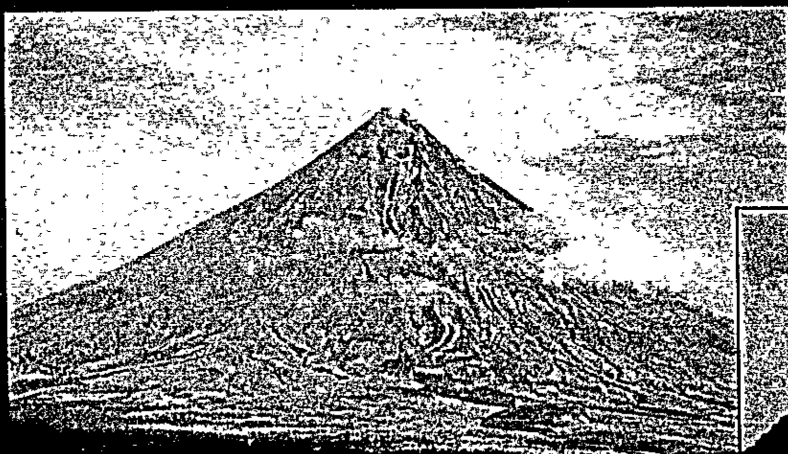
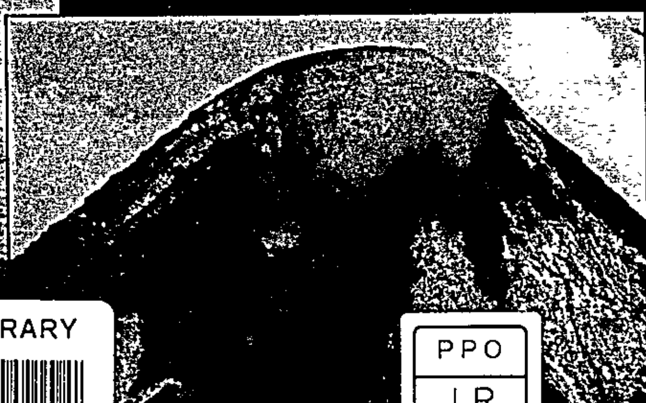
Sabo Works: Challenge and Response





Manila, Philippines
March 1995

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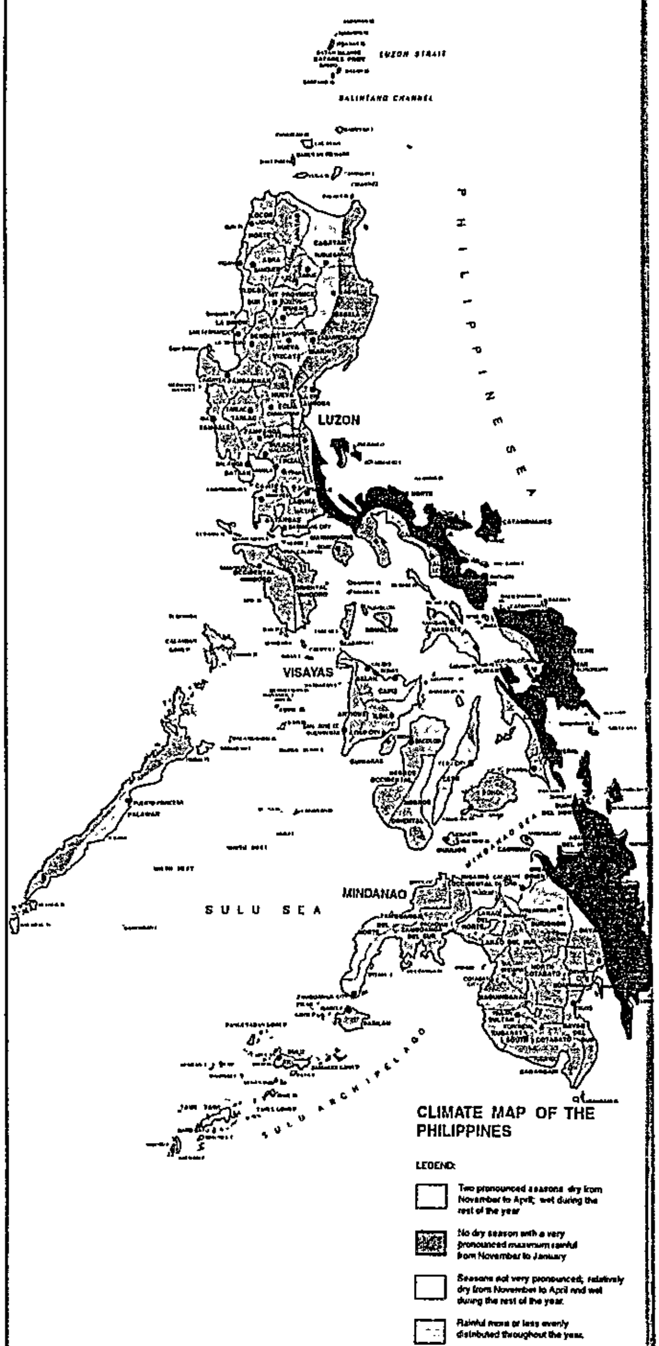
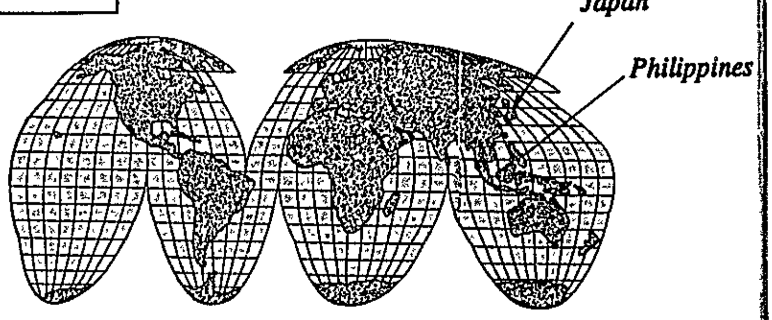
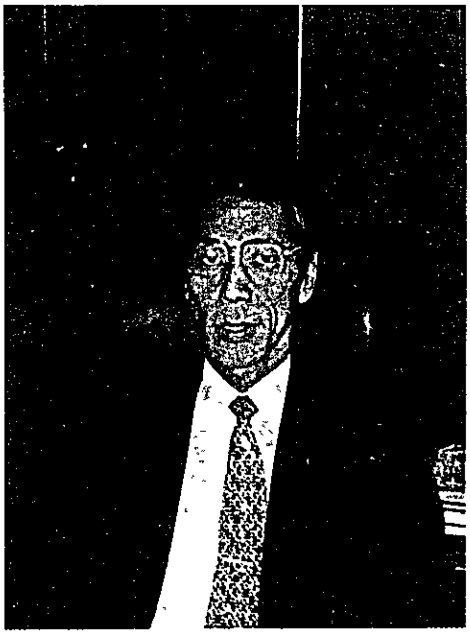




Cover: Mt. Pinatubo eruption in 1991 and Mayon Volcano eruption in 1993

Unless otherwise indicated, photographs used in this publication were provided by Mr. Hiroyuki Ohno, JICA Sabo Expert

Preface



The countries of Japan and the Philippines lie in what contemporary writers call the Asia-Pacific "rim of fire." This is so because many of the world's recorded volcanic and seismic activities are said to occur around the rim of the Pacific Ocean. Active volcanoes in Japan alone consist of close to 10 percent of the world total.

Because of their geological composition, Japan and the Philippines have been beset by a large number of volcanic and other seismic activity.

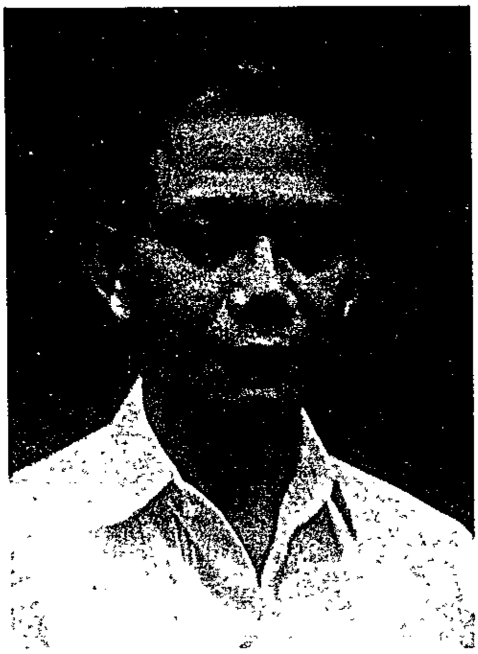
While Japan has gained sufficient experience in mitigating the adverse effects of volcanic and other geological disasters, it was only fairly recently, particularly in the aftermath of the Mayon Volcano and Mt. Pinatubo eruptions, that the Philippines has adopted long-term disaster-mitigating measures for the purpose.

It is therefore due to the long history and vast experience of Japanese experts in Sabo works and other sediment disaster control measures that the Philippine government has requested long-term Japanese assistance in connection with the Mayon Volcano and Mt. Pinatubo disasters. This publication is therefore an attempt at documenting the type, nature and extent of disaster-mitigating measures adopted in Japan and quite recently in the Philippines to alleviate the effects of volcanic and other related disasters.

AKIHIKO HASHIMOTO
Resident Representative
Japan International Cooperation Agency
Manila, Philippines

1 March 1995

Foreword



This publication has been prepared to serve as a ready reference guide on past and current efforts in Japan, and more recently in the Philippines, in mitigating soil erosion and other similar disasters like landslides, slope failures, and debris and mud flows caused by a combination of volcanic, climatic and other geological activities.

The publication consists of six major parts. The first and second parts provide a brief background and history of Sabo works and other erosion control measures in Japan. Some specific cases of volcanic and seismic activity are provided to describe more clearly the various types of control measures adopted for each case.

The third part describes in some detail the geological, climatic and socio-economic conditions in the Philippines and the events leading to and the extent of damage caused by the eruption of Mt. Pinatubo in Central Luzon and Mayon volcano at the Southeastern tip of Luzon in the Philippines. Various foreign and local assistance, as well as the different measures adopted to mitigate the effects of one of the worst natural disasters in this century, are also described in this portion of the book.

A description of the Philippine DPWH program thrusts, organizational structure, and key concerns are also provided in this part of the publication.

The fourth and fifth parts provide a compilation of references and facts and figures on Sabo works and other forms of sediment control measures.

It is hoped that this publication will be readily useful, especially to those who are directly involved in sediment-related disaster prevention, as well as in the rehabilitation and reconstruction work in the aftermath of major volcanic and sediment-related disasters.

GREGORIO R. VIGILAR
Secretary
Department of Public Works
and Highways
Republic of the Philippines

1 March 1995

Overview: Natural & Population Conditions in Japan

Toyohira river (Ishikari river system) (Reference No. 1, page 14)

Denuded hillside of Mt. Tanakami, southeast of Lake Biwa (Reference No. 2, page 11)

Natural disasters occur in Japan with such frequency and magnitude that disaster mitigation had become a major concern in the country dating back to the first century. This is in view of its geological structure and climatic conditions that are prone to natural disasters.

