the foundation.

Applied Geomorphology (Head: Prof. S. Okuda)

This section was established in 1963 for the synthetic research of the exogenetic processes controlling the surface features of the Earth and 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) The weathering of bed rock and wasting of slope

Field surveys of water balance and the geochemical analysis of streams and springs in mountain regions are being carried out in order to study the hydrological conditions which stimulate weathering and to prevent the disasters due to the wasting of slopes.

(2) The thermal soil physics

Geocryogenical studies on the deformation of frozen soil and moisture movement in freezing soil are being carried out in order to prevent soil fracture and frost heaving. Some other thermal effects on soil structure and moisture are being studied, also, with the reference to solifluction and surface freezing.

(3) The applied sedimentology

New instruments for measuring the deposition rate, turbidity, water temperature, conductivity and water depth have been devised and set in the lakes or reservoirs to pursuit study of the relation between hydrological conditions and sedimentation. Flume experiments, hydrochemical surveys and air-photograph interpretation are being carried out for the geomorphological study of river meandering and delta development, and for the planning of reservoirs.

Landslides (Head: Prof. S. Yamaguchi)

There are many landslides in Japan amounting to 6,000 per annum. They include various types, for example, tertiary type, fractured zone type, volcanic or hotspring type, etc. Therefore, the study of landslides arouses a great deal of interest. On the other hand, the rapid progress of civil construction during this century, under the impact of advancing civilization, which has seen the realization of such large construction works as dams, railways, highways, etc., has been the cause of serious damage. Particularly endangered those people who live in districts close to mountains.

As urgently requested, we are improving the methods of landslide investigation and taking into account economic, political and human factors.

This section has been established for the purpose of studying landslides, but disasters that occur on slopes also come into our field of study. In order to achieve these objects we are engaged in the following projects:

(1) The study of the soil in landslide areas

(2) The study of the stereographic mechanism of occurrences and the creeping process in landslides

(3) The study of the forecasting of landslides

(4) The study of techniques of prevention and control of landslides

(5) The geological and geographical study of landslides

(6) The study of the relationship between basic factors and the inducement of landslides throughout the world.

One of our observatories is in Tokushima Prefecture, where there are plenty of landslides, so that we can test our theories by relating them to actual landslide occurrences.

Wind Resistant Structures (Head: Prof. H. Ishizaki)

This section began its research in 1961 and the research projects completed prior to 1966 or in progress now are as follows:

(1) Some studies on the maximum wind speed distribution in the typhoon and their topographic modifications.

(2) The theoretical and experimental research on the characteristics of anemometers, especially on their response to gusty winds. As a result of this study some new type anemometers such as the quick response pressure tube anemometer have been completed.

(3) Some observational studies on the spatial structures of storm gusts with the use of a quick response anemometer network.

(4) Some comparative studies on the actual wind pressure distributions on a house with results of model experiments in the wind tunnel, especially on the problem of negative wind pressure fluctuations on the roof or wall.

(5) The survey of the distribution of wooden houses destroyed by wind for each

of the recent severe typhoons, with special attention to the damage rate in relation to maximum wind speeds.

(6) The theoretical and experimental research on the vibrations of houses, steel towers, large stacks or other structures caused by winds. The experiments are being carried out both in the wind tunnel with models and in the experimental field with actual structures.

Applied Climatology (Head: Prof. C. Nakajima)

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

(1) The effect of the topography on the local climate.
(2) The experimental study of local climate.
(3) The study of heavy rains for flood forecasting.
(4) The forecasting and prevention of fogs.
(5) The transport and diffusion of sea-salt particles in the atmosphere.
(6) The long-range weather forecasting.

(b) Attached Laboratories

Ujigawa Hydraulic Laboratory (Director: Prof. S. Murayama)

In this laboratory the experimental studies, together with the field observations, have been conducted to elucidate the mechanism of the river and coastal current, by use of various apparatus and the method of measurement which has been developed here. Three research projects have been carried out in this laboratory. The first project is to reveal the behavior of open channel flow contributing to the hydraulic design of the river structures and to develop more rational design procedures. The main contents of present research are as follows:

(1) The behavior of varied flow in an open channel with bottom diversion racks.

(2) The applicability of the theory of the gradually varied flow of nonuniform discharge to design procedures of the diversion works which satisfy the discharge requirements.

(3) The hydraulic performance of the stilling basin appurtenances and the mechanism of a hydraulic jump.

The second project is to reveal the turbulence structure of the river flow, which consists of the following items:

(1) The properties of the spectra of large scale turbulence over the river width which are observed by the use of a propeller type of current meter.

(2) The measurement of fine structures of a boundary layer turbulence, such as the flow near the water surface and the corner region, by the use of the ultrasonic flowmeter with two components.

(3) The turbulence spectra of the bottom shear stresses of the open channel

flow which are obtained by the use of the direct balance type and hot film type shear meter

The third project is tidal observation to reveal local characteristics of the tide near the coast and the effect of tidal currents on the other physical factors, which will yield important and fundamental data for theoretical and experimental studies and for the planning of disaster prevention in coastal regions.

(1) Studies on storm surges, tsunami and tides near the coast and river mouth have been continued theoretically and experimentally with successful results.

(2) A hydraulic model experiment on the behavior of storm surges in river and canal has been carried out to prove the effect of the storm surge gates on the piling-up of water by a storm surge.

Sakurajima Volcanological Observatory (Director: Prof. (Assist.) K. Yoshikawa)

This observatory was established in 1962, for the purpose of undertaking fundamental research on the mechanism of volcanic eruptions, and on predictions for the explosion of Sakurajima volcano which is the most active in Japan.

In this observatory, the following routine observations and temporary surveys have been carried out in order to obtain fundamental data for the various volcanic phenomena.

(1) Volcanic earthquakes are observed by high sensitivity and other seismograms in multipartite stations to investigate the nature of them.

(2) Shock waves caused by volcanic explosions are observed by Shida-type and electro-magnetic type microbarographs to estimate the magnitude of the explosion.

(3) Volcanic crustal deformations are observed by tiltmeters, extensometers and tidegauges set in many places in order to investigate the relation between ground deformations and volcanic activity.

(4) Precise levellings are repeated over brief periods to find the vertical crustal deformation associated with the volcanic activity.

(5) Graviemtric and geomagnetic surveys are carried out over brief periods to investigate the crustal structure and the change of physical nature of the magma reservoir with time.

(6) Underground temperature is measured to examine its relation to the volcanic activity.

(7) Meteorological observations are being continued in order to examine the meteorological conditions relating to volcanic phenomena.

Tottori Microearthquake Observatory (Director: Prof. Y. Kishimoto)

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 Kinki District, namely Funaoka (Tottori Pref.), Mikazuki, Oya, Izumi and Hikami (Hyogo

Pref.), Takatsuki and Myoken (Osaka Pref.), Yagi, Kyohoku and Kamigamo (Kyoto Pref.) and Iwaoyama (Shiga Pref.). These stations are equipped with very highly sensitive seismographs, and continuous observation is carried on with a high degree of sensitivity and of accuracy in time keeping.

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, the distribution of earthquake magnitude, the variation of seismicity with time and region, the mechanism of microearthquakes as well as large earthquakes, and other problems have been investigated in the area concerned for the purpose mentioned above. In the future, the construction of new sub-stations is expected especially in the epicentral area of the destructive Tottori earthquake, and also observations of ultra-microearthquakes are planned through car-borne moving stations equipped with an ultra-sensitive seismograph system.

Kamitakara Crustal Movement Observatory (Director: Prof. T. Ichinohe)

The Kamitakara Crustal Movement Observatory was established on April 1st, 1965, for the purpose of investigating the relations between crustal movement and earthquake occurrence and finding some clues for earthquake prediction. The observatory consists of the three parts of the main building, an observation dome and an observation tunnel, the locations of which are as follows:

Observation dome: $\lambda=137°21'57''$E, $\varphi=36°17'20''$N, h=600 m,

Observation tunnel: $\lambda=137°19'42''$E, $\varphi=36°16'54''$N, h=800 m.

The main subjects of observations and investigations being carried out in this observatory are as follows:

(1) The measurements of crustal movements by means of geodetic methods.

(2) The continuous observations of crustal movements by means of extensometers, tiltometers and the like.

(3) The routine observations of seismic activities by means of various seismographs.

(4) The adjustment and analysis of the observational data on crustal movements.

(5) The synthetic investigation of the methods for earthquake prediction.

Shirahama Oceanographic Observatory (Director: Prof. Y. Iwagaki)

The purpose of this observatory is to make organic observations of the whole air-sea system by using the tower station constructed as a branch facility of this observatory. The characteristics of the sea under high speed wind, especially wind waves and storm surges caused by a typhoon, structures of wind above the sea surface and wind driven currents, tsunamis caused by an earthquake or a volcanic erruption, etc., have been investigated.

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

chemical and biological quantities to be measured are as follows:
Atmospheric pressure, precipitation, radiation, air temperature, humidity, wind direction, wind speed, water temperature, salinity, turbidity, current direction and velocity, tide, wave, and plankton.

Continuous records of these quantities are being taken by batteries charged twice a month.

Shionomisaki Wind Effect Laboratory (Director: Prof. H. Ishizaki)

The laboratory was opened in 1961 at Shionomisaki, Wakayama Prefecture in cooperation with the wind disaster section. It is located on a site of about 4000 m^2 near the south coast of central Japan and this area is attacked by typhoons every year so often that it is an appropriate place for making experiments with strong wind. The observations or measurements now in progress are as follows:

(1) Some comparative studies on the responses of various anemometers in a natural wind.

(2) The observation on the structure of wind turbulence with the use of quick response anemometers and sonic anemometers.

(3) The observation on the wind shear near the ground by various anemometers.

(4) The measurement of the wind pressure distribution on actual structures, such as steel towers and houses, especially on pressure fluctuations.

(5) The measurement of the vibrations of some structures induced by wind.

Hodaka Sedimentation Observatory (Director: Prof. K. Yano)

This observatory was established in 1965 in order to perform organic observations of run-off and sediment yield during floods in the Gamata River basin, which is located in the North Japan Alps at an altitude of approximately 1,000 m to 3,000 m. This observatory is composed of an observation house, covering 68 m^2 in area, a soil festing house, covering 40 m^2 in area, and the Hiru-dani Experimental Watershed, located at 1,200 m to 2,400 m above sea level, the basin area being 0.85 km^2. In the Hiru-dani Experimental Watershed there are six rain-gauge stations for observing the characteristics of rainfall and one dam for observing the flood discharge and the rate of sediment yield. Additional facilities for observing the mud flow and the characteristics of snow and its run-off are to be established in the near future.

Ogata Wave Observatory (Director: Prof. Y. Iwagaki)

This observatory which was opened in November, 1966, is located at the Ogata Coast, Niigata Prefecture, facing the Japan Sea. Near the observatory, there is a pier, 314 m long, 3.3 m wide and 15 m high above the mean sea level off this coast, and a tower, which is located 1.5 km off the coast, constructed by Teikoku-Sekiyu Oil Co. Ltd..

The purpose of this observatory is to observe the transformation of coastal waves

in shallow water, longshore currents, sand drift and the variation of beach profiles, etc., by using the facilities and equipments installed in the pier and in the tower.

At present, continuous records of shoaling waves are being measured by one and six step-resistance type wave meters installed in the tower and the pier respectively. In addition, the following meteorological data are being recorded:

(1) The wind speed, (2) The wind direction, and (3) The atmospheric pressure

On the Blast Fence with Expanded Metal

By Hatsuo ISHIZAKI, Yasushi MITSUTA and Junji KATSURA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, 1966, pp. 243–256.

Abstract

Blast fences are used at airports to protect passengers and ground service men from the wake of jet engines. It is necessary for blast fences to diminish wake velocity to within a safety limit of 10 m/sec or so.

T.A. Tucker performed comprehensive experiments with blast fences and tried to bend the axis of a jet wake upward by a solid blast fence. On the other hand, our aim is only to create a calm domain behind the fence with permeable fences such as hedges and without bending the wake axis perpendicularly to the ground. Naegeli experimented with wind-breaking hedges made of reed matting in a natural wind. The effectivenes of fences depends not only on their shape and size but also their permeability. Low permeability brings low wind speed near the fence, but the recovery of speed is not seen so far from the fence. Therefore, weakening the strength of the wind speed to a large extent is inconsistent with spreading the calm region, and permeability should be large enough to allow a wide service area behind the fence.

We made blast fences with expanded metal whose permeability could be changed by adjusting the angle to the ground surface, because the element plates of expanded metal were twisted to its face. Through wind tunnel tests it was found that the case where the fence was inclined 30 degrees to the ground was the most suitable for use as a blast fence. The field tests were made at Tokyo International Airport using a Boeing 727 for the jet source. From the data of these tests we obtained the wake velocity distribution, streamlines around the fence and time variations of the wind speed and the temperature of the jet wake. By means of a spectral analysis of the fluctuating wind velocity observed in a jet wake, it was recognized that the flow field behind the fence was divided into the following three regions: an upper one containing turbulence from the jet wake, a middle one consisting of the flow through the screen and a lower one consisting of the wake of the fence. The stronger the middle one is, the wider is the region of influence of the fence. Even if the height of the jet nozzle is higher than the top of the fence as in this case, the fence of this type is sufficiently effective for protection and moreover is economical compared with other types of fence.

Observational Study of Turbulent Structure of High Winds, Part 1

By Hatsuo Ishizaki and Yasushi Mitsuta

Bulletin of Disaster Prevention Research Institute, Kyoto University,
Vol. 16, Part 1, No. 104, Sept., 1966, pp. 1-9.

Abstract

The requirements on new knowledge of wind environments on structures in high winds can be summarized as follows: 1) the character of high frequency wind fluctuations up to 10 cps and 2) the spatial distribution or structure of such high frequency wind gusts. For this purpose we should use a large number of high resolving anemometers distributed in aerial space of about the same dimension as the structure. But anemometers for use in ordinary weather observations cannot resolve such short period changes. Therefore a new anemometer was made as the first step in the study of the wind environment of structures.

The new type anemometer consists of a pressure tube which rotates with the wind vane, a pressure transducer which is built in the sensor head, a potentiometer as wind direction transducer and an electric component with output devices. The total wind pressure is detected by the pressure tube, which is connected with the bellows of stainless steel built in the sensor. The static holes are open under the sleeve of the wind vane and the pressure in the sensor is equal to the static pressure. The displacement of the bellows, which is proportional to the velocity pressure, is converted into electrical signals by the differential transformer and then into the voltage analogue output by the displacement-meter. The wind direction transducer is a potentiometer, also built in the sensor, whose axis rotates with the wind vane and produces a voltage analogue output proportional to the angular position of the vane.

The response character of the new anemometer was studied. The results show that it can be analyzed as the second order response system and can be described by two parameters, e.g. the free period and the damping ratio. These parameters were tested experimentally from the transient response character to the step wise pressure changes. The free period was 0.038 sec, the logarithmic damping being 0.33. This character is satisfactory for the purpose of the present sudy.

Six of these new anemometers were installed on the masts of the experimental field near the coast of Osaka Bay. The results of storm observation with the use of these anemometers will be reported in the following parts of this paper.

A Response Problem on the Oscillating Circular Cylinder in the Wind Flow

By Hatsuo Ishizaki and Sumio Kawamura

Transactions of the Architectural Institute of Japan,
No. 127, Sept., 1966, pp. 1–7.

Abstract

It is well known that some steel stacks with circular sections oscillate considerably in the direction perpendicular to the wind. Up to now, attention seems to have been paid only to the stability problems in determining the critical wind velocity for the aeroelastic instability of structures. From the point of view of structural design, however, the oscillatory amplitude is of chief interest, so the response problem should be considered.

The assumptions in this paper are the following:

i) The circular cylinder in a flowing fluid behaves as a nonlinear self-excited oscillator subjected to the external force with the Strouhal frequency $f(=S^*V/d)$.

ii) The Strouhal number S^* for the oscillating cylinder can approximately be expressed as a function of the amplitude. Thus $S^*=S(1+2X+\beta X^2)$, where S is the Strouhal number for a stationary one. X is the nondimensional amplitude.

iii) The lift force coefficient C_L^* for the oscillating cylinder can be represented as a function of the amplitude. Thus $C_L^*=C_L(1+2X)$, where C_L is the lift force coefficient for the stationary one.

After a comparison between the theoretical predictions based on the above assumptions and some experimental results, the following conclusions are derived:

i) The resonant curve obtained from this theory agrees fairly well with the experimental results.

ii) The stability diagram based on this theory shows a general consensus with Scruton's experimental results.

iii) Unlike a simple linear-forced sytem, the aerodynamic lift force induced on the oscillating cylinder has a non-linear character such that the magnification factor mf is proportional to $\lambda^{-1/2}$ where λ is the logarithmic decrement of the structures. These results can explain the behavior observed in the field measurements of actual steel stacks.

Wind Tunnel Experiments for a Suspended Roof

By Hatsuo Ishizaki, Inwhan Sung and Tatsuya Kumatori

Transactions of the Architectural Institute of Japan,
No. 126, August, 1966, pp. 9–13.

Abstract

Many suspended roofs have various quadric surfaces at every point and in this type of structure the static wind pressure distributions on the surfaces will be changed by their curvatures or rises. As a result of modern developments in materials and the techniques of stress analysis, structures are becoming finer and their natural frequency lower, while connections are becoming more rigid (as in the case of welding in stead of rivetting) with reduced damping. If the suspended roofs are designed from more daring structural concepts, this type of structure will be subjected to flutter. In order to study the static wind pressure distributions and the response of a suspended roof to turbulence, model experiments were made in a wind tunnel. The model used in tests had a size of 41×31 cm in plan, a height of 18 cm and was roofed by a soft vinyl membrane. In the measurement of the wind pressure distributions, the wind velocities were about 22 m/s and 28 m/s and the fluctuating wind forces and vibrations of the roof were measured under the velocity 13.5, 17.5, 21.5 m/s, in five different directions relative to the model.

Test results may be explained by the following:

1) The static wind pressure on the roof were almost suctions and varied widely in range, ($p=180\sim14$ kg/m, where $q=200$ kg/m^2) and on part of the roof pressures of $p=25\sim30$ kg/m were exerted and therefore it is not satisfactory to consider that wind pressure acts on a roof uniformly in the wind forceresistant design of structures.

2) The distributions of the displacements of the roof were the same as the static wind pressure distributions and the maximum value of these was 9 mm. On the other hand, the motions of the membrane were not unstable as flutter and the amplitudes were small ($a=1.7$ mm). As these values are influenced by the weights, rigidities and the initial tensions of actual roofs, it is difficult now to estimate exactly the displacements and amplitudes of actual roofs.

It will be important in future studies to clarify the relation between fluctuating wind forces and the vibrations of the membrane, as well as the dynamic characteristics of actual roofs.

Some Results of Wind Observations on Kyoto Tower

By Yasushi MITSUTA

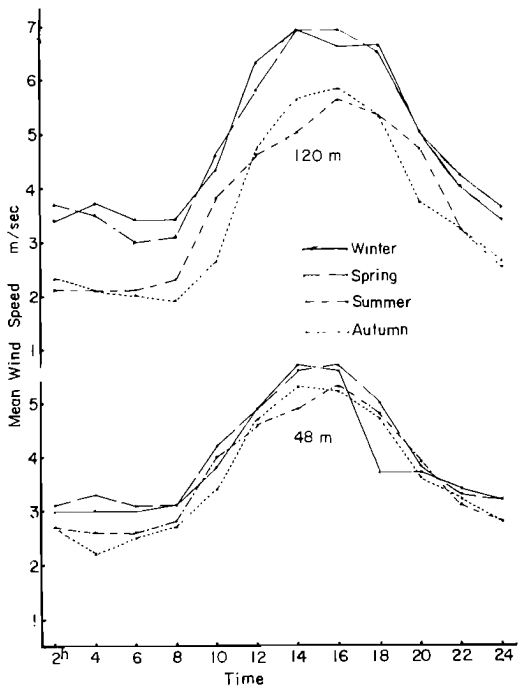
Annuals of Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 273–280.

Abstract

Kyoto Tower which is about 131 meters in height stands in the urban area of Kyoto City. Wind observations have been made at the heights of 120 m near the top and 48 m on the roof of the building. The results of observations in the period from the beginning of January 1965 to the end of October of that year are analyzed and reported in this paper.

The results show that the air current over the urban area is quite turbulent up to 120 m. In case of the storm of Sept. 10, when the Typhoon 6523 was passing near the city, the peak gust speed of 52 m/sec was observed at the height of 120 m. And intensity of turbulence was estimated to be about 0.2 at that height, which is quite large compared to the past observation over flat open land and even larger than the value observed at the same height of Tokyo Tower in typhoon winds. The peak gust speed observed at the height of 48 m was 37 m/sec and was compatible to the value observed at the Kyoto Domestic Meteorological Observatory.

Daily Variations of wind speed are shown in the figure. The maximum wind speeds are observed at 14 or 16 o'clock at both heights. The amplitudes of daily variations are about 3.5 and 3 m/sec at 120 and 48 m heights. The maen wind speeds at the height of 120 m in winter and spring are about 1.5 m/sec larger than those in warm seasons.



Daily variation of wind speed.

The daily variations of intensity of turbulence and wind direction are also studied. Two examples of thunderstorm passages are also shown in this paper.

On the Standard Project Typhoon (2)

By Yasushi MITSUTA

Annuals of Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 267-272.

Abstract

The process of synthesizing the Standard Project Typhoon for use in planning and establishing typhoon design criteria for typhoon protection works is described in this paper.

The indices of the Standard Project Typhoon which should be used in the central and western part of Japan can be summarized as follows:

a) Central pressure on the coast or over the sea:

Area	Occurrence per 100 years			
	1	2	5	10
Kyushu	920 mb	930 mb	940 mb	950 mb
Shikoku	920	930	940	950
Kinki inc. Mie	920	930	940	950
Tookai exc. Mie	940	945	950	960
Kanto	940	945	950	960

b) Radius of maximum wind:
Assumed to be constant and 50 km.

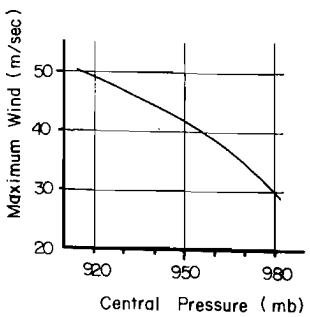
c) Direction of forward motion:
Straight to NNE. The range is from NNW to NE.

d) Speed of forward motion:
50 km/hr on average. The range is from 70 to 20 km/hr.

e) Filling of the central pressure:
5 mb/hr on land.

f) The maximum wind speed:
The maximum wind speed is the function of the central pressure, as shown in the figure

We can synthesize the Standard Project Typhoon from these parameters. In this paper an example of 10 meters over land isovel pattern for the Standard Project Typhoon of 920 mb in central pressure is presented.



Variation of maximum wind speed with typhoon central pressure.

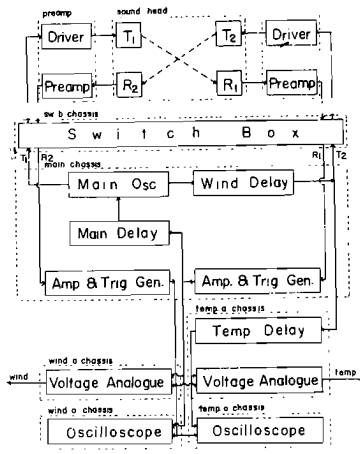
Sonic Anemometer-Thermometer for General Use

By Yasushi MITSUTA

Journal of Meteorological Society of Japan, Series II, Vol. 44, No. 1,
February, 1966, pp. 12–24.

Abstract

The recently developed sonic anemometer-thermometer has many excellent characteristics which cannot be attained by traditional anemometers, and we can measure air temperature as well as wind velocity with the same sensor at the same time. But most of the examples developed in the past were intended for application to the study of micrometeorology in light winds. The present author has aimed to develop the sonic anemometer-thermometer for general purposes inclueing storm observations. The system adopted is that of the pulse-time-difference method. It has been decided to adopt this method because the instrument in this method is less affected by noises and has wide observational ranges. But the past instrument in this method had a fault in that the timing of the receiving pulse becomes erroneous in case of decreasing of receiving power of the signal. This fault is covered in this case by adopting high efficient barium titaniate sound transducers and high gain amplifiers to get sharp rising of the receiving puse wave forms. A new voltage analogue output circuit was developed for this instrument that enables to use various kinds of recorders. The shape of the sound head is of great importance in attaining a good signal to noise ratio when the wind direction coincides with the sound path orientation in high winds. The shape of the head has been developed through wind tunnel experiments and the present one is not a final but a temporary choice. It has been found by the wind tunnel experiment that it does not work well if the wind is stronger than 30 m/sec and in the direction along the sound path. But except in such cases the instrument has proved to work satisfactory well and to be easy to handle with. The sound frequency of the pulse is 100 kc and the pulse frequency is 300 pulses per second. The attenuation of short period changes on the records caused by the line-averaged character of the sensor is also discussed in this paper.



The block diagram of the whole system

Experimental Study of Elasto-Plastic Stability of Steel Portal Frames with Wide-Flange Sections under Vertical and Horizontal Loads (Part 1)

By Minoru WAKABAYASHI and Chiaki MATSUI

Annuals, Disaster Prevention Reseach Institute, Kyoto University,
No. 9, March, 1966, pp. 295–305

Abstract

Unbraced frames may fail by an unstable phenomenon, when large vertical loads and varying horizontal loads are applied to them. The situation is supposedly encountered in lower storeys of a tall frame under earthquake motion.

An experimental study is made of the effects of vertical loads on the behavior of end-fixed portal frames with mild steel wide-flange sections under varying horizontal loads. Test specimens are rigid frames of continuous welded construction and composed of two similarly made plane portal frames, both being connected to each other with wide flange sections at the joints and at the centers of the beams and columns to prevent lateral buckling of the frame. Four specinens are tested. Two of them are annealed to eliminate residual stresses in the frames. All columns of specimens have an H-100 mm $\times$ 100 mm section, and beams H-100 mm $\times$ 100 mm or H-100 mm $\times$ 50 mm. The beam length and the column height are equal and they are both 100 cm. The ratio of the column height to the in-plane radius of gyration is about 24 which is chosen as the representative proportion of a typical frame. The moment of inertia of the beam is either equal to or 0.46 times that of the columns. The horizontal displacements of the specimens are measured by means of dial gauges and the strain distribution of the members are measured by wire strain gauges. Vertical loads are applied by a testing machine to the tops of the columns symmetrically, being kept constant at about 32% of the yield load of a column. A varying horizontal load is applied slowly by an oil jack to one direction of the beam axis.

It is observed that the restoring force of the specimens does not decrease significantly when vertical loads are as large as 32% of the yield loads of the columns. However, it decreases as the beam stiffness becomes small. The maximum horizontal load, applied to the top of a frame, is found to be nearly 10–20% larger than that predicted by the elastic-perfectly-plastic theory which takes account of the axial forces of the columns. The stability limit displacement at which a frame becomes unstable is about 1.5/100 times that of the column height.

An Experimental Study on the Restoring-Force Characteristics of Tall Frames

By Minoru WAKABAYASHI and Tatsuo MUROTA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 317–326.

Abstract

Ordinarily, the aseismic design of tall frames is made by means of dynamic analysis of shear models. In these analysis the relations between the restoring-forces and the horizontal displacements, the restoring-force characteristics, are of primary importance. The restoring-forces are decreased with vertical loads, which may make the restoring-force characteristics unstable, especially in the lower parts of tall frames. In order to investigate the effects of the vertical loads on the restoring-force characteristics of frames under horizontal loads, 15 model tests are carried out. The models are cut out by machines from mild steel plates. Single-bay plane frame models of three- and five-stories are tested. The ratio of the section modulus of the column to that of the beam is taken as 0.5, 1.0 or 2.0. The slenderness ratios of columns obtained from the tangent-modulus buckling load of these frames are 28.6 to 38.7. The constant vertical loads of 0, 20 and 40% of yield loads of columns are applied to the top of the frames, and the horizontal load is applied to the beam of the top storey. The relations between horizontal load and the horizontal displacement are measured. The curves obtained by this experiment are compared with the slope-deflection theory with consideration of the vertical loads of columns, in which it is assumed that 1) both the stress-strain relation of the material and the bending moment-curvature relation of members are perfectly elasto-plastic, 2) the changes in the vertical loads of the columns caused by the shearing forces of beams are neglected. The following results are obtained: 1) the slope-deflection theory agrees with the test results in the elastic range; in the elastic but partly plastic range it gives larger values; in the process of collapse it predicts too unfavorable a situation, 2) a large vertical load induces in a frame an unstable state before a sufficient number of plastic hinges have been formed, corresponding to plastic collapse, 3) the decrease of the horizontal load after the bearing capacity is reached become more rapid when the vertical loads become larger, 4) allowable values of horizontal displacement decrease when the vertical loads become larger, but increase as the section modulus of beams increases, 5) the horizontal bearing capacity decreases when the vertical load is increased and it can be estimated approximately, on the safe side, by the equation, $H/H_p+P/P_{cr}=1$.

Experimental Studies on the Elasto-Plastic Behavior of Steel Portal Frames with Wide Frange Section Under Repeated Horizontal Loading

By Minoru WAKABAYASHI and Bunzo TSUJI

Annuals, Disaster Prevention Research Institute, Kyoto University,
Vol. 9, March, 1966, pp. 307–316.

Abstract

In the aseismic design of structures, it is a primary object to clarify the restoring force characteristics of the structures under horizontal loading. In this report, the experimental results of steel frames under monotonous and repeated loading conditions are discussed.

Test specimens are portal frames with and without bracings, fixed at the roots of the columns. Three kinds of bracings are used such as a single bracing, a K-truss type bracing and a diagonal bracing. The specimens are constructed with rolled and welded wide flange sections. The span and the height of the frames are both 100 cm. To avoid lateral buckling, prior to the overall collapse in the plane of the frame, two identical frames are welded together, some distance apart, to compose a specimen. Horizontal loads are applied statically at the top of the column. Repeated loads are imposed in such a way that the deflection amplitude increases at each half loading cycle.

Horizontal load-displacement curves at the top of the column are obtained for each specimen. Under monotonous loading, the frame without bracing shows the softening type curve; whilst the frames with bracings show unstable equilibrium after the occurrence of the buckling of the compression bracing, and as the displacement increases the load increases a little or stays at a constant value. Theoretical curves are also obtained by considering the post-buckling strength of the compression bracing, and a general agreement is seen with the experimental results.

