LANDSLIDES IN JAPAN

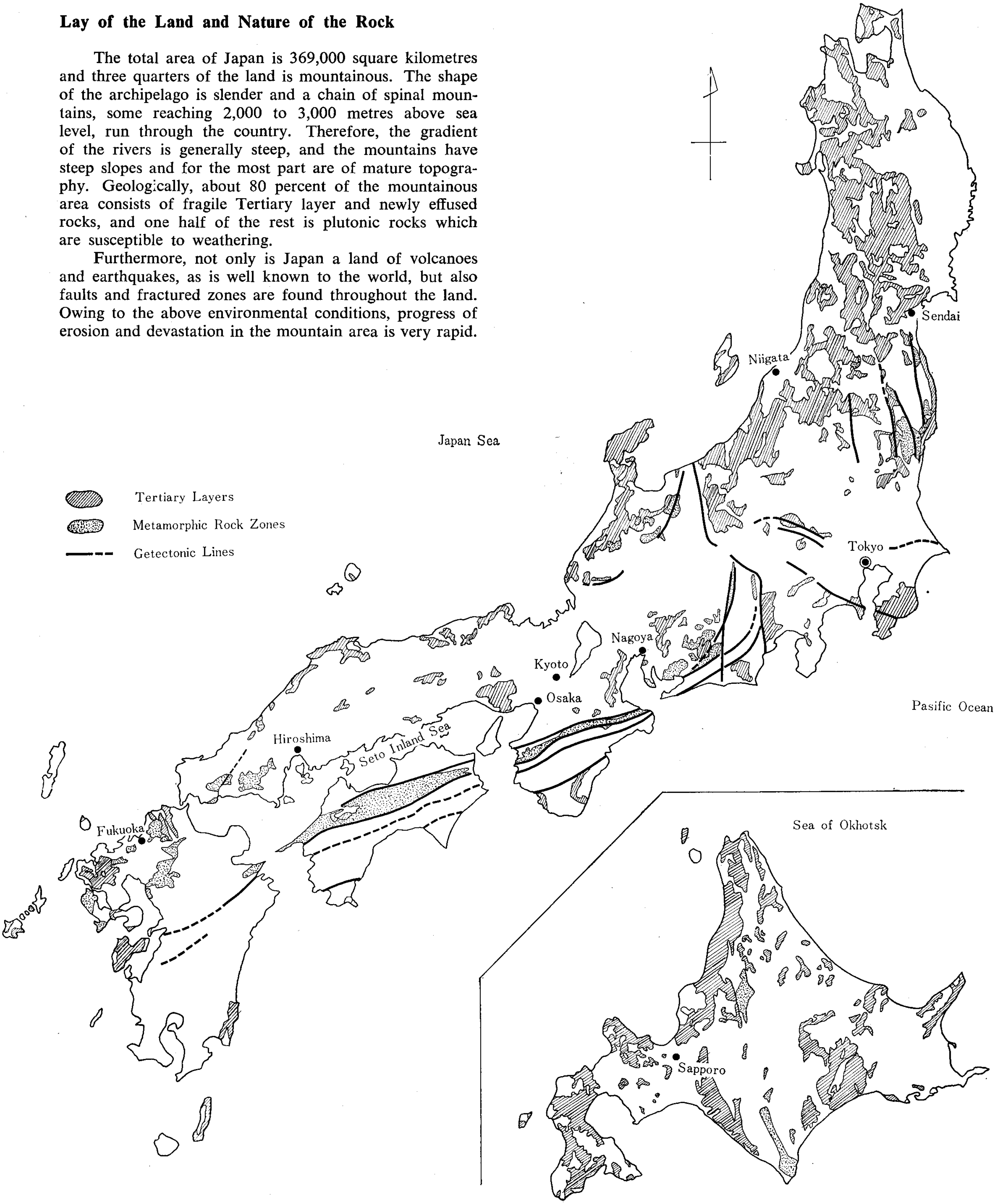
The Japan Society of Landslide
National Conference of Landslide Control

Geological Feature and Distribution of Landslide in Japan

Lay of the Land and Nature of the Rock

The total area of Japan is 369,000 square kilometres and three quarters of the land is mountainous. The shape of the archipelago is slender and a chain of spinal mountains, some reaching 2,000 to 3,000 metres above sea level, run through the country. Therefore, the gradient of the rivers is generally steep, and the mountains have steep slopes and for the most part are of mature topography. Geologically, about 80 percent of the mountainous area consists of fragile Tertiary layer and newly effused rocks, and one half of the rest is plutonic rocks which are susceptible to weathering.

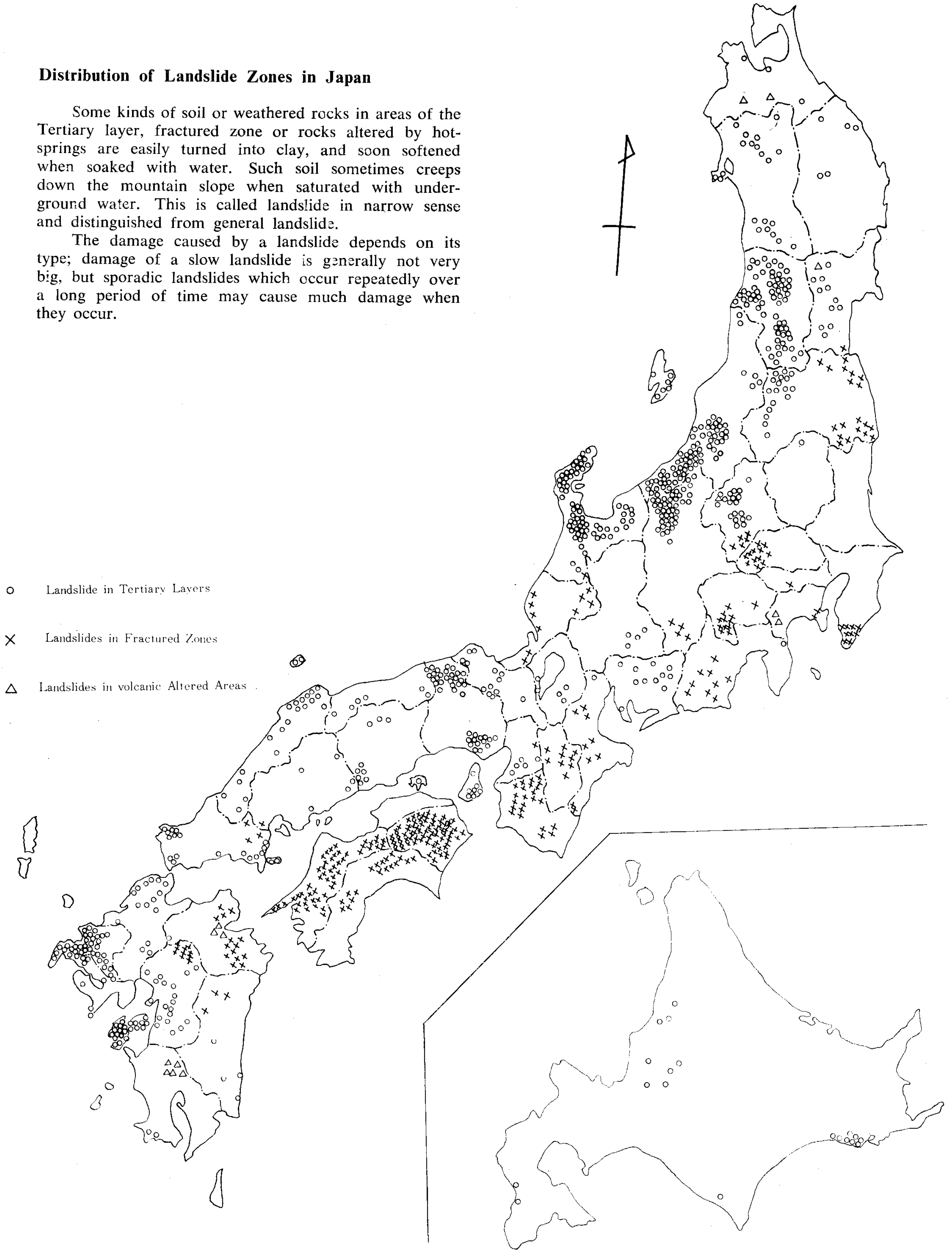
Furthermore, not only is Japan a land of volcanoes and earthquakes, as is well known to the world, but also faults and fractured zones are found throughout the land. Owing to the above environmental conditions, progress of erosion and devastation in the mountain area is very rapid.



Distribution of Landslide Zones in Japan

Some kinds of soil or weathered rocks in areas of the Tertiary layer, fractured zone or rocks altered by hot-springs are easily turned into clay, and soon softened when soaked with water. Such soil sometimes creeps down the mountain slope when saturated with underground water. This is called landslide in narrow sense and distinguished from general landslide.

The damage caused by a landslide depends on its type; damage of a slow landslide is generally not very big, but sporadic landslides which occur repeatedly over a long period of time may cause much damage when they occur.



Organization for the Research and Control of Landslides

The Japan Society of Landslide

(Director: Kenzo Sasa)

This Society was founded in 1964 and is located on Ekoda 2-21-2, Nakano-ku, Tokyo, and consists of

1) researchers in the fields of geology, geography, geophysics, civil engineering, forestry, agricultural engineering, etc., working for the universities,
2) researchers and engineers in charge of control works, of the Ministry of Construction, the Ministry of Agriculture and Forestry, the Japan National Railways and prefectural governments,
3) engineers working for private consulting companies, work executing companies and manufacturers of landslide measuring system.

This Society is striving for exchange and promulgation of research results concerning various landslide phenomena and landslide disaster prevention measures. At present Society consists of 1,200 members, and is active publishing quarterly issue of research journals, and holding research presentation meetings, short training courses, tours of study, etc.

Prof. Kenzo Sasa
Doctor of Science
Director of the Japan Society of Landslide
President of Osaka Technical College
Ex-Dean of Science Department, Kyoto University

National Conference of Landslide Control

(Director; Governor of Nagano Prefecture: Address; Sabo Section, Construction Division, Nagano Prefectural Office, Nagano City)

This Council was organized by 44 prefectural governments for the purpose of technical enhancement of member governments as well as development of landslide prevention works by exchange of research information on landslides.

Related Academic Organizations

The Landslide Forecasting Research Group of the Disaster Science Research Circle—This group is organized by about 40 landslide researchers of various universities. This group is studying physical quantities to forecast landslide occurrences through fundamental researches in motivating causes and mechanisms of landslide occurrences to clarify the relation between these quantities and landslide occurrences. This group is also trying to develop the theory to forecast what kind of change occurs when topography and dynamic equilibrium under the ground is artificiary changed on natural slopes, for the purpose of studying methodology to solve these problems.