Japan, which consists of four major islands, lies off the northeastern rim of the Asian continent. While its landmass comprise only about 0.1 percent of the earth's total land surface, it accounts for about 10 percent of the world's total seismic energy, with about 1,500 earthquakes registered by seismographs a year.

Geologists believe that this is so because the Japanese islands sit on an extremely active mobile belt located at a sea trench where the ocean plate goes beneath the island arc, pushing it in the process.

Violent earthquakes, although occurring only about once every 10 to 30 years, have caused many earth movements, resulting in the great variety of surface features in Japan.

Volcanic activity is also common in Japan. A total of about 200 volcanoes dot its entire landscape from Kyushu island in the south to the southwestern and eastern sides of Hoshu island up to Hokkaido island in the north. About 60 of these volcanoes have been intermittently active over the past centuries.

In some ways, volcanic activity could be beneficial to man. For one, thermal energy from volcanoes can be harnessed for power generation. Another is the use of hot springs for medicinal treatment and recuperation. Other benefits are in terms of its uses in the promotion of tourism and leisure.

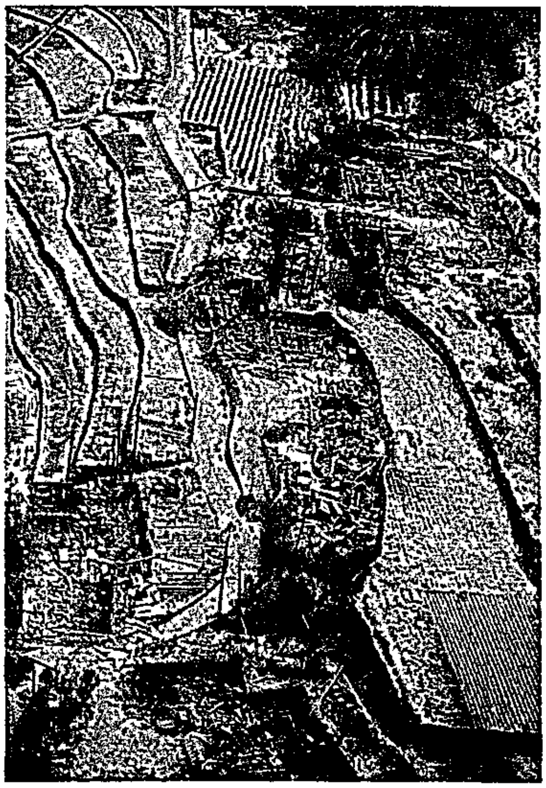
On the other hand, volcanic activity could bring disaster and suffering as was the experience in Japan for many centuries and quite recently in the Philippines due to the eruption of Mt. Pinatubo. Volcanic magma and other debris are spewed out which could turn into pyroclastic flows during heavy rainfall causing death and destruction along their path.

Many volcanoes in Japan are classified as stratovolcanic that contain magma of a chemical type that cause explosive eruptions and the ejection of large quantities of volcanic ash and pumice to surrounding areas. Disasters caused by volcanic activity are often worsenned by the occurrence of heavy rainfall during the year, precipitating heavy lahar and pryroclastic flows in low-lying areas.

The rainy season in Japan occurs during the months of June to September, moving from relatively light rainfall during the early part and becoming heavier towards the end. Typhoons which are tropical cyclones that originate from the warmer parts of the Pacific Ocean usually occur in the latter part, starting August. Typhoons often bring torrential rains that could cause heavy mud or debris flows, landslides, and flooding, causing destruction in downstream and low-lying areas.

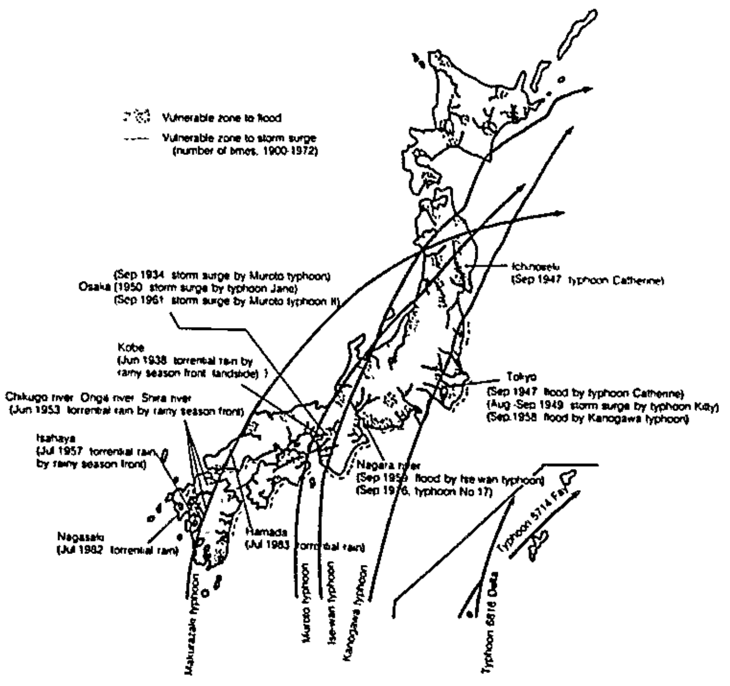
Snowfall occurs from November to March the following year. When snow begins to melt towards spring, snow avalanches, slope failure and landslides, further aggravating scarce land resources.

Land loss due to these natural calamities has become even more alarming in view of the already limited areas available for human settlement, agricultural, commercial and industrial uses. Seventy-six percent (76%) of Japan's total land area of 378,000 sq. km. consist of mountainous areas, while only 24 percent are available for settlement by a population which has now grown to some 120 million.



Burned houses due to pyroclastic flow from Mt. Unsen on June 3, 1991 (Reference No. 6, page 12)

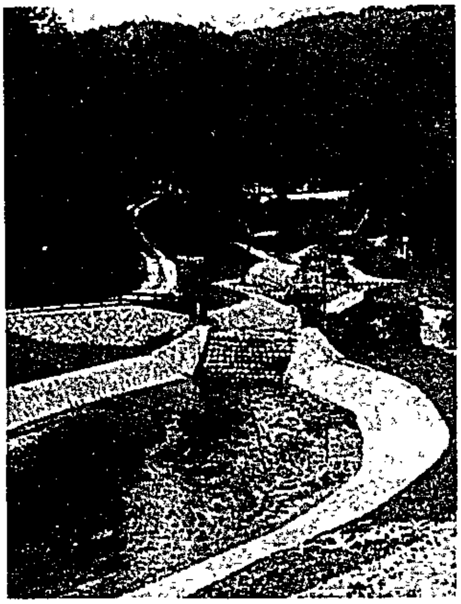
Areas most affected by heavy rains and severe flooding in Japan (Reference No. 1, page 3)



Part I: Sabo Engineering in Japan

1. History of Sabo Works and Other Disaster Prevention Measures in Japan

Steel Slit Dam at Mt. Usu (Reference No. 2, page 17)

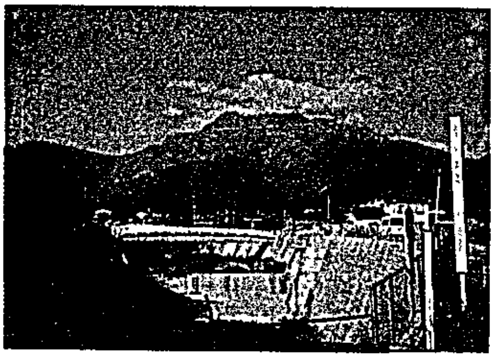


The Sabo dam by Dereke at the Fudo River, Kyoto Prefectural (Reference No. 3, page 22)

Population pressure and the urgency of conserving their country's limited land resources for human settlement has prompted even the early Japanese feudal lords to undertake measures to prevent land loss and other soil erosion disasters.

Early in their history, the Japanese had already determined that soil erosion and land loss are due to a combination of both natural and man-made causes. While harsh geological and climatic activity could render fertile and habitable land areas useless due to landslides and volcanic debris flows, this situation is often aggravated by man's inordinate destruction of the natural forest cover of mountainsides, thus causing irreparable damage to the environment. The uncontrolled use of timber for housing, furniture and other man's needs had very destructive effects on the country's forests and environment, leading to soil erosion, slope failure, landslides and severe flooding.

Hence, in an effort to mitigate this situation, as early as 804 A.D. the first known ordinance prohibiting the cutting of trees was issued. However, due to population growth, the exploitation of timber and timber products for housing and furniture needs continued unabated over the centuries. In view of this, at about the middle of the 17th century, the Tokogawa Shogunate enacted a law to protect mountains and rivers, while at the same time establishing

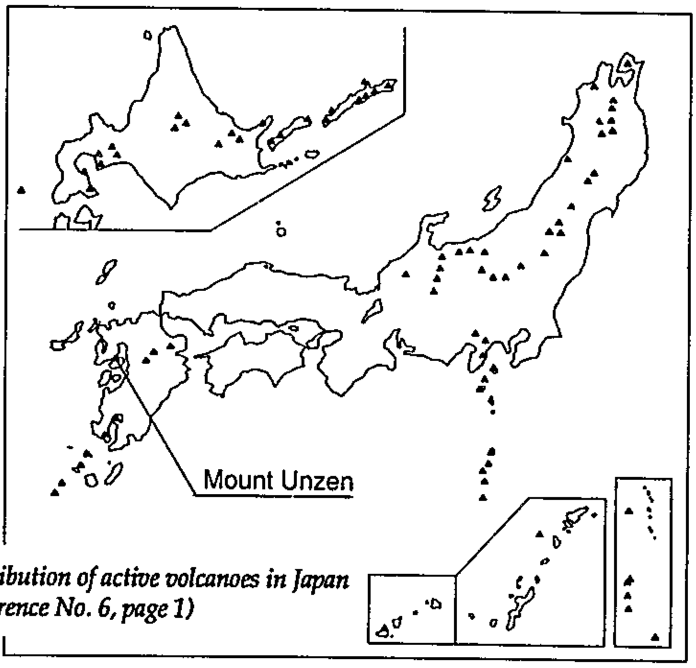


Mizunashi-river channel
(Reference No. 6, page 1)

the necessary administrative system to ensure enforcement of the law. The "head-per-tree" rule prescribed under the Tokogawa law, however, did not deter the further deterioration of forest areas near or around urban centers. Thus, soil erosion, sediment disasters and severe flooding continued to occur with alarming frequency.

In 1873 during the Meiji Era, the Yodo River Headwaters Sediment Control Act was promulgated. This began the various government sediment control projects throughout the country. In addition, in 1896-1897, a string of related laws were enacted: the River Act, the Forest Act, and the Sabo Act.

In 1911, following the great flood disasters that occurred during the previous year, the first comprehensive 18-year River Control Plan was implemented. This was followed by a second and third plan, with construction expenditures sharply increasing in the early 1930s to extend relief to agricultural families severely affected by the economic depression in the latter half of the 1920s.



Distribution of active volcanoes in Japan
(Reference No. 6, page 1)

After the disastrous debris flows in the Rokko mountains in 1938, expenditures for Sabo projects again increased dramatically.

Japan's entry in the Pacific theater of the 2nd World War, however, delayed any further land conservation works during the early 1940s. The postponement of the projects aggravated the devastation caused by the nation-wide disasters that occurred in 1947 and 1953, adding to the nation's woes caused by the war.