Under repeated loading, the frame without bracings shows a spindle-shaped curve. In the case of a frame with bracings, the shape of the load-displacement curve depends greatly on the amount of the displacement. This is due to the buckling deformation of the compression bracing.

The deterioration of the slope of the curves in the unloading process is accounted for, with consideration of the buckling deformation of the bracing. At a small displacement, the experimental and calculated values coincide well.

From the load-displacement curves under repeated loading, the relation between the equivalent viscous damping coefficient ratio ν_{eq} and the displacement amplitude is deduced. For the frames without bracings, the ν_{eq} value increases greatly with the increase of the deflection amplitude. The frames with bracings have a large value of ν_{eq} under a relatively small displacement but the value does not increase so much with the displacement amplitude.

Experimental Study on Buckling Behavior of Angles

By Minoru WAKABAYASHI and Taijiro NONAKA

Annals, Disaster Prevention Research Institute, Kyoto University,
Vol. 9, March, 1966, pp. 327-335.

Abstract

This supplements an earlier paper which describes experimental results on the buckling strength of angles. In this report, main emphasis is laid on experimental techniques for examining the buckling phenomena of compressed struts with small torsional rigidity. Behavior and deformation modes of compressed angles are observed in some detail for various eccentricities by measuring deflections, strains and torsions under varying loads.

A total of fifty-seven specimens are tested, with a L-90 mm $\times$ 90 mm $\times$ 7 mm profile. The end supports are made, with use of oil pressure, so as to eliminate restraints against rotation in all dierection and not to allow any displacement and warping at the specimen ends. Deflections and torsional deformation are measured by means of dial gauges, which are fixed on a wooden frame. The frame is attached to the specimen in such a way that it does not give any contraint on the deformation of the specimen. The torsional angle is obtained by dividing two deflection measurements at the same level by the distance between them. Strains are measured by wire strain gauges pasted at the end and middle parts of the specimen. The deformation measuring device serves also to find the centroid of the cross-section. A necessary eccentricity is produced with the help of this device and the verniers with which the end supports are equipped.

It is seen that torsion, bending or Beulung (local buckling of plate elements) plays an important role in the buckling phenomena of angles, according to the eccentricities and angle dimensions. Centrally compressed angles show that torsional deformation occurs at the middle part more than at the end parts. This indicates a confirmation on the assumption made in the preceding paper that the buckling behavior and the buckling strength are not governed significantly by the boundary condition for twisting at the specimen ends. Angle specimens under eccentric compression in the symmetric plane do not show any appreciable torsion but dominant flexural deformation. In the case of eccentric loading in the asymmetric principal axis of the cross-section, the deformation is governed by the eccentricity prior to buckling, but the buckling mode is dominated by bending in the most flexible direction. Considerable torsional deformation is observed from an early stage of the loading in that case. It is observed experimentally that a linearly distributed initial torsion does not affect the buckling behavior of angles.

Slope-Deflection Method Applied to the Problem of Space Buckling in Frames of Thin-Walled Cross-Section—Part 1, Derivation of the Slope-Deflection Equations

By Minoru WAKABAYASHI and Taijiro NONAKA

Transactions of the Architectural Institute of Japan, Summaries of Technical Papers, Annual Meeting of A.I.J., October, 1966, p. 303.

Abstract

A systematic method is shown for finding the buckling load of a space frame whose members have small torsional rigidity. The method is, in principle, based on similar lines to the slope-deflection method, and includes the inelastic range by applying the tangent modulus buckling theory. Members are assumed to have a thin-walled open cross-section, either with two symmetric axes or with a point symmetry. The principle is as follows:

Starting from the system of equilibrium equations for a small element of a compressed (or tensioned) bar, we first obtain the fundamental slope-deflection equations which express bending moments, shears and twisting moments at the bar ends in terms of rotations and the relative displacement between the ends. Directions or signs of the force and deformation quantities are determined according to the direction and sense of a vector which represents the force, moment, displacement or rotation. The system of equilibrium equations is composed of three equations, two of them concerning the displacement components in the principal axes of the cross-section, and the other the twisting angle. In the process of constructing the slope-deflection equations, it is noted that the former indicates the constancy of the force component in the direction perpendicular to the axis of the bar, and the latter that of the twisting moment along the axis. The fact that the three equations are independent of one another for the deformation quantities simplifies the process. Since the coefficients which correlate the force system to the deformation system contain trigonometric (or hyperbolic) functions of the axial force in a comlex manner, it is convenient to express them approximately as linear functions of the axial force.

In order to find the buckling load, the equilibrium condition is to be expressed for a buckling configuration of the frame under consideration in terms of the deformation quantities with use of the slope-deflection equations. Then, the non-vanishing condition of the deformation quantities gives the equation, from which the buckling load is obtained as the smallest root.

Effects of Warping, etc. on the Buckling Strength of Space Frame of Thin-Walled Open Cross-Section with Single Symmetry

By Minoru WAKABAYASHI, Taijiro NONAKA and Masao WATANABE

Transactions of the Architectural Institute of Japan, Summaries of Technical Papers, Annual Meeting of A.I.J., October, 1966, p. 302.

Abstract

An approach is made towards finding the critical load in the space buckling of a rigid frame, while retaining a reasonable accuracy on the torsional rigidity of the frame members. The members are assumed to have a thin-walled open cross-section with a symmetric property. For the purpose of the use of an electronic computer, the end force system is represented for a compressed (or tensioned) bar in a matrix form as a function of the end deformation system, with reference to the coordinate axes fixed in a bar. The relation is then transformed for the common coordinate axes fixed in the space. The buckling load is obtained as the smallest root of the non-vanishing condition of the deformation quantities, when the equilibrium condition is expressed in terms of those quantities for a certain buckling configuration.

An example is given for the out-of-plane buckling of an elbow type rigid frame. The cross-section has symmetric axis in the plane of the frame. The compressive forces are applied symmetrically in the axes of the members. Attention is paid to the effects of the warping rigidity, the boundary condition for warping, and the eccentricity of the shear center from the centroid of the cross-section, on the buckling load. The results of this particular example are summarized as follows:

(1) The buckling load is increased by the constraints against warping at the ends of the members, the amount being 11% in the largest case.

(2) Consideration of St. Venant's pure torsional term alone in the torsional rigidity produces an error of as much as 10%, on the safe or unsafe side.

(3) The buckling load is increased by the eccentricity of the shear center in the convex side of the elbow type frame, but is decreased by that in the concave side. This is because the eccentricity in the former places some constraints on the torsional deformation of the members, but that in the latter helps the torsional deformation.

(4) The eccentricity of the shear center may possibly have a larger effect on the buckling load than the warping rigidity or the boundary condition for warping.

Studies on Granular Explosives (Third Report) On the AN-FO Blasting Agents (3)

By Yoshikazu WAKAZONO

Journal of the Industrial Explosives Society, Japan
Vol. 27, No. 5, 1966, pp. 288–294.

Abstract

The state of detonating propagation of prilled AN has not been clarified in spite of the fact that many studies on AN-FO have been conducted so far.

In order to clarify this problem, the author has investigated the effect of primer and booster, and loading conditions on the detonation velocity of AN-FO.

The results obtained are as follows:

(1) The detonation velocity of AN-FO depends on both the kinds and quantities of primer and booster, that is, if the explosives having higher detonation velocity are used or if the ratio of the primer and booster to AN-FO is increased, the detonation velocity of AN-FO gets higher.

(2) As the hole diameter or the loading density increases, the detonation velocity of AN-FO increases. Meanwhile, in the case of the other high explosives, the change in the detonation velocity due to the variation of the diameter or loading density is not as conspicuous as AN-FO.

(3) In the case where the loading density of AN-FO and quantities of primer are not sufficient, the detonation velocity of AN-FO falls at a certain distance from the primer in AN-FO. Therefore, this phenomenon suggests that the insertion of the booster at an appropriate location in AN-FO should be effective for a long hole blasting.

Studies in the Application of Explosion (Part 1) On its Application to Measuring the Properties of the Ground

By Yoshikazu WAKAZONO and Shigetaka KITAO

Annals, Disaster Prevention Research Institute, Kyoto Univercity,
No. 9, March, 1966, pp. 289–294.

Abstract

It is generally known that the explosives, AN-FO or dynamite, are usable for the sources of dyanmic pressure and vibration. In order to discuss the mechanical effects in soil caused by dynamic pressure, we measured the propagating velocity of elastic waves in sandy soil. We used AN-FO and dynamite for the sources of vibration and observed the relations between the velocity of elastic waves and the number of blow resulting from the standard penetration test.

From the results of these tests, we found that an interrelation-ship between the number of blow and the velocity of elastic waves in sandy soil existed and that estimation of the number of blow could be obtained from the velocity of elastic waves.

Studies on Explosion II
On the Measurement of the Dynamic Pressure Caused by Explosion of Powders

By Yoshikazu WAKAZONO and Shigetaka KITAO

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 15, Part 3, No. 97, March, 1966, pp. 9–20.

Abstract

Smokeless powders such as nitrocellulose containing nitroglycerine have been used for common propellants. Recently, these powders have also been used as the propellant of rivet steels. The efficiency of a rivet ejector is mainly influenced by the exploding properties of powders. In this respect, we especially measured the dynamic pressure caused by the explosion of powders, and discussed the relation between the dynamic pressure and the several properties of these powders such as the particle size, the particle form, and the surface conditions of particles.

We further discussed the initiating methods of these powders. From the results of these experiments, we noted the following facts:

(1) The wave form of the dynamic pressure caused by the explosion of powders is scarcely influenced by the components and particle form of these powders, if an explosion is caused in a closed chamber with a loading density of powders of 0.3 g/cc or more.

(2) The reacting period of powders in a closed chamber is not effected by the initiating methods.

(3) The wave form of the dynamic pressure is influenced by the state of the closed chamber.

Studies on Fire Extinguishing Agents (3)
Methods for Quick Wetting and Minute Water Spray

By Yoshikazu WAKAZONO and Naojiro ANDO

Annals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 281-288.

Abstract

Recently, means of fire extinguishing such as the use of mechanical water sprays have been employed for common fires and oil fires. By this means, however, it is difficult to make a minute water spray which is highly effective for fire extingusihment or has an adequate distance range. Therefore a variable nozzle is used for fires which it is impossible to extinguish by meachnical means. Although this nozzle has an effective distance range, it is difficult to make a minute spray.

Therefore the authors have investigated the effects of a surfactant for quick wetting and a minute water spray with a variable nozzle for water extinguishing. Our results, to date, confirm that the water solution of alkyl polyethylenglycolether and alkyl aryl polyethylenglycolether had very powerful effect in reducing the surface tension of water and that minute spray was facilitated by this water solution. Also, we have confirmed that by using this water solution and a variable nozzle, it is possible to obtain an adequate distance range. We further confirme that by using water containing 0.008—0.001% of this water solution, it was easy to extinguish a fire which was inextinguishable by water.

We conclude that a water solution of alkyl polyethylenglycolether and alkyl aryl polyethylenglycolether is the most effective of the water extingusihing methods.

Earthquake Response Analysis and Anti-Seismic Design Data of Multi-storey, Elasto-Plastic Building Structure

By Takuji KOBORI, Ryoichiro MINAI, Yutaka INOUE and Toshiharu HISATOKU

Annals, Disaster Prevention Research Institute, Kyoto University, No. 9, March, 1966, pp. 137–164.

Abstract

This paper deals with the anti-seismic design method of an elasto-plastic tall building structure based upon the earthquake response analysis. First, qualitative discussions are made as regards the basic procedure of anti-seismic design method for structures, the earthquake excitations to be adopted in the response analysis, the structural model to simulate the designed building and measures to evaluate the anti-seismic safety of the building.

Secondly, as a typical example, the anti-seismic design of a steelskelton, reinforced concrete building structure with thirty-nine stroies is discussed. In the response analysis by an electronic analog computer, the structure is simulated by a seven-mass-system which has internal viscous damping and elasto-plastic, hysteretic restoring force characteristics. The typical wave forms of the past strong earthquake records are adopted for the excitation patterns and the group of earthquake excitations is prescribed with various intensities and time durations. The maximum ductility factor of each storey is considered to evaluate the anti-seismic safety of the elasto-plastic structure. From the results of the response analysis, useful anti-seismic design data are obtained which give pertinent response characteristics to such structures.

Some conclusive remarks are pointed out as follows:

(1) The pertinent characteristics of the response distribution along the height of structures can be reasonably obtained by adjusting the distributions of the dynamic characteristics of structures.

(2) Internal viscous damping is, in general, effective in decreasing and stabilizing the responses, although the damping effect differes one from another accodring to the excitation pattern and the amplitude of response.

(3) The average response for the height of the structure is approximately expressed as a linear function of the maximum ground velocity, and its slope is determined according to the excitation pattern.

(4) The maximum response can be expressed in terms of the above-mentioned average response and the quantity indicating the maximum deviation of response, both of which are expressed as functions of the strength and frequency parameter of non-dimensional excitations.

(5) The distribution characterisitcs of elasto-plastic responses are mainly affected by the distributions of the strength and potential energy at the elastic limit.

(6) Thus, it is found that the anti-seismic design data for the elasto-plastic, tall building structures can be reasonably obtained from the pertinent dynamic characteristics determined through the earthquake response analysis.

Earthquake Response of Frame Structure Having Elasto-Plastic Joints

By Takuji KOBORI, Ryoichiro MINAI and Tamotsu SUZUKI

Annals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 165–192.

Abstract

In relation to the ultimate aseismic design method of structures, the earthquake response analyses for obtaining pertinent aseismic design data for the preliminary structural design have been already carried out in a wide range of various parameters of structures and of earthquake excitations, by making use of comprehensive structural models and the corresponding measures of aseismic safety. However, to estimate precisely the aseismic safety of an elasto-plastic structure which is designed individually from the various structural design data and to improve the aseismic design data already obtained in the foregoing analyses, a more detailed response analysis should be developed by making use of the structural model composed of the local dynamic characteristics of the structural system, and the earthquake responses should be estimated by the corresponding local measures of aseismic safety in structural elements such as the ductility factor and the dissipated hysteretic energy ratio of the elasto-plastic joints.

In this paper, the methods of earthquake response analysis of a frame structure having elasto-plastic joints are discussed, and numerical examples calculated by a digital computer are shown. The model of the frame structure is supposed to be an elasto-plastic lumped mass system of which the restoring force characteristics are composed of the dynamic characteristics of the elasto-plastic joints and the elastic members. Based on the fundamental vector-matrix equation, three kinds of method of solution are presented. The first is the analytical junction method in which the analytical expression of the solution is successively obtained by connecting the solutions of adjacent linear branches in the multi-linearlized structural system. The second is the extension of G.V. Berg's method for a frame structure with rigid-plastic joints to the case of a frame structure with elasto-plastic joints, in which the step by step solution procedure based on the Runge Kutta 4th order procedure and the Gauss-Seidel iteration method is effectively applied to the numerical analysis by means of a digital computer. The third is the simulation method of solution by means of an electronic analog computer, in which the analog circuit of the elasto-plastic frame structure is easily obtained by using backlush elements. In addition, based upon the first integral of the fundamental equation, the balance of the various kinds of energy and its distribution to each structural element are discussed in detail. Numerical analyses by using the second method are carried out for a three-storey, single-bay frame structure subjected to typical excitation patterns such as a sinusoidal wave and the wave-shape function of the Vernon Earthquake, California, Oct. 2, 1933. Also, the ductility factor of each elasto-plastic joint, the transmitted energy to the frame structure, the sum of dissipated hysteretic energy in the joints and so on are shown in graphical form.

Dynamical Characteristics of Structures on an Elastic Ground

By Takuji KOBORI, Ryoichiro MINAI and Tamotsu SUZUKI

Annals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 193-224.

Abstract

In order to clarify the dynamical properties of sub-soil ground, we have already obtained an analytical expression of "Dynamical Ground Compliance" of a rectangular foundation on a semi-infinite elastic ground. This Compliance, denoted by the ratio of the foundation displacement to a harmonic disturbing force, is equivalent to the transfer function of the elastic ground. Moreover, using the method of numerical integration, we have evaluated Dynamical Ground Compliance in terms of doubly infinite and improper integrals. And so we utilize these numerical values as the basic data for the problem with respect to a semi-infinite elastic ground.

In this paper, the dynamical characteristics of structures on an elastic ground are investigated by making use of the above Ground Compliance in the cases of vertical and horizontal translation or rotation. The four structural models—a rigid body, a one mass-spring system, a continuous body of shearing and bending type—are considered herein. It is assumed that these structural models have rectangular foundations and also that a harmonic incident wave is vertically or horizontally coming up to their foundations through the sub-soil ground. Analytical expressions of amplitude and phase characteristics for the rotational and translational displacements of the structure are obtained in the cases of swaying and rocking motion respectively. The rocking motion means the coupling vibration with the swaying and rolling motion of the foundation. Representing the results of the numerical evaluation in graphical form, we discuss the dynamical effects of the sub-soil ground on such structures in comparision with the uncoupled system as a standard type structure.

The general conclusions are mentioned as follows: (1) The dynamical characteristics of the four structural models, as a whole, have a similar tendency, both in the cases of swaying and rocking motion, except for the mutual difference in the frequency range. (2) The dynamical characteristics of those models are apt to have ground effects as the stiffness (or equivalent density) of the structures is larger (or smallar) than that of ground. (3) The effect of a rolling motion on structures, which are slender at the vibrating plane, appears more remarkably. On the other hand, a structure of shearing type can be reliably expected to be much affected by rolling motion than one of the bending type.

The analytical expressions of these dynamical characteristics are equivalent to the transfer functions of such coupled ground-structure systems. Therefore, the analytical results obtained here are available in principle for studying the earthquake response of a coupled structure subjected to an arbitrary transient ground motions.

Statistical Methods of Determining Dynamic Characteristics of Multi-Degree-of-Freedom Systems

By Takuji KOBORI, Ryoichiro MINAI and Yoshihiro TAKEUCHI

Annals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 225–241.

Abstract

In order to be confident of the reliablility of the adopted aseismic design of a structure, the quantitative knowledge of the dynamic characteristics of the designed structure should be examined by an experimental or measuring technique. Although the most reliable method of detecting the dynamic characteristics of a structure is the vibration test by the excitor which produces sinusoidal excitations, however, the statistical method based on the measurement of structural responses due to the micro-tremor of the ground or a natural wind force has recently been used in determining the dynamic characteristics of structures, because of its instrumentational simplicity.

In this paper, two kinds of statistical method for determining the linear dynamic characteristics of multi-degree-of-freedom systems are presented. The first method is based on the analytical expression of the optimum transfer matrix of a multi-input and -output system, which is obtained by extending the Wiener-Levinson formula of a single-degree-of-freedom system. The optimum transfer matrix of the system can be determined as the solution, in the frequency domain, of the simultaneous integral equations which are obtained by considering the least mean square error criterion as well as the physically realizable condition of the system. The second method is derived from the relationship between the input and output spectral density matrix by only considering the physically realizable condition. In both methods, the same number of independent stationary processes as the number of inputs to the system is necessary to determine completely the transfer matrix of the system. Since, in practical applications, the complete number of independent processes is not always available, the complementary method of determining the unknown parameters in the dynamic characteristics of multi-degree-of-freedom systems is presented, in which the functional form of the transfer matrix is supposed to be known except for a set of unknown parameters. Moreover, it is shown that the dynamic characteristics of a known linear system can be detected with good accuracy by applying the above-mentioned second method on the results of random excitations of a single-degree-of-freedom system, calculated by means of an analog computer.

Vibration tests on a Steel Frame Structure

By Takuji KOBORI, Ryoichiro MINAI,
Yoshihiro TAKEUCHI and Masahiro KAWANO

Reports of the Architectural Institute of Japan (KINKI Sub-division)
May, 1966, pp. 69–72.

Abstract

It is desirable for earthquake engineers to clarify the dynamic characteristics of actual structures, one of which was chosen as a symmetrical five-story steel frame structure with the rectangular plan under construction, for the purpose of obtaining the dynamic characteristics of this structure by using method of vibration tests. Such vibration tests are performed as to three different types of tests; the free vibration test, the forced vibration test and the artificial ground excitation test.

The procedure of the free vibration test follows the usual pattern, namely: the initial displacement of the structure was, first of all, given by stretching a wire-rope fixed at the top of the structure and, secondly, by releasing the tension force of the stretched wire-rope, the free vibration of the structure was produced. Thus the fundamental natural periods and the critical damping ratios of the freely vibrating structure were evaluated from a number of test records.

At the stage of the forced vibration test, a vibration exciter was installed on the roof or the third floor of the structure, and then the steady state vibration of the structure was produced from this exciter in the frequency range about 1–10 cps. Thus resonance curves in this frequency range were obtained and, as a result, natural periods and critical damping ratios of the structure were determined by means of theoretical calculations based upon the method of least mean squares.

From these two vibration tests, it is found that the first and second natural period are 0.55 sec and 0.18 sec in the N-S direction, 0.43 sec and 0.14 sec in the E-W direction respectively. The critical damping ratios corresponding to these periods are 0.7% and 0.8% in the N-S direction, 2% and 0.9% in the E-W direction respectively. Here it is noticeable that the first critical damping ratio in the E-W direction is about three times that in the N-S direction.

The object of the artificial ground excitation test is to obtain some of the data available for the analysis of the behaviour of the structure subjected to actual ground motions. In this test several ground motions were artificially generated by the explosion of ANFO explosive under the ground. From the results of this test, it is pointed out that each vibration mode of the structure corresponds explicitly to the third mode in the N-S direction and to the second mode in the E-W direction. To explain these distinctive response modes of the structure, the dynamic characteristics of a coupled ground-structure system are discussed with the and of the analog computer, using some dynamic models of the shear type five mass system.

On the Statistical Method of Determination of the Linear Transfer Function of Structures

By Takuji KOBORI, Ryoichiro MINAI, Yoshihoiro TAKEUCHI and Masahiro KAWANO

Reports of the Architectural Institute of Japan (KINKI Sub-division), May, 1966, pp. 73–76.

Abstract

At the present stage that the dynamic behavior of structures is not throughout made clear, it is necessary to reexamin, particularly from the quantitative point of view, the dynamic analysis and aseismic design of structures by researching the dynamic characteristics of actual structures. As a method of determining the dynamic properties of actual structure, various vibration tests exist. Moreover, it is possible to find out them by measuring the responses of structure to winds, earthquakes and microtremor of the ground, and by applying the statistical procedures developed in the automatic control engineering. In this case, the dynamic characteristics of a structure can be determined as the optimum linear transfer function, knowing statistical properties of inputs and outputs by measurement techniques. In the case where the functional form of the transfer characteristics is presumable except for a set of unknown parameters, the method of determining the unknown parameters by making use of the least mean square error criterion may be applicable.

This paper presents two kinds of statistical method of determining the linear dynamic characteristics of multi-degree-of-freedom systems. The first method is, as mentioned above, the extension of the Wiener-Levinson formula for a single-input and -output system to a multi-input and -output system. The second method is derived from the relationship between the input and output spectral density matrix by considering physically realizable condition. To find the propriety of the above-mentioned methods the randon responses of a single-degree-of-freedom, linear system to a band-limited white noise are analyzed by means of an electronic analog computer, and it is tried to detect the dynamic properties of the linear system with known parameters by the second method, calculating the spectral densities of the input and output through Fourier transformation of their auto-correlation functions. It is shown that the natural frequency of the linear system is estimated with good accuracy and that the critical damping ratio of the system is detected a little larger than the given value to the system because of the finite total delay of the auto-correlation functions adopted. As this estimation of the dynamic properties of the transfer function is satisfactory for the structural engineering, it is suggested that the second method presented in this paper may be applied to determination of the dynamic characteristics of actual structures with slight damping.

Torsional Response of a Frame-Structure to Random Excitations

By Takuji KOBORI, Ryoichiro MINAI, Yoshihiro TAKEUCHI
and Koichiro ASANO

Reports of the Architectural Institute of Japan (KINKI Sub-division),
May, 1966, pp. 77–80.

Abstract

It is well known that the effect of torsional vibrations should not be neglected in estimating the earthquake responses of structures having ununiform distributions of dynamic characteristics in the horizontal plane. In this paper, the effects of the excitation level and structural viscous damping on the statistical properties of the non-stationary random responses of a single-bay, single-story, space-frame structure consisting of four elasto-plastic frames with different restoring force characteristics are studied by using an electronic analog computer. The excitation group is assumed to consist of one hundred random time-functions with a finite duration, each of which is generated as a sample function from a prescribed stationary random function. As regards the structural model considered, the distribution coefficient of strength is supposed to be proportional to the root of the distribution coefficient of rigidity.

Particularly paying attention to the maximum values of responses and excitations, the distribution characteristics over the stochastic ensemble are studied. As a result, it is found that the rate of the mean value of the maximum response with respect to excitation level is a decreasing function of the excitation level and that the mean value is a linearly decreasing function of the critical damping ratio for the elastic range but a weak function of the critical damping ratio for the elasto-plastic range. And also it is found that the standard deviation of the normalized maximum responses which are defined so that their mean value is equal to unity, is a decreasing function of the excitation level and that the standard deviation is a decreasing function of the critical damping ratio for the elastic range but a weak function for the elasto-plastic range. These statistical properties of random responses are more precisely shown in the distribution functions of the normalized maximum responses presented in graphical form.

As regards the sample function of the stochastic ensemble, the transitional behaviour of the transient response to the stationary state is studied. It is found that if the appropriate viscous damping and hysteretic damping exist, the behaviour of the random responses of the structure due to the sudden application of a stationary excitation seems to be almost stationary except for the initial few cycles of vibration, as theoretically predicted by Dr. T. K. Caughey. Moreover, the amplitude distributions of the sample time-functions of the responses and the corresponding excitation are calculated, and it is shown that the ratio of the maximum value to the root mean square value of response is approximately equal to that of excitation even in the elasto-plastic case, as pointed out by Dr. H. Tajimi for the elastic, stationary case, although the width of deviation of the normalized maximum value of excitation is far smaller than that of the responses.

Response Analysis of a Frame Structure with Elasto-Plastic Joints —Considering Axial Forces of Frame Members—

By Takuji KOBORI, Ryoichiro MINAI and Teizo FUJIWARA

Reports of the Architectural Institute of Japan (KINKI Sub-division),
May, 1966, pp. 81–84.

Abstract

This paper deals with the earthquake response analysis of frame structures with elasto-plastic joints, considering both axial forces due to gravitational acceleration and to swaying of the frame structures. As the local measures of aseismic safety of the frame structure, the ductility factor and dissipated hysteretic energy ratio of each elasto-plastic joint are considered, defining them as the ratio of the elasto-plastic relative rotation between both sides of a joint to its elastic limit relative rotation, and the ratio of the total dissipated hysteretic energy of the joint to its elastic limit potential energy, respectively.

Numerical analyses based on a step-by-step procedure are carried out for several kinds of three-storey, single-bay frame structural models various grades of axial forces being considered, and for two kinds of typical exciting acceleration patterns, one a sinusoidal wave having its duration coincident with the fundamental natural period of the structure, the other the non-dimensional wave-shape function of the acceleration record of the Vernon Earthquake, California, Oct. 2, 1933, S 82°E Component. The restoring force characteristics of the structural model considered are expressed in terms of the dynamic characteristics of the elasto-plastic joints and elastic members, considering the interaction effect between bending moment and axial force on the strength of a joint and the buckling effects of axial forces on the distribution of internal forces in the members.

As a result, it is found that the influence of axial forces is not so remarkable on the responses related to the comprehensive aseismic safety of a structure, for instance, the ductility factor of each storey, but the responses related to the local aseismic safety of a structure, for example, the ductility factor of each joint, are much more affected by the interaction effect of axial forces. The reason may be that the influence of the interaction between bending moment and axial force on the former responses is canceled out by the symmetry of the structure. And also, it is found that the restoring force characteristics of each storey deteriorate through the effect of gravitational axial forces but this deterioration may be easily prevented by modifying the elasto-plastic characteristics of the joints. From the standpoint of the practical aseismic design of structures, it is noted that the local responses of columns can be restrained in almost elastic range by introducing an appropriately larger safety factor to the columns that to the beams, without producing the large swaying of the structure due to the hysteretic damping effect of the beams.

Dynamical Characteristics of Structures on an Elastic Ground

By Takuji KOBORI, Ryoichiro MINAI, Tamotsu SUZUKI
and Kaoru KUSAKABE

Technical Reports of the Architectural Institute of Japan (KINKI Sub-division),
May, 1966, pp. 89–92.

Abstract

For the purpose of clarifying the dynamical properties of soil ground, the authors have attempted to study "Ground Compliance" of a rectangular foundation on a semi-infinite elastic medium, based on the three-dimensional elastic wave propagation theory. This concept means the transfer function of the elastic ground. Making use of Ground Compliance in the cases of horizontal translation and rotation, they have also investigated the dynamical characteristics of some structural models on an elastic ground.

To express one of the dynamical characteristics of the above coupled structural system, the natural period of the system may be considered as a representative measure. It is known that each resonant frequency approximates closely to the corresponding natural frequency of the system, if the damping is sufficiently small.

In this paper, the influence of soil ground on the natural frequencies of the two types of structural models—the continuous bodies of shearing and bending type—is investigated with the numerical results of their amplitude characteristics. Analyses are performed for the two cases of swaying and rocking motions of structural models respectively, and results are shown as the elongation factor of each natural period of the first and second mode of such a coupled system to those of the same above-ground uncoupled system.

The analytical results are summarized as follows:

(1) In the case of swaying motion, the value of the elongation factor is small for both the shearing and the bending type structure having a slender proportion in the vibrating plane. That is to say, the coupling effect of the ground is not so remarkable for the natural frequencies in such a case.

(2) In the case of rocking motion, which means the coupling vibration of swaying and rocking motion, a slender structure of bending type shows almost the same behavior as in the case of swaying motion, but the ground effect becomes remarkable for the slender structure of shearing type.

(3) The coupled structure having relatively larger stiffness or smaller equivalent density than that of the ground, possesses much longer natural periods than those of the same uncoupled structure.

(4) The more slender the cross-section shape of the rectangular foundation becomes in the direction perpendicular to the vibration plane keeping its cross-section area constant, the smaller the elongation factor becomes in the case of swaying motion. On the contrary, in the case of rocking motion, the above-mentioned fact must be reversed owing to the rolling effect of the foundation.