The Erosion-control Engineering Society—Sobo Gakkai
The Japanese Society of Soil Engineers
The Japan Society of Civil Engineers
The Geological Society of Japan
The Geographical Society of Japan
The Japan Society of Forestry

Administrative Organizations

The Ministry of Agriculture and Forestry
Landslide control for the conservation of farms and forests

The Ministry of Construction
Landslide and slope failure control for the conservation of rivers, national highways, dams, residential areas and other public facilities

The Japan National Railways Cooperation
Landslide control for the conservation of railroads

Research Institutes

The Agricultural Engineering Research Station, the Ministry of Agriculture and Forestry
The Forestry Testing Station
The Geological Survey of Japan
The Public Works Research Institute, the Ministry of Construction
The Geographical Survey Institute
National Research Center for Disaster Prevention
The Railway Technical Research Institute, JNR
Technical Research Institute Electric Power of Industry

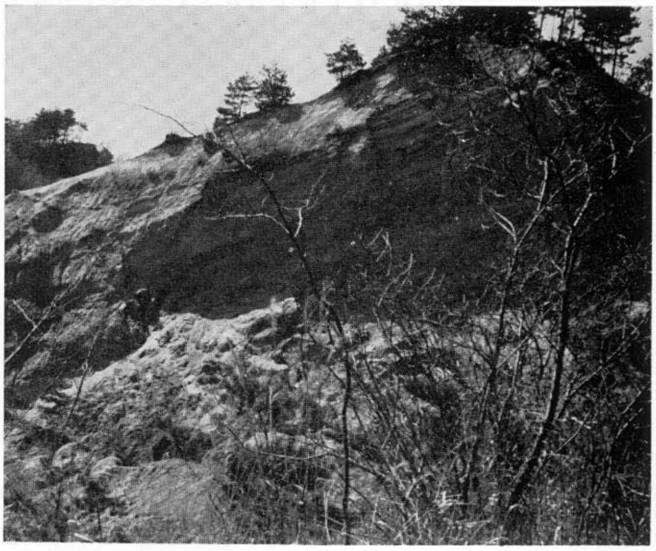
Universities

Faculty of Science
Faculty of Technology
Faculty of Agriculture

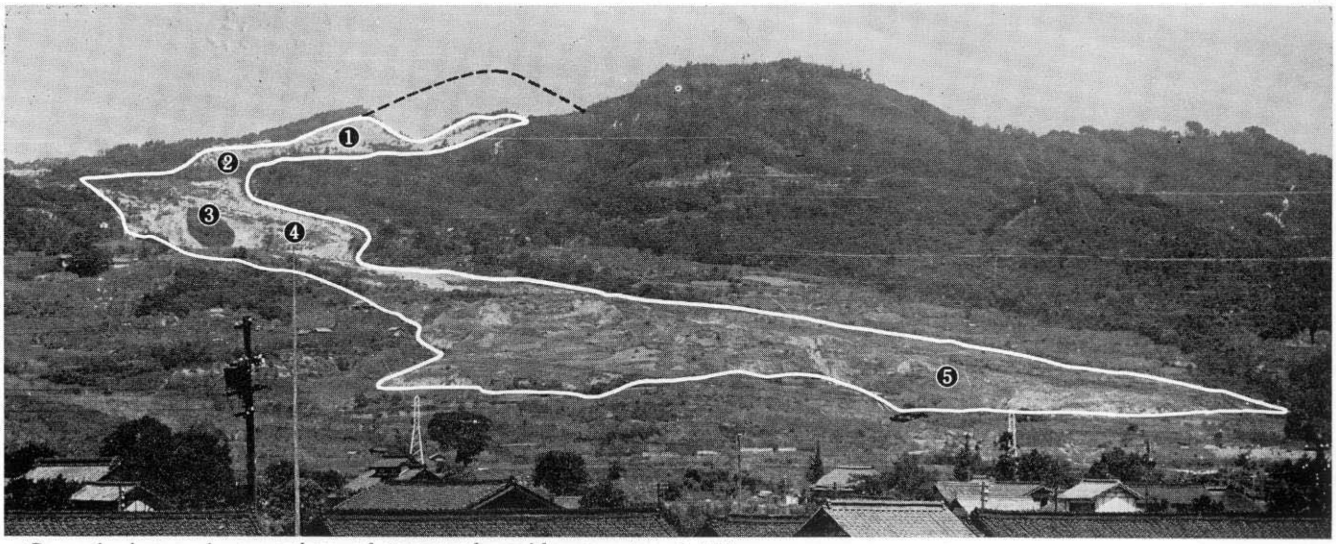
The Disasters Caused by Landslide

I CHAUSUYAMA LANDSLIDE at Nagano Prefecture

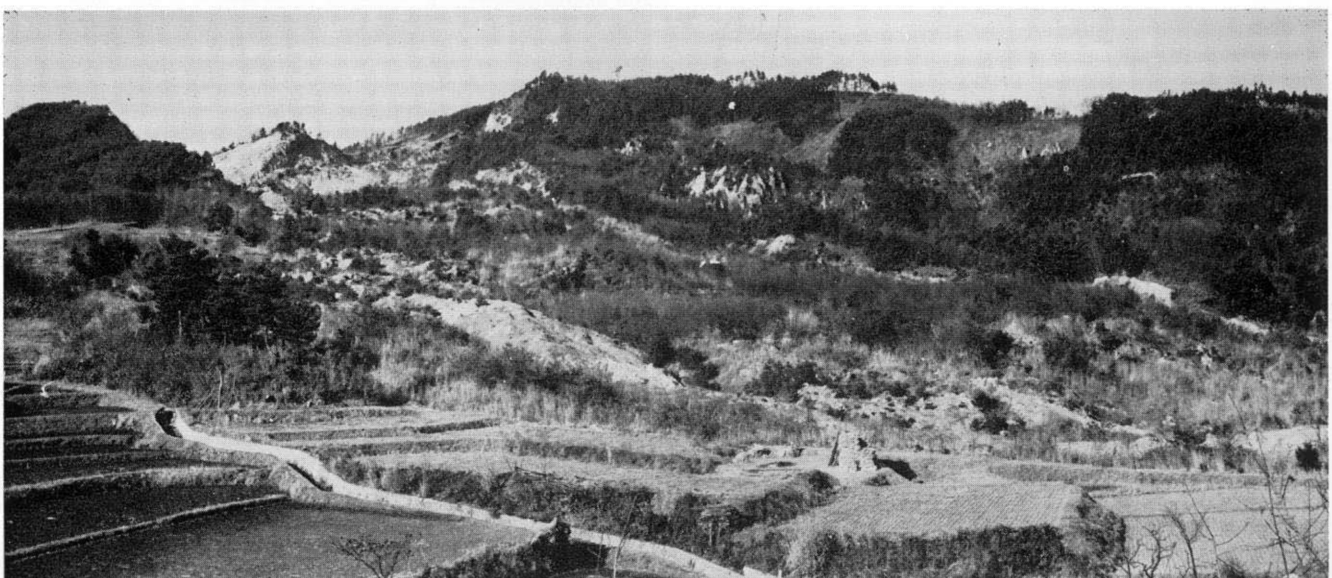
This landslide occurred about 200 years ago and has been called by earthquake. Sliding area is about 46 ha and is divided 3 zones—slump area, flowing area and creeping area. Flowing area has a stable island, creeping area is about 1,200 meters and surrounded by bank for disaster prevention.



Main cliff at Mt. Chausuyama.



General view and comparison of topography with present and 200 years ago. (Dotted line is figure of Mt. Chausuyama about 200 years ago.)
❶ Head, ❷ Carp, ❸ Stable island in slide area, ❹ Flow, ❺ Tangue



The slump zone

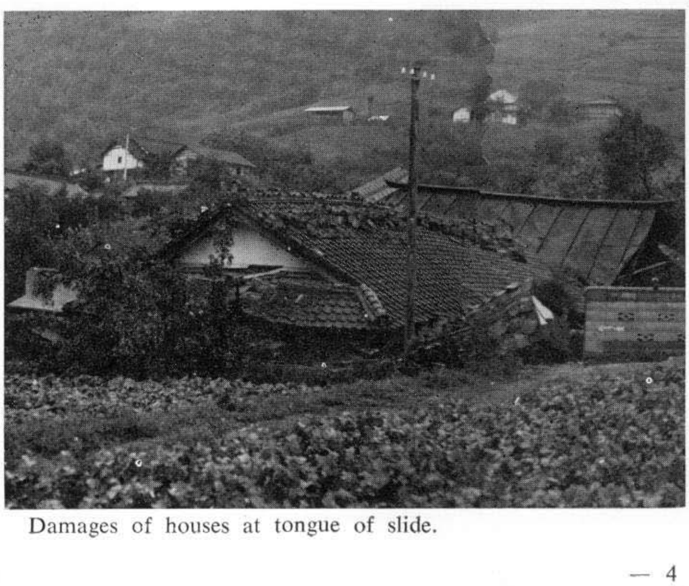
II MAKIUCHI LANDSLIDE at Nagano Prefecture

—Caused by Matsushiro Earthquake Swarm at 1966—

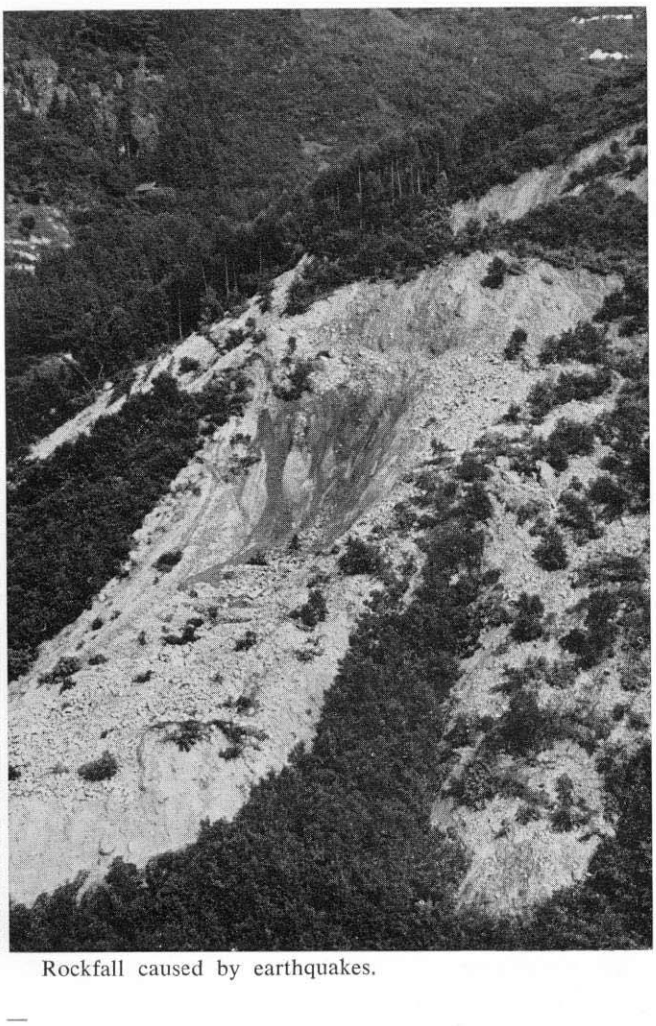
General view of slide caused by spring of much ground-water after earthquakes.

From 3rd August 1965, Matsushiro earthquakes swarm began with about 680,000 small earthquakes at middle part of Japan. According to this earthquake, many cracks on the ground were generated and much ground water sprung out as pressure water.

As the result of these generation, large landslides and rockfalls occurred at natural slope near the foot of mountain.

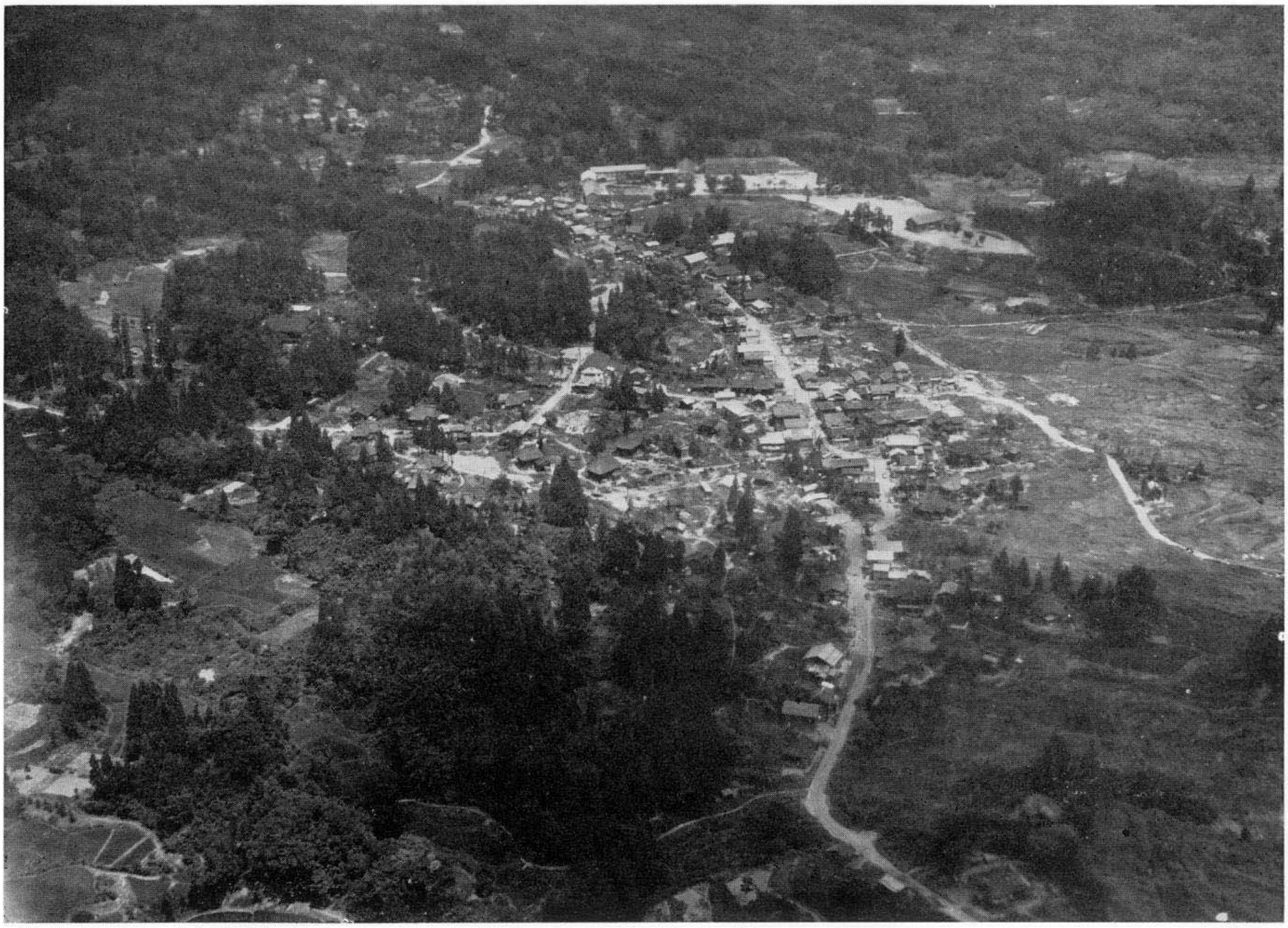


Damages of houses at tongue of slide.