In 1960, immediately after the 1958 and 1959 disasters which left some 8,000 dead, the Emergency Forestry Conservation and River Control Measures were enacted.

2. *Countermeasures Against Sediment Disasters*

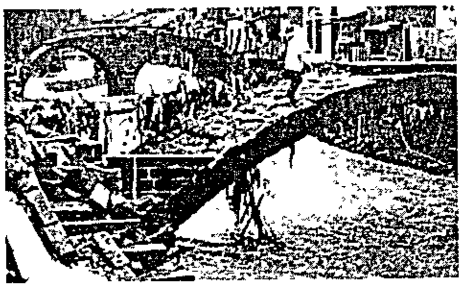
In view of Japan's already limited productive land resources, government efforts have since been directed toward mitigating further land loss due to massive sedimentation and other disasters.

The aggradation of the riverbed often occur due to sedimentation, causing flood disasters. To prevent severe floods, the sediment should be controlled in the mountain area by Sabo works. In Japan, flood disasters are categorized as one of the sediment disasters.

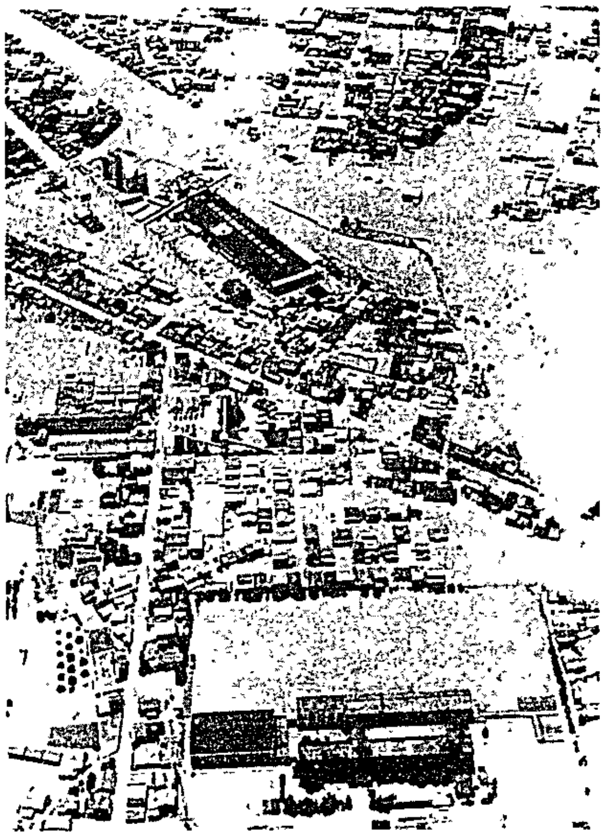
Large scale sedimentation often occur due to slope failures, landslides, and surface erosion especially in hilly and mountainous areas. Aggravated by heavy rainfall, loosened sediment flows down in the form of mud and other debris causing destruction to life and property along its path. Massive sediment flows could bury homes, infrastructure like roads and irrigation systems, and even whole towns and cities.

In view of this, countermeasures have been mainly directed against four main types of sediment-related disasters, namely: (1) debris flows; (2) mud flows; (3) landslides; and (4) slope failures.

Mountainside reinforcements as shown help to regenerate natural growth on the mountains, while preventing erosion (Reference No. 3, page 10)



Stone bridge in Nagasaki washed away and destroyed by heavy floods in 1982 (Reference No. 1, page 4)



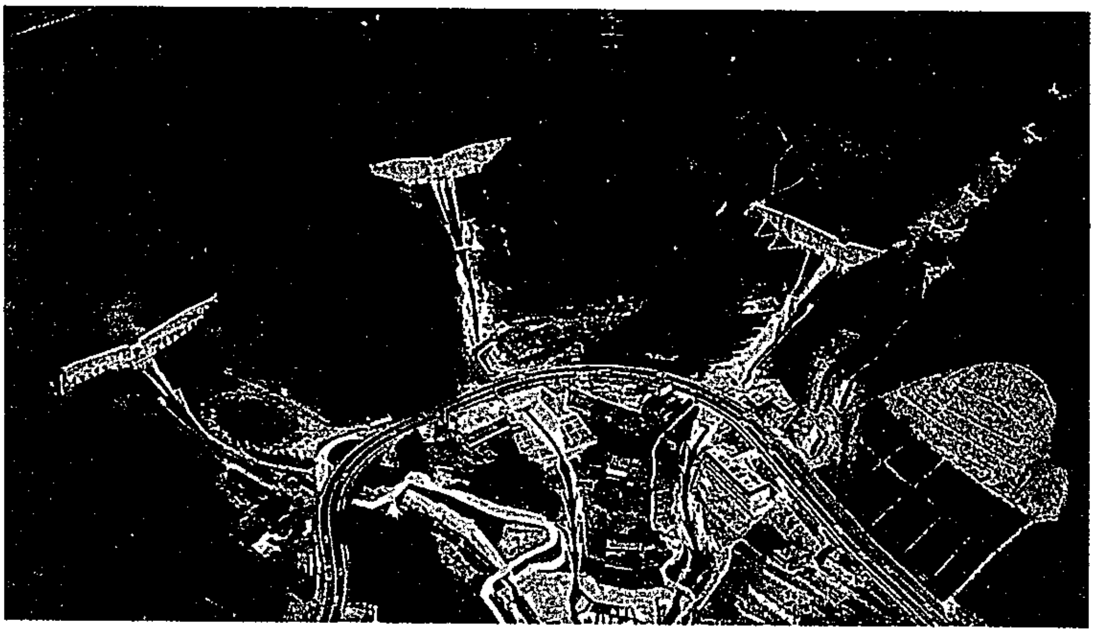
Heavily populated area transformed into a sea of mud during the Yul torrential rain in 1979 (Reference No. 1, page 4)

2.1 Countermeasures Against Debris Flows

Debris flows occur when: (a) riverbed sediment deposits are carried downstream due to an unusual increase in the volume and velocity of water induced by heavy rainfall; (b) sediment from hillside failure and soil erosion are carried downstream due to gushing surface water; (c) landslide soil masses are carried downstream; and (d) sediment which have temporarily blocked a stream suddenly gives way.

Serious studies and observations on debris flows are relatively new, having been started only in 1970. This is the reason for the still inadequate body of knowledge now available on the subject. Nevertheless, there are two general measures normally taken to mitigate the effects of debris flows: (a) prevention of the occurrence of massive debris flows; and (b) control of debris flow conditions, including the identification of potential disaster areas and places of refuge for affected residents.

Community damaged by debris flow during heavy rains in Nagasaki City in July 1982 (Reference No. 3, page 10)



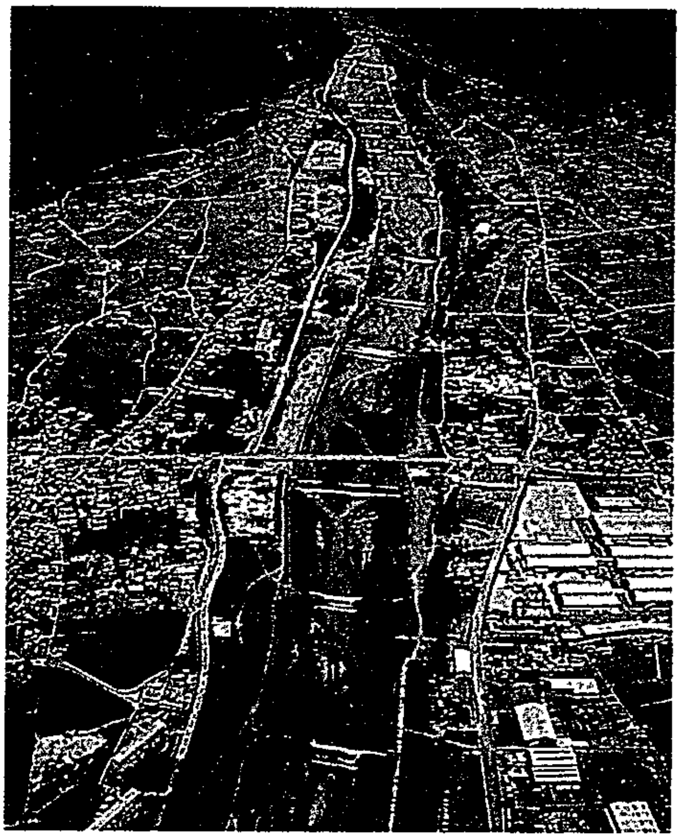
The same community after emergency Sabo works were completed (Reference No. 3, page 11)

2.1.1 *Preventive Methods Against Massive Debris Flows*

Large sediment deposits consisting of layers of sand, gravel and other pyroclastic materials in high areas with inclinations of 15 degrees or greater are most likely to pose grave danger to life and property in low-lying areas. Heavy rainfall is most likely to precipitate massive debris flows of such sediment deposits that would be virtually impossible to prevent.

In view of this, countermeasures could only consist of the construction of several consolidation dams in the upper reaches of rivers or streams where the debris flows are likely to concentrate before these are carried downstream to low-lying areas.

There are also cases where old debris flow deposits in upper valleys are further carried away to much lower areas due to heavy rains. In such cases, the construction of low-lying groundsels and channels could be effective countermeasures.



Sabo channels as pictured here are designed to facilitate the flow of rivers and help prevent the uncontrolled flow of soil and other sediments downstream (Reference No. 3, page 10)

A major road damaged by debris flow at Ichinomiya-cho in Kumamoto Prefecture in July 1990 (Reference No. 3, page 10)

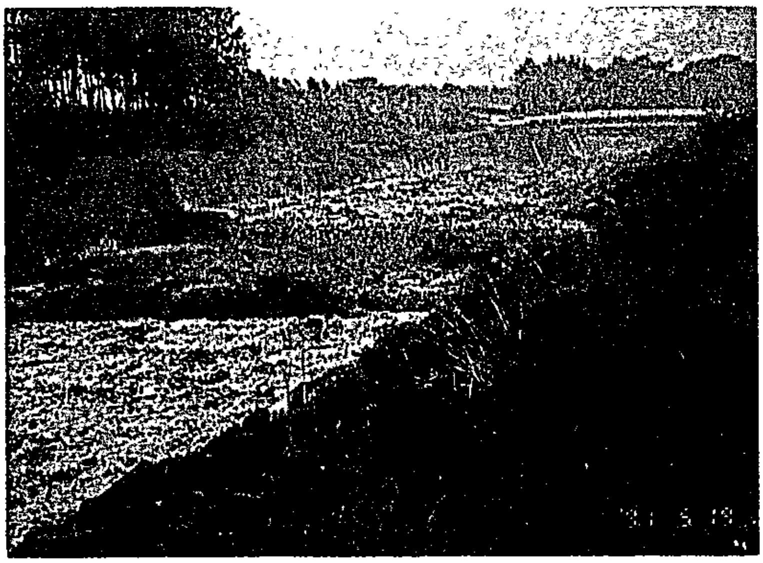
2.1.2 *Control of Debris Flow Conditions*

Massive debris flows could be extremely dangerous. Debris flows carrying large volume of sand and gravel could move downslope at great speed and sweep away entire villages and vegetation along their path.