A Study for the Application of Basic Aseismic Design Data

By Takuji KOBORI, Ryoichiro MINAI and Toshiharu HISATOKU

Reports of the Architectural Institute of Japan (KINKI Sub-division),
May, 1966, pp. 93–96.

Abstract

As regards the practical aseismic design method of typical building structures, it is desirable to obtain a reasonable anti-earthquake structure simply by the conventional static structural design procedure without any complicated dynamic analysis. In relation to this problem, the authors have already discussed the method of obtaining pertinent aseismic design data for the static structural design procedure of elasto-plastic structures from the optimum dynamic characteristics determined on the basis of broad earthquake response analyses.

This paper deals with such aseismic design procedure of a tall building structure by staring from the optimum dynamic characteristics of the elasto-plastic, shear type structural model with the typical mass distribution and with a lower degree of freedom compared with the total number of storeys of the building structure. This design procedure may be said to consist of the following three steps. The first step is the determination of the optimum dynamic characteristics of the structural model with the specific mass distribution of the structure considered from the prescribed optimum dynamic characteristics of the model. The second step is the transformation of the optimum dynamic characteristics obtained in the first step to those of the structural model with the same number of degree of freedom as the total number of storeys of the structure. The third step is the design of each structural element to realize the optimum dynamic characteristics determined in the second step.

The numerical examination is carried out for the above-mentioned first step, by using the seven-degrees of freedom, shear type system having bi-linear hysteretic characteristics. As a result, it is found that the equivalent transformation between the two dynamic characteristics with different mass distribution is successfully obtained by determining the rigidity and strength distribution so as to accord the fundamental frequency, the fundamental mode and the shear coefficients between the two shear type structural models, and without changing the critical damping ratio and the rigidity ratio of the second to the first branch of the bi-linear characteristics in the transformation.

Observation of Matsushiro Earthquakes
(I) Nature of Earthquake Motions
(II) Dynamic Characteristics of a Reinforced Concrete Building

By Takuji KOBORI, Ryoichiro MINAI, Yutaka INOUE,
Teruo KAMADA and Yuichi NAGAI

Reports of the Architectural Institute of Japan (KINKI Sub-division),
May, 1966, pp. 97–104.

Abstract

This paper is our first observation report of the response of ground and structure subjected to Matsushiro earthquakes from Oct. 29 to Nov. 3, 1965, which have been occurring frequently and locally at Matsushiro-cho in Nagano City.

Moving coil type vibration transducers were installed on 1st and 2nd floor of a two storied reinforced concrete school building of the Matsushiro High School and on the ground surface of the campus facing to the building, and the outputs of transducers were amplified adequately and recorded on the magnetic tape using a three channel data recorder. After some of the numerous data recorded on the tape were digitalized, Fourier power spectra and their auto-correlation function were computed. Response spectra were also obtained by means of an electronic analog computer. The general nature of the earthquake motions recorded at the ground surface as well as the dynamic characteristics of the reinforced concrete building are discussed in part I and part II, respectively.

Generally speaking, there is essentially no oscillatory difference between two horizontal components (NS and EW) of the motion of the ground surface. The frequency of the initial tremor of ground is from 30 to 50 cycles per second and its tremor lasts for about a second. The Main shock of large amplitude succeeds to it, the frequency of which is about 11 cps, before the frequency drops to about 2–5 cps. On the other hand, the vertical component of shock is greatly different from horizontal one. Namely, it is recognized that the frequency is higher and the motion is more rapidly damped than horizontal components. According to the auto-correlation function analysis of earthquake ground motions obtained simultaneously at three points located at different distances from the building structure it is found that the ground motion near the building is greatly affected by the vibration of the building itself.

Concerning the response of the building, there are waves of higher frequency than that of the ground surface, and immediately after the main shock comes, the relative motion at each story-floor is noticeable, but it does not last long. Because of the samll earthquake disturbance and relatively rigid structure, the building structure moves mainly as a rigid body. The filter effect of the structure is produced from both the Fourier power spectrum and the response spectrum about ratio between ground and structure response, and the lower frequency oscillation of the structure is amplified, and also the fundamental period of the building is more clearly shown as in the motion at the 2nd floor, where the higher frequency component is less than that obtained at the 1st floor.

Ground Compliance of a Rectangular Foundation on an Elastic Ground (Torsion about a Vertical Axis)

By Takuji KOBORI, Ryoichiro MINAI,
Tamotsu SUZUKI and Kaoru KUSAKABE

Transactions of the Architectural Institute of Japan, Extra,
Oct., 1966, p. 134.

Abstract

It has been noticed that the earthquake response of structures is much influenced by the dynamical properties of the sub-soil ground. In order to explain this fact theoretically, one of the authors presented the analytical solution representing the dynamical response of a rectangular foundation on an elastic half-space, in the case of vertical or horizontal translation and also of rotation about a horizontal axis. Moreover, their numerical evaluation has already been completed.

In this paper, as a sequence of these studies, the numerical evaluation in the case of the torsional motion of a rectangular foundation about a vertical axis is developed. The solution is expressed by the ratio of the foundation displacement to a harmonic disturbing force, the so-called "ground compliance" of a rectangular foundation. Herein are also discussed the equivalent ground characteristics that "ground compliance" is approximately replaced by the dynamical characteristics of spring and dash-pot system. There are shown in graphical representation.

Results for the torsional case, compared with the other cases, are summarized as follows;

(1) The general property of "ground compliance" in this case is different from that in the vertical or horizontal case, but is similar to that in the rotational case. The reason for them seems to lie in the boundary condition of subsoil-stress distribution.

(2) In this case, the residue term around the Rayleigh pole concerned with the Rayleigh Wave is different from the other cases, and the ratio of such a term to the imaginary part varies remarkably with the sectional shape of foundation. For a square-shaped foundation, the residue term is nearly zero, i.e. this is the case that the energy dispersion offered from surface waves is very small. But the residue term becomes larger, as the sectional shape of foundation becomes more slender.

(3) The equivalent ground characteristics in the torsional case are similar to the characteristics in the rotational case. When the frequency becomes higher, the equivalent spring coefficient becomes very small in every case. In the vertical or horizontal case, the equivalent damping coefficient almost remains constant with the variation of frequency but in the rotational or torsional case, its coefficient varies with the value of frequency, and it becomes very small in the vicinity of the zero frequency point.

Non-stationary Response of a Linear Discrete System to Quasi-Stationary Random Excitations

By Takuji KOBORI, Ryoichiro MINAI and Yoshihiro TAKEUCHI

Transactions of the Architectural Institute of Japan,
Oct., 1966, p. 137.

Abstract

In order to obtain a statistical method for the elastic aseismic design of structures, it is necessary to develope the statistical response analysis of structures based on non-stationary stochastic processes. This is because the seismic waves essentially belong to the non-stationary stochastic process, and the transient responses due to the sudden application of excitations are apt to dominate in the initial state. We reported already the analytical expressions of the statistical responses such as the co-variance matrix and the spectral density matrix of multi-input and -output, linear, discrete systems having time-variant coefficients subject to general non-stationary excitations.

In this paper we discuss the fundamental statistical relations between the quasi-stationary stochastic input and the linear discrete system having time-invariant coefficients, because this case is most applicable to the statistical response analysis of structures to earthquake excitations.

The input-vector which belongs to the quasi-stationary stochastic process is defined as the product of the matrix with deterministic elements and the vector with elements which belong to stationary stochastic processes. Here, if we introduce the modified transfer matrix of the linear system defined as the product of the transfer matrix of the time-invariant, linear, discrete system and the above-mentioned deterministic matrix of the quasi-stationary input, the problem can be reduced to that for the case of the multi-output, linear, discrete system having time-variant coefficients subjected to a stationary stochastic input vector. From this point of view, the input and output relations of the basic statistical quantities such as the local co-variance matrix and the one- or two-dimensional spectral density matrix in the non-stationary stochastic process are obtained. And, it is shown that the input and output relations for the quasi-stationary process are reduced to the well-known formulae, if the quasi-stationary input tends toward the stationary input.

Random Response of the Elasto-Plastic Structure Taking Account of Its Torsional Vibration

By Takuji KOBORI, Ryoichiro MINAI,
Yoshihiro TAKEUCHI and Koichiro ASANO

Transactions of the Architectural Institute of Japan. Extra,
Oct., 1966, p. 138.

Abstract

In considering random responses of an elasto-plastic space-frame structure subjected to earthquake excitations, it is important to make reasonable estimate of the effect of torsional characteristics on the statistical properties of the random responses. In this paper, we analize the random response of a single-storey, single-bay, elasto-plastic space-frame structure, which has a non-uniform structural rigidity distribution, subjected to the random excitation group each element of which is represented by the finite duration of a band-limited white, Gaussian stationary random noise. We also try to study the effect of the input level and of the structural viscous damping on the statistical properties of the non-stationary random responses taking account of the torsional vibration. In order to obtain the general properties of random responses, three kinds of excitation group with different input levels and three kinds of structural model with different critical damping ratios are considered. Here, among the statistical properties of random responses which are of interest from the earthquake engineeering point of view, we are mainly concerned with the distribution characteristics of the maximum value of the non-stationary response over the stochastic ensemble which is simulated by a set of one hundred stochastic inputs and the corresponding outputs. The effect of the input level and of the critical damping ratio on the distribution characteristics of the maximum response is studied by means of an electronic analog computer.

The main results are given as follows:

1) The width of deviation of the maximum response of the four structural frames is almost the same in each case but the distribution characteristics of the maximum response of the most rigid frame are different from those of the other three frames. This is due to the fact that the vibrational mode of the most rigid frame is different from those of the other frames.

2) For the elastic response, the structural viscous damping has the effect of decreasing the width of deviation of the maximum response. On the other hand, for the elasto-plastic response, such a tendency is not seen at all.

3) For the elasto-plastic response, the distribution function of the maximum response has a sharp peak around the mean value, and this tendency becomes stronger as the input level increases. This may be due to the fact that the stabilizing effect due to the hysteretic damping of the structural frames increases as the plastic behaviour of responses becomes dominant.

On the Statistical Method of Determining Dynamic Characteristics of Multi-Degree-of-freedom Systems

By Takuji KOBORI, Ryoichiro MINAI,
Yoshihiro TAKEUCHI and Masahiro KAWANO

Transactions of the Architectural Institute of Japan,
Oct., 1966, p. 148.

Abstract

It is convenient for us to apply the procedures developed recently in the field of automatic control engineering to the determination problem of the dynamic characteristics of an elastic structure. The design method of using the optimum linear transfer function for stationary or non-stationary random processes under the least mean square error criterion is considered as one of the methods to detect the dynamic properties of structures. On the other hand, we know another statistical method derived from the simple relationship between the input and output spectral densities. The extensive application of these methods to a multi-degree-of-freedom system is presented by our previous paper, in which such a system is assumed to be separable into each single-degree-of-freedom system in the sense of modal analysis.

In this paper, to find out whether the given dynamic parameters of the linear transfer function can be precisely detected by the above-mentioned methods or not, a single-degree-of-freedom system with known parameters is, at first, simulated as an electronic circuit on an analog computer and then auto-correlations and spectral densities of random responses of the linear system to band-limited white noise excitation are calculated.

As a result, the natural frequency of the linear system is estimated with good accuracy, and the evaluated value of the critical damping ratio in this system is a little larger than the given value. This overestimation about the critical damping ratio may be referred to the finite total delay time of the auto-correlation function. So far as the total delay time is to be shorter in a calculation of Fourier integral, the value of the critical damping ratio estimated only by the above mentioned method must be larger than the given value. So it is necessary to investigate the effect of the inevitable finite condition for auto-correlation function and the calculation procedure for Fourier integral on the numerical estimation about the dynamic parameters of the actual structural system.

Earthquake Response Analysis of an Actual Multi-Storey Elasto-Plastic Building Structure

By Takuji KOBORI, Ryoichiro MINAI and Toshiharu HISATOKU

Transactions of the Architectural Institute of Japan,
Oct., 1966, p. 151.

Abstract

This report presents a process in the qualitative approach for obtaining the distributions of the dynamical characteristics of tall building structure which are pertinent to anti-seismic structural design.

In this paper, the earthquake responses of an actual tall building, which has been designed as a thirty-nine storey building, are analized by an electronic analog computer under the assumption that such a building is idealized as a seven-degrees-of-freedom system of shear type model with both the restoring force characteristics of bi-linear hysteretic type and the internal viscous friction of two percent damping ratio. The particular problem studied herein is the elasto-plastic response of this building, when subjected to the north-south and east-west components of the El Centro Earthquake of May 18, 1940, that is one of the strongest earthquakes among those which have been recorded all over the world.

The specific purpose of this response analysis is to evaluate quantitatively anti-seismic safety, an important non-dimensional measure of which is supposed to be the maximum ductility factor at each storey level of the building. Also the input data express the El Centro earthquake ground accelerations as non-dimensional wave shape functions.

The principal conclusions which may be drawn from this response analysis are given as follows:

(1) When the ground velocity is constant, the mean value of the maximum ductility factor is nearly equal to the shear type models with various parameters.

(2) In the case where the wave shape function of earthquake ground acceleration and the dynamic characteristic distribution of shear type model are determined with regard to ordinary structural design, the mean value of the maximum ductility factor is approximately expressed as a linear function of the ground velocity intensity.

(3) The measure of optimum dynamic characteristic distribution can be expressed by a ratio of mean to standard deviation as regards the ductility factors.

Earthquake Response of a Frame Structure with Elasto-Plastic Joints —Considering Axial Forces of Frame Members—

By Takuji KOBORI, Ryoichiro MINAI and Teizo FUJIWARA

Proceedings of Japan Earthquake Engineering Symposium, 1966,
Oct., 1966, pp. 215–220.

Abstract

Recently, G.V. Berg and D.A. DaDeppo tried to analyze the structure having rigid plastic joints. The authers have extended the Berg's method to the frame structure having elasto-plastic joints. Moreover, extending the method, we evaluate the influence of axial forces on the dynamic behavior of the frame structure in this paper.

Two kinds of such a detailed structural model of a three-storey, one-bay frame structure of which restoring force characteristics can be expressed in terms of the dynamic characteristics of the elasto-plastic joints and the elastic members, are considered. One model corresponds to the case where axial forces are neglected and the other corresponds to the case where axial forces are considered to be represented by the so-called base shear coefficient, $s=0.3$ or $s=0.1$. The structural models are supposed to be undamped systems with mass distribution, $\{m\}=\{1\}$ and with 0.6, the ratio of the elastic limit strength of beam to that of the column. Two types of acceleration wave form are considered as typical excitation patterns for the structure. One type is a cosine wave having its duration coincident with the fundamental natural period of the structure. The other is the normalized nondimensional time function of the typical earthquake acceleration record.

As a result of the numerical solution, the following remarks are obtained.

(1) On the responses related to the comprehensive aseismic safety of the structure (for instance, relative displacements or total dissipated energy), the influence of axial forces of frame members is not so remarkable. The reason is that the influence of the interaction between bending moment and axial force on the responses may be cancelled by the symmetry of the structure. On the other hand, the responses corresponding to the local aseismic safety (namely, the maximum ductility factor of joints) are much more influenced by axial forces.

(2) The restoring force characteristics of each storey deteriorate through the effect of gravitational axial forces, particularly in the case of the low base shear coefficient. Hence, the unstable behavior of earthquake responses may be found in the case where the dynamic characteristics of joints are perfectly elasto-plastic. However, this unstable phenomenon can easily be excluded by introducing the positive rigidity ratio of the 1st to 2nd branch of the bi-linear hysteretic characteristics of joints.

Dynamical Ground Compliance of Rectangular Foundation on an Elastic Stratum

By Takuji KOBORI, Ryoichiro MINAI and Tamotsu SUZUKI

Proceedings of Japan Earthquake Engineering Symposium 1966,
Oct., 1966, pp. 261–266.

Abstract

In order to investigate the dynamical effects of the soil ground on the earthquake response of structures, some studies have recently been made on the basis of the theory of elastic wave propagation. One of authors presented "Dynamical Ground Compliance" of a rectangular foundation on an elastic semi-infinite medium. This is expressed by the ratio of the displacement of a foundation to a harmonic disturbing force, representing the transfer function of the ground.

In this paper, as the first step towards investigating the dynamical properties of a stratified medium, the analytical expression of Dynamical Ground Compliance of a rectangular foundation on a homogeneous, isotropic, elastic stratum with constant thickness over a semi-infinite rigid medium is obtained by a method similar to the case of a semi-infinite medium, for the cases of vertical, horizontal and rotational excitation. The numerical evaluation is carried out for the vertical and rotational excitation.

Two types of boundary conditions at the surface between a stratum and a rigid medium are considered; one of them permits of a free-slide at the boundary surface horizontally, and the other does not. And the numerical results under these conditions are compared with a semi-infinite case.

The following remarks can be made about the characteristics of Dynamical Ground Compliance.

(1) As for the distinguishing differences between a stratum and a semi-infinite medium, we can indicate, first of all, that in the case of a stratum there are three kinds of resonant frequency, corresponding to the natural frequency of an equivalent rod with the same length and similar end conditions as the stratum, to the zero group velocity of some vibration mode, and to the common phase velocity of distinct modes.

(2) Secondly, it can be found that, in the range of low frequency, the diffusive energy, caused by the waves propagated from a source to infinity, is extremely small in the case of free horizontal slide at the boundary, and does not exist in the other case.

(3) Dynamical Ground Compliance for the stratum having a larger thickness in comparison with the width of a foundation, is similar to that for a semi-infinite medium except in the vicinity of resonant frequencies. This result may suggest that such a stratum can be treated as a semi-infinite medium, if the two main aspects mentioned in (1) and (2) are taken into consideration.

The Effect of Ground Compliance on Earthquake Response of Elasto-Plastic Structure

By Takuji KOBORI, Ryoichiro MINAI, Yutaka INOUE and Teruo KAMADA

Proceedings of Japan Earthquake Engineering Symposium, 1966,
Oct., 1966, pp. 267–272.

Abstract

It has been recognized, in general, that the dynamic characteristics of the ground have the effect on the earthquake response of a structure. So it is important and necessary to estimate reasonably the effect of the ground on the dynamical behavior of the structure during earthquakes.

One of the authors has introduced Dynamical Ground Compliance derived theoretically from the relationship between the applied force and the displacement of the rigid foundation on a half-space elastic ground. Dynamical Ground Compliance is expressed as the function of the shape of the foundation, the density and elastic constants of the ground and the frequency of excitation.

In order to obtain the earthquake response of a structural system coupled with the ground, it is difficult to use directly the integral expression of Dynamical Ground Compliance which has been evaluated numerically in various cases. In this paper, we adopt the approximate expression of Dynamical Ground Compliance in the case of horizontal translation assuming as a rational transfer function of the 2nd order. The dynamic system considered includes the nearly rigid-plastic boundary layer which means the sub-soil surrounding a sub-structure. Supposing the bilinear hysteretic restoring force characteristics of the above-ground structure and the boundary layer, the nonlinear transient response of the structure-ground system subjected to the horizontal ground acceleration is analyzed in the wide parameter range by means of an electronic analog computer. As the wave shape function of the ground acceleration, a random time function obtained from a nose generator is adopted here.

The general tendency of the effect of system parameters on the maximum relative displacement responses of the above-ground structure, the boundary layer and the elastic ground are mentioned as follows: Generally, the responses of the coupled system depend mainly on the strength and frequency parameter of the ground acceleration, but the response of the boundary layer is particularly influenced by the mass ratio of the sub-structure. When the mass of the sub-structure becomes larger compared with that of the above-ground structure, large plastic behavior occurs at the boundary layer, which makes the response of the above-ground structure small. On the other hand, it becomes large when the mass ratio of the sub-structure and elastic ground is large, because of the small damping effect of the ground. The response of the elastic ground increases as the stiffness of ground decreases.

Dynamical Characteristics of Structure of Rectangular Foundation

By Takuji KOBORI, Ryoichiro MINAI, Tamotsu SUZUKI
and Kaoru KUSAKABE

Proceedings of Japan Earthquake Engineering Symposium 1966,
Oct., 1966, pp. 273–278.

Abstract

In this paper, the dynamical characteristics of both a continuous shear and bending type structure on an elastic ground are investigated, considering Ground Compliance for horizontal translation and for rotation about a horizontal axis of its foundation. Ground Compliance is equivalent to the transfer function of the ground.

It is assumed that the structure has a rectangular foundation and that the harmonic horizontal waves propagated through the ground are incident upon its foundation vertically. In the case of Poisson's ratio of the ground, $\nu=1/4$, amplitude and phase characteristics for the translational displacement at the top and base of the structure are shown in figures respectively. And also the fundamental period elongation of this coupled ground structure is shown in graphical representation in comparison with the uncoupled structure fixed on the ground.

Thus the following considerations are presented:

(1) In general, both a continuous shear and bending type structure have similar dynamical characteristics, for instance, the resonance phenomenon occurs many times and the value of amplitude characteristics at resonant frequency is much larger for the fundamental natural frequency than for the higher.

(2) Although, in the case of an uncoupled structure, the amplitude at resonant frequency is infinite, it is finite through the damping effect of the ground in the case of a coupled structure. And the resonant frequency of the latter case becomes smaller than that of the former.

(3) In the case of the translation of foundation, only the phenomenon of dynamic absorber exists, but such a phenomenon no longer occurs, when the rotation is added to the translation of foundation.

(4) Phase characteristics of the translational displacement at the top of the structure vary rapidly in the neighbourhood of resonant frequency from in-phase to out-of-phase or from out-of-phase to in-phase with reference to the phase of the ground motion. On the other hand, phase characteristics of the translational displacement at the base vary from in-phase to out-of-phase in the vicinity of the resonant frequency, and then back to in-phase again before reaching 180 deg out-of-phase.

(5) As the ratio of the height of the structure to its width becomes larger, the fundamental natural period of coupled ground structure becomes longer for the continuous shear type structure, but shorter for the bending type structure, if the ratio of distortional wave velocity of the structure to that of ground remains constant.

On Response Characteristics of a Two-Storey, Reinforced Concrete Building to Matsushiro Earthquakes

By Takuji KOBORI, Ryoichiro MINAI, Yutaka INOUE,
Yoshihiro TAKEUCHI and Teruo KAMADA

Proceedings of Japan Earthquake Engineering Symposium 1966,
Oct., 1966, pp. 297–302.

Abstract

It is very important for earthquake engineering to make clear the characteristics of earthquakes and the dynamic properties of a coupled ground-structure system by means of the observation of responses of ground and structure during earthquakes. For the purpose of a study on the earthquake response of the coupled ground-structure, we observed the responses of a two-storey, reinforced concrete building structure and the neighbouring ground motions.

Lots of records obtained by the simultaneous measurement of earthquake ground motions and responses of the structure are digitalized by an analog-digital converter. And, from the Fourier transform of these digitalized response data, power spectral densities are calculated by a digital computer. Also for so many earthquake responses of the ground and structure, velocity response spectra are calculated by an analog computer.

As the results of these spectral analyses, several obvious remarks concerning the dynamic characteristics of a coupled ground-structure system can be pointed out as follows: (1) the coupled system seems to have a fundamental natural period of about 0.15–0.3 seconds, (2) during main shocks, the lower modes of rocking vibration seem to be predominant over the other vibration modes of the coupled system, (3) in the case of the felt earthquake of strong intensity, the maximum amplitude of the absolute velocity response of the structure is 0.7–1.2 times that of the ground, (4) on the other hand, the ratio of the maximum response amplitude of the structure to the ground is somewhat small in the case of a micro earthquake, (5) the coupled system may have a large damping factor, because all of the responses of the structure become similar to the response on the ground located three meters away from the structure, (6) the coupling effect on the ground of the structure may be negligible if the distance away from the structure is more than thirty meters.

On Anti-Seismic Test of Structure

By Takuji KOBORI

Proceedings of Japan Earthquake Engineering Symposium, Oct., 1966,
pp. 491-496.

Abstract

It is very important for us to evaluate the earthquake resistance of structures making use of the dynamic test procedures, because the theoretical research on anti-seismic design is, essentially, within the non-empirical or semi-empirical framework for lack of useful imformation on strong earthquake ground motions.

First of all, the author discusses the general topics concerning the anti-seismic test: test programing, selection of test procedure, excitation and measurement techniques, data analysis and its evaluation. In particular the difference in test procedures between the practical use of the anti-seismic structural design and the development of the theoretical study is pointed out herein.

Secondly, each problem specified by the test objectives is discussed. To obtain information about the dynamical characteristics of the structure such as its damping factors, natural periods and vibration modes in the elastic range, forced vibration tests applying the vibration exciter to the structure have been carried out during about thirty years. But such tests have not been sufficiently done to estimate precisely the resonance curve from the steady-state test, according to the known theory of the forced vibration. The problem of finding out the restoring force characteristics of the various types of structure should receive so much attention in the elasto-plastic deformation range. Also the determination of the dynamical characteristics of soil ground is attended by many difficulties because of the complex factor of the soil ground condition.

Finally, it is very hard to find an opportunity for measuring the earthquake responses of full-scale structures, although there are more than two hundred strong motion seismographs located at the basement of large-scale building structures. It is, therefore, necessary for a solution of this problem that the dynamic test for the response of the small-scale model structure on the shaking table be carried out under various restricted conditions.

On the Observation of the Earthquake Response of a Reinforced Concrete Building and Its Neighbouring Ground, Part 1 and Part 2

By Takuji KOBORI, Ryoichiro MINAI, Yutaka INOUE,
Yoshihiro TAKEUCHI and Teruo KAMADA

Proceedings of the 3rd Japan National Congress for Natural Disaster Science,
Nov., 1966, pp. 188–193.

Abstract

To make clear the earthquake response characteristics of the ground-structure system through the simultaneous measurement of the earthquake response of the ground and the structure, we observed the structural response and ground motion caused by Matsushiro earthquakes which have occurred frequently since August, 1965. The objective structure is a two-storey, reinforced concrete building built on the alluvium and located near the center of Matsushiro Town.

The earthquake responses of the ground and structure were recorded on magnetic tapes. Some typical ones are digitalized among the too many responses recorded simultaneously at several points of the structure, ground and underground. Then power spectral densities are evaluated from the Fourier transform of the digitalized responses. Also, so-called velocity response spectra of earthquake responses of the ground and structure are computed.

In part one of this report, the spectral characteristics of the ground motion are mainly discussed through analyses of the power spectral densities and velocity response spectra, and also the coupling effect on the ground of the structure is considered. In part two of this report, the spectral characteristics of the response of the structure are mainly discussed from these spectral analyses, and, in addition, the dynamic properties of the coupled ground-structure system are considered in comparison with the spectral characteristics of the ground motion.

Obvious remarks are pointed out as follows: (1) the frequency range of 9–12 cycles per second is predominant in the spectrum of the horizontal component of the ground motion during the main shocks, and the vertical component seems to be a random noise in the wide frequency range, (2) the structure vibration may have no effect on the response of the ground surface if the measuring point of the ground surface is located at about thirty meters distance from the structure, (3) the coupling system may have a fundamental natural period of about 0.15–0.3 seconds.

Optimum Design of Building Structures for Earthquake Excitations (Part 1)

By Takuji KOBORI, Ryoichiro MINAI, Yutaka INOUE and Toshiharu HISATOKU

Proceedings of the 3rd Japan National Congress for Natural Disaster Science, Nov., 1966, pp. 194–197.

Abstract

The aseismic design of a structure can be defined as the assignment of reasonable dynamic characteristics to the soil-structural system such that they guarantee the aseismic safety of each part of the structural system and produce a uniform distribution of aseismic safety for a prescribed group of earthquake excitations. As a rule, it is reasonable to design an anti-earthquake structural system according to the elastic, allowable response design method for moderately intense earthquake excitations with large frequency of occurrence, and, at the same time, according to the elasto-plastic, ultimate response design method for very intense earthquake excitations with small frequency of occurrence. Based upon the above-mentioned basic idea, the so-called dynamic aseismic design of a structure proceeds along the following two stages. In the first stage, the reasonable aseismic design data for the preliminary structural design of structures are derived through the earthquake response analyses in a wide range of parameters, by making use of the comprehensive models of structural systems and the corresponding measures of the aseismic safety of a structure. By using these aseismic design data together with other structural design data, the structural elements of an actual soil-structural system are determined according to the conventional static structural design procedure. In the second stage, the aseismic safety of each part of the soil-structural system designed under the specific conditions is reexamined and the local dynamic characteristics of the structural system are improved on the basis of the results of the precise earthquake response analyses by making use of the detailed structural model and the corresponding local measures of aseismic safety concerning the structural elements.

In this paper, the basic procedure for determining the optimum dynamic characteristics which give the pertinent properties of the earthquake responses of structure is discussed in detail. At first, according to the criterion of the uniform distribution of aseismic safety, the measures of the fitness of distributions of dynamic characteristics are introduced. Next, an equation for discriminating the aseismic safety of each part of the structural system is given in a convenient form in order to make use of the results of earthquake response analyses. Finally, taking the economical nature of the structural design into consideration, the method of determining the reference values of the optimum dynamic characteristics is presented. And also, the method of deriving the aseismic design data available to the elasto-plastic structural design from the optimum dynamic characteristics is discussed.

Optimum Design of Building Structures for Earthquake Excitations (Part 2)

By Takuji KOBORI, Ryoichiro MINAI, Yutaka INOUE
and Toshiharu HISATOKU

Proceedings of the 3rd Japan National Congress for Natural Disaster Science,
Nov., 1966, pp. 198–201.

Abstract

In this paper, the process of the aseismic design of an actual tall building structure according to the basic idea described in the preceding paper is discussed. Several kinds of twenty-four-storey frame structures designed by using appropriate aseismic design data are considered, and by comparing the earthquake responses of these frame structures with each other, the most appropriate frame structure is found.

The model of the structures is supposed to be a seven-degrees of freedom, shear type system with internal viscous damping and with bilinear hysteretic characteristics, and the earthquake excitation patterns used are the nondimensional wave-shape functions of the two perpendicular components of the El Centro Earthquake, California, May 18, 1940. Taking the ductility factor of the storey as the measure of aseismic safety, the elasto-plastic response analyses are carried out by means of an electronic analog computer.