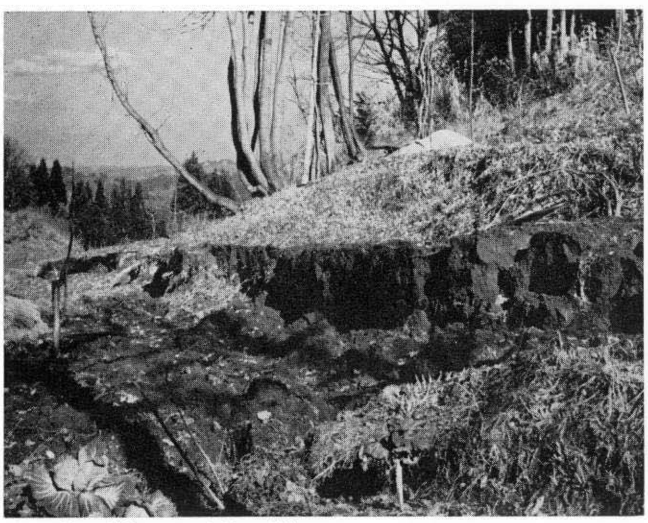
Rockfall caused by earthquakes.

III MATSUNOYAMA LANDSLIDE at Niigata Prefecture



General view of landslide area.

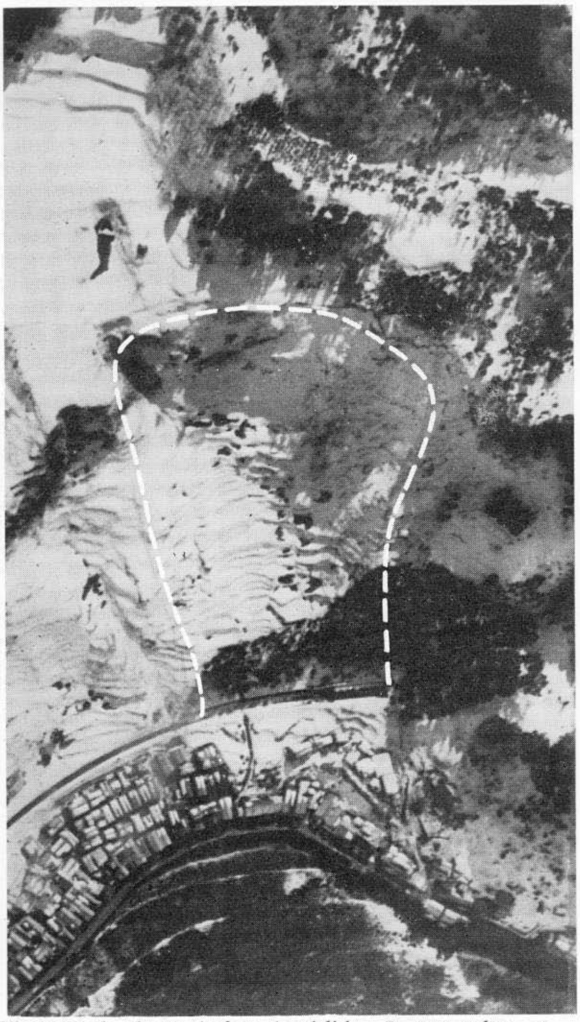
One of the largest landslide in Japan was occurred at Niigata Prefecture. Slide area was about 850 ha and 371 houses, 4 schools, 15 public buildings, 20 km road were damaged. This landslide was generated at tuff layer in Tertiary, and depth of sliding surface was about 30 meters.



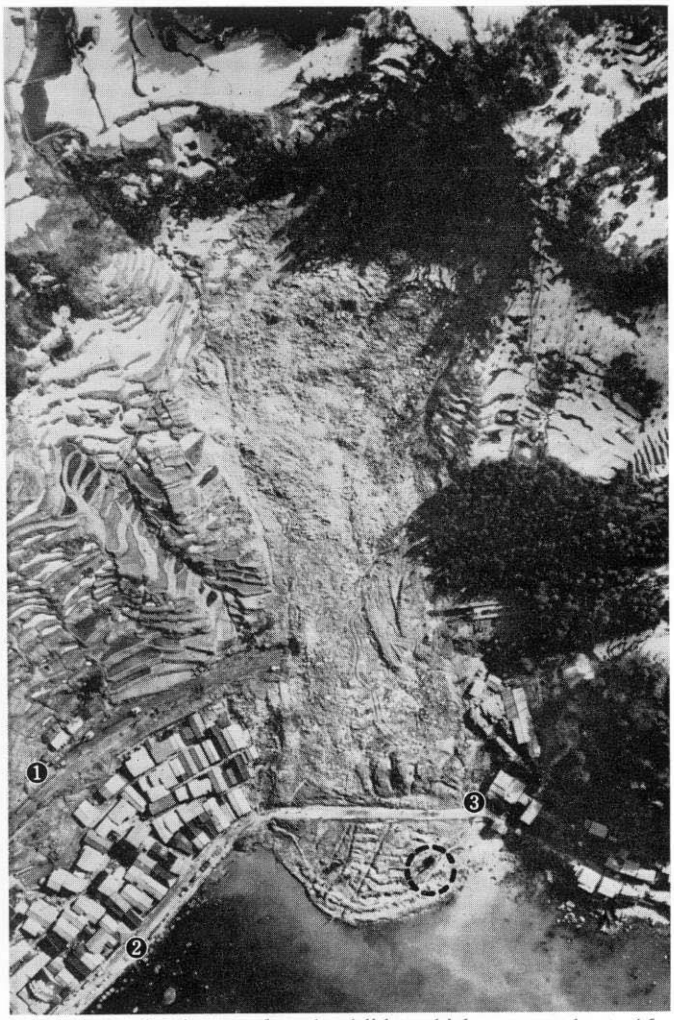
Main cliff caused by slide.

Comparison of road figure with after and before slide.

IV KODOMARI LANDSLIDE along the Hokuriku Railway Line of JNR



Photograph shows before landslide. It was taken at 26 February 1963.



Photograph shows after landslide which occurred at 16 March 1963. The sliding earth mass is estimated about 150,-000 cubic meters.

❶ Railway, ❷ National Road No. 8, ❸ Temporary repairs of road

◌ This spot is lacomotive engine which just arrives at the beginning of landslide and carries away to this point by slide.

Main scarp at the top of landslide.
Seepage water can be seen near the middle part of scarp. The sliding mass consists of mudstone.

V TANABE LANDSLIDE at Osaka Prefecture

The view of Kashiwabara interchange and the neighborhood after landslide.

❶ Kashiwabara Interchange, ❷ Hospital, ❸ National Road, ❹ Kinki Nippon Railway, ❺ Nishi Meihan Highway

This slide occurred at April 1968, railway and national road were lifting about 1 cm a day. Interchange of highway and hospital was damaged by this slide. Long horizontal drillings and drains were very effective to stabilize this movement.

Cracks at retaining wall and pavement of highway.

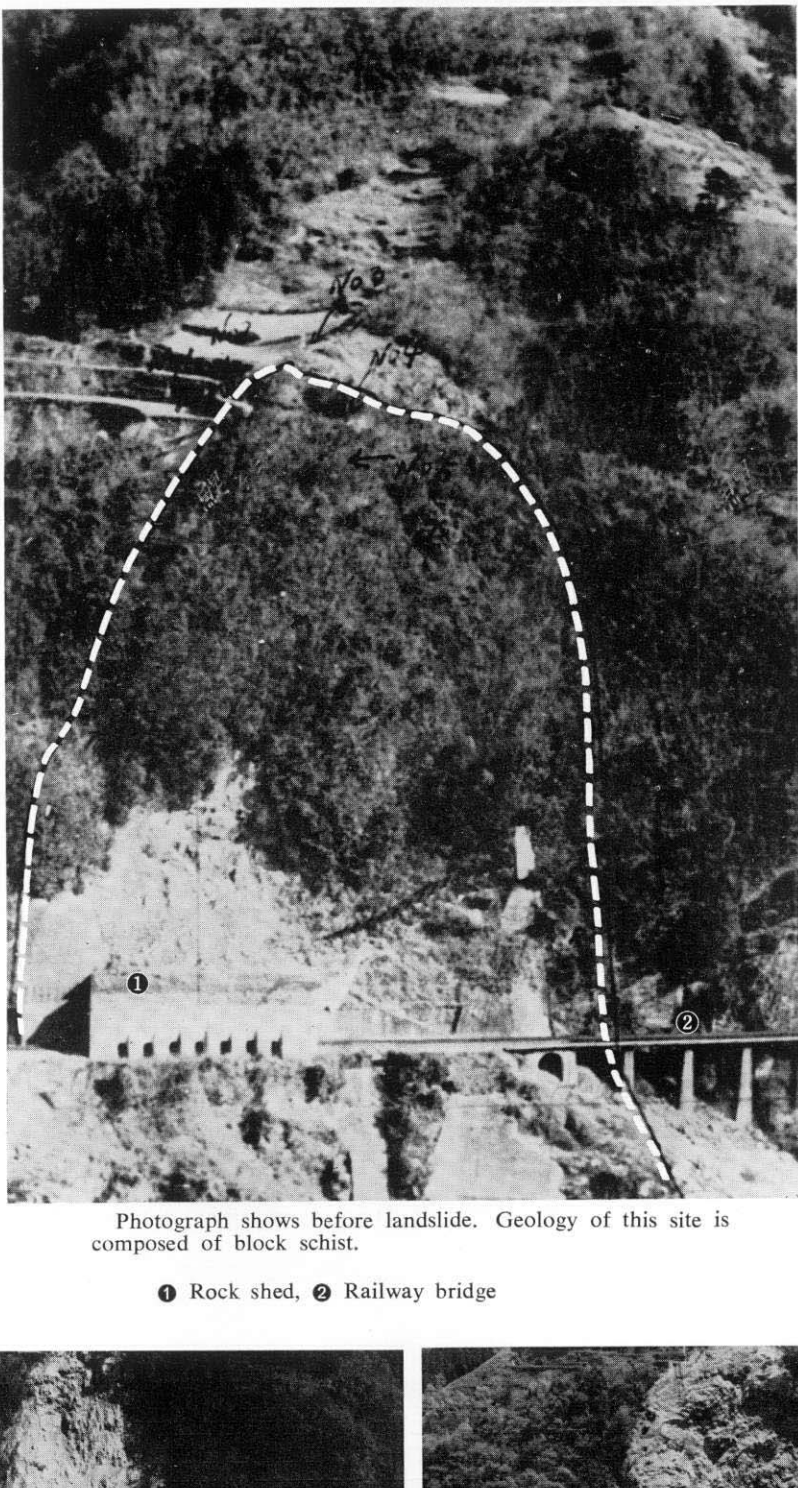
VI HIDOYAMA LANDSLIDE at Shodo Island in Seto Inland Sea

Aerial photo of landslide area.