In addition, it is also known that the speed and energy of debris flows depend largely on the volume of water precipitated by the amount of rainfall, inclination of the riverbed, the contour or size of the river channel, and the volume and size of boulders, gravel or other types of pyroclastic materials. In view of this, countermeasures against debris flow basically aim to:

a. reduce the flow rate of the debris flows;
b. prevent huge boulders from moving downstream;
c. reduce the volume of stones and gravel from being carried downstream;
d. prevent stones and gravel from being swept away by debris flows along their path;
e. prevent driftwood from being carried away by debris flows; and
f. prevent mudflows from spreading after debris flows have subsided.

These measures at controlling debris flow conditions therefore range from large-capacity sabo dams, groups of sabo dams, and groups of groundsels. Such sabo dams are designed to (a) contain or serve as deposit areas for sediment and other debris; (b) filter boulder, gravel, sand, driftwood and other pyroclastic materials and prevent them from moving dowstream; and (c) slow down and channel the debris flows dowstream to "safe" areas.



Occurrence of debris flow at the Mizunasi river on May 19, 1991 (Reference No. 6, page 5)

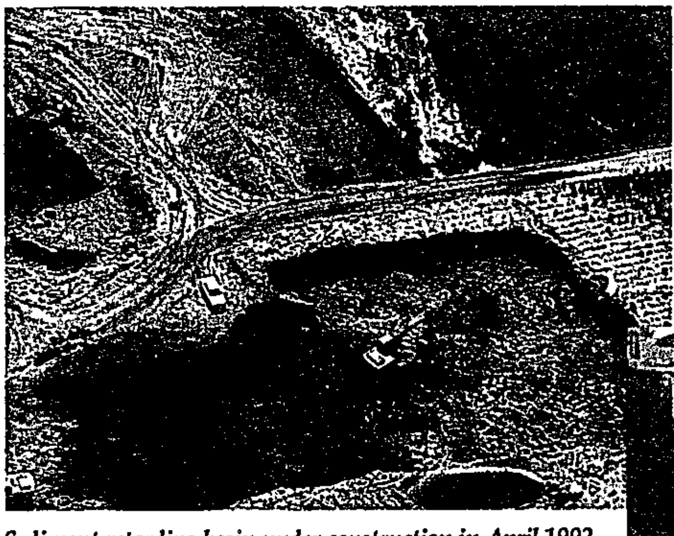
2.2 Countermeasures Against Mudflows

Mudflows often occur in volcanic areas.

Countermeasures against mudflows include revetments, groyne works, and channel construction works in lowland areas. In cases where the coefficient of river regime is large, a multiple cross- section method is adopted for the groundsels.

Countermeasures against mudflows include revetments, groyne works, and channel construction works in lowland areas. In cases where the coefficient of river regime is large, a multiple cross- section method is adopted for the groundsels.

Completed retarding basins (photo taken on May 4, 1992) (Reference No. 5, page 30)



Sediment retarding basin under construction in April 1992 (Reference No. 5, page 29)

Mudflow passing near the Shimabara Railroad on March 15, 1992 (Reference No. 5, page 7)

2.3 Countermeasures Against Landslides

In undertaking any engineering work against landslides, the first step is an extensive investigation of the topography and geographical structure of the affected area. This investigation will include a determination of the presence and distribution of cracks, ground surface inclination, elongation and shrinkage, position of slip plane, ground water level, soil composition — by means of boring and soil and rock sampling.

Actual design and engineering works will then proceed on the basis of findings from such investigation. Should there be any significant change in the phenomena as described in the first investigation, new studies will be conducted. Adjustments or modifications as necessary will then be made in the final design.

Construction work then proceeds by combining appropriate control and restraint measures, depending on the actual and expected occurrence of landslides. Included among the control measures are the elimination of surface and underground water, soil removal works and loading embankment projects. Included among the restraint measures are pilings, shafts, anchors, and retaining walls.

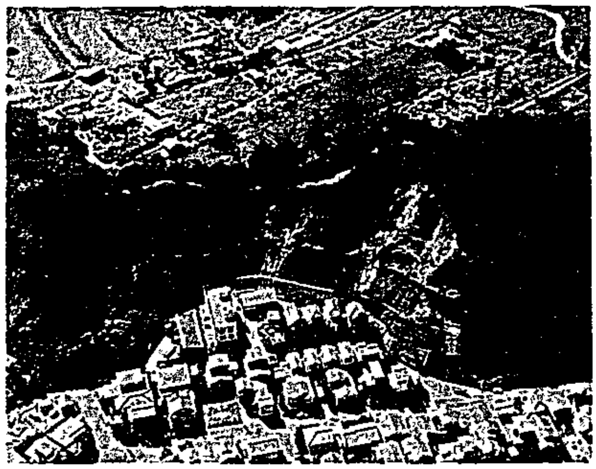
Massive landslide affects community in Nagano City in Jyly 1985 (Reference No. 3, page 12)

The same area after having been cleared and stabilized, with landslide control works completed for more efficient land use (Reference No. 3, page 13)

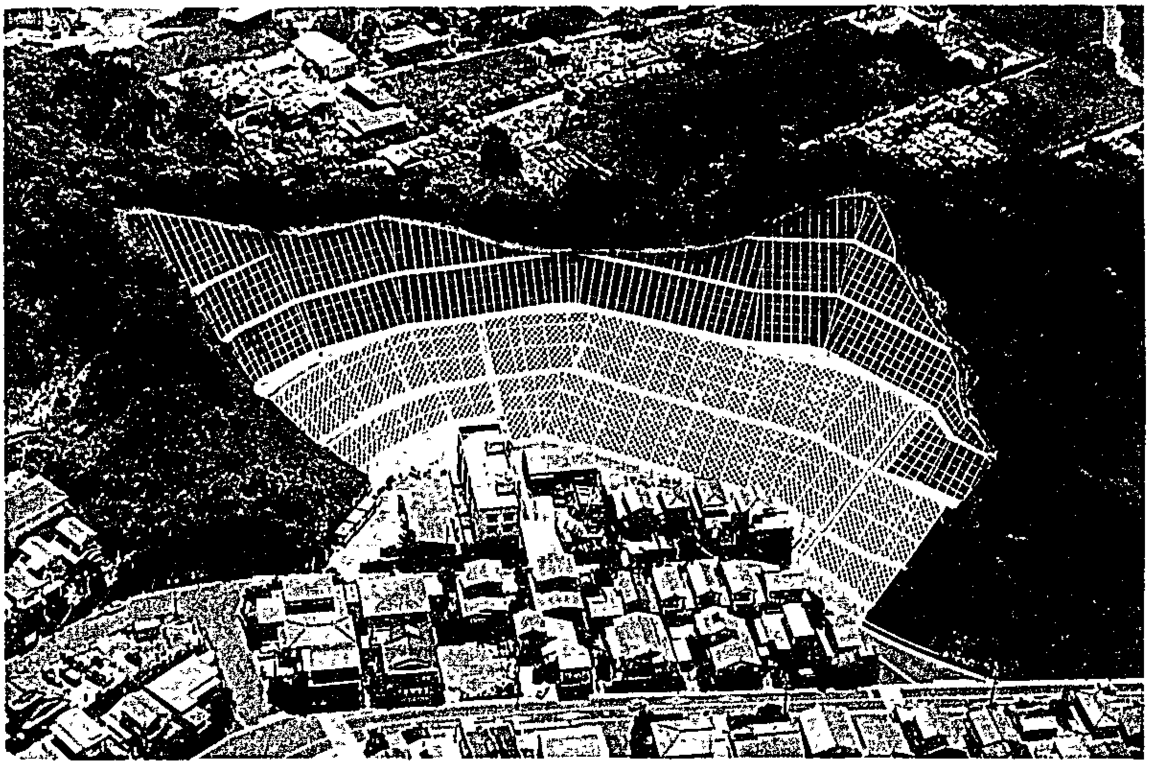
2.4 *Countermeasures Against Slope Failures*

Factors that precipitate or induce slope failures include an unstable topography, geological structure, soil which naturally has a small shear resistance, as well as heavy rainfall, water in the soil, and earthquakes.

Specific engineering countermeasures include (a) drain construction for obviating the effect of heavy rainfall; (b) slope protection through vegetation; (c) protection of slopes with structures, including cribs and stone or concrete plastering; (d) removal of unstable soil masses which are quite likely to collapse; and (e) pilings and anchors.



Slope failure that occurred in Kagoshima in July 1986 (Reference No. 3, page 14)



Photograph of the same place after slope failure control works have been completed (Reference No. 3, page 15)

Part II: Sabo Projects in Japan

1. The Unzen Sabo Project

Mt. Unzen, located in the Nagasaki Prefecture in Kyushu Island at the southern tip of Japan, is considered one of the country's most active volcanoes. It consists of three continguous volcanoes: Mt. Fugen-dake (the highest peak), Mt. Kusenbu-dake, and Mt. Kinugasa-yama. A total of more than 30 volcanic activities and earthquakes have been recorded in and around the vicinity of the Mt. Unzen volcanic chain since 1663.

Before its November 1991 eruption, Mt. Unzen experienced heavy lava flows and mudflows. Affected areas were, however, mainly confined to the side of Mt. Fugen-dake. The frequency of heavy lava flows and earthquakes, aggravated by typhoons and heavy rainfall in the vicinity of Mt. Unzen (see box on the recent activities of Mt. Unzen) have caused a number of sediment related disasters in the area.

To mitigate the effects of such disasters, 30 sabo or erosion control dams and 10 channels have been constructed in the rivers flowing radially from Mt. Unzen. Among these are five sabo dams and one channel at the Mizunashi River.

Date	Activities
1663	The main peak, Mount Fugen (1,359 meters above sea level) flowed out Furuyake lava, and volcanic mudflow from an old crater claimed 30 lives in next year.
Feb.10, 1792	Lava flowed from Mount Fugen (the flow of lava occurred from February 27, Shinyake lava). Mt. Mayuyama largely collapsed. Large earthquake on May 21 triggered to destroy about 0.34km2, 1/6 of the mountain body, and pushed it to sea.
Dec.8, 1922	Earthquake frequently occurred. Two strong earthquakes (M=6.9,6.5), cracks, cinders and landslides occurred. 27 were killed, and some 600 houses collapsed.
1929, 1934, 1935, 1940, 1951, 1954, 1955, 1956	Earthquake frequently occurred.
July, 1957	Heavy rain caused debris flow on the northwest slopes of Mt. Mayuyama giving damage including 13 deaths and missing.
Aug.13, 1958	A new eruption occurred at a spa.
1959, 1962, 1966, 1968	Earthquakes frequently occurred.
Aug.2, 1968	Sand and stone erupted at a height of about 10m at Hachiman Jigoku.
1969 to 1982	Earthquakes frequently occurred.