From the standpoint of the uniform distribution of aseismic safety, a few kinds of reasonable dynamic characteristics are selected, by using the measures of the fitness of dynamic characteristics which are expressed in terms of the statistical quantities concerning the earthquake responses. Based on the results of the earthquake response analyses concerning these adoptive structural systems, the standardized average value of the maximum ductility factor is determined as the linear function of the velocity amplitude parameter of the nondimensional excitation pattern. Then, on the basis of the maximum value of the maximum ductility factors in the system which can be estimated in terms of one of the measures of fitness of dynamic characteristics and the above-mentioned standardized average value of the maximum ductility factors, the aseismic safety of the structural system is examined. The reference values of the dynamic characteristics can be determined from the standpoint of the assurance of aseismic safety of every part of the structural system for the prescribed earthquake excitation group. Finally, the optimum dynamic characteristics are find from the several frame structural systems considered by making use of a measure, obtained from the consideration of its economy, which is expressed in terms of the distribution coefficients of the dynamic characteristics and their reference values.

On the Horizontal Resistance of Wing-Walled Caissons

By Hisao GOTO, Kyoji NISHIKAWA (JNR), Takashi AKIYOSHI
and Hajime EGUCHI

Proceedings of the Eighth Japan Congress on Highway Engineering,
April, 1966, pp. 564–567.

Abstract

A wing-walled caisson consists of a caisson of common type with wing walls attached to it to improve the horizontal resistance as a foundation construction without increasing the size of the main part of the caisson. This study has been made on the earthquake resistance of wing-walled caissons. Model tests, prototype tests and discussions on formulas to calculate the horizontal resistance have been carried out, from which the following conclusions have been derived:

(1) It has been found from static model tests in dry sand that the horizontal resistance of a wing-walled casison is very close to that of a usual circular caisson with diameter equal to the total width of the wing-walled caisson (diameter of main part+total width of wing walls), provided that the four wing walls stretch for more than 1/2 of the total depth of the caisson.

(2) From the results of horizontal loading tests on a prototype wing-walled caisson in which strain gages and earth pressure cells had been set, it has been ascertained that the wing walls had hardly been deformed so that they had effectively resisted the horizontal soil reaction, thus providing a hopeful prospect for the usefulness of this type of structure.

(3) There was fairly good agreement between the results of these tests and the formula for calculating the static horizontal resistance of the whole caisson derived in this study with consideration of wing walls.

Wing-walled caissons are considered to have an advantage as an economical type of foundation structure when the surface layer is soft and the base layer to support the vertical loads has a sufficient bearing capacity. However, the penetration resistance during construction at the lower tip of the wing walls can not be neglected, and it is even expected that the construction will become difficult if gravel of large size is sandwiched in the surface layer. It is proposed that investigations be continued in regard to methods of constuction for such cases and to dynamic responses to earthquake motions etc.

On the Earthquake Response of Bridge Piers on Pile Foundations

By Hisao GOTO and Hiroyuki KAMEDA

Transactions of the Japan Society of Civil Engineers, No. 131,
July, 1966, pp. 7–18.

Abstract

This study has been made in an attempt to clarify the earthquake-response characteristics of bridge piers resting on deep pile foundations. A single pier has been reduced to a vibration model with a single degree of freedom which is to be excited by earthquake motions varying with depth through horizontal springs representing the elasticity of the ground. The ground motions at these levels have been calculated with the aid of the theory of the propagation of plane shear waves in elastic or visco-elastic layered media.

From the results of this study, the following conclusions may be derived:

(1) The filter effect of the surface layer on seismic waves is most prominent in the upper half of the interior of the surface layer.

(2) The maximum earthquake acceleration on the ground surface would be 1.3–2.8 times that on the surface of the exposed base layer.

(3) The distribution of the earthquake acceleration in the surface layer is nearly linear when the predominant period of the incident seismic wave is close to or greater than the natural period of the surface layer, and otherwise rather uniform along the depth except that it rises suddenly on the ground surface. The same is true of the mode in which individual pulses in the incident seismic wave are modified.

(4) The bending moments which would occur in the part close to the ground surface of the pile foundation of a bridge pier are determined mainly by the acceleration of the superstructure, while those in the deeper part, say more than several meters deep, of the foundation are dominated by the state of deformation of the surface layer. They may amount, within the range of the numerical computations in this study, to 2–4 times the maximum values obtained from statical computations.

(5) The maximum acceleration of bridge piers on pile foundations decreases as h/d (h: height of pier, d: depth of foundation) increases, and as the relative rigidity E_fI_f/k_1d^3 of the pile to the ground decreases.

(6) The maximum acceleration of bridge piers on pile foundations is approximately 0.4–1.0 times that of piers with rigid foundations depending on E_fI_f/k_1d^3, h/d, and the natural period of the pier.

Generation of Artificial Earthquakes on a Digital Computer for the Aseismic Design of Structures

By Hisao GOTO, Kenzo TOKI and Takashi AKIYOSHI

Proceedings of Japan Earthquake Engineering Symposium,
Oct., 1966, pp. 25–30.

Abstract

This paper deals with the procedure for the construction of a random process with an arbitrary power spectrum and performed the comparison with the known properties of real earthquake accelerograms in respect of the velocity response spectrum. The model earthquakes were expressed by a series of harmonic functions in which frequencies were random variable with arbitrary probability density. Then the power spectrum of this process is found by analysis to be similar to the probability density of frequency. From the discussion on the amplitude of this process, it was found that the probability distribution of amplitude would tend to Gaussian distribution for the large number of the superposition of harmonic functions.

A set of fifteen artificial earthquakes were generated on a digital computer by the Monte Carlo method and it was of interest to note that these accelerograms were similar to that of the strong motion earthquake records in spite of quite different frequency characteristics. The ensemble averages of the power spectra were calculated to show the similarity with the probability density of frequency. Because of the similarity of the power spectra and the probability density of these ranndom processes, it is possible to generate artificial earthquakes which have arbitrary frequency characteristics suited to the ground and the structures. Moreover they can provide the ground motion of any desired intensity and duration.

If these artificial earthquakes are to simulate strong motion earthquakes successfully, the velocity response spectra also must agree with those of real earthquakes. So the response spectra were calculated for various damping constants and they had been corresponded with the velocity spectra of real strong motion earthquakes which tend to a constant value for a natural period of structures larger than about 0.6 sec.

From these studies it was concluded that the processes which were generated on the digital computer by the above-mentioned procedure possessed the known properties of real earthquakes and that these artificial earthquakes were useful for structural response analysis.

Mechanical Characters of Mudstone

By Sakuro MURAYAMA and Norio YAGI

Annals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 403–408.

Abstract

In this paper, mechanical characters of mudstone are investigated in relation with propagation velocity of ultrasonic longitudinal and transverse wave through a sample. The natural samples of mudstone obtained from diluvial layers and artificial clay sample highly consolidated isotropically in the triaxial cell were used. A clyndrical specimen has 8.0 cm hight and 3.6 cm diameter. The barium titanate transducers producing ultrasonic longitudinal and transverse wave were used with frequency of 50 kc/sec and 25 kc/sec respectively.

The dynanic elastic constants, namely, Young's modulus, Poisson's ratio, bulk modulus and shear modulus are derived from these velocitis. On the other hand, the uniaxial compression tests were carried out by mean of strain controlled method for natural samples and stress controlled method for artificial clay sample to determine the uniaxial compressive strength and the statical Young's modulus.

The test results are as follows; (1) The large majority of Poisson's ratios are in range between 0.45 and 0.50. (2) Generally, dynamic Young's modulus E_d is larger than static one E_s. The relationship between E_d and E_s for artificial sample can be expressed by straight line through the origin and the ratio E_d/E_s equals to five, while it is scattered for natural samples of mudstone. (3) The relationship between uniaxial compressive strength and dynamic shear modulus of any kind of samples can be expressed by straight lines through the origin.

Consequently, magnitude of propagation velocity of ultrasonic transverse wave has close relation with mechanical characters of mudstone.

Swelling of mudstone due to sucking of water

By Sakuro MURAYAMA and Norio YAGI

Proceedings of the First Congress of the International Society
of Rock Mechanics, Vol. 1., October, 1966, pp. 495–498.

Abstract

It happens occasionally that new slopes or tunnel walls fail due to swelling of mudstone or claystone in consequence of water sucked. In this paper, various mechanisms of such failure were investigated, and their cause can be classified into the following 3 main cases:

1) Deviatoric stress may be generated in the mudstone or claystone due to the anisotropical expansion caused by the sucking of water. In order to examine the hypothesis stated above, some samples of mudstone from the diluvial layer and claystone belonging to Paleozoic era were tested. In these tests, it was shown that the swelling strain perpendicular to the bedding is larger than that parallel to the bedding. Accordingly, if the stress on the mudstone or claystone is decreased under a nearly confined state, the stress generated in the stone becomes anisotropical.

2) The failure of the structure of the rock may be caused by the local unequal expansion of the minerals contained and fine seam of different materials when the rock sucks water. To observe such phenomena, micrometric local expansive deformation was measured by means of a microscope.

3) The failure of the stone may occur in consequence of ununiform swelling due to the unequal distribution of sucked water.

Some Problems on Ground Exploration

By Soji Yoshikawa, Michiyasu Shima and Noritoshi Goto

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 99–110.

Abstract

Seismic prospecting using P and SH waves and an electric survey (resistivity method) were carried out in the eastern section of Osaka, where the surface layers of the ground are composed of silt and silty sand and the basic layers are composed of sandy gravel. The method used for the generation of SH waves was to strike horizontally a wooden plate pressed down on the ground surface with a hammer. Surface geophones were set along a line perpendicular to the direction of the strike. The ground structures obtained in this region were expressed by the propagating velocities of P and S waves (V_p, V_s), the attenuation constant of S wave (α) and the specific resistivity (ρ), and were compared with those of the boring data, i.e., values of N (penetration index) and other results of soil tests. Thereafter, methods for estimating how the dynamic characteristics of the ground used as the foundation of the structure are correlated to the propagating velocity, the attenuation constant and the specific resistivity of the ground were discussed from the earthquake engineering point of view. As the soils in this region were saturated with water below the level of several meters in depth, the velocities of the P wave were nearly constant and of the order of 1000 m/sec from this level to 20–40 m in depth, and then the boundary between the silty surface layer and the basic layer could not be revealed by the velocities of the P wave. The velocities of the S wave were 70 m/sec$\sim$150 m/sec in the surface layer and 230 m/sec$\sim$400 m/sec in the basic layer, and the latter values corresponded to coarse sand or sandy gravel and the N values were more than 30. The attenuation constants of the S wave decreased abruptly from the surface layer to the basic one.

In conclusion, the propagating velocity of the S wave was found to be closely connected with the strength of the soils and proved to be an efficient physical constant for obtaining the depth of the layer forming the floor of the basin and the rigidity of the composing material.

Vibrational Characteristics of the Ground from the Observation of Natural Earthquakes and with the Use of an Oscillator

By Soji Yoshikawa, Michiyasu Shima and Kojiro Irikura

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 119–136.

Abstract

Investigations on the vibrational characteristics of the ground chosen as construction sites have been carried out through the observation of earthquakes on the ground surface. When the foundation of the structure is set deep below ground, the amplitudes and the phase differences along the vertical line from the surface will be required and hence it is necessary to investigate the vibrational characteristics underground.

And when an oscillator is used as the disturbance origin, the frequency characteristics of the source are relatively controlled and hence the predominant period of the ground can be conveniently obtained. However, the wave in this case is spherical and not a plane wave as is the case with an earthquake wave. It can be presumed that the vibrational characteristics will be clarified when the origin is designed so as to emit SH type waves, even though the method will be indirect.

In view of the above, the vibrational characteristics of the ground were examined experimentally by means of natural earthquakes and oscillators.

The experiments were carried out at Fukui Pref. where the seismographs were set at ground surface and in the pit and the drift which were 10–40 m below ground.

From the seismographs, Fourier components were obtained by an IBM 7090 computer and the spectra were compared with those of the oscillator, and the theoretical results were obtained by the calculation of multiple reflections of the wave corresponding to the geological structure obtained by the seismic prospecting and boring data.

The ground structure was rather complicated; however the amplitude and phase distributions at each measuring point (on the ground surface and in the drift) coincided well with that of theoretical calculation in regard to ground structure and the spectrum of the place.

Generally vibration tests are generally considered to be very difficult because of the distortion of the wave form, the vibration of a higher mode caused by the rocking motion of the oscillator and the inefficiency of instruments. But in this experiment the instruments were set firmly onto the base and with the improvement in their efficiency a very good sine wave was obtained.

Reflection of SH Waves on Unsettled Ground

By Noritoshi GOTO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 111–117.

Abstract

It is required to investigate the local characteristics of layered media, consisting of a few discrete layers from the point of view of the earthquake-proof capacity of unsettled ground, with which rigidities of near-surface layers are closely connected.

A few seismic explorations by refraction and reflection methods of SH waves were carried out in East Osaka, where paddy-fields and ponds were recently reclaimed and assimilated into urban development. Artificially generated seismic waves provide information as to the rigidity of shallow layers for engineering purposes. One of the available methods for genenting SH waves is to strike a wooden plate pressed down on the ground surface with a hammer in the direction parallel to the plate surface. Surface geophones along a line perpendicular to the force register horizontally polarized shear waves. A means of exerting a localized force at the surface of the ground will generate shear waves in this manner, and the detection of these waves at different distances along the surface will give shear speeds and the ground structure in shallow reflecting layers. Regarding the refraction method, however, it is difficult to catch head waves from deep layers because an SH wave does not propagate for a long distance by this method. Using the reflection method, it is possible to obtain information from deeper layers.

Generally it is difficult to obtain reflection waves from a shallow layer because of the interference of noise waves such as critically refracted waves and surface waves. However, if the subsurface of the unsettled ground is laminated with a layer of high rigidity, such as a road passing through paddy-fields, SH waves propagating in the first layer will be transmitted in the second layer, though they will never come back to the upper layer as critically refracted waves, and Love waves do not travel since the shear speed of the upper layer is higher than that of the lower layer. So it is possible with comparative ease to separate reflection waves on the remainder of the recorded trace. Some records containing reflection waves were successfully obtained on the unsettled ground in East Osaka. Field experiments in this manner give promise of future application.

Internal Constitution of the Earth

By Haruo MIKI

The Jorunal of the Geological Society of Japan,
Vol. 71, No. 843, December 1965, pp. 574–581.

Abstract

There are two sources from which the seismic wave velocities are derived. One is the travel-times of seismic body waves and the other is the dispersions of surface waves. Neither can give a unique solution to the problem of the distributions of seismic wave velocities. The solutions obtained differ only in their small, but important, portions depending upon the choice of materials, the mathematical method, etc.

The equation of WILLIAMSON-ADAMS does not consider the superadiabatic temperature gradient. The calculation based upon the finite strain theory is not always reasonable from the physical background. Furthermore, the earth's mantle contains inhomogeneous regions. These circumstances make it difficult to estimate the density distribution within the earth.

Physically, if we know the equation of the state of the material composing the earth's interior and one of the thermodynamic elements, we can know the physical state of the earth's interior. The efforts in this direction are guided by the high pressure and high temperature experiments of materials and rocks, and by the theoretical investigation of the chemical composition of the earth's interior.

The main object of the former is to determine the elastic and thermodynamic properties of minerals and rocks under high pressure and high temperature, and that of the latter is to determine the equilibrium constitution within earth that is composed of abundant elements.

The Volcanic Crustal Deformation

By Keizo YOSHIKAWA

Bulletin of the Volcanological Society of Japan 10th Anniversary Volume.
December 1956, pp. 110–118.

Abstract

In order to detect revertible deformation, a temporary survey of precise levelling and routine observations using tiltmeters or extensometers are carried out in the vicinity of volcanoes. In this paper, some interpretations of the results of precise levellings in the Sakurajima volcano and the modes of abnormal tilt before the eruption in some volcanoes are introduced and discussed.

1) discussions on the results of precise levelling.

In the 1914 eruption of the Sakurajima volcano, great subsidence occurred in its vicinity. Many investigators studied this phenomenon from various standpoints. There is a incompatible point in their treatment of the results of precise levellings, although each analysis approximately satisfied the mode of crustal deformation. These treatments can be divided into two groups, those that analyse the great subsidence as the tilt motion of rigid ground blocks and those that analyse it as the half-infinite elastic deformation of the earth's crust. But at the present time we can not determine which of them is correct.

Looking into the time change of the vertical displacements of bench marks in Aira caldera, great subsidence in the 1914 eruption was revertible deformation according to the change of the under-ground state, but it seems that even today it has not perfectly recovered its pre-1914 state. For this reason, some investigators maintained that the elastic subsidences caused by small eruptions after 1939 partly veiled the recovering upheaval after the 1914 eruption because the recent precise levellings were carried out just after the small eruption, others maintained that a part of the subsidence in the caldera remained as permanent deformation because a slip down at the caldera rim took place at every eruption.

To avoid this discrepancy, it is necessary to repeat the surveys frequently and to obtain the data of precise levelling just before the eruption.

2) discussion on the tilt observation.

Abnormal tilts of the ground surface have sometimes been observed before eruptions, and give us a clue in predicting them. But the direction of the abnormal tilts was different for each volcano. These differences would depend on the character of the place in which the tiltmeters were set rather than the type of activity of each volcano. Therefore, to estimate the underground state of a volcano by these observations, it is necessary to set tiltmeters in a place where the local gound motion is as small as possible.

Seismic Observation at Volcano Sakurajima (5)

By Keizo YOSHIKAWA and Kiyoshi NISHI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 47–54.

Abstract

Since 1962 when the Sakurajima Volcanological Observatory was established in order to study the predictability of volcanic explosions, tripartite seismic observations using the wire-telemetric method have been continuosely carried out. In previous papers, the nature of some volcanic earthquakes and some forerunning phenomena of volcanic explosions were reported.

To prevent volcanic disaster, it is desirable to predict the volcanic explosion as early as possible. So, in this paper, in order to predict a volcanic explosion one day before it occurs, the vulnerability rates of explosion are calculated from the daily frequencies of volcanic earthquakes at Sakurajima using the same methode as that as Dr. Minakami used at Asama volcano. But vulnerability rates do not indicate an increase corresponding to an increase of the number of volcanic earthquakes as they did for the Asama volcano. This means that this method is not so effective for the Sakurajima volcano at the present time. Only one useful result is that the explosion never occurs on the following day when the number of volcanic earthquakes for five successive days is less than a hundred.

Since Sept. 1963, the number of observed volcanic earthquakes amounts to 3×10^4, so Ishimoto-Iida's empirical formulae are examined for these earthquakes. At the nearest station from the active crater, the maximum amplitude and frequency relation is not expressed by a linear line in either logarithmic scale graph, but by an upward concave or a bent line. On the other hand, at the other two stations where small amplitude earthquakes at the nearest station died out because they were at a distance from the active crater, the maximum amplitude and frequency relation is expressed by a line. This fact implies that the maximum amplitude and frequency relation at the origin of earthquakes should be not expressed by a linear line in either logarithmic scale graph.

On the Observations of the Long Period Oscillations of the Earth by Means of Extensometers and a Water-tube tiltmeter

By Izuo OZAWA and Tsuneo ETO

Bulletin of the Disaster Prevention Research Institute
Vol. 15, No. 93, Nov. 1965.

Abstract

We performed observations of the Earth's free extensional oscillations with highly sensitive extensometers at Osakayama Observatory, Kishu Mine and Suhara Observatory at the time of Chilean, Alaskan and Aleutian Earthquakes. We also observed the tilting's oscillations with a water-tube tiltmeter at Osakayama during Aleutian Earthquake.

We were able to note remarkable oscillations at ten minutes period in all these extensograms during these earthquakes, and those of about thirty and sixty minutes which are in the same phase shift for a short time after Aleutian Earthquake. We also noted oscillations for six minutes in the tiltgram during Aleutian Earthquake.

We have carried out the analyses of these variations and obtained their power spectra from their auto-correlation functions which had been calculated by means of the geometrical method.

According to our analyses, the extensional oscillations of the multiples of about ten minutes are dominant on these extensograms, and ones of about six and eleven minutes are dominant on the tiltgram. And the periods of the tilting oscillations seem to have been longer with the lapse of the time.

A Recording Water Tube Tiltmeter

By Tsuneo ETO

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 15, Part 3, No. 98, March 1966, pp. 21–33.

Abstract

Water tube type Tiltmeters which measure the respective elevations of points of the earth's surface are indispensable for the measurement of secular tilting movements of the earth's crust. In this paper, the writer discusses his development of a recording water tube tiltmeter with a long distance between two water reservoirs installed in an observation tunnel under the ground.

In order to record continuous information on volcanic crustal deformations in the vicinity of Volcano Sakura-jima, one component recording water tube tiltmeter was installed in the undergound tunnel at the Hiyamizu observation station which belongs to the Sakura-jima Volcanological Observatory.

The recording methods of the change of level in the water surfaces of the apparatus are divided into two groups: instruments with visual point readings by micrometers, and instruments with continuous recordings by optical methods. A hardened vinyl chloride tube with an inside diameter of 16 mm and 45 meters in length serves as the water tube. On both side of the water tube, a compensating reservoir and a recording pot are attached. The compensating reservoir is a stainless steel tub of 50 cm in diameter. On the other hand, the recording pot is a glass pot which is 12 cm in diameter. On the water surface of the recording pot, a glass float, 8 cm in diameter, is suspended by a counter-balance with super invar wire of 50 micron in diameter. This wire is hung over a pulley. Continuous optical recordings of the change of level in the water surface are given by a recording mirror which is mounted on the pulley axis.

It is possible to control the sensitivity of the water tube tiltmeter on the recording photographic paper by changing the optical magnification in various methods. The sensitivity of the recording water tube tiltmeter at the Hiyamizu station can be changed to 0.0069 second/mm, 0.011 second/mm and 0.013 second/mm by the diameter of the pulley. Good results were obtained when this water tube tiltmeter was set in an underground tunnel where the effects of the atmospheric pressure gradient and the temperature change were few.

Volcanic Crustal Deformations (II)
—On the Anomalous Tilting Movements Accompanying the Explosions of Volcano Sakura-jima—

By Tsuneo ETO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March 1966, pp. 83–98.

Abstract

Magmatic pressures associated with volcanic activity, in addition to causing volcanic earthquakes, can produce a change of level and marked tilting of the earth's surface near the volcano. This aspect of volcanic behaviour has received particular attention from volcanologists because of its value as a prediction aid.

Besides repeated precise levellings, continuous registrations of volcanic crustal deformations are being carried out at Volcano Sakura-jima. Tilt measurements by means of horizontal pendulum type tiltmeters have been carried out for many years at the Kita-dake and the Haruta-yama stations which are located on the flank of Volcano Sakura-jima. In this paper, abnormal tilting movements recorded at the Kita-dake and the Haruta-yama stations accompanying the volcanic explosions of Minami-dake crater were analyzed during the period from October, 1963 to October, 1965.

The greater part of the anomalous tilting movements recorded at the Kita-dake station showed sudden commencements of particular north-eastward dips prior to the volcanic activity. Abnormal tilts measured at the Haruta-yama station also showed the same tilt pattern in a northern direction. Some features of the vector diagrams showing azimuth and rate of tilt observed at the Kita-dake station were studied during each period of abnormal tilts. Once the abnormal tilting movements began, the azimuth of the tilt vectors at the Kita-dake station changed their direction abruptly to the north-eastward and retraced their steps to the south-westward. In many cases, volcanic explosions at Minami-dake crater occurred near the points where tilt vectors changed their course to the south-westward. The daily velocity of abnormal tilts showed fairly close correlation with the volcanic activity. There were many cases where the daily velocity of abnormal tilts reached their maximum value a few days before the coming volcanic explosions. The maximum daily velocity of abnormal tilts at the Kita-dake station exceeded 1.5 second in angle per day.

There were 117 volcanic explosions in the Minami-dake crater during tilt observations from October, 1963 to October, 1965. We were able to observe abnormal tilting movements in the cases of 106 explosions out of 117, but we could not observe anomalous tilt in eleven cases. It was with 90.6% of the explosions which occurred during tilt observations that the abnormal tilting movements were registered on the tiltgrams at Volcano Sakura-jima.

High Sensitive Seismometric Observation Near the Crater of Volcano Sakurajima (Part 1) —On the Initial Motion of B Type Volcanic Micro-earthquake—

By Kiyoshi NISHI

Bulletin of the Volcanological Society of Japan, Vol. 11, No. 2, Sept, 1966, pp. 84–92.

Abstract

It is generally recognized that in the vicinity of the active crater of a vulcanian type volcano, there occur so-called B type volcanic micro-earthquakes. Many investigations about the nature of the B type earthquakes have been come out, but its mechanism remains unsolved. To study the mechanism of the B type earthquake, one of the most useful method is to collect knowledge about the geographical distribution of the initial motion. And judging from the nature of the B type earthquake, high sensitive seismometric observation near the crater is indispensable so as to record its initial motion.

From this view point, the author has begun a preliminary observation at the two stations near the crater of volcano Sakurajima. Seismic signal from the SH-II type electromagnetic seismograph is amplified with the transisterlized preamplifier, and recorded on magnetic tape with a PWM modulation 6 channel data recorder (TEAC R-1500). Reproduced seismic signal from the data recorder is recorded finally on photographic paper with an electromagnetic oscillograph. Maximum magnification of the seismograph system is about 2×10^5 times at 15 c/s.

The results obtained through the observation are as follows. At No. 1 station which is 1,600 m away from the active crater, some initial motions of B type earthquakes were recorded clearly, but at No. 2 station which is 2,700 m away from the crater, the initial motions were observed vaguely. This remarkable attenuation is attributed to the small magnitude of the B type earthquake, the shallow origin, and the large attenuation coefficient of the constituent substance of the volcano. The direction of initial motions at No. 1 station are not uniform, that is some are upward and others are downward. This fact seems to suggest that the mechanism of the B type earthquake and that of the explosion earthquake are not of the same nature, because at Asama or Sakurajima, when the initial motions are clear, the explosion earthquakes always begin with upward phase.

Volcanic Earthquake

By Akira KUBOTERA

Bulletin of the Volcanological Society of Japan 10th Anniversary
Volume 1965, pp. 91–99.

Abstract

The characteristics of earthquakes originating from volcanoes which have been obtained by many investigators were summarized.

Those earthquakes are classified tentatively into *explosion-earthquakes, volcanic-earthquakes* and *volcanic micro-tremors.*

The *explosion-earthquakes* occur almost simultenaously with the outburst of the volcanoes of Vulkanian type. Therefore it is generally concluded that such earthquakes are generated from the mechanism of a single positive force. However, there are the examples having a mechanism of tension-cracking type.

The *volcanic-earthquakes* are the small swarmed earthquakes occurring in a limited region in the volcanic distrcit and closely related to the activity of volcanoes. There are different kinds. One is the A-type earthquake. Its focal depth is not extremely shallow (1∼10 km) and the wave form on the seismogram is similar to that of a shallow earthquake of tectonic origin. Another one is B-type occurring in the limited region beneath the active crater.

The *volcanic micro-tremors*, customary called, include following various kinds of tremors. In the case of Strombolian or Hawaiian type eruptions, they follow the tremors originating from these frequent eruptions. On the other hand, there are non eruptive kind of tremors originating from the very small earthquakes beneath the active crater. And the tremors generating from the free vibration of magmatic chamber or column of lava and so on, are also found.

The B-type earthquake or the volcanic micro-tremor are mainly composed of the seismic surface waves (Rayleigh or Love-type) which have been guided from the layered structure in the volcanic district, hence they have their own characteristic period.

Such various kinds of volcanic earthquakes can be classified in the following three categories according their mechanisms of occurrence or origins of vibration, i.e. (1) The deeper earthquakes of volcannic origin (A-type), (2) Non eruptive earthquakes such as B-type one or some of the tremors originated from very small earthquakes, and explosion earthquakes occurring at shallow depth, (3) The tremors generated by the vibrations of magmatic chamber or column of lava and so on.

A Gravity Survey on Aso Caldera Kyushu District Japan (I)

By Akira KUBOTERA and Norihiko SUMITOMO

Special Contributions, Geophyscical Institute, Kyoto University,
No. 5, 1965, pp. 139–150.

Abstract

On Aso Caldera, gravity surveys have been made by using a Worden gravimeter from 1964 to 1965, in order to investigate the problem, whether there exsists or not a cecular change in gravity value connected with volcanic activities, and to get clues for figuring out the subterranean structure of this caldera.

In this paper, the gravity values observed at each station and the distribution of Bouguer anomalies are reported.

The distribution of Bouguer anomalies shows that the low gravity anomaly decreasing toward the center of the caldera is very conspicuous. The iso-anomaly contour lines conform to the caldera shape, and the relative anomaly at the center of Aso caldera to the neighbour amounts to about –20 mgal. This fact shows that Aso caldera is characterized by strong negative anomalies in contrast to the outer somma part and it can be classified as "low anomaly type caldera" such as Kutcharo caldera lake or Aira caldera of the so-called Krakatau type.

Comparing the gravity values obtained by the present surveys with the ones obtained by the Earthquake Research Institute in 1964 and by the Geographical Survey Institute in 1959, it is concluded that there was no significant secular change in gravity value during the period from 1954 to 1964. And further discussions on atmospheric pressure and temperature effects on the Worden gravimeter are made.

Volcanic Micro-Earthquakes at Mt. Aso (I)

By Shigetomo KIKUCHI and Mikio SAKO

Bulletin of the Volcanological Society of Japan, Series II, Vol. 11,
No. 2, September, 1966, pp. 59–71.

Abstract

In summer 1963, six 14 c/sec vertical pick-ups were set around the crater and volcanic micro-earthquakes were observed. Because of the disturbance from volcanic micro-tremors, it is difficult to find the initial P waves of micro-earthquakes recorded near the crater. Tomoda's method was applied to obtain the crosscorrelation function between P wave portions of micro-earthquakes recorded at two adjoining stations and hypocentres were determined. The energy spectra of P wave portions of micro-earthquakes were calculated making use of the same method.

The results obtained are summarized as follows:

1) Volcanic micro-earthquakes were observed every few seconds at their most active period. Their focal depth was about 500 m and corresponding to these micro-earthquakes the fourth kind micro-tremors, the period of which was about 0.2 sec, were recorded. It has been ascertained that volcanic micro-tremors are generated by micro-earthquakes occurring near the crater. Accordingly, when the focal depth of the micro-earthquake is about 500 m the fourth kind micro-tremors are predominantly generated. Since the micro-earthquakes occur every few seconds, the generation of continuous micro-tremors can be explained by swarmed micro-earthquakes.

2) The distribution of the initial P wave motion of micro-earthquakes seems to indicate the quadrant type.

3) The frequency at which the maximum value of the spectrum is found varies regularly around the epicentre.