At 10th Sept. 1965, a landslide occurred at small island in Seto Inland Sea after a typhoon with 200 mm precipitation. The local sinking velocity was 5 cm an hour at maximum. At the tongue area a debris flow occurred and damaged a house, a road and farms. This slide frightened many inhabitants and houses at foot of the slope.

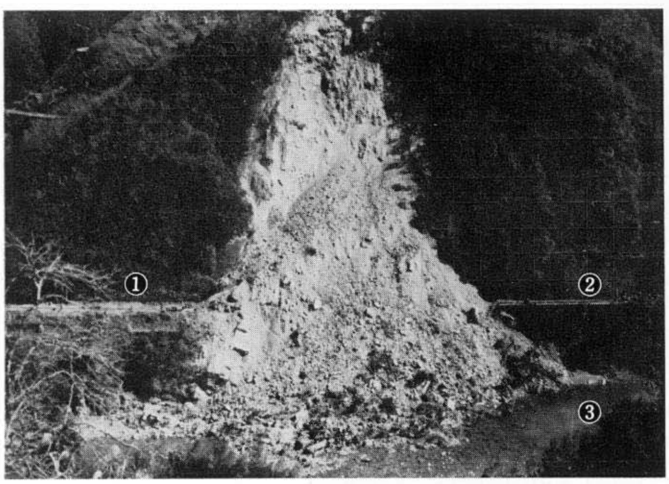
Slump occurred at left side of slide area and generated a pond by local ground sinking.

VII LANDSLIDE along Dosan Railway Line in Shikoku Island



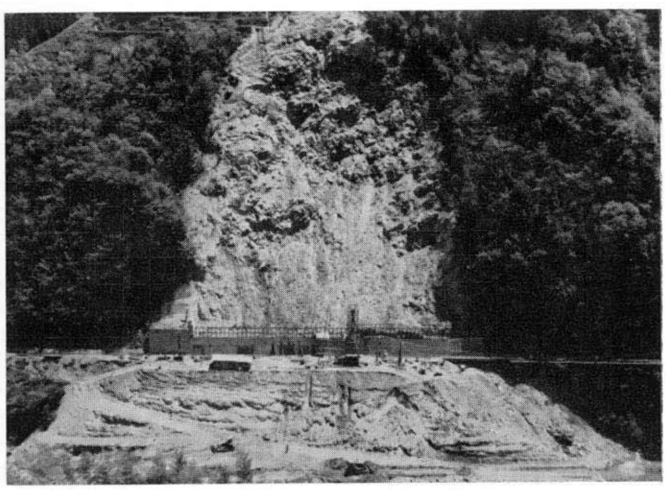
Photograph shows before landslide. Geology of this site is composed of block schist.

❶ Rock shed, ❷ Railway bridge



Landslide occurred at 20 February 1962, the collapsed rock mass is estimated about 60,000 cubic meters.

❶ Railway, ❷ Railway bridge, ❸ Yoshino River



Reconstruction of railway and equipment.

Method of Landslide Investigation

The landslide investigation is divided into rough survey and detailed survey. The rough survey is principally used when the precise plan of investigation can not be made only by the field exploration, and the detailed survey is used to clarify the mechanisms of landslides and to make landslide control plans. The rough survey and the detailed survey consist of the following surveying methods:

I) Rough Survey
  1) Seismic prospection
  2) Resistivity survey
  3) Natural radioactivity prospection

II) Detailed Survey
  4) Drilling survey
  5) Electrical logging
  6) Slide surface survey by inclinometers
  7) Ground surface movement survey
    a) Aerial survey
    b) Observation of displacement of posts
    c) Method by a tensometer
    d) Method by a tiltmeter
  8) Groundwater survey
    a) Tests of quality of groundwater
    b) Groundwater prospection
    c) Groundwater tracing
    d) Observation of groundwater level
    e) Observation of pour water pressure
  9) Soil tests

The purposes, the principles and the analyzed results of some of the above surveying methods will be explained in the following.

1. Seismic Prospection

The seismic method is a method to presume rock qualities and underground structures of strata by obtaining propagation velocities of refractive waves or reflection waves and analyzing seismographs, and is now widely spread for landslide investigations in Japan. This method is proving to be fairly effective in presumption of underground structures of landslide areas and in researches on landslide phenomena by developing the measurement of initial movement of primary waves as well as the viscosity measurement of the landslide area utilizing secondary waves, the shallow layer reflection method and the miscellaneous slight vibration measuring method.

2. Specific Resistance Logging

After the drilling survey have been done in the landsliding area, various kinds of investigations are made using boreholes. The specific resistance logging is one of these investigations and examines deposit conditions of layers and variations in specific resistance. Comparing with the specific resistance logging carried out on the ground, this

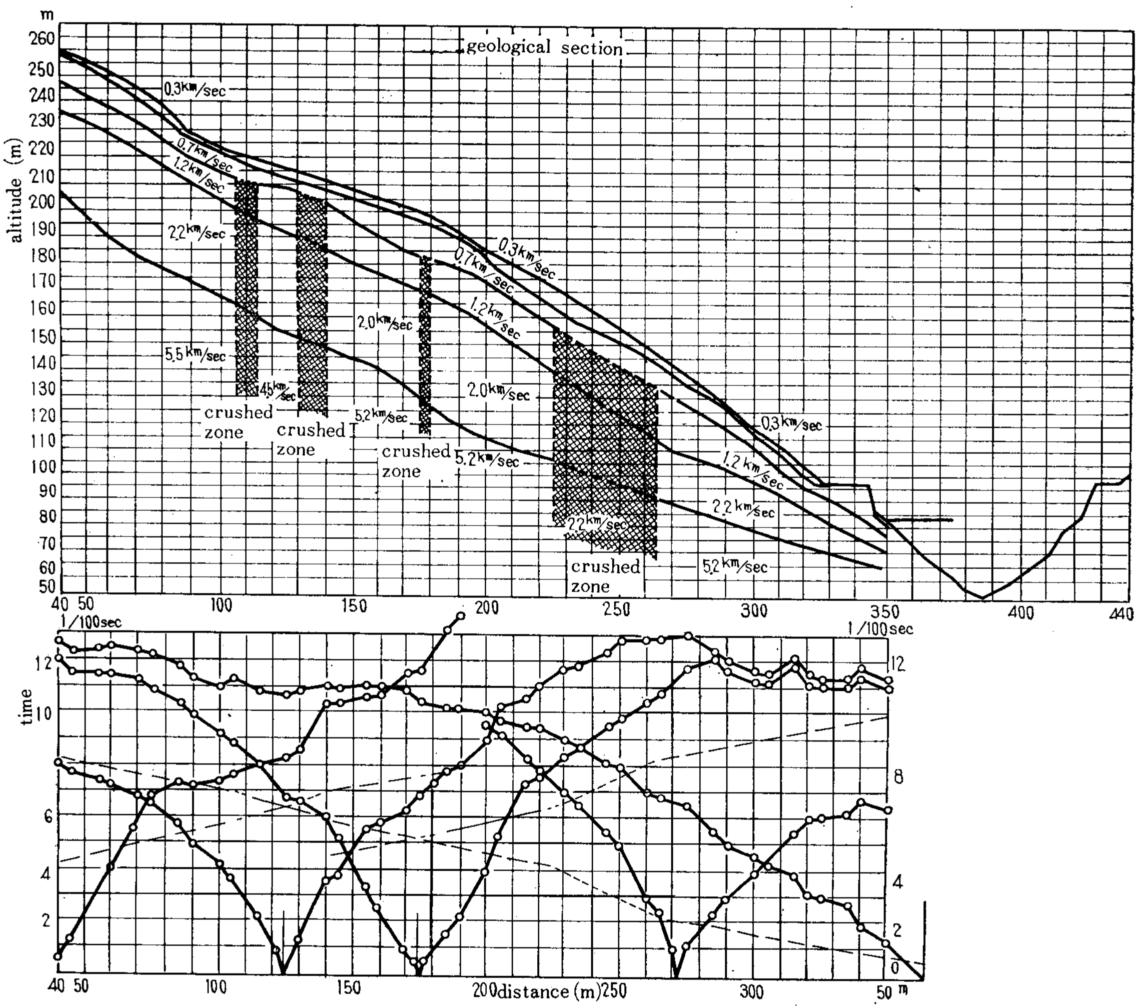


Fig. 1.1 Distance velocity curve

method can show more accurately correlations of specific resistance values and geological layers and clarify accurately underground structures of the landsliding area. Furthermore, this logging is one of effective methods to draft a drainage plan of groundwater in the landsliding area by localizing groundwater aquifers and judging their conditions.

3. Electrical Surveying Methods

Out of several kinds of electrical surveying methods, the specific resistance method is used for landslide investigations. This method distinguishes constituent soil masses in the ground by differences in specific resistance and underground structures are presumed comparing with geology of layers.

The specific resistance method can be divided into the vertical surveying method and the horizontal one by its analyzing method. In order to know properties of moving soil masses and distribution conditions of groundwater in the landslide area, the horizontal surveying method is more effective. Since this method gives important fundamental data for drainage works and enables forecasting of the moving range of landslide, this is an effective surveying method as an initial survey.

4. Natural Radioactivity Survey

In general, rocks forming the earth crust contain natural radioactive elements of uranium and thorium series, and these elements release radon and thoron gases in their decay processes. These gases are also radioactive and released from deeply seated rocks to the ground through faults and fissures of rock beds. In the natural radioactivity survey, gamma-rays emitted by these radon and thoron gases are measured with a scintillation survey meter at each spot of the ground, and the existence of faults and crushed zones is judged with a gamma-ray intensity distribution map of the surveying area. This survey method proved very effective as a rough survey.

Fig. 4.1 Scintillation survey meter

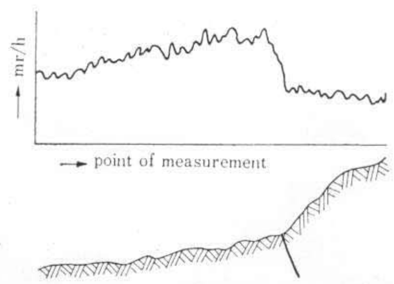


Fig. 4.2 Radioactivity at points of measurement

Drilling Survey

Boreholes shall be arranged so that a distance of 30 m should be kept as a standard on the main line of measurement, more than 4 boreholes, at least 3 inside the landsliding block on the line of measurement and 1 on the upper slope, should be drilled, and the subsidiary line of measurement should keep a double distance as the main line of measurement. Another consideration shall be paid again in the case of specially complicated topography.

The bottom of the borehole shall go more than 5 m into the bed rock, therefore the depth of the borehole shall be the presumed thickness of the landsliding layer plus 5 m.

The borehole diameter shall be larger than 65 mm and be of all-core boring. The standard penetration test shall be done along with drilling.

The geological logs shall be drawn judging from core samples, referring to geological structures of neighboring places under the responsibility of the chief engineer. Bed rocks and weathered zones shall be clearly distinguished from debris, detritus and volcanic rock fragments.

5. Measurement of Displacement Velocity and Ground Surface Strain with a Tensometer

This device is mainly used for 1) measurement of displacement velocity and 2) surface strain. In the former case, it is set extending over an immovable place and a moving place, or covering a main rock. Displacement quantities are automatically recorded with a several-fold accuracy.

Correlations between displacement quantities thus obtained and rainfall, groundwater level, etc. are analyzed for the data for studying mechanisms of landslide and for deciding the method as a landslide control.

In the latter case, the strain between two points on the landsliding slope is measured. This strain shows a striking change previous to the collapse of the slope. Since the relation between the constant strain velocity shown by a linear part of secondary creep and the time of creep failure can be represented as a linear relation in a logarithmic graph, this strain measurement is a very effective method for forecasting landslide occurrences. Danger will be automatically warned when the displacement velocity reaches some fixed level.

6. Measurement of Ground Surface Fluctuation with a Tiltmeter

In the area where landslide occurs, a slight change in tilt of the ground is usually generated as a forerunning phenomenon which can not be noticed by our own sense. This slight tilt fluctuation can be utilized for forecasting landslide activities.

Two types, an automatic recording type and a manual one, of this tiltmeter are sold in Japan, however, mechanically simple and cheap tiltmeters of water pipe type are generally used. The accuracy of measurement is about 1.2 second.