Recent volcanic activities of Mt. Unzen (Reference No. 5, page 1)

Date	Natural Disasters
September 1828	Typhoon (Death toll 71)
October 1893	Typhoon (Death toll 136)
July 1985	Typhoon (Death toll 30)
August 1905	Typhoon (Death toll 304)
October 1906	Typhoon (Death toll 734)
September 1924	Typhoon (Death toll 55)
1928	Large scale of debris flow occurred in Mount Mayuyama.
June to August 1935	Heavy rain (Death toll 5)
July 1936	Typhoon (Death toll 8)
August 1942	Typhoon (Death toll 35)
1950	Landslide at Mount Washio in Nagasaki pref.
July 1962	Landslide caused by heavy rain buried 200 houses.
October 1945	Typhoon (Death toll 17)
September 1948	Typhoon (Death toll 133)
June 1953	Heavy rain (Death toll 21)
September 1956	Typhoon (Death toll 23)
July 1957	Heavy rain (in Isahaya, death toll 539) Debris flow occurred in Mount Mayuyama.
July 1967	Heavy rain (Death toll 50)
July 1971	Heavy rain, Debris flow in Shimabara city.
July 1972	Heavy rain (Death toll 2)
July 1982	Heavy rain (Death toll and Missing 299)

Recent natural disasters in Nagasaki Prefecture (Reference No. 5, page 1)

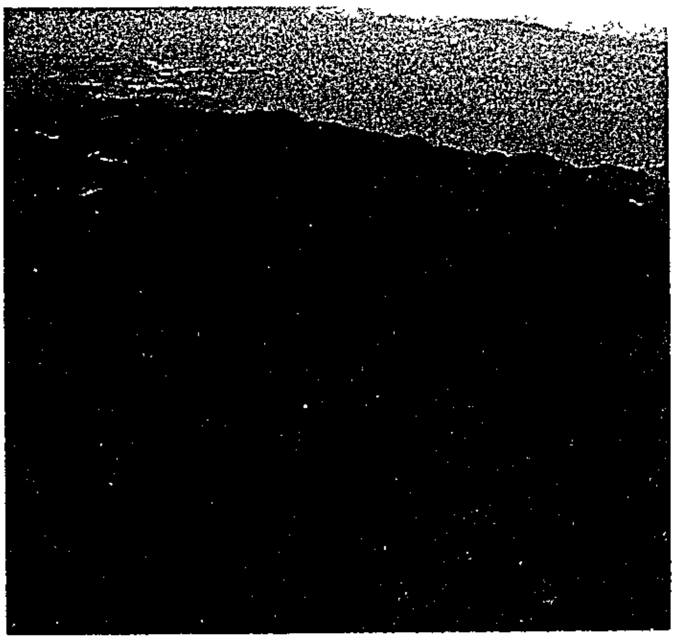
The Unzen Sabo Plan

The extensive damage to life and property caused by the disasters (see box on the recent disasters in the Nagasaki Prefecture) had prompted the Nagasaki Prefectural Government to conduct extensive studies and hold a series of consultations with the local commununities to draw up plans and emergency measures.

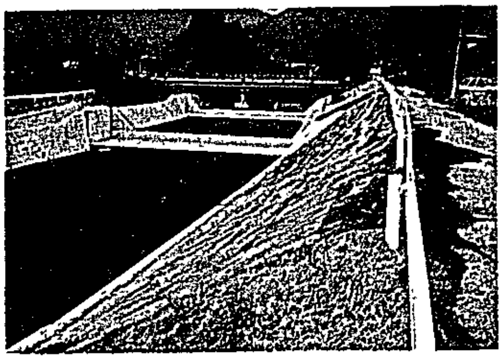
Finally last February 22, 1992, no less than the Governor of the Nagasaki Prefecture, accompanied by the Mayors of Shimabara-City and Fukae-Town, called for a meeting to present and explain the sabo or erosion control project plans for the Mizunashi River system in the vicinity of Mt. Fugen of Unzen. Participants during the meeting were the different representatives of the prefectural, municipal and township conferences and the chairmen of local self-governing bodies and organizations in the affected areas.

The plan includes not only various safety and security measures against disasters, but also long-term plans for the development of the towns and communities in the areas.

The Mt. Fugen of Unzen Sabo Plan and Temporary Measures include the following:



Mt. Fugen-dake of Unzen before its eruption in November 1990 (Reference No. 5, page 1)



River channel at the foot of Mt. Fugen of Unzen (Reference No. 5, page 1)

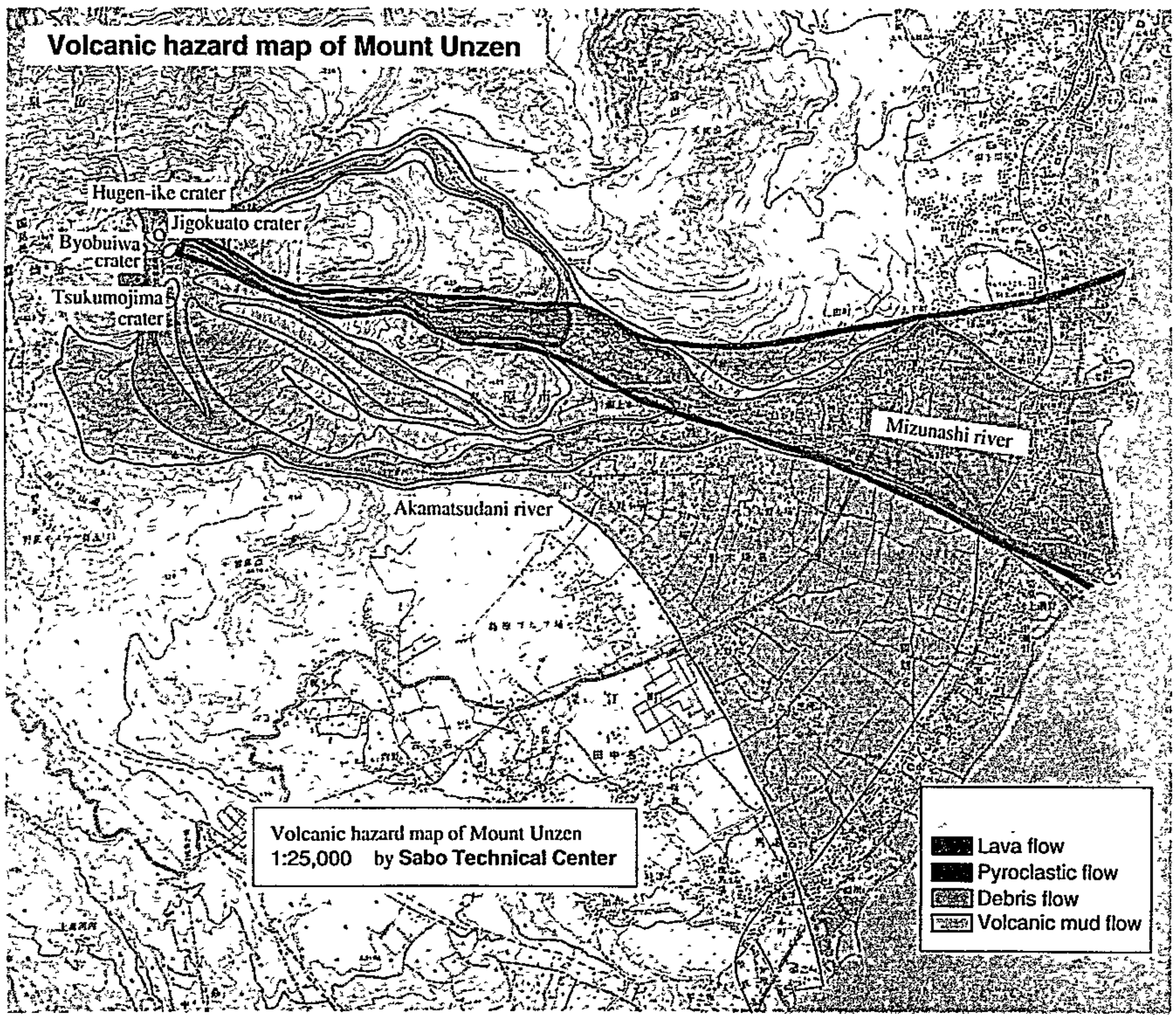
a. **Sabo Dams** - a total of 30 Sabo dams were proposed to be built upstream at the confluence of the Mizu Akamatsudani rivers to contain heavy debris and pyroclastic flows. The dams will be constructed for the long-term safety and security of downstream towns and communities;

b. Drainage Dikes and Diversion Channels -

a total of 10 temporary drainage and diversion channels are to be constructed in strategic middle and downstream areas to mitigate the hazards arising from extensive debris and pyroclastic flows.

c. Temporary Sediment Retarding or Catch Basins -

on decision made by the Joint Budget Committee of the Japanese Lower House and Upper House, on recommendation of the Special Committee for Counter-Measures against Natural Hazards and of the Construction Committee, two temporary sediment retarding basins were immediately constructed between National Road No. 57 and the Shimabara Railroad. Construction was started in March 1992 and was completed in May the same year.



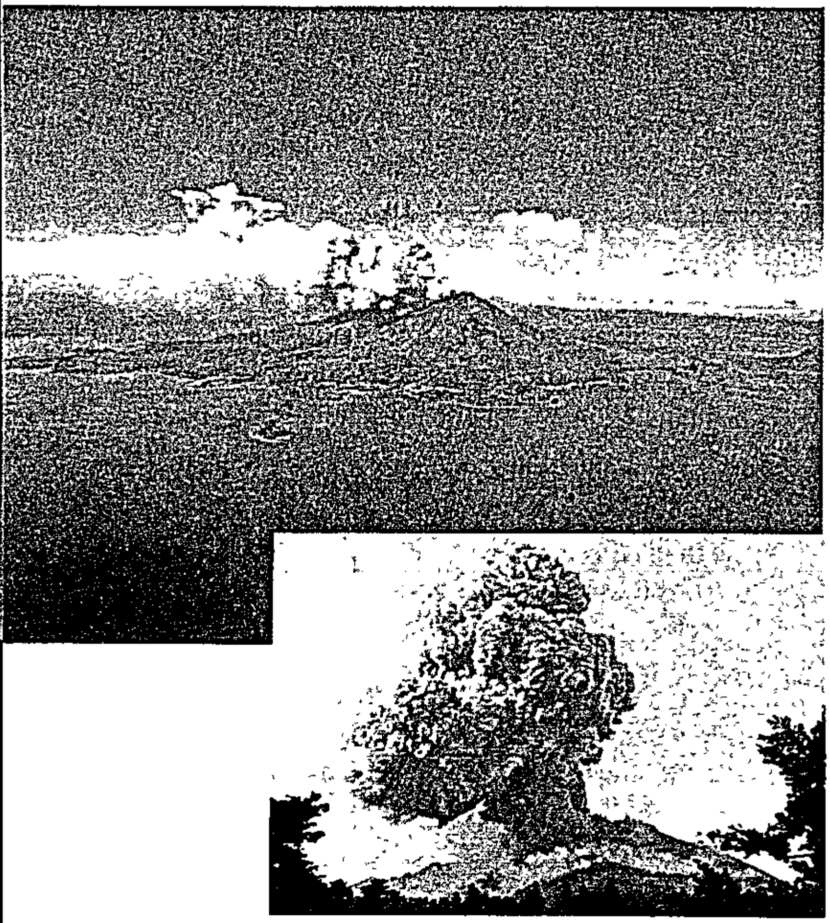
Volcanic Hazard Map of Mt. Unzen
(Reference No. 5, page 26)

2. *The Sakurajima Sabo Project*

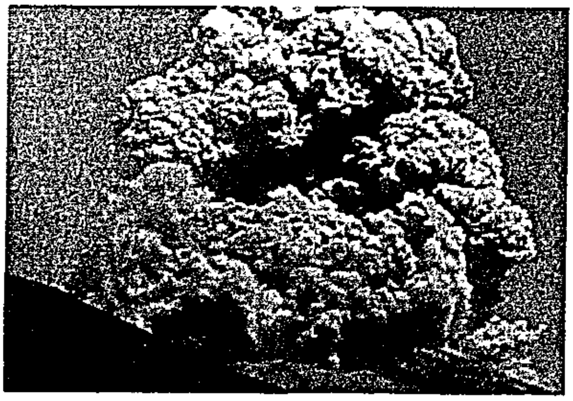
Sakurajima Volcano, considered the symbol of the Kagoshima Prefecture in the southern tip of Japan, is estimated to have been formed about 13,000 years ago. The volcanic activity of Sakurajima has been the most violent among Japan's active volcanoes. Its eruption in 1914 produced large amounts of lava that buried straits of water that virtually connected the island of Sakurajima with Ohsumi peninsula to the north.