4) To explain the above-mentioned results, the authors assumed the following conditions and calculated the equations with the method of least squares. Assume that the phenomena mentioned at 3) comes from the Doppler effect of the moving source. Suppose that the fracture occurs at the hypocentre and generating the waves of the same spectrum moves at constant speed in a certain direction. When the speed of the fracture is slow and the duration time of the fracture is not so different from the time of the spectrum analysis, the velocity and the direction of the fracture are easily calculated. The direction is nearly vertical and the velocity is about 1300 m/sec. This result is inadequate for explaining the known facts. Further investigation is necessary.

On the Mechanism of Earthquake Swarm at Hamasaka

By Yoshimichi KISHIMOTO and Michio HASHIZUME

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 16, Part 1, 1966, pp. 41-55.

Abstract

In June, 1965, a microearthquake swarm occurred near Hamasaka, Hyogo Pref.. It was composed of about 70 shocks with two main shocks of M=3.6 and M=3.1, and continued for 20 days. For the purpose of investigating the characteristics of a microearthquake swarm, an analysis of this swarm was made with particular attention being paid to its fine mechanism.

The dimensions of focal domain were estimated as about several hundred meters. The magnitude distribution was very well fitted to the formula, $\log N=\alpha-\beta M$, with $\beta=0.8$. The strain energy which can be sotred in this focal domain does not contradict that calculated by the formula, $\log E=11.8+1.5M$.

This swarm is separated into three sequences, bounded by two main shocks. The focal mechanisms of these earthquakes are considered to differe from one earthquake to another, judging from the different waveform of the respective earthquake observed at any one station, and also from the very confined focal domain abovementioned. About 15 earthquakes out of 70 were well recorded at 4 or more stations. Two methods were utilized to derive the focal mechanism of each well-recorded earthquake, one being an analysis of the amplitude of the initial P motion, and the other an analysis of the S/P maximum amplitude ratio. The latter method gave a consistent result with the former, and therefore the S/P maximum amplitude ratio is considered useful for the investigation of focal mechanisms. From these analyses, the so-called Type II model was considered preferable for the focal mechanism of the earthquakes in this swarm. The focal mechanism of this swarm seems to deviate somewhat from that of earthquakes in this district in a stationary state, that is, the direction of principal pressure in the latter case is nearly east-west, but that in the former deviates counterclockwise by 20–30 degrees. However, it seems gradually to approach the stationary state at the end of each sequence. This variation of focal mechanism may have some relationship to the mode of strain release of the earthquake swarm, as discussed by Benioff.

Investigation of Microearthquakes in Kinki District —Seismicity and mechanism of their occurrence—

By Michio HASHIZUME, Kazuo OIKE and Yoshimichi KISHIMOTO

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 15, Part 3, 1966, pp. 35–47.

Abstract

Observation of microearthquakes in the western part of the Kinki District was carried out at 5 stations attached to the Tottori Microearthquake Observatory. Epicenters of about 200 earthquakes observed during ten months since August, 1964 were determined by a graphical method using the *S-P* interval. The geographical distribution of epicenters shows a particular pattern, in which both seismically active areas and aseismic ones are pretty sharply separated. Seismicity is relatively high in such areas as, for example, the Tamba Belt, near Tottori City, the belt-like zone around Oya station, Rokko Mountains and the Yodo River zone. On the other hand, it is especially low in a few areas such as the circular region of radius of about 30 km around Oya station, the western part of Hyogo Pref. and the neighbouring area of Sasayama, Hyogo Pref.. Focal depths of these earthquakes are mainly distributed from 5 to 15 km, and earthquakes deeper than 30 km were not observed.

The magnitude of these earthquakes was distributed from −1 up to more than 4, and the frequency distribution of earthquakes with magnitude is considered to be nearly the same in respective areas of high seismicity. The Ishimoto-Iida coefficient, m, was examined for the ten months above-mentioned at 4 stations, Mikazuki, Funaoka, Oya and Hikami, and each station gave the value of 2.0.

The distribution of direction of the initial P motion was investigated by a method of the superposition of many earthquakes in a certain seismic active area. The superposed graph of distribution of the initial P direction shows that two push zones are clearly separated from two pull zones by two orthogonal lines, NE-SW and NW-SE. This fact means that almost all microearthquakes in this district are generated by a tectonic force acting in a direction almost due east-west. This circumstance of distribution is the same in cases of larger earthquakes with a magnitude of more than 5, observed at the network of the Japan Meteorological Agency. It is worthwhile to note that all earthquakes in a very wide range of magnitude from 0 to 7 are generated by the same tectonic force irrespective of their magnitude.

A Study on Crustal Structure in Japan by the Use of Seismic and Gravity Data

By Takeshi MIKUMO

Bulletin of the Earthquake Research Institute, the University of Tokyo,
Vol. 44, No. 3, 1966, pp. 965–1007.

Abstract

The crustal structure along 7 profiles in Japan has been discussed on the basis of the results of refraction measurements, the correlation between computed and Bouguer gravity anomalies and between theoretical and observed phase velocities of Rayleigh waves.

The results show that single-layer crustal models do not seem to be consistent with observed gravity and surface wave data, even if allowance is made for related crustal parameters. Alternative models with double-layered and three-layer crusts have been presented for all the profiles by the re-interpretation of travel time data from explosion observations. The theoretical gravity anomalies and phase velocity curves of Rayleigh waves were computed for the presented crustal models and compared with their observed values. The synthetic comparison favors a three-layer solution for western and central Japan, while two solutions are possible for eastern Japan. The main conclusions obtained by the present analysis are summarized as follows.

The P-wave velocity in the upper mantle may be closer to 8.0 km/sec in all the regions rather than to 7.7 km/sec which was proposed by the R.G.E.S. in their earlier work. It is reasonable to suppose that there may be a lower crustal layer with velocities of 6.5–6.8 km/sec and a thick intermediate layer having a velocity of about 7.4 km/sec, both in western and central Japan. The observations of Rayleigh waves suggest a high Poisson's ratio in the intermediate layer and the upper mantle under central Japan including the Chubu mountain region. In eastern Japan, on the hand, it is not certain whether there is an intermediate layer or not. If it exists, the layer should be much thinner than in the other regions, and Poisson's ratio should have a high value. The gravity anomalies indicate that the average crustal density could be smaller by a few percent in this region. The depths to the base of the lower crust are estimated to be 31–33 km in the Tohoku, 27–32 km in the southeast Kwanto, and 37–40 km in the northwest Kwanto regions (in double-layered models); 30–40 km in the Chubu, 30–35 km in the Kinki, and 25–28 km in the Chugoku regions (in three-layer models), respectively.

The average crustal structure in Japan and North America are compared, mainly on the basis of gravity anomalies.

On the Peculiar Mode of Crustal Movements Accompanied with the Activities of Shallow Earthquakes

By Tokio ICHINOHE and Yutaka TANAKA

Special Contributions of the Geophysical Institute, Kyoto University,
No. 6, December, 1966, pp. 247–254.

Abstract

Since 1937 continuous observations of the crustal movements with tiltmeters and extensometers have been carried out by the members of Kyoto University at the observing stations in Japan, of which the number reaches twenty at present. In these observing stations about fifty tiltmeters and thirteen extensometers are in operation at present. During about thirty years from 1937 to the present there have occurred scores of remarkable earthquakes and innumerable moderate and small earthquakes in and near Japan. Some of these remarkable earthquakes were accompanied with characteristic crustal movements before and after their occurrence.

The analysis of the observational data on the crustal movements before and after the occurrence of earthquakes proved that the characteristic movement of the crust proceeded generally through three stages, in relation to the occurrence of earthquake. In the first stage, the tilting movement of the ground was most prominent in the direction of the horizontal displacement of the ground at the observing station, that is, in this stage, the tilting movement of the ground is considered to be closely related to the operation of a geotectonic force which caused the horizontal displacement of the ground, though the relation existing between the geotectonic force and the earthquake-generating force is an unsolved problem.

In the second stage, the tilting movement of the ground was prominent in the direction towards the epicentre of the earthquake, that is, in this stage, the tilting movement of the ground is considered to be closely related to the accumulation of strain energy in the crust of the focal region. In the third stage, just before the occurrence of the earthquake, the tilting movement of the ground increased its speed or reversed its direction, that is, in this stage, the tilting movement of the ground is considered to be closely related to the rapid creep or forerunning fractures of the rocks in the focal region. After the occurrence of an earthquake, the tilting movement of the ground used to continue until the termination of the activity of the aftershocks. This behaviour of ground movements was especially conspicuous in the cases of shallow earthquakes.

Though it can't be asserted that this kind of crustal movement occurs in all cases of earthquakes, it is certain that some clues for earthquake prediction can be derived from the observational facts mentioned above.

Observations of the Ground Tilt with Highly Sensitive Tiltmeters of Double Horizontal Pendulum Type (Part I)

By Yutaka TANAKA and Masaaki KATO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 69–79.

Abstract

In order to observe the free oscillations of the earth, the earth tides and the anomalous crustal movements before and after earthquakes, tiltmeters of double pendulum type were designed.

This new tiltmeter is composed of two horizontal pendulums coupled with each other. The mass of the first pendulum is 2,271 grams, and suspended by two wires of super invar of 280 microns in diameter. That of the second pendulum is 5.7 grams, and suspended by two extra fine wires of 30 microns in diameter. The end of the upper wire of the second pendulum is fixed to the first pendulum, so that the compound period of the pendulums becomes very long, though the period of each pendulum is short. The magnification of this tiltmeter is expressed as a function of the compound period and that of the second pendulum, $n=17.5\ (T_0T_2)^2$, so it is very easy to obtain a higher sensitivity than that of the tiltmeters of the usual horizontal pendulum type under a stable state.

From the results of the tests carried out in Uji laboratory, it proved that the theoretical magnifications coincided sufficiently with the experimental ones, and this tiltmeter had a sensitivity high enough for the detection of micro tilting, such as the free oscillations of the earth.

Comparative observations of ground tilt with both new tiltmeters and those of the usual type started in 1961 at the three observation stations, namely, Ōsakayama, Akibasan and Nagashima. Since the Akibasan station was closed at the end of March,1965, observations are being carried out at the two stations, Ōsakayama and Nagashima, for the present. Looking through the data obtained up to the present, the secular ground tilts observed with the new tiltmeters do not always coincide with those observed by tiltmeters of the usual type. Some incoinsistency seems to arise from a defect in the structure of the instrument. This will be rectified hereafter.

However, at the time of the Alaskan earthquake of March, 1964, the tilt variations having a period of roughly one hour were recorded by these new tiltmeters, though they could not be recorded by those of the usual type installed on the same concrete foundation. These variations might have been the free oscillations of the earth, and this record proves that both the stability and the sensitivity of the new tiltmeters are higher than those of the usual kind.

On the Earth Tides Observed on the Asian Continent and in the Pacific Area

By Ichiro NAKAGAWA

Special Contributions of the Geophysical Institute, Kyoto University,
No. 6, December 1966, pp. 201–213.

Abstract

A great many observations of earth tides are being made by means of gravimeters, tiltmeters and extensometers at many stations in the world since the International Geophysical Year. But the values of three characteristic numbers on the earth tides h, k and l, related to the elastic behaviour of the earth, obtained at many stations are not always identical and regional differences are clearly recognized in the values of the characteristic numbers. A considerable divergency in their values, far in excess of observational error is also observed with time, even at one station.

Results of earth tidal observations made with gravimeters at some stations on the Asian Continent and in the Pacific Area since the beginning of the IGY, are described in the present article. Data have been analyzed by the method of least squares, the Fourier transform or the usual harmonic analysis for obtaining the gravimetric factor $G \equiv 1-3k/2+h$ and the phase lag. The most reliable value of the gravimetric factor G for continental stations in Asia is 1.14 but that for oceanic ones is slightly larger. The value of the phase lag is very small for both the continental and the oceanic stations.

According to recent observational results, the value of the gravimetric factor G is 1.14 in Asia and 1.19 in Europe. Such a difference between Asia and Europe is also recognized in the phase lag. This is very small for both Asia and Europe, but its sign is opposite. That is, the observed tide lags behind the theoretical one in Asia, while the former advances the latter in Europe. Theoretical investigations show that the gravimetric factor G for semidiurnal tides must be smaller than that for diurnal ones. The results obtained in Asia prove it. On the contrary, the G for semidiurnal tides is clearly larger than that for diurnal ones in Europe. The regional difference between Asia and Europe could be due to a regional heterogeneity in the elastic properties of the Upper Mantle for both continents.

Free Oscillations of the Earth Observed by a Galitzin Seismograph at Abuyama, Japan

By Ichiro NAKAGAWA, Hiromu NODA and Asahi HATTORI

Special Contributions of the Geophysical Institute, Kyoto University,
No. 6, December 1966, pp. 255-265.

Abstract

The great Chilean earthquake of May 22, 1960 was observed with a Galitzin seismograph installed at Abuyama Seismological Observatory of Kyoto University, Japan. Only a vertical component of record was used in the present investigation.

The record was read at every minute during a period of about 5.5 days beginning on May 19, 11h00m, 1960 (UT). The whole reading was divided into five intervals in order to investigate the free oscillations of the earth excited by both the main shock and one of the large foreshocks of the Chilean earthquakes. A low-cut filter was applied twice to all of the reading values, and then a Fourier analysis was made for every interval. It has come to be established that the free oscillations of the earth—spheroidal oscillations—could be detected by the present investigation and that their periods were in excellent agreement with periods obtained at other observation stations for the same earthquake and also with those predicted by theoretical investigations. Q values for higher modes (${}_0S_9 \sim {}_0S_{30}$) calculated from amplitude decay were hundreds. They were much larger than the values obtained in some other stations at the time of the same earthquake.

An analysis was also made using data reread from the record at 15 second intervals in order to investigate a fine spectral structure for lower modes of the spheroidal oscillations, and splitting was found in spectral peaks corresponding to modes ${}_0S_2$, ${}_0S_3$ and ${}_0S_4$. The ${}_0S_2$ peak had maxima at 54.6 and 52.1 minutes, the ${}_0S_3$ at 36.3 and 34.4 minutes, and the ${}_0S_4$ at 25.9 and 25.3 minutes. The splitting of the ${}_0S_3$ peak was less clear than that for the ${}_0S_2$ and ${}_0S_4$ peaks. The periods of the splitting obtained were slightly shorter than those obtained with strain seismograph at Isabella, California by H. Benioff and others.

Spectral Structure of the Earth Tides and Related Phenomena —Gravimetric Record—

By Ichiro NAKAGAWA, Takeshi MIKUMO and Torao TANAKA

Special Contributions of the Geophysical Institute, Kyoto University,
No. 6, December 1966, pp. 215–223.

Abstract

The spectral structure of the earth tides and of some related phenomena has been obtained by the Fourier transform technique, from the record of one year's duration observed with an Askania gravimeter at Kyoto.

The results show that spectral peaks for principal constituents of the semidiurnal and diurnal tides are in excellent agreement with theoretical prediction. The amplitude and phase of 8 principal constituents, M_2, S_2, N_2, K_2, K_1, O_1, Q_1 and P_1, were determined for their proper frequencies, with a certain uncertainty estimated from noise levels. The gravimetric factor and phase lag obtained were then compared with those from the method of least squares, indicating satisfactory agreement.

Spectral features for longer period ranges up to one month are also investigated. The analysis has revealed long period gravimetric variations with periods of 3.7, 4.8, 5.6, 7.1, 11.1, 11.9, 16.2, 18.5 and 29.6 days, including the fortnightly constituents *Mf* (13.66 days) and *MSf* (14.77 days). The sources of the variations are not yet precisely known. It would be necessary to make long term observations concurrently at many stations to obtain conclusive evidence of the phenomena.

—Tiltmetric Records—

By Torao TANAKA, Takeshi MIKUMO and Ichiro NAKAGAWA

Special Contributions of the Geophysical Institute, Kyoto University,
No. 6, December 1966, pp. 225–231.

Abstract

Tidal analysis has been made by the Fourier transform method for the tiltmetric records obtained at Akibasan, Wakayama City in Japan.

The analysis gave the spectral peaks corresponding to the principal constituents of the semidiurnal and diurnal tides. The amplitudes and phases obtained show good agreement with those determined by the least squares method. Several prominent oscillations of the ground tilt with periods of 3.8, 6.0, 6.6, 8.4, 10.7, 13.2, 13.9, 16.7, 17.7, 18.9, 19.9, 25.3 and 28.7 days were also found in the spectra for long period ranges, and some of them are coincident with spectral peaks obtained from the gravimetric record at Kyoto. Although the origin of the tilt oscillations remains unsolved, the analysis for observed records of oceanic tides, temperature and atmospheric pressure variations is under way in order to examine possible correlations between the tilting motion and related phenomena.

An Application of Digital Filtering to the Record of Ground Deformation

By Torao TANAKA and Takeshi MIKUMO

ZISIN (Journal of Seismological Society of Japan) Ser. II,
Vol. 18, 1965, pp. 235–244.

Abstract

An attempt has been made to detect minor anomalous changes of ground deformation by an application of digital filtering to tiltmetric records.

Observations of ground deformation are usually disturbed by meteorological changes, earth tides, effects of oceanic tides and some other factors. It is therefore necessary to eliminate these disturbances from observed records, in order to find the possible correlation between the ground deformation and the occurrence of earthquakes. A possible method for this purpose is the use of digital filters.

The first step in this study is to get the spectral structure of variations of the ground tilt. 50 days' tiltgrams of the N-S and E-W components have been Fourier analysed, indicating predominant amplitudes for semi-diurnal and diurnal tides. Based on the results of the analysis, several types of band-pass or high-pass filters were designed, to pass some signals with specific frequency ranges. Output signals can be obtained by cross-correlating the impulse response of the filters with original observed records. A number of tests have shown that sharp Gaussian or triangular filters are effective for picking up periodic signals such as tidal phenomena, while simple box-car type filters with continuously shifted pass-band frequencies may be useful for detecting aperiodic changes masked behind predominant variations. It was also shown that composite box-car type filters with rejecting bands for periodic changes serve to identify the anomalous tilting motion of the ground.

Study on the Relation between Local Earthquakes and Minute Ground Deformation Part 2. An Application of the Digital Filtering to the Tiltgram for the Detection of the Minute Anomalous Tilting of the Ground

By Torao TANAKA

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 16, Part 1, September, 1966, pp. 57–67.

Abstract

Digital band-pass and high-pass filters have been applied to the records obtained by tiltmeters of horizontal pendulum type at the Akibasan Observation Station at Wakayama in Japan, (135°10.4′ E, 34°11.8′ N), in order to detect small anomalous deformations of the ground relating to the occurrences of the local earthquakes in this region. The sensitivities of the tiltmeters are about 0.004″ per 1 millimeter deflection on the records. First of all, the Fourier spectra of the tiltgrams were calculated from the 50 days data from May 6, 00h00m to June 24, 23h00m, 1961 (JST), in order to investigate the periodical construction of the observed tilting motions of the ground. The results show that not only the amplitudes of tidal changes of the M_2, O_1, N_2 and S_2 constituents, but also those of the daily changes of the period of 24 hours are predominant, and that the amplitudes due to tidal terms and the noise level of the E-W component are larger than those of the N-S, which may be explained by the influence of the oceanic tides and meteorological changes which appear more noticeably in the former than in the latter.

On the basis of the Fourier spectra of the records, some types of digital filters have been designed and applied to the tiltgrams. Since the diurnal and semidiurnal changes are predominant, we have divided the periodic range into six parts and filtered the tiltgrams from Oct. 1 to Dec. 31, 1960 by six filters which have such amplitude characteristics as 1 in the periodic ranges from 2 to 5, 5 to 7, 7 to 11, 11 to 23 and 23 to 25 hours and 0 outside the intervals, respectively. In addition, with regard to the periodic changes of the diurnal, semidiurnal and quarterly diurnal terms, we have tried to apply some other filters having different shapes. It is concluded that the band-pass filters suitably designed serve the purpose and those of properly narrow response are more effective. A peculiar tilting motion of the ground to the extent of about 0.002″ is found on the tiltgram of the N-S component in connection with the occurrences of the earthquakes, but more observational data are needed to verify the relation between them.

On the Extensometer of a Variable Capacitor Type

By Torao TANAKA

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 15, Part 3, No. 9, March, 1966, pp. 49-59.

Abstract

Descriptions of a newly devised extensometer of a variable capacitor type and some observational results at Kamigamo and Osakayama Observatories are here given. The principle of this extensometer is based on the change of the series-resonance frequency due to that of the capactitance in the equivalent circuit of a crystal oscillator. Variation of the strain of the earth produces relative displacement between two disks which form a parallel-plate capacitor. This capacitor is connected in series with the crystal of a crystal controlled oscillator and the variation of the strain causes the frequency change of the output of the crystal oscillator. Then, the frequency of the output is multiplied by ten, a hundred or a thousand times and mixed with the output of the other standard crystal oscillator, to make the difference between their frequencies. The mixed beat is recorded on a frequency meter. A linear strain of 10^{-10} is easily detectable by this method when the standard length is 10 meters.

A preliminary observation was carried out in the adit of the Kamigamo Geodetic Observatory to examine the stability against the humidity from Dec. 1, 1963 to Oct. 13, 1964. After the test observation at Kamigamo, we removed the extensometer to the Osakayama Observatory and have continued the observation since July 6, 1965, with a standard length of 10 meters. Its azimuth is S 38°W. The sensitivity is 2.8×10^{-10} for 1 millimeter deflection of the record. When the pen of the recorder reaches either end of the recording paper, the pen is returned automatically to the middle of the paper by a compensative micro-capacitor in order to prevent scale-out. The amplitude of the M_2 constituent obtained from Dec. 1, 00h00m to Dec. 30, 23h00m, 1965 (JST), by the harmonic analysis is 7.3×10^{-9} Periodic changes of the strain of the period of 2 or 3 minutes have been found in the record, the amplitudes of which amount to 10^{-9} when they are large. They are not phenomena from the instrumental source but real ground deformations. The origin remains unexplained at present.

This extensometer can be used not only for the observations of earth tides and crustal movements, but those of seismic strains by increasing the recorder speed.

The Processing of Seismic Data Using an Analog-Digital Converter

By Tamotsu FURUZAWA

Annuals, Disaster Prevention Research Institute, Kyoto University
No. 9, March, 1966, pp. 55–62.

Abstract

Seismic data (the aftershocks of the Niigata earthquake of June 16, 1964) were recorded on magnetic tapes using a 3-ch. tape recorder. The analog data were converted to digital form and stored on digital magnetic tape using the A-D (analog-digital) converter and punched on paper tape. As a sampling frequency 100 cps were used. The digitized data were then filtered with digital filters of three different frequency bands. The time functions of the filters are:

$$D(t) = \frac{1}{\pi}\frac{\sin(2\pi f_1 t)}{t}, \qquad f_1 t \leq 3.75$$

The frequency bands of 10 cps high pass, 1–10 cps, and 1 cps low pass were used. The results of filtering are: 1 cps low pass data have small amplitude and no significant phases, so it may be considered as noise because of the low sensitivity of the seismograph at longer periods than about 1 sec. The component of 1–10 cps has a large amplitude in the vertical component just after the initial P phase and has a distinct phase in the horizontal component at about 1.2–1.5 sec after the initial P. But on the whole there is no remarkable difference between 10 cps high pass and low pass data.

Particle motions of the P and S waves in the horizontal plane were obtained from filtered and unfiltered digitized data. They were plotted on section paper using an X-Y plotter from data punched on paper tape. For the portion of the initial P phase the polarization is the azimuth of about N40°W at both high (10 cps high pass) and low (1–10 cps) frequencies. It is also the same as unfiltered data. But after the initial P motion the high frequency component has a different polarization compared with the low frequency component has no clear polarization while the low frequency component has an azimuth of N70°E, which also corresponds to the unfiltered data. Perhaps, these discrepancies with periods in horizontal polarization are due to differences in the propagation path and the geological structure between the high and low frequency components.

Movement Mechanism of the Gotenyama Landslide

By Shinichi YAMAGUCHI, Yuji TAKADA and Atsuo TAKEUCHI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 339–358.

Abstract

The Gotenyama landslide took place in Muraoka town, Mikata-gun Hyogo Pref. It occurred several years ago and was gradual in its movement. In the geological point of view, this region is a Tertiary formation-Muraoka Group- consisting of tuff, mudstone, sandstone, and its alternations. The circumstances of the occurrence of this landslide are very special, because in this area a landslide occurred about 100 years ago, and the reconstruction work was done by means of surface soil cuttings and bankings on which a school house was built.

We have carried out seviral investigations by means of internal strainmeters, extensometers, inclinometers and an electric survey in order to discover the mechanism of this landslide movement and a method for its prevention. We obtained the following results;

1) This area did't move as one large mass, but as several small blocks, the moving directions of which were not the same.

2) The movement of the ground surface layer suffered remarkable effects from snow fall and thaw, which meant that the main effect on the landslide movement was underground water.

3) The main force of this soil movement came from the upper part mass which had been adapted as construction land and made into a ground field by means of banking.

4) At first, the landslide movement began in the upper part of this area and the superficial soil mall moved to the school buildings, which stimulated the deeper slide surface that had occurred formerly.

According to these results, the C.I.P. were driven into the ground near the school house, having 10 m in length to stop the surface soil movement, and the underground water was taken out by borings in the upper part of the landslide area about 30 m under the surface level.

It is cleared that these constructions for the landslide movement were not enough to stop the movement of the soil mass by calculating the safety factor of the slope. The authorities executed the cutting construction of the upper part mass to increase the safety factor to 1.5.

Consequently, the measuring values of the tiltmeter, the iclinometers and so on were decreasing during these constructions and the movement of the lower part of the landslide stopped.

Some Characteristics of the Mikage Landslide Area

By Shinichi YAMAGUCHI, Yuji TAKADA, Atsuo TAKEUCHI
and Akimichi NAKURA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 359–373.

Abstract

The Mikage landslide is situated in Ogo town, Hyogo-ku, Kobe City, Hyogo Pref.. The landslide took palce on 16, July, 1963, having cracks about 20 m in length, 2 m in width and 1 m in sinking respectively. Two months later the cracks increased in width, length and sinking, and formed an approximate letter L, which shaped the boundary of the landslide area. The maximum velocity of the landslide movement was about 2 m per year. The inclination of the slope is 35 and there are several ponds in the area, and there is a river at the end of the landslide. In the geological point of view, this region is a Tertiary formation in which are included standstone, shale, mudstone and its alternations. The landslide is seen to be a small scale one. The authors studied the mechanism of the occurrence of the cracks and sinkings by means of tiltmeters, internal strainmeters, extensometers and so on; furthermore we carried out an electric survey and a natural radioactivity survey to ascertain the underground structure.

As a result of the analysis from the records of the internal strainmeters with 2 points, it was found that there were two slide layers at 6 m and 30 m respectively. Moreover a detailed analysis was made, and we found that the shallower slide layer was moving down the landslide slope, while on the contrary, the deeper one, the soil mass, was not moving but changed from the same direction to the opposite direction of the landslide slope.

From underground water results, we assumed that the ground water is mainly gathered from the surrounding area and from the upper slope of the area, flowing into the landslide area. The 30 m slide layer, which consists of shale, suffers weathering action by groundwater containing H S gas; this is why the records of the internal strainmeter showed as above. The shallower layer is influenced on infiltration accompanied with rainfall.

Some Effects of Estuarine Topography on Salinity Distribution

By Setsuo OKUDA and Seiichi KANARI

Annuals, Disaster Prevention Research Institute, Kyoto University.,
No. 9, March, 1966, pp. 501-512.

Abstract

Some effects of estuarine topography on salinity distribution were studied by field observations and model experiments.

Salinity distribution in an estuarine region in the river Nagara (Mie Prefecture) was observed in order to investigate the effects of river bed undulation and meandering on the rising velocity of the salt wedge and diffusion process of salt. The results of observation show that the narrow neck of a river course prevents the upstream flow of salt water and causes a steep gradient of salinity along the river, and that brackish water often stagnates in the downstream section of convex bank of a meandering place at the ebb stage.

A change of salinity distribution by the opening and closing of sluice gates was observed in an estuarine region in the river Old Yoshino (Tokushima City) in order to investigate the flushing effects of fresh water from sluice gates.

It was found that the lighter fresh water flows down through an upper layer of 2 m thickness over the heavier salt water which lies in a stagnant layer along the river bed, and that a considerable mixing occurs at a bend in the river course.

Model experiments were carried out in a test flume which consists of a sea part (3 m$\times$3 m) and a river part (7 m$\times$0.5 m), in order to study the effects of fluvial topography on the salt intrusion and salinity distribution. The flow patterns were observed under various combinations of topographic conditions (bottom ridge, narrow neck, deep waterway) and hydrological conditions (fresh water inflow, tidal range, density difference).

Experimental results show that the bottom ridge and narrow neck in a river course bring about the reduction of salt intrusion and the increase of mixing between fresh and salt water, that the deepening of a river bed facilitates the salt intrusion and that salt water once stored in a deep hollow can hardly be drained off by the flush of fresh water.

This study shows the possibility of effective prevention of salt intrusion by an artificial change in the micro-topography of an estuary.

On the Rheological Behavior of Frozen Soil

By Yoshiaki FUKUO

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 15, Part 3, 1966, pp. 1-7.

Abstract

It is well known that the mechanical strength of soil is dependent on the cohesion between soil particles and water. When the soil is frozen, its cohesion will be highly increased by the cementation of particles due to ice formation. Recently in our country, utilizing the increase of strength practically, the soil freezing method has been used in engineering projects. In construction work, the mechanical strength of frozen soil must be understood exactly and fully for safety reasons. From this point of view, the deformation of frozen soil has been examined by an experiment of axial compression.

Blocks of frozen soil from the alluvial layer were sampled at 5, 7, 8.5 and 10 meter depth in Tokyo and were formed into a cylinder 5 cm in diameter and 9 cm in height. The blocks at 5, 7 and 8.5 meter depth were silty clays considerably consolidated. The blocks at 10 meter depth were silty sands containing gravels and fragments of shells. Soon after each test piece was moulded, it was coated by grease all over its surface and was set on the base of an axial compressive device which was placed in an ice box kept at $-5°C$ or $-10°C$ by a thermostat and stirring fan with an accuracy of $\pm 0.5°C$. The deformations of the pieces in the axial and radial directions were converted to D.C. voltage through linear differential transformers and were detected on the dotting auto-recorder with an accuracy of ± 0.02 mm.