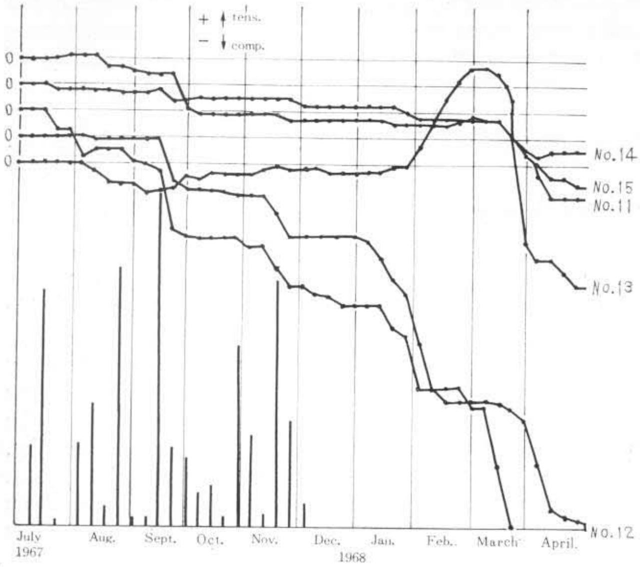


Fig. 5.1 Daily variation of displacement velocity (No. 12-14 point measurement)

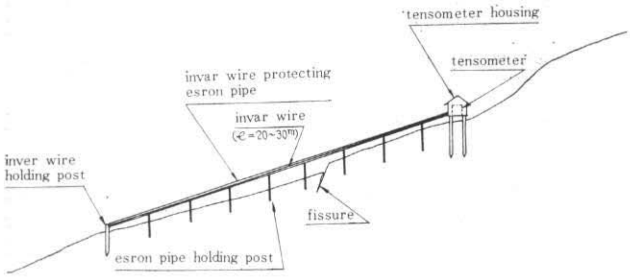


Fig. 5.2 Setting of tensometer

7. Measurement of Slide Surface with a Pipe Strain Gauge

In order to analyze landslide phenomena and make a prevention work plan, it is necessary to know the depth and the shape of slide surface as accurate as possible. An underground strain gauge is one of the effective methods which have been developed for this purpose. This gauge consists of a vinyl chloride pipe on which side a pair of perfect waterproof paper strain gauges is fixed at each measuring depth, and changes in electric resistance of strain gauges by the deformation of a pipe caused by ground displacement are measured with a strain meter.

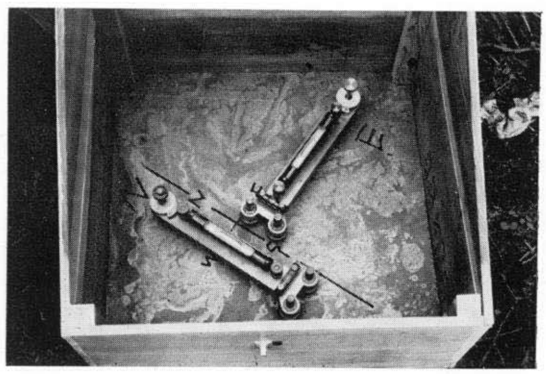
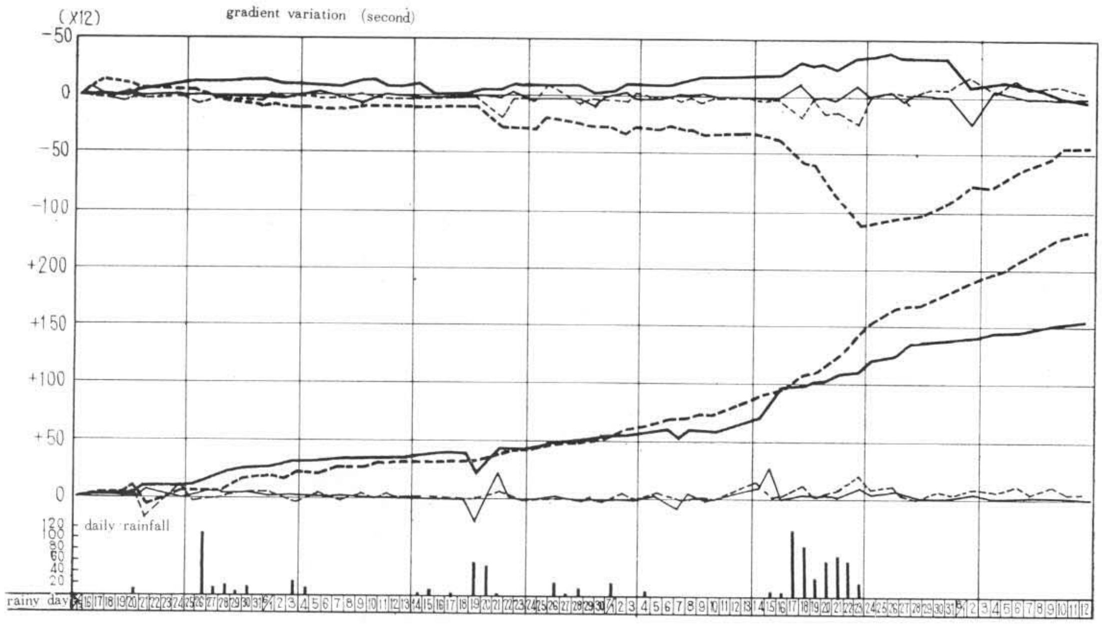


Fig. 6.1 Setting of tiltmeters



Note: —— tile fluctuation in the direction of X (N-S) ...... tile fluctuation in the direction of Y (E-W)
—— accumulated tilt fluctuation in the direction X (N-S) ...... accumulated tilt fluctuation in the direction Y (E-W)

Fig. 6.2 Example of measurement of tiltmeters

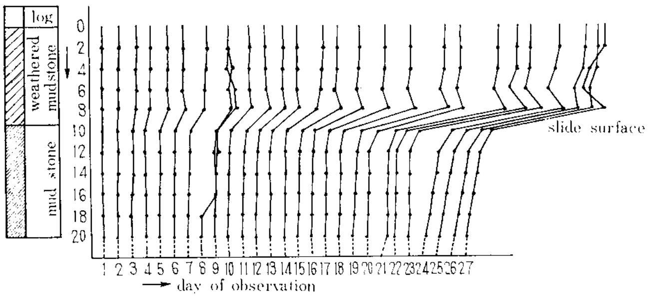


Fig. 7.1 Analysis chart of slide surface with a straingauge pipe

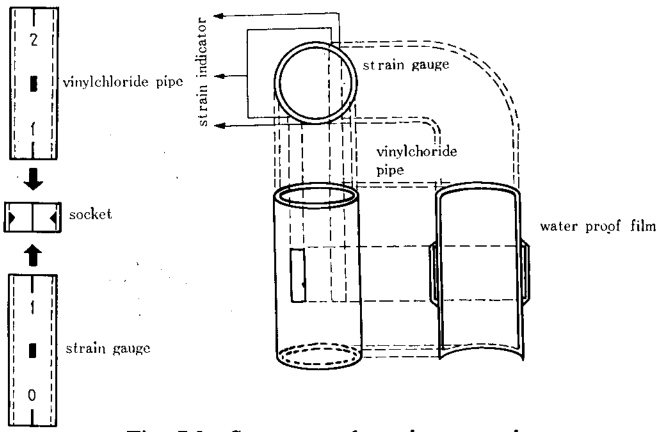


Fig. 7.2 Structure of straingauge pipe

8. Groundwater Prospection

In this test the flow conditions of groundwater are investigated using boreholes. Salt solution is injected into the borehole and thoroughly mixed to reduce specific resistance of water in the borehole to about one-tenth of the initial value. The water in the borehole is partially replaced and diluted by groundwater of high specific resistance flowing from layer of high permeability and changes its specific resistance. Changes in specific resistance are measured with this instrument which is made of a combination of measuring systems consisting of a pick-up with many electrode pairs, an alternate current oscillating circuit and a bridge circuit.

9. Groundwater Tracing Test

After some flowing routes of groundwater have been presumed in the landsliding area and the neighboring area survey, water levels measurements in boreholes, groundwater prospection, tests of groundwater quality, etc., flow velocities and velocity distribution of groundwater flowing of these routes are measured in-situ with this groundwater tracing test.

Groundwater tracers generally used are as follows

a. Inorganic chemicals: manganese sulfate, sodium dichromate, ammonium chloride, salt, potassium chloride