Recent volcanic activities of Sakurajima started in October 1955, and since then, Mt. Minamadake in the Sakurajima volcanic chain had continued its volcanic eruptions for more than 30 years. In 1972, Mt. Minamadake had become more active. Thousands of residents in its vicinity have continued to suffer from ashfalls, volcanic ejecta and volcanic gas. Heavy pyroclastic flows continue to cause loss of lives and damage to property and the area's economy.

Because of this, the Ministry of Construction of Japan had started its studies and investigation in 1975, and starting the following year, various disaster countermeasures have been set up in the area.



Sakurajima Volcano became active in 1955, with a total of about 5,400 eruptions recorded in 1987 alone (Reference No. 4, page 5)



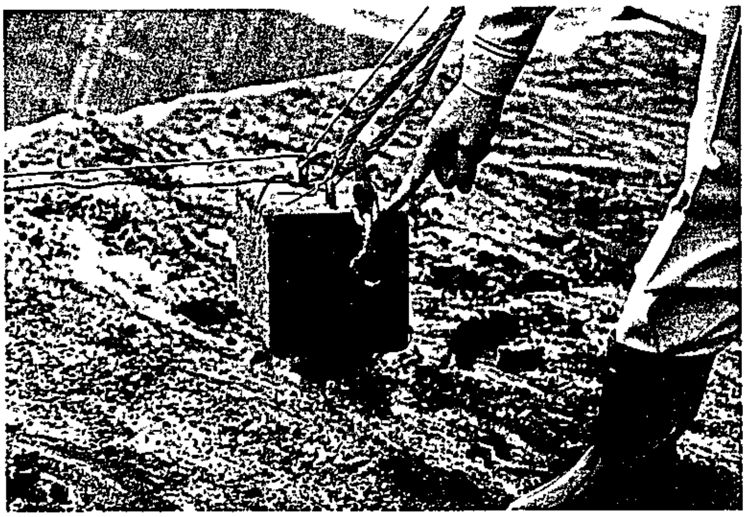
Observation and Data Gathering Facilities

To accurately gather data in Sakurajima, a number of observation and data gathering devices and instruments have been installed in strategic points throughout the island.

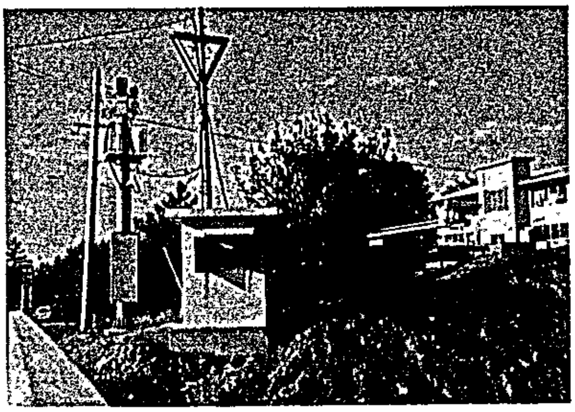
(1) **Rainfall** - Rain gauges have been installed in the Nojiri River, in Mochiki, the Yumoto Sabo Office, Furusato, Arimura, Kurokami, and Shirahama. Rain gauges with a tipping bucket of 0.5mm rainfall are used.

To prevent clogging of the rain gauges as Sakurajima's active volcano continue to eject volcanic ashes, the over-flow type was developed and was set up at the Nojori Number 5 Dam and the Arimura River.

(2) **Debris flow discharge and speed** - To monitor debris flows, video cameras have been installed at the Nojiri River, Harumatsu River, Furusato River, Arimura River, and Kurokami River. In 1987, supersonic floodometers have been set up and the following year, supersonic water current meters have been installed.



Mud sampling box comes in two sizes: 15 cm.x15 cm.x30 cm and 30cm.x30cm.x60cm.
(Reference No. 4, page 39)



Observation cottage and video cameras at Nojiri river
(Reference No. 4, page 38)

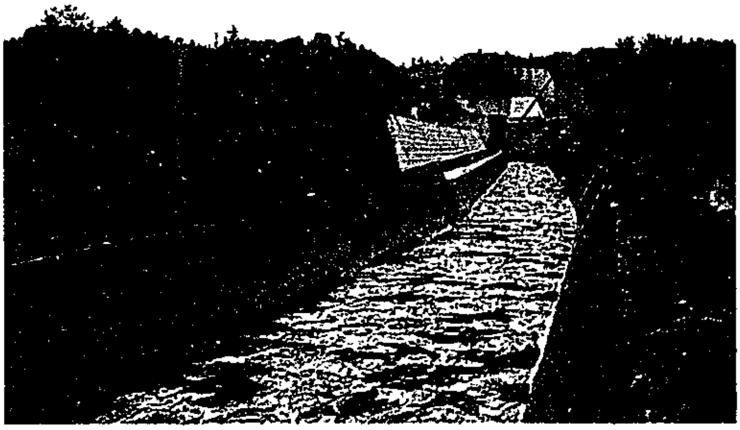
To automatically operate the video cameras during debris flows, automatic fiber sensors have been installed.

(a) **Time of debris flow occurrence** - Recording of the time of the flow is done with the timer-sensor which automatically trips the camera to start filming after the sensor detects an oncoming debris flow.

(b) **Speed of the debris flow** - This is calculated by the elapsed time between the startup time of the video cameras along the river or path of the debris flow. The distance between cameras have already been predetermined and measured.

(c) **Water or flow level** - This is measured through observation with the use of marked poles or stakes placed in strategic areas in the debris flow path within the range of the video cameras.

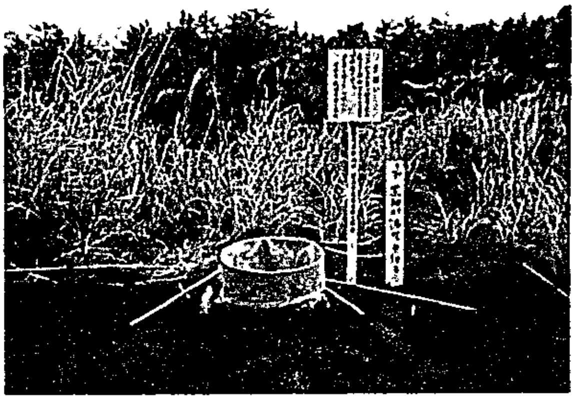
(3) **Mud Sampling** - To collect debris flow material and mud samples, hanging steel boxes are strategically positioned under bridge piers. The lid of the boxes automatically close upon impact by the debris flow, scoping up sufficient volume of mud or debris material for analysis and study.



Supersonic velocity meter and water gauge at the Nojiri river to measure the water level, current speed, and flow velocity (Reference No. 4, page 39)

(4) **Impulsive Force** - Debris flows carry rocks, stone, sand and mud which when flowing downstream could gather momentum and produce high potential energy and destructive force. The strength of the impulsive force created is measured with the use of an aluminimum impulsive force gauge attached to river walls or hanging from bridge piers. The impact of onrushing debris flows produce a dent on the hanging aluminum gauge which could be used for determining their actual strength or impulsive force. At the Nojori River, a maximum impulsive force of 250 tons per sq. meter was recorded in 1981.

(5) **Attrition of Channel Works** - Gravel and sand that go with debris flows greatly damage Sabo dams and river channel walls through constant pounding and scraping. Hence, the rate of attrition or deterioration of river walls and dams is periodically monitored. The one-meter thick concrete front apron of the Nojori River Dam No. 4 was completely carved away after 46 debris flows during a two-year period. This means that each debris flow carved out an average of 2.2 cm of the concrete apron.



Oil barrel with plastic bag to measure the amount of ashfall (Reference No. 4, page 38)

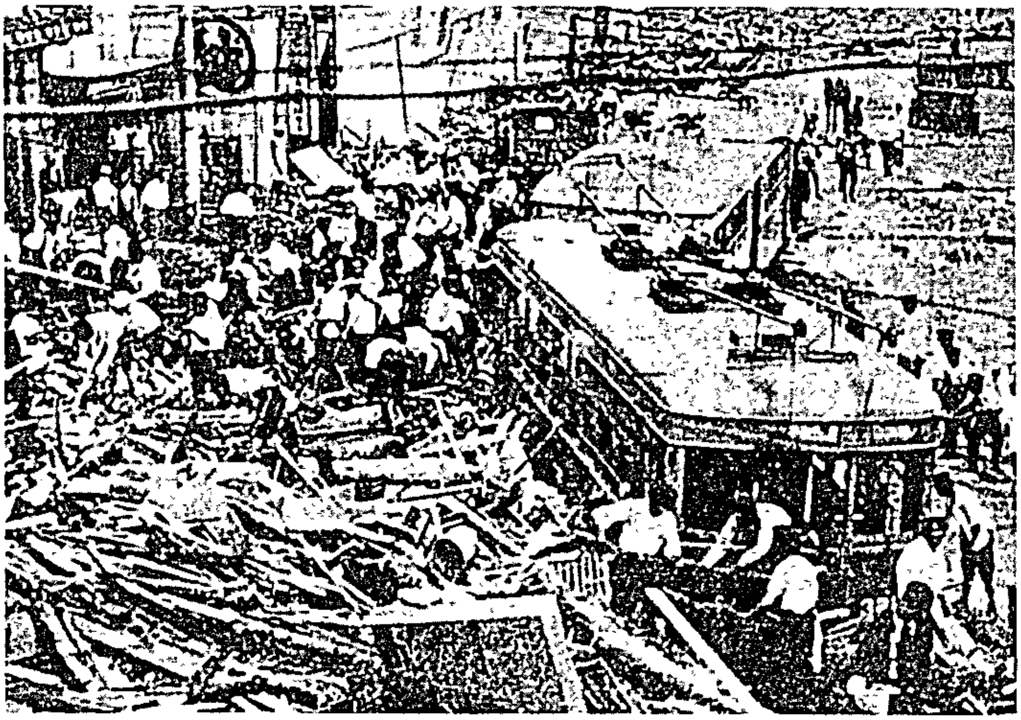
(6) **Ashfall** - Ashfall is measured by collecting falling ash with the use of plastic bags placed inside oil barrels in strategic places around the island. Collected ashes are measured twice a month. Based on the amount of ashfall collected and measured, contour maps are prepared indicating the levels and extent of ashfall in each area at particular times of the year.