All the test pieces underwent creeping deformation. The results of experiments were analysed with reference to the theory of Drs. Murayama and Shibata for the rheological character of clay. According to their theory, the axial compressional strain increases linearly with the logarithm of time taken from loading under a compressional stress smaller than the upper yield value and when the compressional stress exceeds the upper yield value, the strain increases along a curve concaved upward with the logarithm of time. From the results of the analysis based on the above theory, it was concluded that

i) the upper yield value of frozen silty clay was between 10 and 20 kg/cm^2 at $-5°C$ and greater than 20 kg/cm^2 at $-10°C$.
ii) the lower yield value of frozen silty clay was about $2 \sim 4$ kg/cm^2
iii) the deformation of frozen silty sand was greater than that of silty clay under the same temperature and load.

A New Method for Tracing Ground Water Flow with Low Head Gradient

By Kazuo OKUNISHI and Setsuo OKUDA

Special Contributions, Geophysical Institute, Kyoto University,
No. 5, 1965, pp. 93-97.

Abstract

A new method was presented for the determination of the velocity of the ground water flow with tracer method without raising the ground water head around the injection borehole. This method consists of three parts. First the depth of the active permeable layers (the layers in which the flow of the ground water exists) is determined. A little quantity of salt water is poured into the injection borehole and a homogeneous increase of salinity of the water in the borehole is made up by mechanical stirring. After a few minutes the distribution of electrical conductivity is measured and the depths of the active permeable layers are determined at which the ground water flow through the active permeable layers dilutes the injected salt and lowers the electrical conductivity. Secondly the direction of the ground water flow is determined with the ordinary technique. Lastly the velocity of the ground water flow is determined. The tracer material is packed into a capsule made of gauze and suspended at each depth of the active permeable layers. The flow of the ground water dissolves the tracer and carries it to the detecting boreholes. Thus the velocity of the ground water flow through each permeable layer can be determined separately.

Moreover this method facilitates the accurate detection of the tracer at the detecting boreholes, because the tracer is dissolved by the ground water continuously at an almost constant rate and for a long time if the capsules of the tracer are renewed periodically.

The result of the field practice has shown that this method is more effective than other tracer methods in the case in which the distance between the injection and the detecting boreholes is short and the gradient of the ground water head is small.

An Experimental Study on Slope Failure (1)

By Kazuo Okunishi

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, 1966, pp. 375–384.

Abstract

Model experiments on slope failure conditions were carried out giving priority to the effect of hydrological conditions on the beginning of the failure succeeding the experiments described in the preliminary report. Weathered andesite from a landslide area was used as the soil sample. Because of the improvement of the measuring technique and of the exploitation of the sample soil of finer grain size, the distribution of the earth pressure was measured satisfactorily.

Two dimensional boundary problem was solved for the theoretical distribution of the earth pressure taking into account the effect of pore pressure and ground water flow and assuming that the weight of earth constituting the slope was supported sloely by the tangential stress in the earth. Under ordinary conditions with moderate ground water flow and a small inclination of the soil flume, the measured distribution of the earth pressure was in good agreement with the result of the theoretical calculations. When the inclination of the soil flume was increased and the water table was raised up, or when heavy rain was applied on the steep slope, the result of the measurement of the earth pressure deviated from the theoretical result.

A small movement of soil mass and a sudden change of the earth pressure were observed when the lower end of the soil flume was open and the inclination of the flume was increased with the water table held near the soil surface.

It is suggested that the regime of the stress within mountain slopes shows a sudden change when the failure phenomena begin and that such an oversimplified assumption as used in this study is no more appropriate for this case. It was shown that the small soil flume used in this study is useful for model experiments on slope failure though it has not yet been made clear whether or not the two dimensional equilibrium of the stress in the slope can be held in this soil flume.

Dispersion and Adsorption of Tracer Material in Tracing Ground Water Flow

By Kazuo Okunishi

Special Contributions, Geophysical Institute, Kyoto University,
No. 5, 1965, pp. 99–108.

Abstract

Experiments on the dispersion and adsorption of tracer material in ground water flow were carried out using NaCl and uranine (sodium fluorescein) as comparative tracers in a soil flume 5 m long, 50 cm wide, and 50 cm deep. A certain quantity of the water dissolving the tracer material was injected into the simulated ground water flow from the upper end of the soil flume and detected at the lower end. It was confirmed that almost all NaCl injected into the upper end of the flume reached the detecting point at the lower end. On the other hand, in the first experiment only one fourth of the uranine injected into the upper end was detected at the lower end, and after the concentration of NaCl injected simultaneously with uranine had receded to zero, the concentration of uranine kept a certain level though it was gradually decreasing. In the second experiment, about half of the uranine injected was detected at the lower end. It seems that there exists a sort of equilibrium between the dissolved and the adsorbed state of uranine and that when the soil has not yet adsorbed the tracer it has a large capacity of adsorption and when it has adsorbed enough tracer and the concentration of the tracer in the ground water flow has decreased, it releases the tracer into the ground water flow.

The differential equation of the dispersion of tracers in ground water flow was solved analytically under the assumption that adsorption of the tracer by the soil does not take place, and using the point source solution in the problem of heat conduction and the principle of superposition. This solution was shown to be in good agreement with the experimental results of the time change of the concentration of NaCl, and to give a useful method for the experimental determination of the value of the dispersion coefficient as a function of the velocity of the ground water flow. When this solution was applied to the result of the measurement of the concentration of uranine, it was found that the apparent value of the dispersion coefficient became too large.

Exploratory Study of a Photoelectric Sediment Meter and its Applications to Deposits Surveys in Amagase Resevoir (I)

By Seiichi KANARI and Setsuo OKUDA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 491–499.

Abstract

This paper describes a few types of photoelectric sediment meters capable of determining the thickness of sediment deposited in lakes or reservoirs for a short period, and shows some results of deposits surveys in Amagase reservoir.

As described in the preliminary report (Annuals, Disaster Prevention Research Institute, Kyoto University, No. 8, 1965, pp. 555–565), the A-1 type sediment meter was based on the analogue reading of an electric current of photoelectric cells in series connection. However, this type was often affected by turbid water and blot on the surface of the cells.

The new type of D-2, and D-3 (Step type) have nineteen pieces of photoelectric cells (3.5 mm × 4 mm) which are mounted on a vertical plastic bar (15 mm × 15 mm × 250 mm) fixed on the base plate (20 cm × 25 cm), and a long filament lamp (20 mm dia, 300 mm long) is set so that the light beams strike uniformly on each surface of the cells (Photo 1). Therefore, when a cell is covered by sediment, the cell comes into a state of electrical cut-off, and this state can be discriminated from the decrease of the output current, which is due to the turbid water or blot of th cell surface.

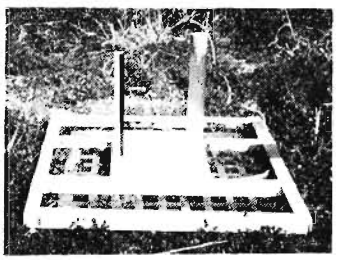


Photo 1. View of D-3 type sediment meter.

As the measurement of the deposition is made by discrimination of the cut-off for each cell successively, the turbid water or blot of the cell surface never causes a reading error.

The new type sediment meters were applied to the deposition survey of Amagase reservoir for a period from Aug. 18, 1965 to Nov. 11, 1965, and it was observed that the local deposition due to bed load movement in a flood period reached about 25 cm/day, while in the small inflow state during the winter the deposition rate due to suspended load did not exceed 2 cm/month.

Underwater Acoustic Telemetry for Oceanographical and Limnological Research (Part I)

By Seiichi KANARI

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 15, Part 3, March, 1966, pp. 71–80.

Abstract

In oceanographic and limnological studies, it is desirable to measure physical quantities (temperature, current speed, electrical conductivity, and turbidity) continuously in space and time. In order to satisfy such a requirement, some instruments which can electrically measure those quantities have been developed. All such instruments transmit the data through an electrical cable and give a continuous record. Although the instruments of this type are very useful in shallow water because of their reliability, and can supply continuous information, these advantages are eliminated by the fact that it requires long elęctrical cables to connect the sensers and indicators (or recorder). Therefore, we designed an acoustic telemetry system based upon the same principle as a radio wave system which transmits and records the data on water temperature and depth alternately.

The telemetry system consists of two units, one an underwater unit (Acoustic Transmitter) and the other a deck unit (Receiver and Recorder). The underwater unit has two oscillators whose frequency varies with the following form

$$f = \frac{1}{2\pi C_0 R}$$

where C_0 is a constant capacitor, and R is an electric resistance for temperature and depth measurement which corresponds to the resistance of the thermister, and the variable resistor connected to the spiral Bouldon Tube respectively.

These oscillator outputs are amplified to a power level required for transmission, and drive a sound projector, converting an electromechanical signal into a sonic wave.

The transmitted signal is picked up from the water by a receiving hydrophone, and converted again to an electrical signal and converted to the original information and then recorded on a D.C. recorder.

The frequency of the transmitted signal varies from 10 kc/s to 21 kc/s in accordance with the temperature change from 10°C to 30°C.

The efficiency of an electro-acoustic transducer depends on the driving frequency, and it was estimated that the highest efficiency is about 15 per cent at the frequency of 20 kc and the total acoustic power emitted at that frequency is about 0.075 watts, which may be transmitted over the range of 100 m under the condition of the attenuation coefficient of 4.3 db/km.

Underwater Acoustic Telemetry for Oceanographical and Limnological Research (Part II)

By Seiichi KANARI

Bulletin of the Disaster Prevention Research Institute, Kyoto University
Vol. 15, Part 3, March, 1966, pp. 81-94.

Abstract

The acoustic telemetry system described in this paper is designed for measuring depth, water temperature, and turbidity in lakes or reservors. This instrument has five channels; depth, water temperature, turbidity, and two references. The underwater transmitter contains five subcarrier oscillators. Three of them generate sine wave signals and their frequencies vary from 240 to 420 cps according to each piece of information on water temperature, depth, and turbidity respectively within the following ranges: water temperature; 10～30°C, depth (in hydrostatic pressure); 0～50 kg/cm^2, turbidity (in silit concentration); 0.1～3.0 g/l. The other two generate the reference signals with constant frequencies of 241 cps and 420 cps respectively. These five signals are selected successively by a mechanical commutator, and they modulate the frequency of 40 kc maincarrier, which is emitted through a sound signal projector as a super sonic wave after amplification of their electrical power.

The transmitted FM signal is received and then demodulated to recover the original information by a specially designed FM receiver, and recorded on a D.C. recorder.

The modulation factors of each channel are shown in Table 1.

Table 1.

channel	subcarrier	frequency	modulation index m_f	required max. spectrum band width (B max)
1	temp.	270 to 360 cps	1.66 to 2.22	10×420 cps= 4.2 kc (±2.1 kc)
2	press.	240 to 420 cps	1.43 to 2.22	
3	turb.	300 to 380 cps	1.58 to 2.00	
4	refer.-1	240 cps	2.49	
5	refer.-2	420 cps	1.43	

Simple tests on the vertical and horizontal transmission were carried out in Amagase reservoir. In a vertical transmission test, a clear record was received, though the record of a horizontal transmission test was unstable, which was due to the multi-path interferences of the water surface, and it was concluded that the interference restricts the use of this instrument within a certain condition so far as horizontal transmission is concerned.

On the Significance of the Crustal Movements in the History of Lake Biwa-ko, an Ancient Lake in Japan

By Shoji HORIE

Annales Academiae Scientiarum Fennicae Ser. A, III, Geologica-Geographica 90,
Proceedings of the Second International Symposium on Recent Crustal Movements,
Aulanko, Finland, August 3–7, 1965. 1966, pp. 143–151.

Abstract

Along the shore of Lake Biwa-ko, there are six steps of lacustrine terraces. Among them, evidence of a remarkable time gap between the highest terrace and the following five terraces was discovered. This indicates that after the slow drop of the first lake level, five minor drops in level occurred. The cause of such a drop in the lake level is regarded as the result of the upwarping of the surrounding area, the downwarping of the lake bottom, or both, and climatic changes, as well as the gradual lowering of level by discharge. However, the iso-uplift lines show us that the mode of crustal deformation resembles the outline of the present shape of Lake Biwa-ko. Accordingly, the basin-making crustal movement, i.e. the downwarping deformation of the earth's crust seems to be the most important one. This basin-making crustal movements being continuous, Lake Biwa-ko has a history of over several million years and it still remains an oligotrophic lake type having endemic species of northern and marine origin.

Synthesis of Magnesian Calcite at Low Temperatures and Pressures

By Yasushi KITANO and Nobuko KANAMORI

Geochemical Journal Vol. 1, No. 1, December, 1966, pp. 1–10.

Abstract

As one of the steps that lead to an understanding of the secretion of magnesian calcite in the skeletal parts of marine organisms, the laboratory synthesis of the mineral from aqueous solutions was carried out at low temperatures and pressures. Magnesian calcites are precipitated from calcium bicarbonate solutions containing magnesium ions and certain organic materials such as citrate, malate and pyruvate ions, which are found in the body fluids of carbonate-secreting organisms, in various concentrations: A calcium bicarbonate solution, a magnesium chloride solution and sodium citrate, malate or pyruvate solution were mixed in various proportions, put in Erlenmeyer flasks, plugged with cotton, and allowed to stand at constant temperatuers (5, 20, and 30°C) for 2 to 8 weeks. Over this period of time the carbon dioxide gas gradually escaped and carbonate crystals precipitated. The carbonate crystals are just magnesian calcites.

The present experiments indicate that sodium citrate, sodium pyruvate and sodium malate favor the formation of magnesian calcite, probably by complexing calcium ions, reducing the precipitation rate of carbonate, giving a stable calcitic lattice configuration and causing a capture of magnesium in the calcitic lattice. Further, an increase in concentration of both magnesium ions and these organic materials causes formation of a magnesium-richer calcite. The laboratory experiments show that an increase in temperature causes an increase in the magnesium content of the calcite when sodium citrate, sodium pyruvate and sodium malate are added.

While the magnesium carbonate content of magnesian clacites increases with increasing temperature and concentrations of magnesium ions and the organic compound in a mother solution, it differes with the kind of organic compound.

It was reported that the magnesium carbonate concentration in skeletal magnesian calcites of marine organisms increases with increasing temperature and salinity of sea water and varies with the phylogenetic level of the organism. If we can consider that the increase in salinity means an increase in the concentration of magnesium ions, and that a biological group or species can be characterized by a metabolic cycle involving organic compounds, in other words, by the composition and concentration of organic materials in a body fluid, the present laboratory results seems to have some analogy to the observational facts of natural calcareous marine organisms concerning the conditions of magnesian calcite formation.

Salt Error for the Colorimetric Determination of Molybdate-reactive Silica (Soluble Silica)

By Kikuo KATO and Yasushi KITANO

Journal of Earth Sciences, Nagoya University, Vol. 14,
No. 2, December, 1966, pp. 1–10.

Abstract

Colorimetric silicomolybdic determination has been generally used for the determination of "soluble silica" (molybdate-reactive silica) in natural waters, since it was reported by E. Dienert and F. Wandenbulke (1923). This determination is conducted always in the routine work of marine observation.

It is known that ammonium molybdate at pH of 1.1 to 1.5 reacts with soluble silica.

Salt effect or salt error has been known as an interference of coexisting salts in the determination. A lower silica concentration is determined in a concentrated salt solution than in a dilute salt solution.

The ratio of a silica concentration measured in distilled water to that in salt solution is termed the salt factor. The factors were reported with a wide variation between 1.09 and 1.66 in sea waters. I. Iwasaki and T. Trutani (1959) showed that the salt factor varies with the wave length used for the colorimetric determination; but a wide variation can not be explained simply by the difference in the wave length.

The authors have found that the variation of the salt factor is greatly caused by the buffer capacity of a sample solution. Then, the most suitable amount of acid to be added is studied.

In conclusion, 2 ml of 4 to 6 N acid must be added to 50 ml of sea water for the determination of "soluble silica", being followed by the addition of 2 ml of 10% ammonium molybdate solution. And the best procedure still gives the "salt factor" with 1.02 for sea water, 1.03 for 1M sodium chloride solution and 1.14 for 0.5 M sodium sulfate solution. This should be called a real "salt factor"

Finally, the mechanism of "the real salt error" is discussed.

It is seen that α-silicomolybdic acid is easily formed in sodium sulfate solution where β-silicomolybdic acid is mostly formed in distilled water. The difference between the color intensity of β-silicomolybdic acid equivalent to α-silicomolybdic acid formed in salt solution and that of the formed α-silicomolybdic acid should result in the salt error in the determination of silica.

And this should be a source of the real salt error.

Spectrophotometric Determination of a Small Amount of Magnesium in Natural Waters and Carbonate Sediments

By Nobuko KANAMORI and Yasushi KITANO

Journal of Earth Sciences, Nagoya University Vol. 14,
No. 1, June, 1966, pp. 11–20.

Abstract

The present paper reports a new sensitive spectrophotometric method for determining a small amout of magnesium in natural waters and carbonates. Magnesium is determined spectrophotometrically with Thymolphthalein Complexone (TPC; 3,3′-bis N,N′-di(carboxymethyl)-amino methyl-thymolphtalein), after masking the other alkaline earth ions with EGTA (Ethylene glycol-bis-(β-aminoethyl ether)-N: N′-tetracetic acid) and Zincon indicator (2-carboxy-2′-hydroxy-5-sulphoformazyl benzene).

The present methods make it possible to determine 2 to 40 μg of magnesium directly, rapidly, simply and accurately without any special chemical separation. The determination can be made within 0.5 to 1 hr. and with ± 2 to 3% in error.

The presence of strontium ions less than 200 μg or barium ions less that 300 μg does not interfere with the colorimetric determination of the magnesium ions. Calcium ions of higher amount than 20 μg should be masked.

Common ions in natural waters and carbonate sediments such as sodium, potassium, chloride, carbonate or sulfate have no influence on the color intensity of the Mg-TPC complex. Heavy metal ions and alkaline earth ions form complexes with TPC. All elements other than copper are masked with EGTA and triethanol amine, and cause no interference to the coloration of Mg-TPC. A large amount of copper ions must be masked with cyanide.

The procedure consists of two steps:

1) Masking of other alkaline earth ions with EGTA and Zincon as indicator.

The sample solution is acidified with dilute hydrochloric acid, boiled for a few minutes and made up to about 10 ml. The solution is neutralized to pH ca. 5.0 with dilute sodium hydroxide solution (0.3–0.5 N) using methyl red as an indicator solution.

To this solution are added successively : 3 to 6 ml of the borate buffer, 0.5 ml of triethanolamine solution, 3 to 4 drops of Zincon indicator and 2 to 3 drops of Zinc-EGTA solution. Finally other alkaline earth ions are carefully masked titrimetrically with EGTA.

2) Photometric determination of magnesium.

After masking other alkaline earth ions, 1 ml of TPC solution is added and made up to 25 ml with water. After 5 min. to a few hrs. standing the absorbance is measured at 610 mμ.

In conclusion, the present method can be applied to the determination of a small amount of magnesium in most natural waters and carbonate sediments with no serious interferences of diverse ions.

Analysis of a well-developed Cold Vortex over the South-Western Part of Japan

By Chotaro NAKAJIMA

Special Contributions on the Geophysical Institute Kyoto University,
No. 6, December, 1966, pp. 27–37.

Abstract

There are two heavy snowfall areas in Japan. One of them is Hokkaido District (northern part of Japan) and the other is Hokuriku District (along the Japan Sea Coast). It is well known that the former heavy snow occurs when the upper cold vortex moves over Hokkaido and arrives at the east side of Hokkaido, and that the latter heavy snow occurs while the upper cold vortex moves over the Japan Sea. Such heavy snow falls occur several times during a winter season.

But when a wave in the upper westerly current becomes extremely developed, the cold vortex formed in the trough comes down directly to lower latitudes and becomes a very strong cold vortex. In such a case heavy snow falls in the south-western part of Japan, where heavy snow fall seldom occurs in an ordinary winter season. We have analysed in this paper one example of such extraordinary strong cold vortices.

We have analysed the nature of this strong cold vortex using the vertical time cross-section through the center of this vortex. In such a developed cold vortex, the centrifugal force due to the rotation of the vortex is so strong that the subsidence of the cold core due to gravitational force is not particularly remarkable. So the shape of the cold vortex is very simple. The wall-shaped side boundary of the cold vortex is nearly perpendicular between 850 and 500 mb levels, and the axis of strong wind outside the wall in the cross-section is also nearly perpendicular between 1000 and 400 mb levels.

The wet portion, with a humidity of more than 80%, is concentrated in the band region outside the wall of the cold vortex, but in the cold dome it is very dry. This fact can be explained also by the cloud distribution shown by radar echoes. Remarkable line-shaped echoes locate very closely the position of the surface cold front. But the rear line-shaped edge of the all cloud mass is also very distinct. This rear edge coincides closely with the eastern wall of the cold vortex.

The structures of the cold vortices passing through the Japan Sea are not similar to our case. The intensities are not so strong and the heavy snow falls occur in the inner region of the cold vortices.

On the Rainfall over the Daido River Basin (1)

By Chotaro NAKAJIMA and Yukio GOCHO

Proceeding of 3rd Conference of Disaster Science, 1966, pp. 123-124.

Abstract

As a preliminary study on the rainfall over the basin of Lake Biwa, the distribution of the main 24-hour precipitations over the Daido river basin in 1965 are investigated. This basin is in the central part of the Kinki district and south of Lake Biwa. The area of this basin is 352 km^2 and in the basin there are ten stations of rainfall observation. One of the stations that is at the west end of the basin is a monitoring station. We have investigated the variations of the ratio of precipitation over this basin to the other regions in the Kinki district and the ratio of precipitation at the monitoring station to the other stations in the basin are shown for various rainfall types.

Rainfall types may be divided into two broad classes according to winds at the 850 mb level.

(1) S～E wind type. This type occurs when the S～E wind is strong on account of a cyclone or a typhoon on the Pacific Ocean. In this type the rainfall over the basin is less than the rainfall over the south-eastern part of the Kinki district and the mountains east of the basin, but more than that over the plains of Osaka and its vicinity. In the basin rainfall over the south-eastern part is slightly more than that estimated at the monitoring station.

(2) SW～W wind type. In the central Kinki district lowland extends northeastward from Osaka Bay to Lake Biwa along the Yodo river. The monitoring station is in the lowland.

i) When the SW～W wind is weak, the main rainfall belt appears frequently in the lowland. Therefore precipitation at the monitoring station is in some degree more than that at the other stations in the basin.

ii) When the SW wind is strong, the main rainfall belt tends to shift somewhat northward. And when the W wind is strong, the belt shifts somewhat southward. In these cases precipitations in the basin are considerably uniform.

On Tidal Currents off the Eastern Harima Coast (Toban Coast)

By Haruo HIGUCHI and Shigehisa NAKAMURA

Annals, Disaster Prevention Research Institute No. 9, 1966, pp. 771–777.

Abstract

A tidal observation was carried out along a line of 1 km perpendicular to the Eastern Harima Coast, where the beach erosion is remarkable. The currents were observed under a little wind from 13 to 19 February, 1965. The current directions were 110° and 290°, which shows that tidal currents are predominant.

The current velocities increase with the distance from the coast. The velocity and the direction of the current varied with time. Horizontal profile of tidal current along the line may be caused by the bottom topography, and phenomenologically the current velocities are proportional to the logarithm of the distance from the coast.

The change of the vertical profiles of the currents was obtained at a station 0.2 km off the coast where the mean water depth is 4.3 m, with a time interval of 10 minutes. According to the result of the observation, the maximum current velocity off the coast is 70 cm/s, which is about one third of the predicted maximum tidal current at a station in center of the Akashi Strait. And the tidal phase precedes that at the center of the Akashi strait by about 2 hours.

The bottom friction was estimated under the assumption of logarithmic low in in the vertical profile of the velocity, by expressing the relation between the bottom stress and the velocity at 1 m above the sea bed u_1 by $\tau=k\rho U_1^2$ The coefficients of friction were evaluated in a range of 2.6×10^{-2}.

The vertical component of eddy viscosity (Reynolds stress) is defined by

$$\frac{\tau_z}{\rho}=\eta_z\frac{\partial u}{\partial z}=\overline{u'w'}$$

where η_z is the coefficient of vertical eddy viscosity, u' and w' are x and y components of turbulent currents respectively. Assuming that the velocity gradient $\frac{\partial u}{\partial z}$ is approximated by $\frac{\delta u}{\delta z}$ and $\overline{u'w'}$ is replace by $\frac{1}{2}\rho(\delta u\cdot\delta z)^2$, the eddy viscosity is writtern $\eta_z\sim\frac{1}{2}(\delta u\cdot\delta z)$.

It is found that the coefficient of vertical eddy viscosity evaluated by this equation varies with time but it does not correspond directly to the phase of tide and seiche in the Harima-Nada.

Hydraulic Model Experiment on the Diffusion Due to Tidal Currents

By Haruo HIGUCHI and Takashige SUGIMOTO

Proceeding 13th Conf. on Coastal Eng. in Japan, Dec., 1966, pp. 227–284.

Abstract

The diffusion phenomena due to the tidal current in a shallow broad estuary are here studied in a hydraulic model experiment for which Ariake Bay in the Omuta area of Kyushu, was used as the prototype. Only the tidal current is taken into account, the effect of the other factors, the oceanic current, density stratification, the wind, waves and so on, which may influence the diffusion in the estuary, is not considered.

A model of the northern half of Ariake Bay, with a horizontal and vertical scale of 1/2000 and 1/200 respectively, was constructed, and a semidiurnal tide generated by an automatically controlled pneumatic tide generator was provided for it. The water level at 5 stations, the current ellipsis at 4 stations and the flow pattern were measured and compared with those in the prototype. The diffusion from an instantaneous point source was investigated maintly by the photographic method.

Experiments have shown that the tide and the tidal current are accurately reproduced in the model. However, the diffusion coefficient evaluated through the rate of increase of the dye patch is about 1/3 of that in the prototype. This may be due to the difference between the flow in the model and that in the prototype, the former belonging to the perfect turbulent regime and the latter to the transient regime.

On the Similitude at the Opening of a Breakwater in a Hydraulic Model Experiment involving Tidal Current

By Haruo HIGUCHI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March 1966, pp. 763–770.

Abstract

The discharge coefficient plays an important role when the maximum current velocity at the opening of the breakwater in the prototype is estimated from the result of the hydraulic model experiment involving a tidal current.

The discharge coefficients of three kinds of models, of which the horizontal scales are the same, namely 1/700, and the vertical scales are 1/500, 1/250 and 1/125, are obtained for two kinds of widths of the opening.

After comparing the coefficients of three models and considering the effects of the Froude number and model distortion, a kind of scale effect is found, that is, the larger model has the larger coefficient.

On the Transport and Distribution of Giant Sea-Salt Particles over Land (1) Theoretical Model

By Masaaki TANAKA

Special Contributions, Geophysical Institute, Kyoto University
No. 6, December, 1966, pp. 47–57.

Abstract

The transport and distribution of giant sea-salt particles inland from the coast are studied on the basis of the diffusion theory. The horizontal transport of the pasticles due to air advection, sedimentation due to gravitational force and vertical eddy diffusion are taken into acount. But horizontal diffusion of the particles is disregarded. The wind speed and the vertical eddy diffusivity are assumed as constant. It is presumed that sea-salt particles originate only on the sea surface, and that vertical distribution of the particles on the coast is given by an exponential decrease in the number concentration with height. On land, a ground sink caused by sedimentation plus the impaction by trees and other obstacles on the ground surface is considered. The magnitude of impaction is expressed by the product of an impaction factor, the horizontal wind speed and the number concentration of the particles near the ground.

The outstanding result of the solution is that a maximum value in the vertical distribution of the number concentration of the giant sea-salt particles always appears at some height above the land, in agreement with the observational fact of the vertical distribution of the particles inland obtained by Byers et al. (1957), Podzimek and Cernoch (1961), etc. The vertical distribution of the particle concentration far inland is nearly constant, except near the ground. In other words, the shape of the vertical distribution far inland approximates to an inverse "L" shape, as a result of the lowering of the particle concentration near the ground due to the effect of the impaction.

The effect of the impaction by trees and other ground obstacles is expressed by the impaction-sedimentation ratio. A preliminary estimate of the ratio, obtained by an application of the present model to observational data made by Byers et al. (1957), Toba and Tanaka (1963), indicates a value of the order of magnitude of 10 to 100.

Turbulence Measurements in a River Flow

By Yasuo ISHIHARA and Shōitirō YOKOSI

Proc. of the 3rd Symposium on Disaster Science,
Nov., 1966, pp. 34–36.

Abstract

The turbulence structure of a river flow is characterized by two different dimensions: the width of a channel horizontally and the water depth vertically. It seems to be expedient to split the spectrum of the turbulent velocity of a river flow into two regions, because the horizontal scale of a flow is much larger than the vertical scale. The turbulence characterized horizontally by the width is large in scale. On the other hand, the turbulence characterized vertically by the depth is three-dimensional and the same as that of an usual boundary layer turbulence, except in the neighbourhood of the water surface. Each region is expected to have the cascade process of an energy transmission.

Generally, the turbulence spectrum measured by a current meter is cut at the low and high frequencies which correspond to the inertia of the device and the measuring period, respectively. Therefore, in order to understand the whole figure of the spectrum of the flow, the size of the largest and smallest eddies must be estimated by available methods before observation is made.

In order to estimate the size of the horizontal largest eddies of the river flow, a turbulent velocity for a long time interval is made in Uji River. The stream section is about 100 m wide and 2 m deep and the mean velocity near the surface is about 1.3 m/sec. The propeller type of current meter used is 14 cm in diameter and its time constant about 1 sec. The measurement is made for 30 min at the center of the flow, suspending the current meter near the water surface. By making the moving averages on the original data for 1.2 sec, 6 sec, 1 min and 5 min, several features of the river turbulence are obtained. The size of the horizontal largest eddies is about ten times the width of the flow longitudinally and has the same width as that of the flow laterally. The size of the smallest eddies is evaluated as about 1 mm by the Kolmogorov theory of local turublence and the results of experiments of diffusion carried out by many researchers. Therefore, the range of the turbulence spectrum of the river flow is of order of 10^6.

Recent Flood Problems in Japan

By Tojiro ISHIHARA

Annuals of the Disaster Prevention Research Institute, Vol. 9, pp. 7-20, March, 1966.