b. Fluorescent or coloring reagent: sodium salt of fluorescein, rodamin

c. Radioisotopes: tritium, iodine

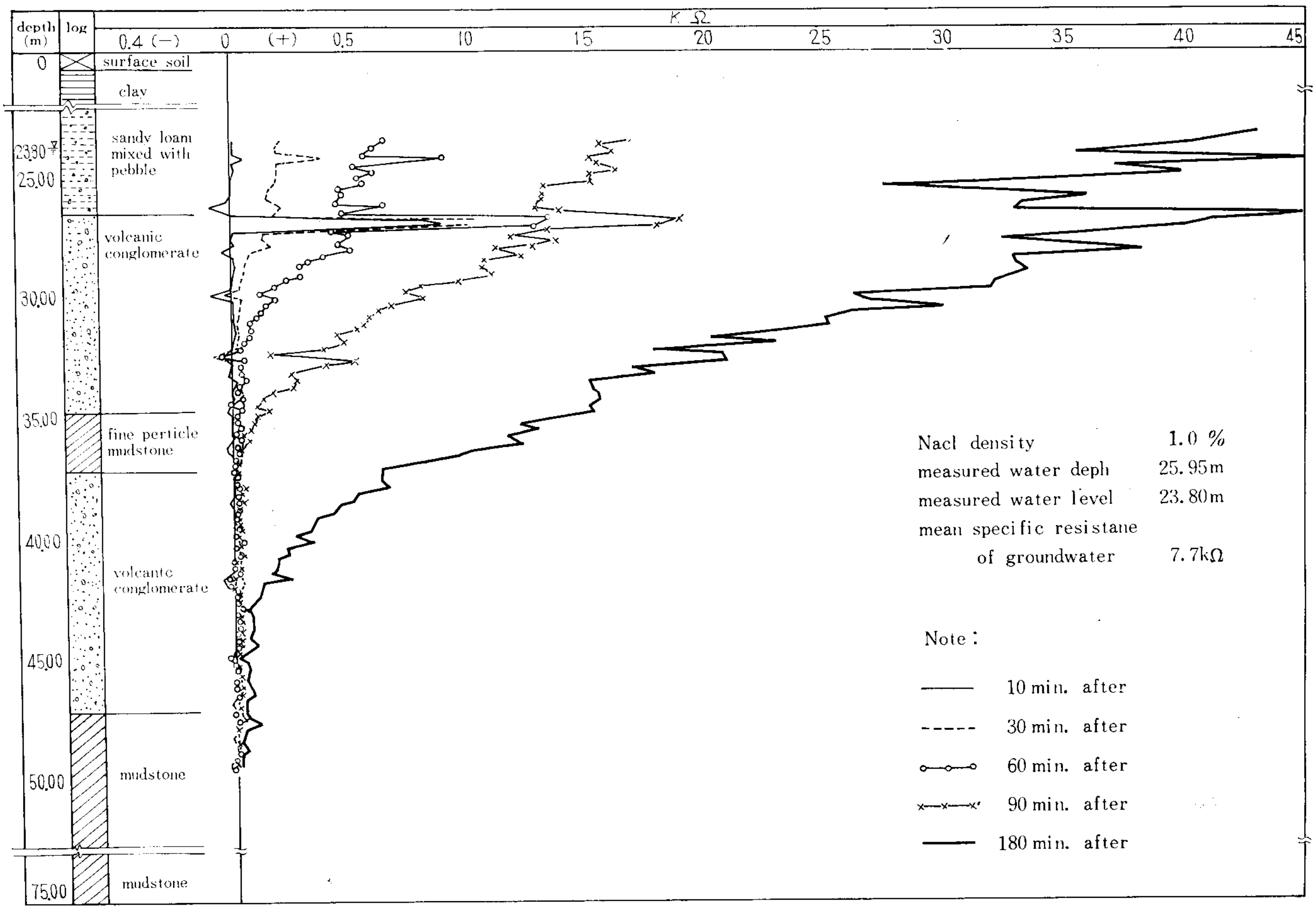


Fig. 8.1 Groundwater prospection at Nakagiyama, Gunma Prefecture

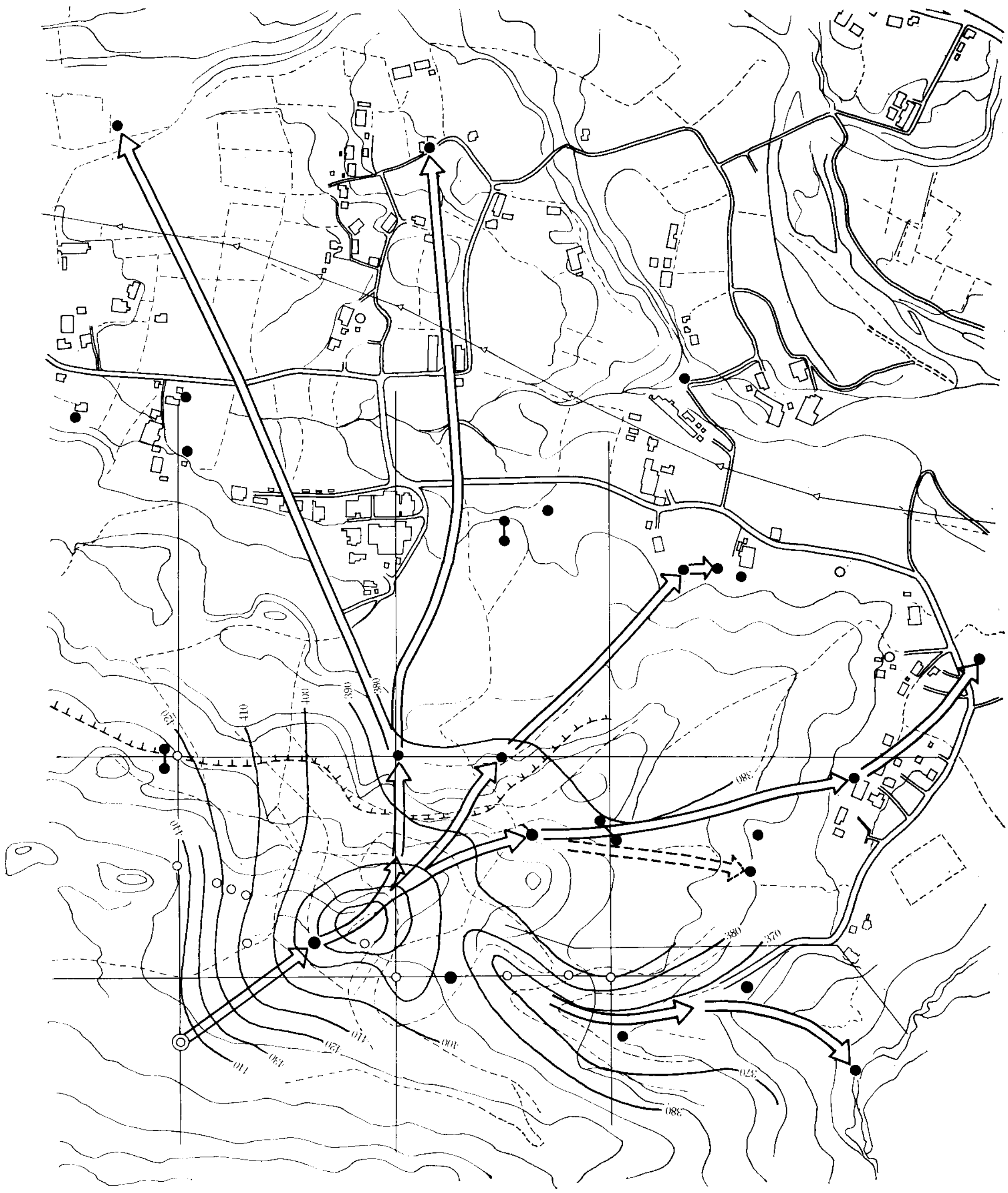


Fig. 9.1 Results of groundwater tracing test

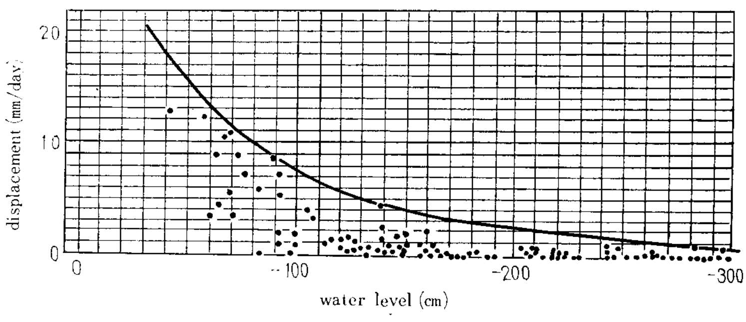


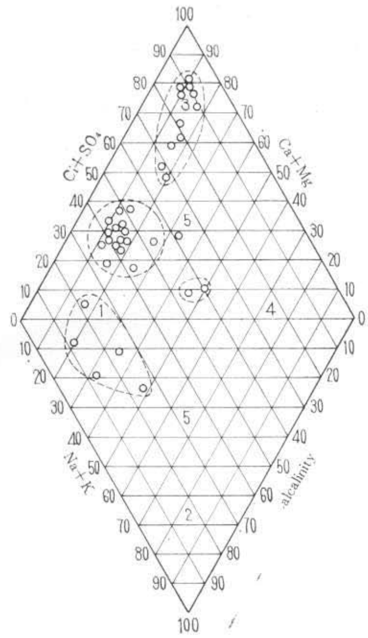
Fig. 9.2 Relationship between displacement velocity and groundwater level at landslide

10. Groundwater Level Survey

Measurement of groundwater levels of boreholes is an indispensable survey measure for studying mechanisms of landslide occurrences and planning appropriate control works. Various kinds of automatic recording apparatus such as a water-level gauge of float type, of needle touch type, etc. are generally used for measuring groundwater levels. In this survey method, correlations are analyzed between groundwater levels and rainfall, ground displacement, etc.

11. Quality of Groundwater Survey

In this survey method the flowing routes of groundwater are presumed by classifying characters of the groundwaters existing in the landsliding area with quality of groundwater and assuming where they came from. In general, tests are made on water temperature, pH, BCG alkalinity, specific resistance, Cl, SO_4, SiO_2, Ca, Mg, Na, K, and the results are plotted on a rhombic diagram to classify groundwater characters. Trace elements are also quantitatively analyzed as occasion demands.



1. Carbonate Hardness
   Waters containing calcium and magnesium bicarbonates as main constituent
2. Carbonate Alkali
   Waters containing potassium and sodium bicarbonates as main constituent
3. Non Carbonate Hardness
   Waters containing earths chloride and sulfate as main constituent
4. Non Carbonate Alkali
   Waters containing alkali chloride and sulfate as main constituent such as waters mixed with sea water and fossil brine
5. Intermediate type between 1 and 2

Fig. 11.1 Rhomic diagram to classify groundwater characters

Prevention and Control of Landslide

In order to know the stability factor of the slope of present condition by calculating safety factor from stability analysis on the slope where landslide is occurring as well as to stabilize sufficiently the slope, it is necessary to keep the safety factor to at least 1.1∼1.2, and an appropriate control work must be planned for this purpose.

In general the following works are used for controlling landslide.

1. Excavation Removal of Soil Mass

To reduce the driving force of soil mass, some quantity of movable materials is removed at the head of the landsliding area. Sometimes all of soft surface soil mass is removed. Fig. 1 shows a project plan of soil removal at the Yui landsliding area and a photograph of working condition.

2. Surface Drainage

In order to prevent permeation of surface water in the landsliding area into the ground, a net of ditches is planned to collect and discharge surface water. Fig. 2 shows an example of surface drainage. Lawn ditch, concrete ditch, etc. are generally used for this purpose. Fig. 3 shows an actual example.