3. *Sabo Projects in the Rokko Mountains*

Since 1925, a total of 14 sediment-related disasters due to steep-slope failure precipitated by localized torrential rains had occurred in the Kobe area in the south side of the Rokko mountains. The massive debris flow that occurred in 1938 destroyed a total of about 151,000 homes while some 700 persons were reported to have perished.

To mitigate this situation, a total of 174 sediment control dams, 5 groundsels, and 12 channel works have since been constructed in and around the Rokko mountain area by 1967. Hence, during the disaster that occurred in July that year precipitated by torrential rains with about the same volume as that in 1938, there were less casualties and number of homes lost owing to the presence of the Sabo dams and other disaster control measures already in place.

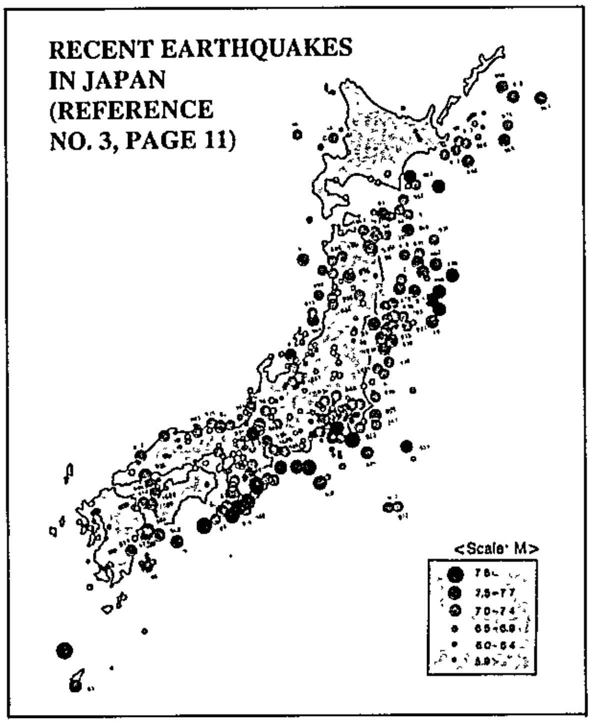
Mainly due to the rapid urbanization and population growth, there was strong pressure for the preservation or rehabilitation of available land for residential and production purposes. Hence, the construction of sediment-control works continued. By 1982, a total of 308 sediment control dams have already been completed in the area.

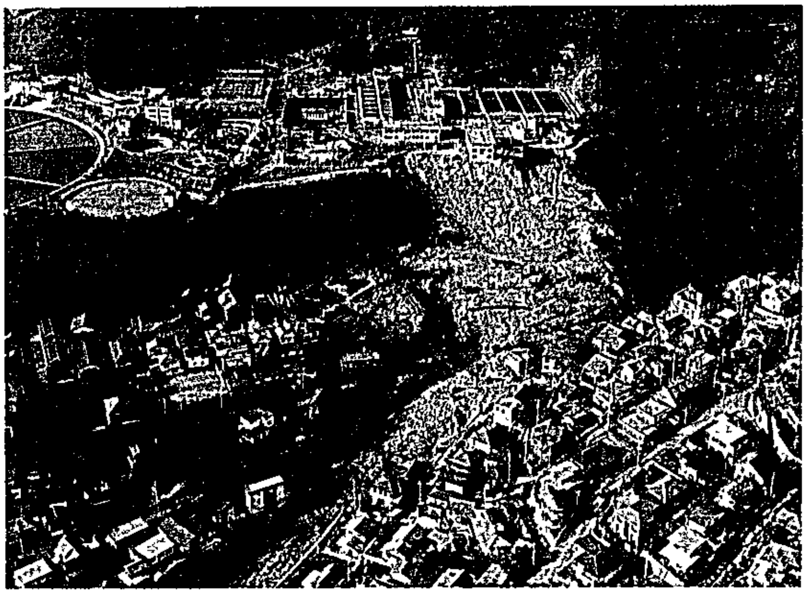


Major disaster at Mt. Rokko and environs in 1938
(Reference No. 3, page 10)

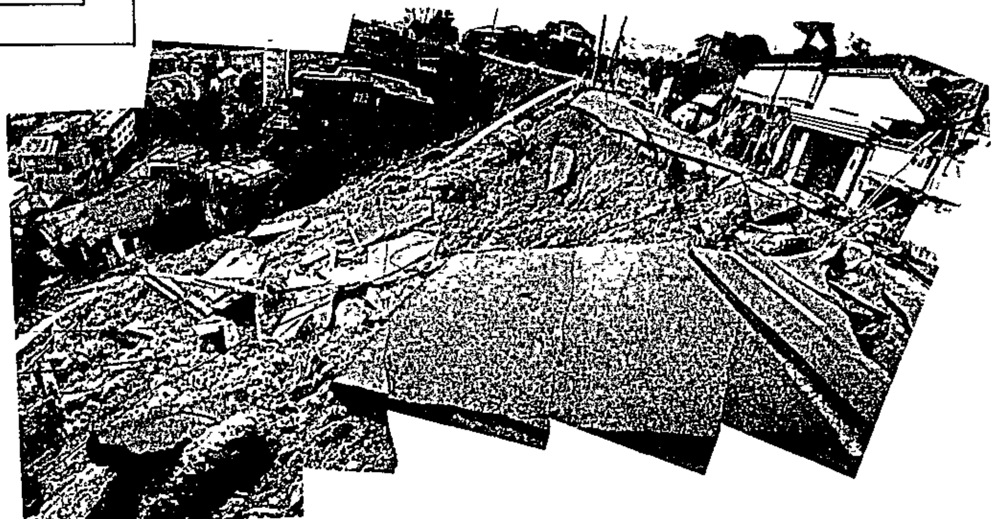
The Great Hanshin Earthquake of 1995

The catastrophe that struck Hanshin Area on January 17 this year was the worst since Tokyo's Great Earthquake in 1923. Although milder -- measured at 7.2 on the Richter Scale, compared to the 7.9 recorded in the Tokyo disaster -- it was nevertheless the worst to hit Japan in several decades. The disaster destroyed more than 6,000 buildings, left 100,000 homeless, and more than 5,400 were reported dead or missing. Kobe's elevated Hanshin Expressway toppled from its moorings, wharves caved in, while parking lots were covered with mud -- indicating that underground liquefaction had occurred.





Landslide in Nikawa Yurinodai in Nishinomiya City caused by the Great Hanshin Earthquake



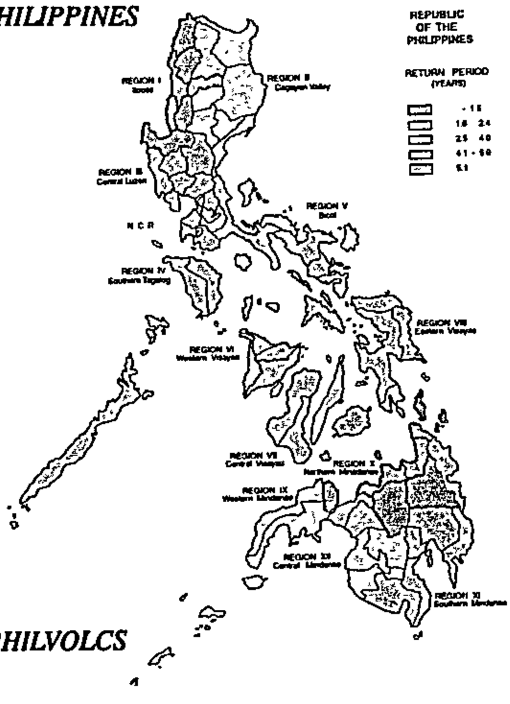
Extent of damage in the upper portion of landslide in Nishiokamoto 6 chome in Higashinada-ku,Kobe City, caused by the Great Hanshin Earthquake

Part III: Mitigating Volcanic Debris and Other Related Disasters in the Philippines

1. Geological and Climatic Conditions

Like Japan, the Philippines is beset by natural disasters like earthquakes, volcanic eruptions and severe flooding caused by typhoons and heavy torrential rains. The country is an archipelago in Southeast Asia bounded by the Pacific Ocean in the east, the South China Sea in the West, the Bashi Channel in the North, and the Sulu and Celebes Seas in the South. It consists of some 7,000 islands, the largest of which are Luzon to the north, followed by Mindanao to the south, and a number of islands in between comprising the Visayas.

FREQUENCY OF EARTHQUAKES IN THE PHILIPPINES



Source: PHILVOLCS

Geological studies show that the islands of the Philippines are on top of a partly submerged geological chain believed to have been part of the Asian continent. They lie on the sub-duction zone (an area where moving continental plates come in contact with each other) for the Asian and Pacific plates. This makes the Philippines prone to earthquakes and volcanic activity.

The country's mountains and volcanoes are scattered across the archipelago, the most prominent of which are Mt. Apo in Mindanao which rises to 9,692 feet above sea level, and Mt. Pulog in Luzon, at 9,606 feet.

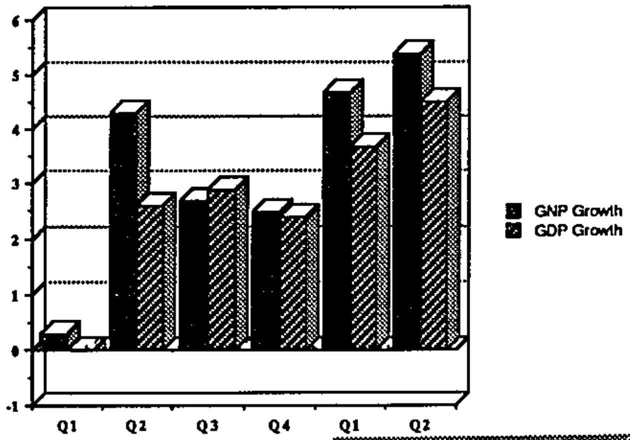
The mountains are part of a girdle of active volcanoes around the Pacific Ocean. Hence, volcanic eruptions and earthquakes in the Philippines occur occasionally, causing great damage to life and property. In recent years, the most active are Mt. Pinatubo in West Central Luzon with its violent explosive eruptions in 1991 and Mayon Volcano in the southeastern end of Luzon.

In addition, every year, the country is visited by typhoons and heavy rains due to its proximity to sea and storm tracks emanating from the Pacific Ocean and its exposure to the moonsoons. Its eastern parts experience heavy rains all year, while taking the brunt of typhoons emanating from the Pacific Ocean.