Abstract

Destructive floods occurred in the middle and western parts of Japan in July and September 1965. This paper describes the disasters in outline, and the flood problems are discussed through the results obtained by field investigations, that is, the problems of the areal distribution and the amount of storm rainfall caused by different meteorological circumstances, the flood-control operation of a reservoir with a relatively small drainage area, the role of sediments, debris or degradation in flood hazard, the destructive force of flood flow, and the policy of preventing flood disaster and the comprehensive management of a river.

Flow Behaviour at the Sudden Expansion of open Channels

By Tojiro Ishihara and Toshiyuki Shikata

Transactions of Japan Society of Civil Engineers, Vol. 128, April, 1966, pp. 12–28.

Abstract

This paper deals with the hydraulic behaviour of open channel flows through sudden expansions, as the first phase of research work in the whole project for revealing the transitional characteristics of the flow at discontinuities of open channels contributive to the hydraulic design of channel transition and controls. Several investigations on transitional configurations, form resistance, local velocity distributions and length of flow separation are made theoretically and experimentally by means of the one-dimensional hydraulic analysis and hydrodynamic theory on jets.

The flow through a sudden expansion separates strongly from the backward flow along the boundary, which comes a remarkable influence on the hydraulic behaviour of the flow itself. In this paper, assuming that the subcritical flow through a sudden expansion is the diffusion process of a turbulent jet issuing into a confined flow field through experimental study, and introducing a confine parameter as one of the indices to express the confining effect of boundary evaluated experimentally, the hydraulic characteristics of the flow at sudden expansions are described.

Experimental Study on the Vertical Infiltration of Rain-Water

By Yasuo ISHIHARA, Fusetsu TAKAGI and Yoji BABA

Annuals of the Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 551–563,

Abstract

The infiltration phenomenon is one of the most important processes in the hydrologic cycle. In order that rain-water can infiltrate into the ground in an unsaturated state, it is necessary that a portion of the bulk of air in the void of the soil or sand be compressed or exchanged by the penetrating water, because generally there is a ground surface or a rock surface underneath the soil or sand stratum. Therefore, the behaviour of the air, in addition to capillary and gravitational potentials, contributes greatly to the infiltration phenomenon. This paper describes such behaviour of air during the period of rain-water penetration into unsaturated sands and its contribution to infiltration. Experimental results show that (1) there is a criterion for water ponding on the surface of a porous stratum, (2) the exchangeability of air and water changes largely in this criterion. (3) a heavy rainfall over the criterion forcibly compresses the air in the sand void, and is confined into the regions just under the sand surface and just above the ground water surface.

Geomorphology of Drainage Basins Effecting Flood Runoff

By Masashi NAGAO

Annuals, Disaster Prevention Reseatch Institute, Kyoto University

Abstract

In order to clarify the phenomena of flood runoff, it is essential to ascertain the character of a river basin in which rain waters concentrate from the many small mountain slopes or tributaries and finally flow down the channel of a river. The purpose of this study is to investigate the general geomorphological character of upstream drainage basins effecting the flood runoff in Japan. The study was accomplished by using the method of order analysis for the stream channels and mountainous slopes of the 16 basins which are located in the upstream areas of the multipurpose reservoirs. The analysis was carried out on the basis of a topographical map with the scale 1–50,000.

The results obtained are as follows: (1) As for the composition of the drainage network, the bifurcation ratios of the stream numbers show a nearly constant value for the upstream area between the 1st, 2nd and 3rd order within one similar climatic district. (2) As for the stream channels, the mean stream lengths show a nearly constant value for the upstream area of the 1st and 2nd order for all the drainage basins. (3) As for the mountainous slopes subdivided by the stream order number, the mean slope lengths of the 1st order seem to have a rather larger value and wider fluctuation than those of the larger orders. (4) Between the slope length and the slope angle, a certain positive correlation is discerned within one similar climatic district.

A Study on the Recession Characteristics of Ground water Run-off

By Fusetsu TAKAGI

Transactions of Japan Society of Civil Engineers,
Vol. 128, April, 1966, pp. 1–11.

Abstract

In this paper, the author deals with the recession characteristics of the discharge of stream water in an extended period from the point of view of the runoff mechanism of ground water runoff.

Phenomenological considerations show that the runoff discharge in a low flow state consists of the seepage component from a confined ground water aquifer and the leakage component from an unconfined aquifer. There are different characters in the kinematical phase between those two components; thus, the stream water in an extended period or ground water runoff may be characterized by these kinematical characters. The author has clarified the characteristics of ground water runoff, by menas of a discussion on the flow in a mathematical runoff model for these components, and has applied the analysis for several river basins.

Through-out this research, it is made clear that the recession rate of the unconfined component is much more gentle than that of the confined one, and the stream water during an extended period is mainly supplied by the unconfined runoff component. By theoretical discussion the author has made clear the physical significance of recession characteristics and the role of these components in the runoff process.

Studies on the Geomorphological Character of the Gamata River Basin (1)

By Katsumasa YANO, Yoshito TSUCHIYA and Takenobu OKUMURA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 433–444

Abstract

Some field observations are planned on the mechanism of the yielding of sediments and water run-off in a high altitude desolate basin, the Gamata river basin, and as a first step towards understanding the characters of the basin, its geomorphological character is analyzed. The Gamata river is a tributary of the Jintsu running into the Bay of Toyama in Japan, which is a typical torrential river and is transporting sediments of great quantities from the desolate basin. The basin is located in the North Japan Alps at approximately 1,000 m to 3,000 m above sea level and the basin area is approximately 98 km^2. Although geomorphological characteristics are analyzed to find the topographic effects on hydrological phenomena and on the mechanism of the yielding of sediments, only its topographical character is considered in this paper, and an order analysis of the streams, drainage density and a texture ratio analysis, a frequency analysis of stream length, and a hypsometric curve analysis are made with the aid of a quantative analysis of watershed topology with regard to the development of streams. The analysis are made on a topographic map drawn to a scale of 1/20,000.

The order to the basin is estimated as six. Although for the basin and two elementary basins of order 5 (the basin area is about 30 km^2), the logarithmic regression of the number of streams of each order of stream yields a straight-line plot with very little scatter, as Maxwell described, and the inclinations of the lines to each other are nearly constant, it seems that in the elementary basins of order 4 such a relation cannot be found and the inclination of assumed lines is considerably different. From this fact, it should be possible to analyze difference between the characteristics of basins and the lower limit in the area of basins.

It is considered that the bifurcation ratio is dependent on the shapes of basins, even if geologically the basins are same. The authors assumed a basin shape factor represented by the ratio of the distance from the summit to the basin mouth to the maximum distance from ridge to ridge measured normally against the former distance, and they examined the relation between the factor and the bifurcation ratios. From this examination it is appeared that the narrower basin has a larger value in the bifurcation ratio and that in geologically similar basins the regression of the value of the shape factor in the bifurcation ratio yields a straight-line plot but that inclinations of the lines depends on the geology of the basin.

On a Fall-velocity-frequency Analysis of Sediments with a Differential Pressure Gage

By Yoshito TSUCHIYA and Takenobu OKUMURA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 417–425

Abstract

In studying the mechanics of the transportation of sediments by streams, particularly in dealing with the sediments in a mountain stream, it is desirable to know the fall-velocity-frequency distribution rather than the size frequency distributions of sediments. The usual methods for observing the characteristics of sediments are mainly intended for the size frequency analysis of granular particles as Stokes' law applicable. A few methods for fall-velocity analysis have been used in studying the mechanics of falling, but these methods are undesirable for the fall-velocity frequency analysis, as they a lot of time and personnel.

The application of differential pressure gages to the sedimentation test was carried out by Appel, but his method is limited to minute granular particles. In order to establish a better method with a differential pressure gage to analyze the fall-velocity-frequency distributions of sediments of considerable coarse such as gravels in mountain streams, the authors carried out some experiments with two sedimentation columns of 7.55 cm and 3.49 cm in diameter and with sediments of 3.42 mm and 0.53 mm in mean diameter.

As a result of the experiments, the following improvements in the method can be put forward:

1) The ratio of sediments to water in the sedimentation column should be less than about 3% in weight. When the ratio exceeds about 3%, there occures mutual interference in the falling phenomena of sediments.

2) In practice, a longer column is generally desirable to analyze the fall-velocity of sediments, but this is unhandy. The ratio of the length to the diameter of a sedimentation column should exceed twenty and the diameter should be determined considering the influence of the side wall of a column on the falling of sediments.

3) It is very important in practice to know how to gauge the pressure in a section of a sedimentation column and how to put sediments into a column in a moment. It would appear that when a column of larger diameter is used, the measured pressure in a section will differ from the average and the falling phenomena of coarse particles do not become steady in the initial stage. It was however concluded through this experiment that the method for the fall-velocity-frequency analysis can be made suitable for sediments of considerable coarse by using a suitable apparatus for gauging the pressure difference and putting the sediments into a column, although the applicability of the method is limited by the ratio of the length to the diameter of a column and concentration of the sediments.

An Experimental Study on the Critical Tractive Force for Gravel in a Mud Stream

By Atsuyuki DAIDO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 427–432.

Abstract

This paper deals with the critical tractive force of gravels in a mud stream. Whether the stream is muddy of a clear flow, the mechanism of the initial movement of gravels is similar. But it is hard to analyze theoretically the mechanism in a mud stream because the fluid characteristics in the turbulent region have not yet been clarified.

As the mud stream has the character of fluid plasticity the character can be applied to estimate the velocity profile of a stream and the drag coefficients of gravel in considering the initial movement of gravels.

In this paper, the author presents an arrangement of the experimental results on the critical tractive force in a mud stream using a Reynolds number derived from the kinetic similitude of the movement of gravels. The Reynolds number is expressed by a function of the Reynolds number of the critical tractive force proposed by Shields and the ratio of the yield stresses of the fluid to the boundary shear. It was found from the above treatment that the dimentionless function of the critical tractive force for gravels in a mud stream can be expressed by the relation between $U_{*C}{}^2 \cdot a' \left\{1+\left(\frac{1}{a'}-1\right)I\right\} \Big/ \left\{\left(\frac{\sigma}{\rho}-1\right)gd\tan\varphi\right\}$ and $(U_{*C}\cdot d/\nu)\cdot\left\{a'\Big/1+\left(\frac{1}{a'}-1\right)I\right\}$, instead of the relation between $U_{*C}{}^2\Big/\left(\frac{\sigma}{\rho}-1\right)gd$ and $U_{*C}\cdot d/\nu$ proposed by Shields, where U_{*C} is the critical friction velocity, a the ratio of the yield stresses of the fluid to the boundary shear, I the correction factor for inertia, σ and ρ the density of gravel and fluid respectively, g the acceleration gravity, d the diameter of gravel, φ the friction angle of gravel. It was concluded from the treatment that the critical tractive force for gravels in a mud stream can be expressed by the same relation as that in a clear stream proposed by Iwagaki (1956), and that the relationship is in good agreement with the experimental results.

Moreover, the treatment showed that the experimental results in the case of gravels on a granular bed are also in good agreement with the results of Iwagaki and Tsuchiya's study (1965).

On the Flood Propagation through a Backwater Reach (2)

By Kazuo ASHIDA and Tamotsu TAKAHASHI

Annual, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 579–591.

Abstract

This paper studies the characteristics of a flood wave under the boundary condition where the water stage downstream is held constant. In the backwater reach under such conditions, the flood wave has many peculier characteristics in comparison with those in a prismatic channel.

The authors obtained the following experimental results:

(1) In the cases where the flow-in flood has a comparatively sharp hydrograph, the stage of the flood can exceed that of the steady flow, of which the discharge is the same as the max. discharge of the flood.

(2) The peak of the stage occurs before the occurence of the discharge maximum; thus the direction of the loop of the discharge-stage relationship is the opposite of that in a prismatic channel.

(3) The celerities of the propagation of the stage and discharge max. are very large and the stage max. can occur downstream before it appears up-stream.

(4) Deformation of the hydrograph is small.

The authors discussed these results theoreticaly using Saint-Venant's equation under the assumption that in such a backwater reach, especially near the boundary, the curvature of the water surface is small and so the surface can be considered to change its height linearly towards the downstream end. This assumption is valid for the extent of the experiments.

The authors succeeded in explaining all the characteristics mentioned above and, further, finding that the stage of the flood differs for the same max. discharge by the rate of increase of the discharge and depth, they made clear the condition under which the stage of the flood exceeds the steady stage. And finally they proposed a practical calculation method for the flood stage in this reach using the characteristics thus clarified.

An Experimental Study on Sand Waves (2)
—The influence of a side wall on sand wave formation—

By Kazuo Ashida and Yuichiro Tanaka

Annual, Disaster Prevention Rescarch Institute, Kyoto University,
No. 9, March, 1966, pp. 445–456.

Abstract

Sand waves occur at almost time when bed materials are moved by running water and they present various difficult problems. Therefore it is necessary to make clear the mechanism of sand waves in order to solve the mechanism of sand movement and the resistance law for a movable bed.

One of the most important characteristics of sand waves is the irregularity in their shapes and sizes. Therefore statistical treatment is necessary to describe them quantitatively. So the authors started a series of studies on the assumption that these phenomena are a stochastic process. Their first step was to manufacture some equipment which measures the water level and bed elevation by means of an ultra-sonic device.

Sand waves on a movable bed usually have three-dimensional characteristics and it is necessary in measuring bed forms to consider that the side wall has a large influence on them. In this paper, the authors examine experimentally the side wall effects on the characteristics of sand waves.

The mean values of the steepness of sand waves differ from each other in cross-section. This means that the character of sand waves can not be fully shown by steepness alone. Two types of side wall effects are considered, namely the shear defect and the secondary current due to the side wall.

For the defect of the shear stress, it could be assumed to be distributed logarithmically across the channel bottom from the measurement of the velocity distribution, but the effect of the non-uniformity of the sheat stress distribution on sand waves was not so much.

On the other hand, the secondary currents due to a side wall exerts a large influence on the deformation of sand waves and the occurreace of meandering flow. The authors have given some qualitative consideration to these secondary currents.

Study on the Hydraulic Behaviour of Dunes (Meander) in Channels

By Kazuo Ashida and Yasukuni Shiomi

Annual, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 457–477.

Abstract

Diagonal dunes are formed and meandering flow occurs even in a straight channel with movable bed and rigid side walls under the special conditions of hydraulic quantities and flow geometries. Dunes in a channel with not straight alignment are different from those in a straight channel. To clarify the characteristics of dunes in channels of various alignments is a very important problem in river engineering. In this paper, the authors discuss the hydraulic characteristics of dunes in a straight channel and those in meandering channels of three kinds of amplitude with rigid side walls which have same wave length equal to the one of the dunes in the straight channel. In the case of small amplitude, dunes move downstream as in straight channels but the movement stops for an amplitude which is larger than the critical one. The authos discuss the above critical condition and the configuration of dunes and flow geometries after the movement of the dune has stopped.

The following results are obtained.

(1) The length of the meander due to dunes over the channel width was represented by a function of the Froude number, and also a function representing the progressive velocity of the dunes was obtained.

(2) The slope of the mean bed elevation and of the water level was nearly constant even in the case of dunes beds.

(3) The movement of dunes stops when the curvature of the side wall is larger than the critical one, which is given by the condition, $2a/B=0.6$, where a is the amplitude and B is the width of the channel.

(4) The form of the edge of the dunes can be predicted by an equation obtained theoretically in the case where the dunes have stopped.

(5) The flow and geometrical characteristics were made clear in the case where dunes have stopped.

Internal Structure of Flow through Curved Open Channels (II)

By Yoshio MURAMOTO

Annual, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 525–537.

Abstract

As described in the first paper of this subject, the flow through a curved open channel as a mathematical model may be divided into three regions—a generating region, a developing region and a fully developed region of secondary flow.

In the first part of the present paper, the extent of these regions and their properties are reexamined by a series of experiments in several kinds of single curved open channels with a 90° or 180° central angle and a ratio of cetnral radius to width 1∼3 under the condition of subcritical and super-critical flows. According to the observed results of the longitudinal distribution of mean vorticity, it is considered that the flow in the curved section has the characteristics of the generating and the developing region, and rarely reaches the fully developed region in many practical cases. The extent of these regions seem mainly to depend on the ratio of the central radius to the width. Further, it is confirmed that the properties of the local vorticity distributions at the points of different depths and radii, as a whole, correspond to those of the mean vorticity.

In the second part, the velocity distributions of secondary flow in the generating region with or without the effects of bed wall friction are discussed. The radial velocity distributions without the effect of bed wall friction are derived from the Helmholz equation of vorticity by using the assumptions of a free vortex for the primary flow and the longitudinal velocity distributions of laminar or turbulent flow. The theoretical distribution of radial velocity except near the wall agrees fairly well with the experimental results in the generating region. While on the other hand, the extent of the generating region and the vertical distribution of radial velocity at the limit of the region are discussed on the basis of the longitudinal vorticity equation in consideration of the viscous diffusion of vorticity affected by the channel bed. The experimental verification of the present theory and the previous study developed by I.L. Rozovskii are also presented.

Analysis of Groundwater Flow in a Small Mountain-Stream (1st report)

By Mutsumi KADOYA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 593–599.

Abstract

The method of estimation of the groundwater flow from rainfall in the area of a mountain-stream has been discussed in this paper. The increment of the groundwater flow caused by rainfall, $\Delta q_0 = q_f - q_0$ in which q_f is the groundwater flow at the end of recharge and q_0 at the beginning of rainfall, has been discussed based on the model constructed by the following assumptions: (1) The discharge of groundwater flow is in proportion to the amount of water stored in the groundwater layer of the basin. (2) The recharge of groundwater occurs only when the soil moisture content in the surface layer equals or exceeds the field capacity. (3) The recharge intensity of groundwater is a part of the infiltration capacity in Horton's formula.

After some consideration, it became clear that Δq_0 is affected by various factors related to the history of rainy and dry periods. In the first examinations, the hydrologic data of three small mouatain-streams where each basin in about 1 km^2 were used. In these cases, Δq_0 was estimated using only the total amount of rainfall, its duration and q_0.

In order to make more clear the runoff mechanism, the following characteristics were considered theoretically; (1) the deficiency of soil-moisture and the recovery of infiltration capacity in dry periods, (2) the successive diminution of infiltration capacity in rainy periods. Sufficient data have not been gathered yet, so the examinations have been suspended so that these considerations can be supported by proof.

Runoff Analysis in Paddy Field District

By Eiji TOYOKUNI and Mutsumi KADOYA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 631-636.

Abstract

The runoff analysis in a low-lying drainage basin, where residential and agricultural land is extensive, presents a troublesome task because of the complications of its phenomena.

In such a case, the unit-hydrograph method has generally been adopted without recourse to theoretical reasoning but empirical sense. In order to establish the method of runoff analysis in a low-lying drainage basin in this paper, it is shown that analyzed results of higher accuracy are obtained by introducing the effect of innudation into the process of runoff analysis. These results are expressed as follows:

1 Principal rainfall-loss in the paddy field is composed of rainy water which is stored in the notch of the paddy field (see Fig. 1).

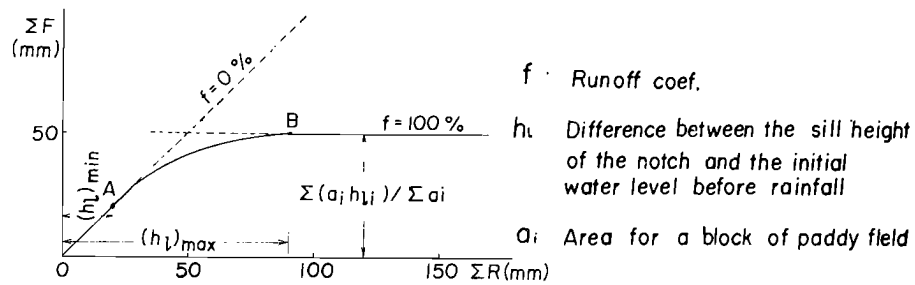


Fig. 1. Schematic diagram illustrating the relation between the accumulated rainfall ΣR and the accumulated lost rainfall ΣF.

2 The separation of base-flow in the paddy field should be given attention because the base-flow parts occupy a higher proportion on the runoff hydrograph.

3 The runoff process has been examined by the method of the characteristics of the fundamental equation of the flow with lateral flow, by considering the inundation phenomena which are caused by a deficiency of section, meander and local contraction in the drainage channel. As a result, it has been found that the effect of inundation is very important in the runoff analysis, and this effect should be introduce into the process of runoff analysis in the case of the paddy field basin.

Inundation Characteristics in Low-lying Basin of Lower Reaches of Yamashina River —Study on Exclusion from Flooding Trouble in Low-lying Basin of Lower Reaches of Yamashina River (2)—

By Eiji Toyokuni and Mutsumi Kadoya

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 601–614.

Abstract

This hydrological observation has been carried out since 1963 in Yamashina river basin to make clear the runoff characteristics in the basin. Yamashina river is a branch of the Yodo River, and has a drainage basin of 56.1 km^2 which contains a low-lying district of 11.7 km^2 in its lower reaches. This low-lying district, where residential and agricultural land is extensive, has had flooding troubles very often hitherto, but the cause of the trouble has not yet been established.

In this paper, the inundation characteristids in this district are discussed on the basin of observed data from Typhoon No. 24 in 1965 which caused various disasters in many places in the Kinki District because of heavy rainfall. As a result, it has been found that the inundation in this district principally results from the back water of the Yodo River.

The equivalent roughness in the method of runoff analysis by the characteristics studied in the previous report has been reexamined using this data, and its fitness has been recognized. Moreover, the states of inundation have been examined under various conditions. As a result, it has been concluded that inundation troubles in the district will be greatly mitigated when the embankment work for protecting the inland area has been completed, but mechanical drainage facilities will become necessary if the urban land is further developed.

A theoretical Analysis of Unconfined Groundwater Flow in Kofu Basin

By Gyozo OHASHI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 615–629.

Abstract

This study has been done to clarify the hydraulic behaviour of the unconfined groundwater movement in an alluvial fan, making the Kofu Basin the object of study.

First, field investigations were carried out in the Kofu Basin to make clear the characteristics of the seepage flow in the alluvial fan. This basin has a triangular form. It has been pointed out from the results obtained in this field investigation that the groundwater in the basin is supplied from the Kamanashi and Ara Rivers and is drained into the Fuefuki River through many drainage channels, and that the effect of the water level in the drainage channel on the seepage flow is significant.

Next, the effect mentioned above is discussed as the first step of the theoretical study. In this stage, the basin and the groundwater in question were modeled by referring to the results obtained in the field investigation as follows: (1) the alluvial basin may be divided into several basins of rectangular shape each having a drainage channel on two parallel sides; (2) the vertical changes in the hydraulic characteristics of the seepage flow are negligible. With the intention of obtaining an analytic solution to the steady flow equation, a technique has been proposed as follows: the seepage flow in a rectangular region is divided into longitudinal and lateral flows which are respectively parallel and orthogonal flows to a drainage channel, and both flows can be related to the recharge elements which are defined as the difference between inflow and outflow through the section in unity width at any point in the longitudinal flow.

In order to discuss the propriety of the solution obtained by the analytical technique, the experiments of the seepage flow in the modeled region have been carried out by using the apparatus of a sand tank which is 6.15 m long, 1.0 m wide, and 1.2 m deep, and possesses a sloping impervious bed: 1/50, two water levels on both upper and lower sides, and a sloping drainage channel (605 cm long, 2.5 cm wide, and 25 cm deep): 1/100.

From the compariosn between the experimental results obtained above and the calculations by the analytic method relating to the maximum height of the groundwater table in the flow, it is found that the analytic method proposed above is a practical one.

Studies on Cnoidal Waves (Third Report) —Experiments on the Wave Profile, Wave Velocity and Wave Length—

By Yuichi IWAGAKI and Masahiko HOSOMI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 637-645.

Abstract

This paper deals with the measurements of the wave profile, wave velocity, wave length and height of still water level above the wave trough in the case where the ratio of water depth to wave length is small and with the comparison of these experimental results with those of cnoidal waves of the second approximation based on Laitone's theory, of Stokes waves of the third order approximation and of small amplitude waves.

The wave tank used in the experiment is 50 cm wide, 65 cm deep and 63 m long and has a piston type wave generator. As to the wave profile, the time change of the water surface was measured by an electric resistance type wave meter, regarding as permanent type waves. The wave velocity was computed from the time necessary for the progression of waves between two stations 301.5 cm apart determined by wave records within a limit of the error of 0.5%. The wave length was measured by finding the positions of two wave meters where the phase of the corresponding waves in the records taken at two stations was just 2π within a limit of the error of 1%.

The comparisons between the theoretical and experimental results show that (1) it is not yet clear which theory, that of cnoidal waves or that of Stokes waves is applicable to the wave velocity and wave length, because these experimental results agree fairly well with those of both cnoidal and Stokes waves case by case, (2) with respect to the wave profile, the cnoidal wave theory agrees with the experiment better than the Stokes wave theory, and (3) the experiments for the height of the still water level above the wave trough agree with those of the cnoidal wave theory better than those of the Stokes wave theory in the cases $T\sqrt{h/g}=15$ and 20 (T: the wave period and h: the water depth).

Studies on the Effect of Wind on Wave Overtopping on Seawalls (Second Report)

By Yuichi IWAGAKI, Masao INOUE and Koichi OHORI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 715–727.

Abstract

This paper is the second report on studies undertaken to clarify quantitatively the effect of wind on the wave overtopping on seawalls and seadikes, in which the experimental results of wave overtopping on vertical seawalls set on a model beach of 1 on 15 slope in a high-speed wind-wave tunnel are described for the incident steepnesses of 0.01 and 0.02.

The main results obtained from the experiments are summarized as follows:

1) When incident waves do not break in front of the seawall, the quantity of wave overtopping begins to increase suddenly with an increase in the wind velocity when it reaches a certain point. The increasing segment of the quantity of wave overtopping due to the wind is considerable compared with other cases.

2) When incident waves break just in front of the seawall, the quantity of wave overtopping changes in a complex manner with an increase in the wind velocity for the wave steepness of 0.01, and it becomes approximately constant over a low wind velocity for the wave steepness of 0.02.

3) When incident waves break before they reach the seawall, the effect of wind on wave overtopping is not very great, and in particular when the seawall is constructed along the shoreline or on shore, the quantity of wave overtopping tends to decrease a little at a high wind velocity.

4) The effect of the crest height and the water depth at the toe of seawalls in a storm condition are similar to those in a calm condition; that is, increasing the wall height above still water level to decrease the quantity of overtopping water is not so effective when incident waves break just in front of the seawall as in the cases where the waves do not break or have already broken, and the quantity of wave overtopping becomes maximum when waves break a little offshore the seawall.

Some Experiments on Cnoidal Waves

By Yuichi IWAGAKI and Masahiko HOSOMI

Proc. of 13th Conference on Coastal Engineering in Japan,
Dec., 1966, pp. 1-8.

Abstract

This paper presents synthetic descriptions of the first and second reports of the studies on cnoidal waves, in which, on the basis of Laitone's cnoidal wave theory, the graphs and method for computing the wave profiles were provided, together with an easy method for finding the wave velocity and wave length for practical use, and also of the third report, of which the abstract is described in this Bulletin, in addition to complementary experiments on wave velocity, wave length, wave profile and height of still water level above the wave trough in the case $T\sqrt{g/h}=25$ and for the cases $2<h/H<3$ (T: the wave period, h: the water depth, and H: the wave height). As a result, the experimental results of the wave characteristics described above are seen to agree fairly well with those obtained by the cnoidal wave theory, though this is not clearly verified in the case $T\sqrt{g/h}=30$ because the wave profile is not completely regular.

On the Effect of Wind on Wave Overtopping on Vertical Seawalls

By Yuichi IWAGAKI, Yoshito TSUCHIYA and Masao INOUE

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 16, Part 1, No. 105, Sept., 1966, pp. 11–30.

Abstract

In designing seawalls and seadikes, it is very important to estimate as accurately as possible the quantity of wave overtopping that may occur.

The estimation, however, is difficult because of the complicated phenomena of wave overtopping, and in particular the effect of wind on wave overtopping is entirely unknown. In view of this difficulty, the authors have begun a study to clarify quantitatively the effect of wind on wave overtopping by using a high-speed wind-wave tunnel.

In this paper, firstly, the structures and performances of the wind-wave tunnel, the blower and the wave generator are described briefly. Secondly, experimental results on wave overtopping on vertical seawalls are shown for the cases of both calm and windy conditions, and the effect of wind on wave overtopping is discussed.

The conclusions are described in the abstract of "Studies on the Effect of Wind on Wave Overtopping on Seawalls (Second Report)" presented in this Bulletin.

Studies on the Mechanism of Wave Damping Due to Bottom Friction
—In the case of Laminar Boundary Layer—

By Yuichi IWAGAKI, Yoshito TSUCHIYA, Masayuki SAKAI and Huoxiong CHEN

Annuals, Disaster Prevention Research Institute, Kyoto University, No. 9, March 1966, pp. 647–665.

Abstract

The present paper is part of the results obtained from basic studies on wave damping, in particular on the laminar damping characteristics of oscillatory waves due to bottom friction which have been carried out for several years at the Ujigawa Hydraulic Laboratory, Disaster Prevention Research Institute.

In order to discover the mechanism of the laminar damping of oscillatory waves, experimental investigations were made in detail by the direct measurement of instantaneous shearing stresses acting on a smooth bottom due to waves, and by the obervations of wave amplitude attenuation with distance. In addition, a theory of the laminar damping of oscillatory waves was established on the basis of an approximate solution of the laminar boundary layer equations, and the influences of convective terms in the basic equations on the bottom shearing stress and on the wave energy dissipation in the boundary layer developing both on the bottom and on the side walls of a wave channel were considered with the above solution.

The conclusions derived from the comparison between the theoretical results and the experimental ones are as follows: the influences of the convective terms on the bottom shearing stress and the wave energy dissipation are negligible within the range of the present experiments, but those on the side walls are considerable, that is about 20% at maximum within the range of the authors' exepriments. The experimental values of the shearing stresses on the bottom agree well with the result of the linearized theory if the data are corrected for the pressure forces acting on the edges of the shear plate. With regard to wave damping the experimental values of the wave decay modulus are approximately 40% larger than the theoretical ones derived from the linearized theory and even if they are corrected for the effect of the convective terms, they are still approximately 30% larger than the theoretical ones.

The reason for the discrepancy between the theory and the experiment seem to be the existence of some other dissipations.

Experimental Study on the Mechanism of Wave Run-up on Sloping Structures

By Yuichi IWAGAKI, Masao INOUE and Koichi OHORI

Proc. of 13th Conf. on Coastal Eng. in Japan,
Dec., 1966, pp. 198–205.