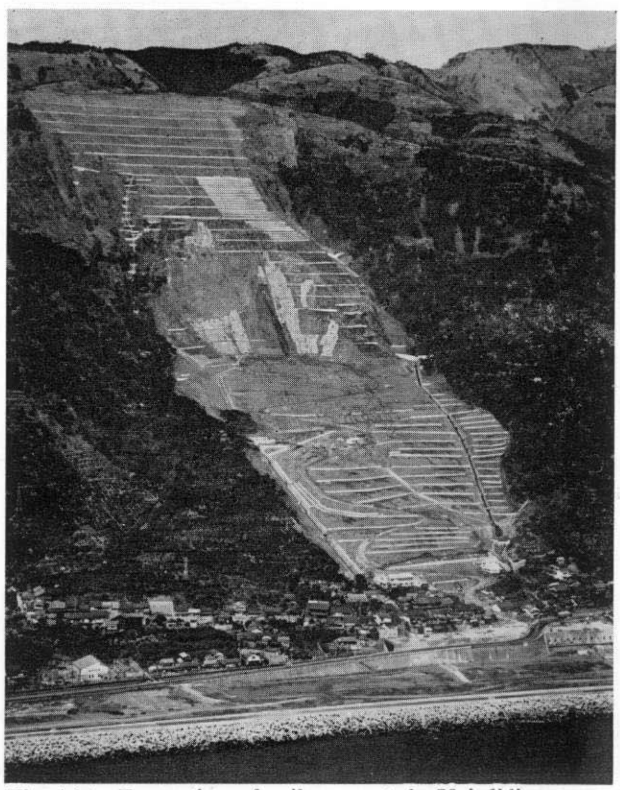


Fig. 1 (a) Excavation of soil mass at the Yui sliding area

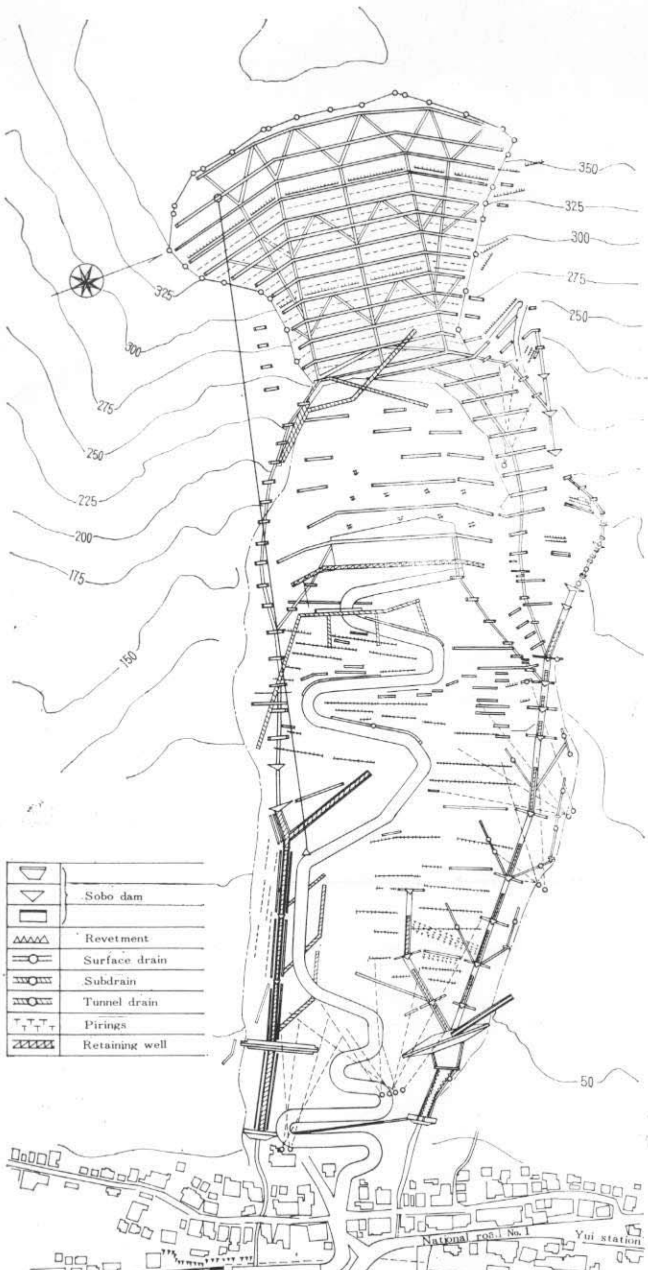


Fig. 1 (b) General control works of Yui slide area

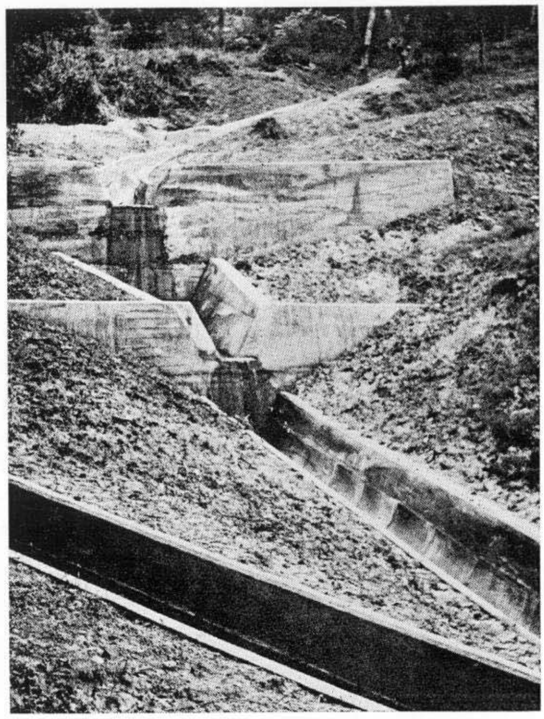


Fig. 2 (a) Surface drain

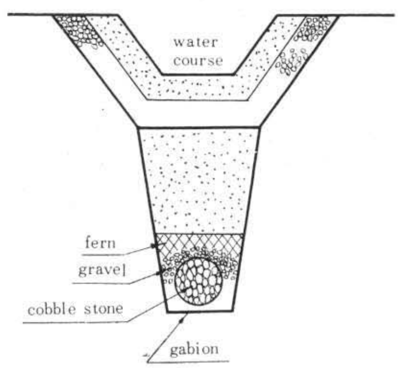


Fig. 2 (b) Surface water drainage channel and subdrain

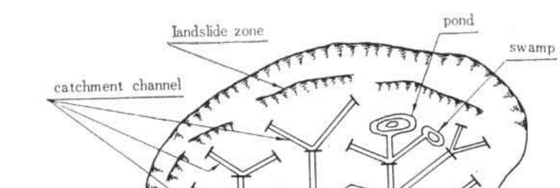


Fig. 2 (c) Preventive work by water drainage net

3. Subsurface Drainage

In order to increase the resisting force of sliding soil mass, the following methods are taken to drain seepage water permeated into the ground.

- horizontal drain by drilling
- drain by intercepting wall
- cement grouting
- chemical injection
- subdrainage
- drainage tunnel
- drainage well

The drainage well is installed to reduce the length of horizontal boreholes as a primary aim by installing a vertical well at a suitable place in the case that the length of horizontal boreholes from the ground becomes too large.

The drainage well consists generally of a convertible corrugated pipe of larger than 3.5 m in diameter and many short horizontal boreholes from its side wall. Collected groundwater is drained to the down slope by natural drain through a horizontal borehole of large diameter from the bottom of the well or by pumping drain.

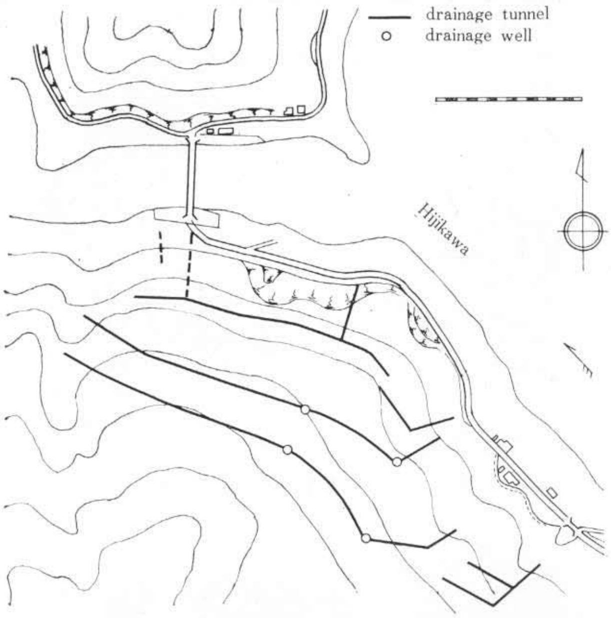


Fig. 3 (a) Plan of drainage tunnel and drainage well

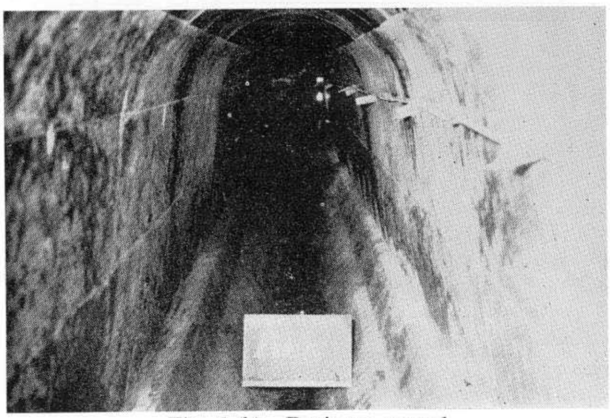


Fig. 3 (b) Drainage tunnel

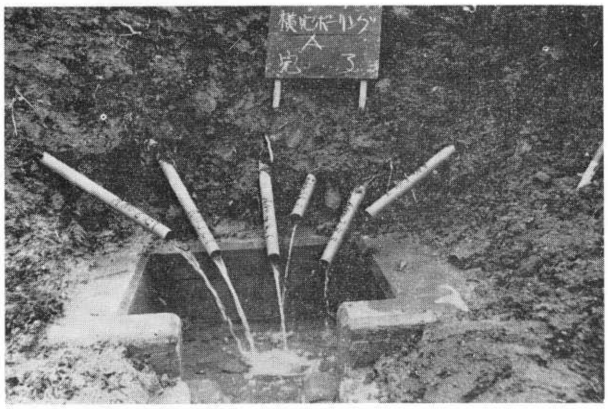


Fig. 3 (d) Horizontal drainage drilling

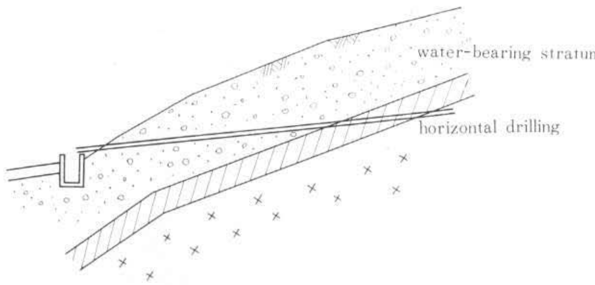


Fig. 3 (e) Section of horizontal drilling

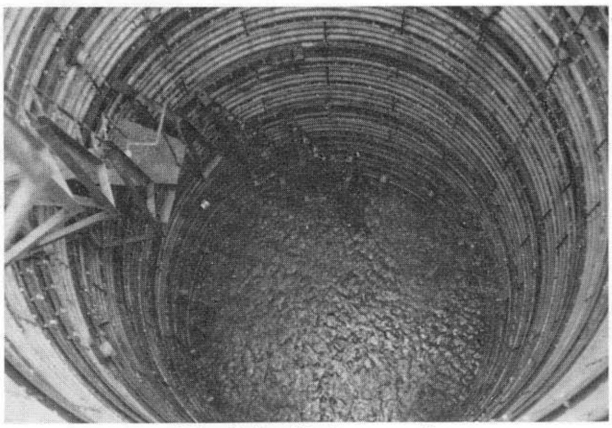


Fig. 3 (f) Drainage well

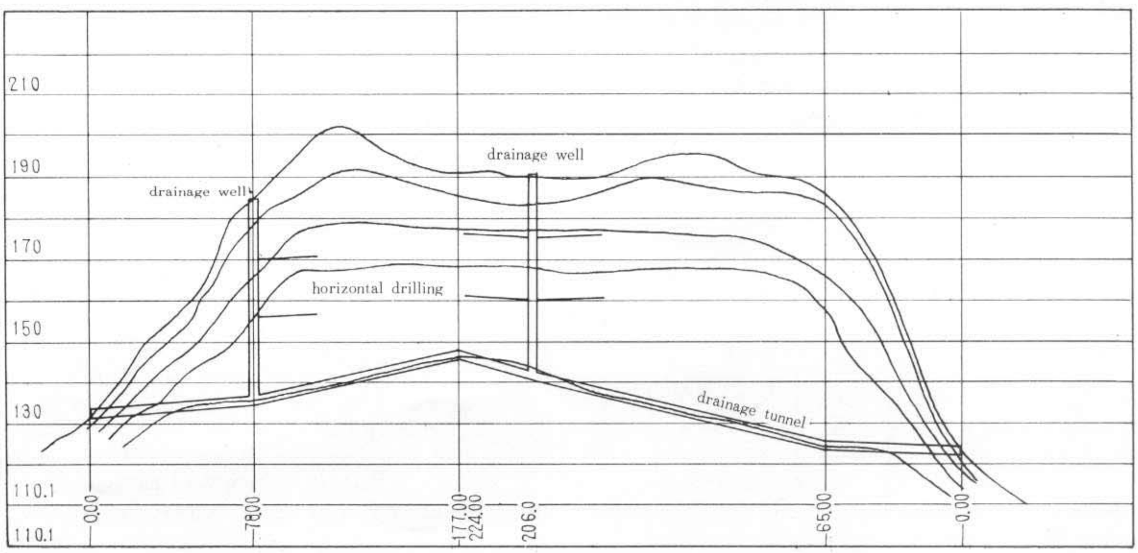


Fig. 3 (c) Section of drainage tunnel and drainage wells

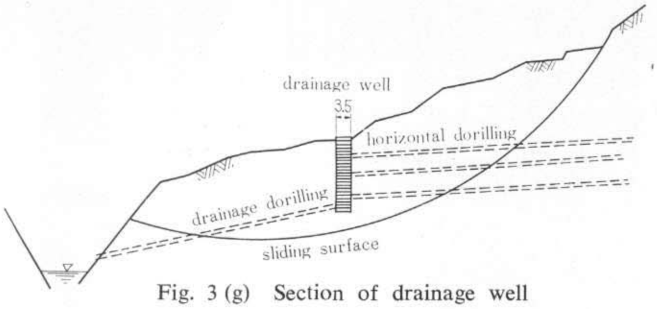


Fig. 3 (g) Section of drainage well

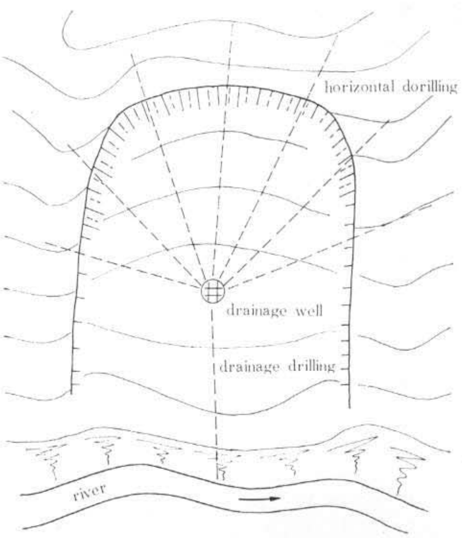


Fig. 3 (h) Plan of drainage well

4. Restraining Structures

In order to increase the resisting force directly to slide movement, the following restraining structures are constructed:

retaining walls
buttresses
cast-in-place piles

5. River Structures

Erosion-control dams
Consolidation dams, groin, revetment

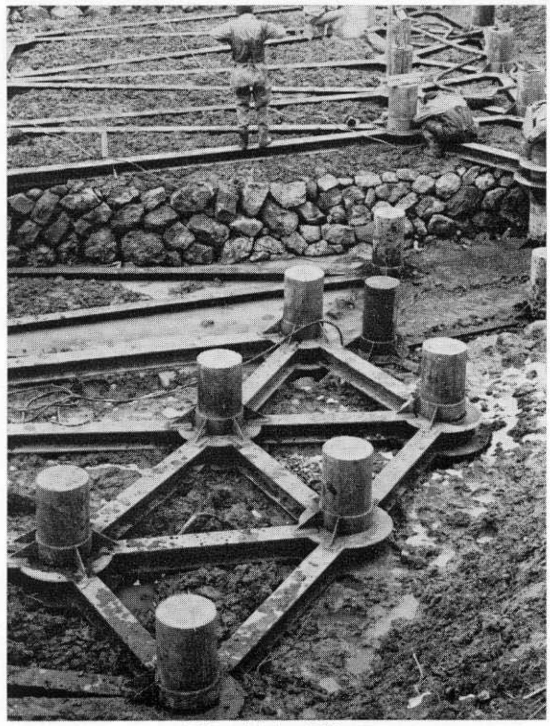


Fig. 4 (a) Piling

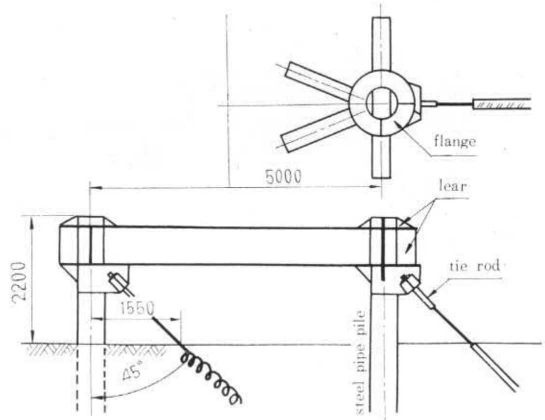


Fig. 4 (b) Connection of top of pile

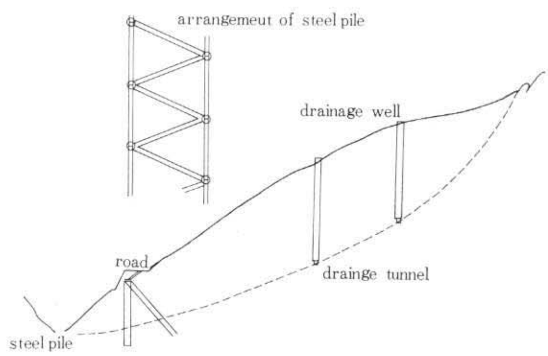


Fig. 4 (c) Section of steel piling

List of Research Paper

Principal research papers appeared the Journal of the Japan Society of Landslide from No. 1 to No. 16 are in the following:

No. 1

[General essays]

Keizaburo Nakamura: On landslide disasters

Hiroshi Koide: A direction for landslide research

Michitaka Saito: Landslide research and utilization of research results

Toshio Taniguchi: Landslide control and its problems

[Reports]

Yuji Takada: On the deformation under the ground and the slide surface in landslides of Tertiary formation

Goji Yamada: Landslide investigation and control methods in the vicinity of 19.980 km of Hetonai Railway Line

Chugoku-Shikoku Agriculture Administration Bureau: Considerations on a landslide control method

Shin-ichi Yamaguchi, Masasuke Watari, Mitsuharu Tsumoto, Yoshio Takada, Saburo Nakamura and Yuji Takada: On geophysical surveying methods for landslides

Hideo Takano: Two problems on landslide control

No. 2

[Reports]

Kyoji Tajime, Hiroshi Okada, Kazuro Hamada and Toshiro Koyanagi: Preliminary investigations by the electric resistivity method for the landslide at Ikantai, Hokkaido

Kazuo Kuroda: On topographical development of landsliding areas at the Noto Peninsula

Shigefumi Oka: On airphoto interpretation of landslides in the Hokushin Region

Yoshijiro Kishimoto and Seijin Ohira: On groundwater and surface water in landsliding areas (I)—Their ground inflow and hydrogeological properties at Shimotokura, Naniai Village, Nagano Prefecture

Yoshijiro Kishimoto and Seijin Ohira: On groundwater and surface water in landsliding areas (II)—Distinction of groundwater systems at Nishihiragu, Nagano Prefecture

Saburo Nakamura: On some characteristics of landsliding areas observed around volcanic deposits (I)

Masaharu Sakiyama: Horizontal drainage work by a horizontal auger for landslide control

Nobuyoshi Kishihara: On Kohlrausch Bridge

Michio Takada: On landslide of Kamenose Area

Kiminori Sasaki and Akitoshi Fujiwara: On landslide at Nemorida, Akita Prefecture

Shin Iwanaga and Karyu Tsuda: On Matsunoyama Landslide—at Mizunashi Area (I)

Takasuke Yazawa: History and present condition of Shorinzan Landslide, Gumma Prefecture

Toshio Taniguchi: On Kurumi Landslide at Himi City, Toyama Prefecture

No. 3

[Reports]

Takamasa Maki and Toshiyasu Tomita: On quality characteristics of groundwater in Matsunoyama landsliding area

Fujiya Komamura: On characteristics of clays in Matsunoyama landsliding area

Hiroshi Kano, Kenji Tomidokoro and Yoshio Shindo: Geological consideration on Toyomaki Landslide, Yamagata Prefecture

No. 4

[Reports]

Masasuke Watari and Atsuyuki Sakai: On vertical groundwater survey with boreholes (Groundwater prospection)

Masasuke Watari and Atsuyuki Sakai: On electric resistivity of groundwater in Shorinzan landsliding area, Gumma Prefecture

Takuji Sugimoto: On landslide investigation in a crystalline schist region with the seismic prospection

Masasuke Watari and Akitoshi Fujiwara: On landslide investigation in the vicinity of Ōtani No. 3 Tunnel of National Road Route No. 8

Hidetake Hitomi and Kenji Nakao: On landslide control work at Yui, Shizuoka Prefecture

No. 5

[Reports]

Fujiya Komamura: Analysis of landsliding movement by the viscoelastic theory—trial of displacement measurement

Michitake Saito and Hiroshi Kamizawa: Warning of time of slope failure

Kazuo Yamazaki and Shin Iwanaga: Outline of Makinoda Landslide, Niigata Prefecture, and effect by the control works

Toshio Taniguchi: Landslides in the U.S.A. and Canada (I)

No. 6

[Reports]

Hitoshi Kawamoto: Research on Kamenose Landslide (I) —On the relationship between displacement and rainfall

Itsuo Tamaki, Hitoshi Kawamoto, Takashi Fujita and Yasuyuki Oba: Research on Kamenose Landslide (II) —On fractured zone at Shimizudani area

Masasuke Watari, Atsuyuki Sakai, Toshiyasu Tomita and Akira Nakajima: On the mechanism of landslide in volcanic altered area in region of Hakone volcano (I)

Junshoku Shin and Norimoto Tanaka: Methodological research on landslide investigation methods (I)—comparison of the results of seismic prospection, radioactivity survey and horizontal electric survey

Sohichiro Nakamura: Landslide at Yoshikawa Village

Toshio Taniguchi: Landslide in the U.S.A. and Canada (II)

No. 7

[Reports]

Takashi Ando and Taiji Okubo: Geological study on the mechanism of landslides in Owakudani, Kanagawa Prefecture (I)

Mitsuharu Tsumoto and Yuzo Ito: On special sinking of sliding area

Atsushi Takenouchi: On viscosity coefficients of clays of landslide areas in Japan

Itsuo Tamaki, Hitoshi Kawamoto, Takashi Fujita and Yasuyuki Oba: Measurement of viscosity coefficients of landsliding areas by amplitude variations of secondary waves

Hitoshi Kawamoto: Observation of land strain at Muraoka Landslide—Specially on the effect of soil removal work

Masayoshi Matsubayashi: On the influence of Matsushiro earthquakes on landslide occurrence

No. 8

[Reports]

Fujiya Komamura: On plastic viscosity coefficients of landslide clays

Hiroshi Kano: On the relation of landslide failure occurred between Arikabe and Ichinoseki of Tohoku Railway Line with geological structures

Shin-ichi Yamaguchi: On landslides in Southeast Asia

Takeshi Ando and Taiji Okubo: Geological study on the mechanism of landslides in Owakudani, Kanagawa Prefecture (II)

Kyoji Tajime: Problems of geophysical prospection in soil mechanics

Masasuke Watari, Atsuyuki Sakai, Toshiyasu Tomita and Akira Nakajima: On the mechanism of landslide in volcanic altered area in the region of Hakone Volcano (II)

No. 9

[Reports]

Tadao Mine, Yukinobu Baba, Seiichi Okazaki, Yasusachi Nagao and Hiroyasu Namba: Application of the Hummel method to electric survey and its error for analysis

Takeo Moritani: Analysis of underground structures by the shallow layer reflection method

Hiroshi Fujimoto: On clay minerals of landslide soils in West Japan (I)

Ryojiro Kishimoto: Groundwater and surface water in landslide area (III)—A study of fluctuation phenomena of groundwater level and groundwater pressure observed at various depth in ground at a landslide area

Yasumasa Fukumoto: On variations in the ground surface of Tonoya Landslide

Saburo Nakamura, Akira Koyama and Yoshinobu Koibuchi: Fluctuations of land surface and underground temperature in the Owakudani landslide area

No. 10

[Essay]

Hideo Takano: On general control measure for landslide

Shin-ichi Yamaguchi: On causes and motives of landslide occurrence

[Reports]

Kaori Takashino and Hideo Yugeta: Outline of New Kamenose Landslide

Mitsuharu Tsumoto and Yuzo Ito: On improvement of piling to restrain landslide—On the effect fixed by compaction rod pile

Takashi Fujita: Studies of the Kamenose Landslide (III)—On the geology of the Kamenose area

Hitoshi Kawamoto and Yasuyuki Oba: Studies of the Kamenose Landslide (IV)—On the fractured zone at Shimizudani area (2)

No. 11

[Reports]

Takeshi Ando: Studies on the landslides and its formations in the Hokusho area in Kyushu

Fujiya Komamura: On the moving behaviors of landslides based on rheological characteristics of landslide

Takahiko Furuya: Preliminary landslide research in fractured zone

Enso Rin: On landslides in Formosa

No. 12

[Reports]

Michitake Saito: Forecast of time of slope failure by tertiary creep

Takeshi Ando: Studies on the landslides and its formations in the Hokusho Area in Kyushu (II)

Mamoru Suzuki and Kohei Matsui: Geological considerations on the volcanic landslide at Kogane Hotspring, Sapporo City

Tadao Miya and Yukinobu Baba: On analysis of vertical electric survey by an electronic computer

Shin-ichi Yamaguchi and Atsuo Takenouchi: On the specific upheaval phenomenon at the tongue of the landslide area (I)

No. 13

[Reports]

Takeshi Ando: Studies on the landslides and its formations in the Hokusho Area (III)

Takahiko Furuya: On some informations about the landslides on the mid-stream in the Yoshino River and Iya River

Kojiro Kashiwabara: New excavating method of a drain hole at a drainage well

Naruaki Kato: An example of soil restraining method in landsliding area

Masasuke Watari and Hiroyuki Nakamura: On the design of landslide restraining method (for piling)

No. 14

[Reports]

Yoshinori Nakano and Seijin Ohira: Investigation on the mechanism of landslide at Gode in Niigata Prefecture with special reference to the earth pressure exerted on vertical drainage-wells and the stresses induced in their Liner Plates

Hiroshi Uezawa: Stability analysis of slopes by electronic computation

Tamao Uchiogi: Measurement of landslide conditions by aerial photographs

Masaatsu Ozaki and Akihiko Ito: On the Aug. 17 heavy rain disaster and the accident of buses by landslip.

No. 15

[Reports]

Takeo Moritani: Improvement of the device of shallow layer reflection method

Kozo Yuhara: Sensitivity of water-level gauge to measure the water-level in small well pipe

Masayoshi Matsubayashi and Koichi Mochizuki: On the groundwater at the upper part of Chausuyama Landslide

Masao Iwasaki: Geology and landslides in the Iya River basin

Chuzo Nakagawa: Causes of landslides occurrence in Shikoku (I)—Landslide in Morito area

No. 16

[Reports]

Hiroshi Kawakami: Stability analysis on landslides of Susobana and Makiuchi

Hiroshi Fuse: Mechanism of landslide observed in black mudstone layers in Niigata Prefecture

Shin-ichi Yamaguchi, Yuji Takada and Atsuo Takenouchi: On the landslide at Kushibayashi area

Shoji Okaji and Hiroshi Kato: On the control work at Kushibayashi landslide, Okoto area, Shiga Prefecture