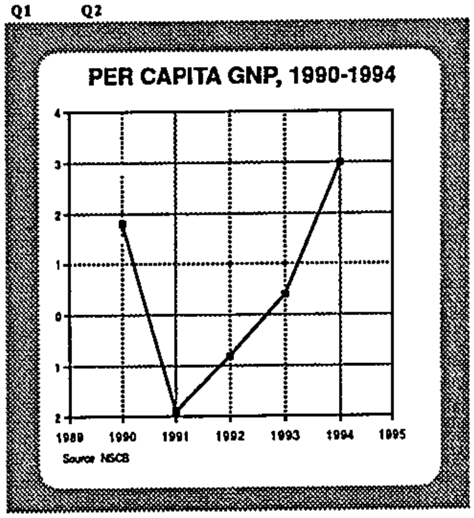
2. *Philippine socio-economic conditions*

The Philippine economy is basically agricultural, producing mainly sugarcane, coconut oil, palay and corn. Although, its manufacturing and services sectors have continued to grow, albeit moderately, economic planners expect them to outpace agriculture in terms of growth rate and contribution to real Gross Domestic Product (GDP) over the next 4-5 years.

QUARTERLY GNP AND GDP GROWTHS 1993-1994



Source: NEDA



Source: NEDA

Driven mainly by the country's development vision of a modernizing and industrializing economy which President Fidel V. Ramos has called Philippines 2000, the economy is expected to grow at a faster rate of at least 10 percent in Gross National Product (GNP) by 1998. This vision, which is contained in the Medium-Term Philippine Development Plan (MTPDP), 1993-1998, will be pursued through the twin strategies of people empowerment and global competitiveness. This means providing the country's rich human resources greater access to the country's basic services and productive resources and enabling them to produce products and provide services that can compete with the best in the world market.

President Ramos himself said when he launched Philippines 2000 early in his administration, "To achieve our vision of sufficiency, modernization and global excellence, we have prepared the path to its realization. The MTPDP will be our development roadway for the next six years towards achieving NIC-hood or a Newly Industrializing Country status by the year 2000. Hence, our battlecry shall be Philippines 2000!!!"

Hence under the MTPDP, the majority of the Filipino people is expected to already enjoy by the turn of the century a relatively improved quality of life living in a country which is politcally, economically and socially stable. At the same time, poverty incidence is expected to decline to 30 percent by 1998 from the 40 percent recorded in 1990, GNP will grow at an average of 6.8 percent annually, per capita GNP to increase from $730 in 1990 to a minimum of $1,000 by 1998.

3. *The DPWH Medium-Term Infrastructure Program, 1993-1998*

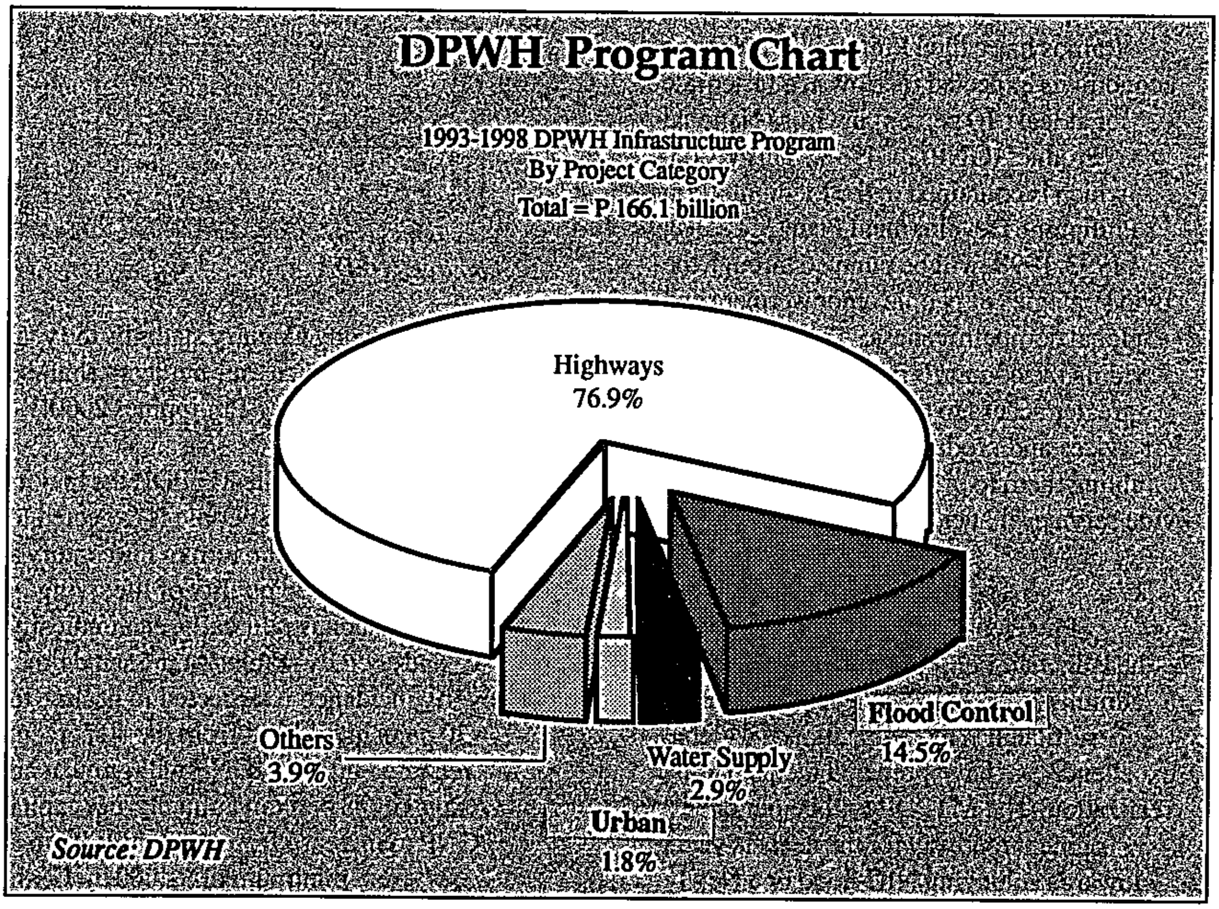
A major component of the MTPDP is the Infrastructure Development Program of the Department of Public Works and Highways (DPWH). The Program has the following development objectives:

3.1 Rehabilitation/improvement/construction of the national road network, with emphasis on the arterial road system, to provide for more efficient flow of people and goods among regions and between principal production and consumption areas;

3.2 Provision of flood control works in the major river basins, to mitigate losses from flooding thereby inducing greater production;

3.3 To a lesser extent, the provision of potable rural water supply (Level I or wells) for improved health and production, but limited to on-going foreign-assisted projects, considering that rural water supply has been devolved to the Local Government Units (LGUs); and

3.4 To a similar limited extent, the provision of small urban community infrastructure under on-going foreign assisted projects to help improve the economic base of the country's urban centers.



3.1 DPWH Organization and Responsibilities

3.1.1 General Responsibilities

1. **Highways** - Integrated planning of the Philippine highway system; funding, design, construction, and maintenance of national roads. [Provincial, city, municipal, and barangay roads are with Local Government Units (LGUs)]

2. **Ports** - Planning, funding, design, and construction of foreign-assisted fishing ports and municipal (feeder) multi-purpose ports (Other ports are with the DOTC and LGUs)

3. **Flood Control** - Planning, funding, construction, and maintenance of major flood control and drainage facilities

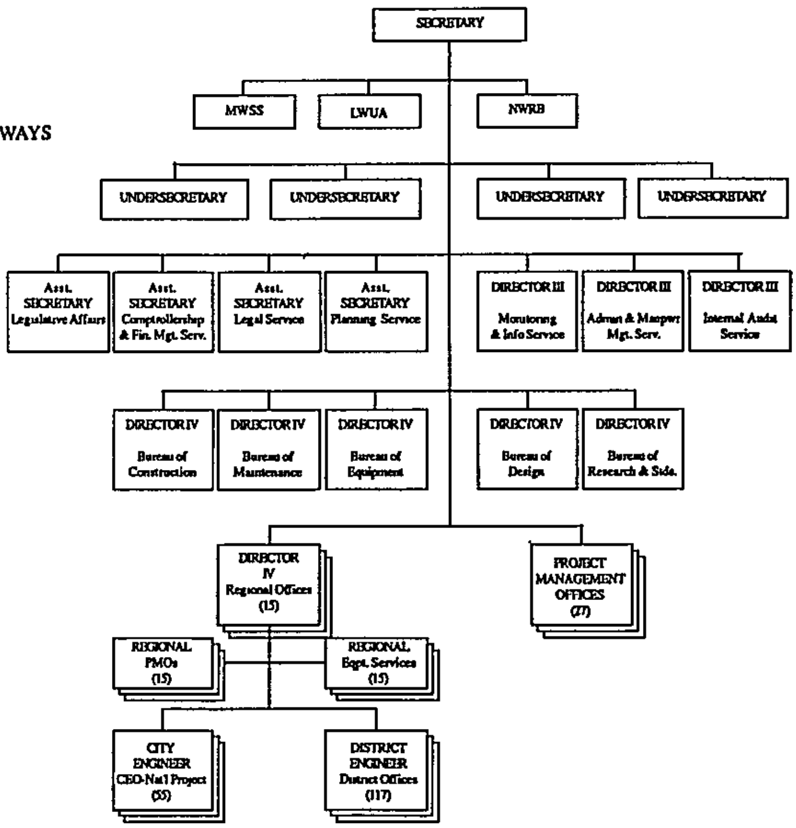
4. **Water Supply** - Funding, design, and construction of Level I facilities (Point Sources) with foreign financing (Locally funded Level I is with LGUs)

5. **National Buildings** - Design, construction, and maintenance of buildings of National Government agencies (Funded mainly by concerned agencies)

6. **Urban Community Infrastructure** - Planning, funding, construction and maintenance of basic national infrastructure in depressed areas of urban centers with foreign assistance (Locally funded community infrastructure is with LGUs)

7. **Other Public Works** - Design and construction of schoolbuildings and other nationally-funded public works (funded by end-user agencies).

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
ORGANIZATION CHART



3.1.2 Special Program Concerns

The DPWH has a number of special concerns one of which is flood mitigation, especially in low lying areas and the harnessing of excess water in major river basins for productive programs.

3.1.3 Flagship Programs

For the period 1994-1998, the DPWH has identified a number of flagship infrasructure programs. This include the Pampanga Delta Development Project which covers a total area of 20,000 hectares. It consists of civil works, land acquisition compensation and engineering administration. Civil works cover land preparation, excavation by dredging, diking, revetment works, provision of drainage/intake services, bridge construction and improvements, as well as miscellaneous works.

The project is estimated to cost P2,870 million to be implemented until 1998.

3.2 Japanese Official Development Assistance to DPWH Infrastructure Projects

Official Development Assistance (ODA) from Japan — through the Overseas Economic Cooperation Fund (OECF) and the Japan International Cooperation Agency (JICA) — under the 1987-1992 DPWH Infrastructure Program amounted to P19.3 billion. This constituted 44 percent of the total funds for all DPWH foreign-assisted projects (FAPs) and 27 percent of the overall DPWH Infrastructure Program, including locally funded projects.

Under the present 1993-1998 Infrastructure Program, it is envisioned that investments for Japanese-assisted projects, both on-going and pipeline, will increase to P57 billion. This will constitute 43 percent of the total DPWH FAPs projects, and 34 percent of the overall DPWH Infrastructure Program until 1998.