Abstract

It is very important to make clear the mechanism of wave run-up on sloping structures not only for hydraulic interests but also for practical purpose such as the designing of seawalls and seadikes. However, it is difficult to solve the problem comprehensively because of complicated phenomena of wave run-up.

By using a wave tank, which is 21.6 m long, 0.75 m wide, 1.0 m deep, the authors have carried out experiments in order to ascertain quantitatively the behavior of waves running up on a smooth sloping plate set on the shoreline for both solitary and periodic waves.

The results obtained from the experiments were compared with those of the theoretical analysis derived from the method of characteristics proposed by Freeman-Méhauté.

The main conclusions derived from comparisons for the case of a solitary wave are summarized as follows:

1) The mechanism of wave run-up can not be explained without taking into account the effect of friction on the surface of a sloping structure.

2) The transformation from the bore to the rarefaction wave agrees well with the result of the theoretical analysis.

3) The mechanism of wave run-up on structures with steeper slopes than 1/5 can be explained by considering only the characteristic curve in front of the rarefaction wave.

The mechanism of the wave run-up of periodic waves seems to be similar to that of a solitary wave for the structure with a steeper slope than 1/5.

On the Bottom Friction Factors of Some Japanese Coasts (2)

By Yuichi IWAGAKI and Tadao KAKINUMA

Proc. of 13th Conf. on Coastal Eng. in Japan,
Dec., 1966, pp. 21–29.

Abstract

In order to forecast shallow water ocean waves, the value of the bottom friction factor in shallow water has to be given for the estimation of wave energy loss due to bottom friction.

In this paper, from the damping of the significant wave heights and the transformation of the wave spectra observed off some Japanese coasts, the bottom friction factors are computed and the relationship between the bottom friction factor and the wave Reynolds number is presented.

It should be noted that the estimated values of the bottom friction factors of some Japanese coasts are much greater than 0.01, which was given by Bretschneider for general use in forecasting shallow water ocean waves.

It is found that the estimated values of the bottom friction factors of some Japanese coasts f are

(1) in the case of the significant wave method, $f=0.027\sim0.091$ for $10^6\leqq R_{eT}<8\times10^6$ (quadratic drag region), where R_{eT} is the wave Reynolds number,

(2) in the case of the wave spectrum method (spectral peak only), $f=0.032\sim0.18$ for $(1\sim2)\times10^6\leqq R_{eT}<3.3\times10^7$ (quadratic drag region), and

(3) for $R_{eT}<10^6$, the bottom friction factors increase with the decrease in the wave Reynolds number.

Analysis of Ocean Waves by a Spectrum Analyzer

By Yuichi IWAGAKI, Haruo HIGUCHI, Tadao KAKINUMA
and Hiroshi MIYAI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 703–713.

Abstract

The performances and characteristics of the spectrum analyzer at the Disaster Prevention Research Institute are first described.

Tape speed of the data recorder: 7.5 inch/sec or 15/16 inch/sec;
Time compression: 1/100 or 1/1000;
Type of analyzer: heterodyne;
Band width of the bandpass filter: 2 cps, 4 cps, 10 cps, or 20 cps;
Range of analyzing frequency: 5～1000 cps.

Second, some examples of the amplitude and energy spectra obtained by this analyzer are presented. The energy spectra obtained are compared with those obtained by the digital analyses of the same records. The agreement of the spectral shapes obtained by the two methods is fairly good except in the range of extremely low frequency.

On Wave Observations at Nishikinohama Coast

By Haruo HIGUCHI and Tadao KAKINUMA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 685–701.

Abstract

Forecasting shallow water ocean waves is one of the most important problems in coastal engineering at present. Nevertheless among the characteristics of shallow water ocean waves, the wave height reduction due to bottom friction is not well known.

To clarify the transformation process of shallow water ocean waves for relatively small waves, wave observations were made at Nishikinohama Coast in 1964.

This paper presents the results of wave observations analyzed both by the significant wave method and the wave spectrum method.

Four buoys were set along the direction of the waves at water depths of 8.6 m, 7.1 m, 6.2 m, and 2.4 m, respectively, and the four buoys in wave motion were photographed simultaneously for ten～fifteen minutes by using two 16 mm cine-cameras with a 400 mm and a 1000 mm telephoto lens.

Eight wave data were obtained at the corresponding two or three stations offshore and onshore. From these data were obtained the transformations of ocean wave spectra in shallow water which are very important in clarifying the energy transmission in shallow water.

In addition, it is found that the estimated ratios of various mean heights of shallow water waves are somewhat smaller than the theoretical values obtained by Longuet-Higgins (1952).

Model Experiments on Sand Drift at Gumizaki Fishery Harbor (Part I)

By Hideaki NODA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 729–741.

Abstract

Gumizaki Fishery Harbor where is located on the coast facing the Japan Sea has been filled up annually by drifting sand, so that the harbor has been maintained for navigation by dredging. However, it is urgently necessary to establish protective measures against the filling-up of its basin by drifting sand.

This paper is concerned with model experiments undertaken for the purpose of studying the mechanism of coastal sediment movement and depostion in the basin due to waves and currents and to consider protective measures against the filling-up of the basin by drifting sand. In such experiments, it is necessary that the similarity of the sediment movement as well as the wave motion be satisfied between the model and the prototype. It is especially important to establish the similarity condition for the sediment movement. From the results of previous investigations, the similarity condition of the sediment movement is determined by taking account of sediment suspension and is expressed by $W_{om}/W_{op}=(1_m/1_p)^{1/2}$ (W_o: the fall velocity of the sediment, 1: a representative length, m and p: the quantities for the model and the prototype). It is then found that the characteristics of the model sediment are approximately satisfied by using vinyl pellets of median diameter 0.13 mm and specific gravity 1.15.

The reproductivity of the model experiment is verified by the fact that the deposition profile in the model is in good agreement with that in the prototype. The results of the model experiment to discover the mechanism of the filling-up of the basin indicate that the invasion and deposition of drifting sand are greatly influenced by the currents and the harbor oscillations induced in the basin. As a result of the experiments on the protective measures against the filling-up of the basin, it is found that the penetrating sediment is effectively prevented by stopping the currents and the harbor oscillations.

Study on the Initial Movement of Sediment Particles Due to Wave Action

By Hideaki NODA

Proceeding of 13th Conference of Coastal Engineering in Japan,
No. 13, December, 1966, pp. 135–141.

Abstract

In the previous report, of which the abstract was described in the Bulletin, Vol. 14, Part 4, March, 1965, a theoretical treatment of a critical tractive force under wave motion applying the theory of the oscillatory laminar boundary layer was presented in order to estimate the critical depth for the movement of sediment particles under wave action. The results of the theory indicated that the initial movement was expressed in terms of three dimensionless quantities $U_0^{*2}/[(\sigma/\rho)-1]gd \tan\varphi$, U_0^*d/ν and U_0^*/U_0, in which U_0^{*2} is the amplitude of the shear velocity, U_0 the maximum water particle velocity of the bottom, σ and ρ the density of sediments and water, d the diameter of sediment, ν the kinematic viscosity of water and φ the static friction angle.

In this paper, U_0^*/U_0 one of the three dimensionless quantities described above is replaced by $U_0\delta/\nu$ on the basis of the study on the inception of turbulence on a bed under the action of periodic gravity waves by Collins and that on sediment transport by Vincent, in which δ is the quantity related to boundary layer thickness. The experimental results show that the theory's quantitative prediction of initial movement is quite good when the values of U_0^*d/ν and $U_0\delta/\nu$ are less than about 20 and 160 respectively. However, the agreement of the theoretical value with the experimental one becomes poor gradual with an increase in the value of U_0^*d/ν. This seems to be because the boundary layer becomes turbulent and the initial movement is influenced by the roughness of the bottom when $U_0^*d/\nu>20$ and $U_0^*\delta/\nu>160$.

On Some Properties of Sediments at Takahama Coast

By Hideaki NODA and Teruo SHIBANO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 743–762.

Abstract

Many investigations have been conducted to clarify the mechanism of sediment transport by waves and currents, but it seems that a satisfactory method of field investigation on sand transport has not yet been established. This paper is an attempt to clarify the beach process, the direction of sediment transport by waves and currents, and the source area where beach materials come from, by investigating the properties of sediments. Some properties of the beach sediment on the Takahama Coast were analyzed by physical and mineralogical methods using the data of sediment sampling obtained from the field investigations.

The methods used to collect the sediment samples are as follows: 1) sampling of beachface materials along the shore, 2) sampling of sediments on the sea bottom, and 3) sampling of suspended sediments made by bamboo-trap samplers. In order to find the characteristics of these kinds of samples, the analyzed items are: 1) size composition of sediments, 2) mineral configuration, 3) specific gravity, and 4) roundness. From the results of sieve analysis, it was found that size frequency curves of beachface materials have bi-modal distributions divided with the gravel and sand groups. In addition, from the results of alongshore distributions of the median diameter, the gravel content and diabase content for beachface materials and bottom sediments, and also the source area and the predominant direction of sediment movement were estimated.

Courant de Maree et Toubilion dans la Region Cotiere

By Shigehisa NAKAMURA

Bulletin de la Societe franco-japonaise d'oceanographie, Tome. 4,
No. 2, 1966, pp. 108–110.

Abstract

Tidal currents near the coast are not always uniform, due to the effects of the coastal line, bottom topography and bottom friction. Vorticity associated with tidal currents is also not necessarily uniform, and there should be a relation between vorticity and the other physical factors. In this article, tidal vorticity near the coast is studied. First the vorticity equation near the coast is derived and solved. The solution is a simple one, known as a solution of the diffusion equation. Taking the eddy viscosity η as a constant, the solution is obtained

$$\varpi_1 = \frac{pX_0}{\pi}\int_{-\infty}^{\infty} \exp(-\xi^2)\cdot[y+2\sqrt{\eta t}\cdot\xi]^{-1}d\xi\,,$$

where y is distance from coast, t is time and X_0 is a function of x. And p is found from a result of current observation for a velocity profile

$$u=p\ \log\ y+q' \quad (q\text{: const.})$$

On the other hand the effect of the earth's rotation upon vorticity is considered but it is found that this effect is negligible in a coastal region, as has always been ever thought.

To glance at a trend in vorticity, it may be convenient to consider a macroscopic flow pattern of parallel flow and to express vorticity as follows:

$$\varpi' = \frac{\partial u}{\partial y}-\frac{\partial v}{\partial x} = \frac{p}{y}$$

As references, two kinds of data are cited in this article. One is vorticity reduced from the result of tidal current observation off the Eastern Harima Coast, which supports the above expression of vorticity and proves the effect of the earth's rotation to be negligible. The other is vorticity reduced from the result of the aero-photographic observation of tidal currents at Akashi Strait (with the courtesy of Kinki District Construction Bureau, Ministry of Construction). The vorticity in the Akashi Strait is similar in its trend against distance from coast. And it is found that the meandering zero line of vorticity is not at the center of the strait, and shifts to north. These seem to be caused by the remarkable effect of the non-linear term, which was neglected in this article, and to the configuration of bottom topography.

A Note on Tidal Vorticity

By Shigehisa NAKAMURA

Bulletin de la Societe franco-japonaise d'oceanographie,
Tome. 4, 1966, pp. 215–219.

Abstract

The author tried to study tidal vorticity off the coast with reference to certain field data. The theoretical result was not exact mathematically but gave a relation between vorticity and distance from the coast.

In the coastal region, tidal currents are more significant compared with the other components of currents. And vorticity associated with tidal currents or tidal vorticity is an interesting problem. It seems, however, that the concept of vorticity has not been introduced into the problems of coastal and near shore phenomena.

In this article, the author tries to study tidal vorticity further applying the successive approximation method to the vorticity equation. The vertical component of tidal vorticity was considered only in this case. From the result of the analysis, it was found that the solution has a factor of y^{-1} in the case of a moderately large value of y when the solution is taken up to a higher (in this case, the solution is solved up to the third order).

If the solution is limited to the approximation of the first order, non-linear effect disappears and the solution is

$$\varpi_{Re} \sim -\frac{\zeta f}{H} - \exp\left(-\sqrt{\frac{\omega}{2\eta}}\, y\right) \cdot \frac{c_1}{2\sqrt{2}} \sqrt{\frac{\eta}{\omega}} \cos\left(-\sqrt{\frac{\omega}{2\eta}}\, y + \omega t\right),$$

or

$$\varpi_{Re} \sim -\frac{\zeta f}{H} - \frac{c_1}{4y}\left(\frac{2\eta}{\omega}\right) \cos\left(-\sqrt{\frac{\omega}{2\eta}}\, y + \omega t\right)$$

From the above solution, a relation between ϖ_{Re} and η is found. If the Corioli effect is negligible, it is easily found that the tidal vorticity ϖ_{Re} is proportional to η. Through this analysis, the coefficient of eddy viscosity has been considered as a constant which is independent of time and location. This solution seems to be fairly similar to the relation between vorticity and eddy viscosity as a tensor for a steady flow, or η in the solution seems to correspond to one of the diagonal components in the tensor which was introduced formerly by Hayami. And, it was found that the solution is fairly consistent with the result reduced from the field data of tidal currents.

Tsunami et Houle au Voisinage des Bouches D'un Fleuve

By Shigehisa NAKAMURA

Bulletin de la Societe franco-Japonaise d'oceanographie,
Tome. 4, No. 4, 1966, pp. 220–227.

Abstract

The problem of the change of water level near and at a river mouth is an interesting in itself as it is of importance for solving the related phenomena there. Here, to begin with, an analytical result of the change of water level near and at a river mouth derived by the one dimensional and successive approximation method is introduced The coordinate is taken as follows: the x axis upstream from the river mouth on the mean level of the water of the river and the z axis upward postive from the river bed at the river mouth. And assume that the mean level of the water surface is parallel to the river bed which has a gradient I_0, and that the water depth h is constant in the river. In the analysis, the vertical profile of current velocity is assumed to hold logarithmic law. From the result of the analysis, the important factor in finding the characteristics of the change of water level near and at the river mouth, i.e., $\Lambda_n^{\pm}$ is introduced and discussed.

But the result obtained above is not always applicable to the problem of the field as it is. So, several results reduced from the field data are introduced here and what should be additionally considered in discussed or taken into account. On the problem of tsunami, the wave height and period of the tsunami in the Tone River which was caused by the Aleution Earthquake on 4 Feb., 1964 is mentioned. On the problem of tides, references similar to those in the case of tsunami are considered. These suggest that it is necessary to take into account local changes in the water depth and width of the river. The other examples are shown as sketches of wave (swell) breaking at the mouth of the Niyodo River and the Monobe River under several conditions.

Lastly, the effect of the curvature of a river is studied by a graphical method in the case of wave propagation into the river under several simplified conditions. The effect of friction on the banks and the bottom is assumed to be negligible. Waves propagate straight forward without reflection. Only reflection at the banks is considered. The results are shown in several diagrams which might suggest the result of an analysis of the effect of the curvature of a river in the case of wave propagation into the river. These results are considered to be applicable to some practical problems in the field. The example introduced here is a problem at the mouth of the Teshio River.

On Shirahama Oceanagraphic Tower Station and Some Interesting Records

By Shōitirō HAYAMI, Hideaki KUNISHI and Katsuya NISHI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 7, March, 1964, pp. 434–458.

Abstract

The necessity of continuous observation with reference to a fixed coordinate system has recently been recognized. We have been the first in our country to put this into practice and have been making continuous observation since 1961 when an oceanographic research tower was constructed off Shirahama near the mouth of Tanabe Bay. This tower is called the Shirahama Oceanographic Tower Station and this paper is a report on the outlines of the structure of the tower and of the measuring system installed in the tower.

The tower consists of two parts. One is a recording room with dimensions of 2.4m×2.4m×2.2m at 7.3m above the mean sea level. The other is a circular wooden floor with a diameter of 6m just below the recording room. The lower ends of the four legs of the tower are concreted into the rock. The depth below mean sea level is about 5m. The distance from the tower to the nearest coast is about 300m.

In this tower, the following elements are continuously measured: atomspheric pressure (in preparation), radiation (in preparation), rain, air temperatures at four levels, hummidities at four levels, wind direction, wind velocities at four levels, water temperatures at three depths, salinity, turbidity, plankton, tide, wave, current direction and current velocities at three depths. Much of those measurements are automatically recorded on the four print-recorders of parallel-coil type and two counting recorders of electric contacts set in the recording room. All of those instruments can be operated for a month by eleven Ni-Cd alkaline batteries of 6V×90AH.

Some interesting records observed till now are shown. Among them, it is most noticeable that the water temperature abruptly changes at intervals usually by an order of 0.5°C, sometimes by 3∼4°C. From the inspection of data we suppose that the sea in and near the bay consists of several water masses whose representative length is 2km and the width of their boundaries is some 300m.

On the Behavior of Water Temperature Observed at Shirahama Oceanographic Tower Station

By Hideaki KUNISHI, Katsuya NISHI and Yuki YUSA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 8, March, 1965, pp. 479–493.

Abstract

Several types of variation in water temperature are found in the continuous thermograms obtained at Shirahama Oceanographic Tower Station. Most of the fluctuations seen in the summer season are considered to be due to internal waves. The most interesting variation is the quick shift in water temperature which can be commonly seen throughout the year. The water temperature suddenly changes, usually in the order of 0.5°C for a relatively short time of ten and some odd minutes. Sometimes the magnitude of such rapid change reaches 2.5°C. It suggests that the sea in and near this bay consists of several weak thermal water masses. This condition of the sea is partly supported by the preliminary survey of the horizontal distribution of water temperature held in the summer of 1963.

Some of these quick shifts in water temperature break off after the lapse of a relatively short time of several hours to a day. In others, however, the changes in water temperature seem to be retained thereafter. We name such cases of quick shifts the net shifts in water temperature. The net shift in water temperature is considered to mean the ultimate alternation of water masses, and is found to occur at intervals of 3 to 16 days. The hypothetical assumption that such water movement is in effect the only process of water exchange between the bay and the open sea is tested from the points of view of the heat budget and of the horizontal diffusion.

The fluctuations in the daily mean water temperature also have periods of 3 to 16 days. It can be understood mainly to be associated with the above-mentioned process. The factors causing these phenomena seem to be related to a variation in the meteorological state. The scale or extent of these phenomena has been found by inspections of the variations in water temperature at various places in and near the Kii Channel to be as wide as the whole region of the Kii Channel.

On the Growth of Wind Waves (High-Speed Wind Flume Experiment)

By Hideaki KUNISHI and Norihisa IMASATO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 667–676.

Abstract

The experimental study of the growth of wind-waves under a strong wind (8～34 m/sec) with the use of a high-speed wind flume of the Disaster Prevention Research Institute of Kyoto University is here reported. The dimension of this flume is 0.8 m×2.3 m×40.0 m and the depth of the water is about 1.5 m. The mean wave height $\bar{H}$ and the mean wave period $\bar{T}$ are calculated from wave records taken at five points in the flume (Fetch: 7.9～20.0 m) with the resistance type of wave meter. All of the waves in this experiment are proved to be in the sea-wave stage introduced by Kunishi (1963), but they are young waves. On the other hand, the wind profiles taken at the same time with a small cup-anemometer are found to be logarithmic.

Some discussion of our results in comparison with those of Kunishi's experiment (1963) is made. Our results are generally considered to be an extension of those of Kunishi's experiment, but there are some differences between them as below mentioned. The friction factor γ^2 obtained from the wind profiles becomes larger and larger with wind speed depending on the fetch. Within the limits of our experiment, it reaches the maximum value of 5.6×10^{-3} for the wind speed at 10 m above the mean water surface W_{10} of 50 m/sec. The roughness length z_0 also behaves in a similar manner as γ^2 with wind speed and fetch. Though Charnock and Ellison have insisted that gz_0/w_*^2, where w_* is the friction velocity, takes a constant value in the open sea, the result of our experiment shows that this value is not a constant and depends on the fetch. It is seen that the value of z_0 increases in proportion to $\bar{H}^2$, though its meaning is not obvious.

From this study, the wind waves are considered to have a somewhat different nature from that of the roughness of a solid wall. In this connection, it is very important to study where the zero level of the wind profile should be taken.

Study of Waves at Shirahama Oceanographic Tower Station (I)
—On the Waves Caused by Typhoon 6420 (WILDA)—

By Hideaki KUNISHI, Katsuya NISHI and Norihisa IMASATO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 677-684.

Abstract

This is a report on the waves which were caused by Typhoon 6420 (Wilda) and recorded by the pressure type of wave gauge set at about 2.7 m below the mean sea level at Shirahama Oceanographic Tower Station. Typhoon 6420 was a large one whose central pressure reached the value of 895 mb. It came near the Tower Station before dawn on the 25th of September. At 0 o'clock of Sep. 25, the significant wave height was 187 cm which was the maximum value recorded at this Tower during the period of this typhoon. The period of this significant wave was 10.0 sec. The largest period of significant wave of 14.7 sec was recorded at 12 o'clock of Sep. 23.

During the period of the problem, waves were automatically recorded for 13 minutes twice a day at 0 and 12 o'clock. The nine wave records from 12 o'clock of Sep. 22 to 12 o'clock of Sep. 26 are analysed in the power spectra by the digital method after Tukey (1949) by the use of the computer KDC-1 of Kyoto University. The degree of freedom of these spectra is in the order of 30. The most interesting fact is that the spectra have two dominant peaks. The first peak has its center at about 13 sec, and the second peak at about 7 sec. It is shown that the change in the position of the first peak has a good correlation with the change in the central pressure of the typhoon by assuming that those waves propagate with their group velocities from the center of typhoon. There is a little difficulty in deciding where the source of waves in the second peak of the spectra lies. In this report, it is mentioned that the position of the second peak seems to depend on the speed of the movement of the typhoon, those waves being assumed to come from the central region of the typhoon.

Studies on the Hydraulic Design of Lateral Diversion Structures

By Hiroji NAKAGAWA and Tadashi UTAMI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 539–550.

Abstract

This paper presents the theoretical expressions with experimental verification of the diversion works which satisfy the discharge requirements.

In the earlier part of the paper the properties of various factors included in the fundamental equation of gradually varied flow of a decreasing discharge, such as the coefficient of discharge, the momentum flux of the released flow etc., are discussed and established by experiment on a lateral weir with a sharp crest under a free overflow condition.

In the middle part of the paper the requirements for desinging various types of diversion structure are explained and dynamic expressions for giving the proper dimensions of channel and diversion structures, which satisfy the requirement for securing a constant released rate throughout the diversion section, are deduced from the above established fundamental equation. It is verified by use of the theory of singular point in the ordinary differential equation, that the requirements would be satisfied even where the transitional flow condition appeared on the diversion section.

In the last part of the paper, the experimental verification, conducted in a flume 0.30 m in width, 1:200 and 1:800 in bed slope and with a lateral weir 0.6 m in length, is presented. By the results of the experiments, it is confirmed that the hydraulic performance of a theoretically designed channel nearly satisfies the hydraulic requirements for the subcritical flow condition, and that for the supercritical one they are not always satisfied because of the water surface disturbances due to shock wave occurrence.

Observations of Turbulence in Sosui Canal

By Shōitirō Yokosi

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 9, March, 1966, pp. 513–523.

Abstract

Our knowledge of the structure of river turbulence is very poor, because of the lack of a suitable device for measuring the turbulent velocities in water accurately. The turbulence structure in a river flow is different from that in other fields, such as atmospheric, oceanic and wind tunnel turbulence. A river flow is bounded by the bottom and the surface of a river vertically, and by the side walls horizontally. The river turbulence is not understood satisfactorily by direct analogy with the other fields of turbulence.

This paper describes the results of the measurements of turbulence characteristics in Sosui canal by a small propeller type of current meter, in order to make clear the nature of the turbulence structures in a river flow and to obtain fundamental data for developing a new type of velocity meter. Sosui canal is a straight open channel 13.3 m wide and 1.8 m deep, with mean velocity of about 0.8 m/sec. The time constant of the current meter is less than 0.02 sec. The observation period is 3 min.

The results obtained are as follows: The Reynolds number of the flow is about 10^6 at the measurements. The mean velocity profile is in good agreement with the logarithmic law except for the region near the surface of the flow. The longitudinal turbulence intensity is about 0.1 in the upper part of the flow. The longitudinal integral scale is about 1.8 times of the height, which is obtained from the Eulerian time correlation with the aid of the concept of semiscale and the frozen turbulence hypothesis. The longitudinal eddy viscosity is about 1.5×10^2 cm^2/sec near the surface of the flow, which is obtained by the use of the method of Taylor and Sutton. Dependence of the turbulence intensity and eddy viscosity on the height is very similar to that in the usual boundary layer flow. Normalized power spectra of the longitudinal turbulent velocity show that the length of the largest eddies is about 10 times of the height, which is in good agreement with the results in the atmospheric turbulence. The conclusion is that turbulence structures of the river flow are similar to those of an usual boundary layer flow except for the region near the free surface and side wall, as expected.

Meaning and Reliability of the Vane Shear Strength of Clays

By Toru SHIBATA

Proceedings of the 11th Internal Symposium on Soil Mechanics and Foundation Engineering, Oct., 1966, pp. 105–110.

Abstract

Very little is known concerning the conditions under which clay is brought to failure by means of the vane test. In spite of this fact the vane test is used in field investigations for determining the shear strength of clay. The question arises–if the test conditions are unknown, can the test results be correctly interpreted? This question was considered by Kenney (1963) and on the basis of his suggestions laboratory and field investigations were begun for the purpose of studying the vane test. This paper presents the results of comparison between a field vane and the following three kinds of laboratory test on normally-consolidated clays: unconfined compression, box shear and triaxial K_0-consolidation tests. Moreover, varying the ratios of diameter to height of field vane a study was made of the relation between the shear strength on vertical and horizontal failure surfaces.

The tentative conclusions reached are as follows: (1) The comparison of the results of the field vane test and the box shear test indicates that the effective normal stress on the vertical failure surface in the vane test is nearly equal to the horizontal consolidation pressure $K_0\bar{p}$. Although it has not been confirmed, the cause is believed to be a rapid dissipation of excess pore pressures induced along the failure surface. (2) The shear strength on the horizontal failure surface on the vane τ_H is essentially independent of the horizontal consolidation stress, but primarily dependent on the vertical consolidation stress. On the other hand, the shear strength on the vertical failure surface τ_V is dependent on both of these consolidation stresses. (3) The ratio of strength anisotropy τ_V/τ_H measured in the field vane increases with increasing value of the plasticity index, and for low plastic clays the τ_V/τ_H-ratio is in agreement with the coefficient of earth pressure at rest measured in the triaxial K_0-consolidation test on the same undisturbed clay as used for the field vane test. (4) The ratio of the vane shear strength to the effective overburden pressure, $c/\bar{p}$, calculated by the usual Cadling's method is nearly equal to the value of $\tau_V/\bar{p}$; the ratio of c/τ_V for normally consolidated clay (PI; 30–80%) is less than 1.05.

Response Characteristics of Saturated Clay to Impact Loading

By Koichi AKAI, Yukio YAMAUCHI and Mineo TOKUDA

Proc. Japan Earthquake Engineering Symposium 1966,
Oct. 1966, pp. 91–96.

Abstract

Earthquakes can be considered to have two different characters, one of which is a cyclic loading and the other a random pulsative loading. As structures are apt to oscillate at their natural frequency, we regard the important part of an earthquake as a pulsative loading; experimentally applying an impact load to specimens of saturated clay.

As the testing appratus a triaxial compression cell is used, measuring the acceleration response, and the displacement of specimens as well as the dynamic stress recorded on the electro-magnetic oscillograph. The pattern of dynamic loading can be changed as step pulses, sinusoidal or rectangular load and random oscillation by the vibratory machine.

Comparing the dynamic stress-strain relationship with the static one, it can be found that the dynamic shear resistance is one and a half or two times the static one and that the dynamic modulus of elasticity is much larger than the static one. The acceleration wave damps with a comparatively constant period under the state of free vibration. The axial displacement starts several milliseconds later than the acceleration response. At first the clay specimen deforms remarkably and creeps later. Assuming that the saturated clay is represented by a Voigt-type model, this time lag can be explained theoretically.

From the correlation between the vibration mass and the amplitude of the acceleration response, the initial wave peaks at a certain value of vibration mass. The dynamic stress for the peak value is approximately equal to the static unconfined compressive strength. Therefore, it can be said that when the dynamic stress beyond the unconfined compressive strength is applied to the clay specimen by the impact, the acceleration wave decreases with the vibration mass.

Two kinds of method for finding the spring constant and the viscosity constant are analytically proposed. As a result, it is concluded that the mechanical behaviour of the saturated clay can be explained by the Voigt model, considering the fact that the maximum value of the acceleration response exponentially decreases with time, that the spring constant and the viscosity constant are almost constant for the definite moisture content and that the logarithmic damping ratio decreases with the increase in the vibration mass.

Study on the Quasi-One-Dimensional, Non-Steady Seepage Flow through Soil

By Koichi Akai and Takao Uno

Trans. of JSCE, No. 127, March 1966, pp.14–22.

Abstract

The development of a free surface in a river-bank in the Kizu Branch of the Yodo was observed when a flood came on October 28, 1961. It was found that the free surface in the river-bank varied very fast corresponding to the viriation in the outer water level and the steady seepage state occurred in a short time. The authors consider that the reason lies in the large permeability of the foundation of the river-bank, and on that basis have carried out the present theoretical and experimental study.

It is pointed out that as a limit in the application of the fundamental equations to the non-steady seepage phenomena, the effective porosity β should be used instead of the total porosity of the soil and that there exists a good accordance between the equation of continuity and the seepage flow on the permeable foundation. Effective porosity is defined as the difference between the part occupied by the seepage water and that occupied by the initial water content. The effective porosity β is therefore very small. As β depends also on the initial degree of saturation in the soil, it is much affected by the initial condition of the soil. In order to examine these facts, the variation in the head and rate of discharge occurred when a step rise or fall is caused in the sand model is investigated.

If the experimental results are compared with the calculated results from the proposed equation of seepage on an impermeable foundation, some doubtful points are rised, as, for example, how to grasp the correlation between the permeability and the initial moisture content and the concept of the fundamental equation. Most of the equations proposed in the previous studies correspond to the free surface by the seepage through soil of which water content is comparatively constant, or through dry soil. In the actual case where the deep part of the soil has much water content, however, the distribution of water content has much influence upon the changes of free surface. The ratio k/β in the seepage on the impermeable foundation is calculated to be about 1.9 cm/sec.

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