Wind and Seismic Effects

Proceedings of the 30th Joint Meeting

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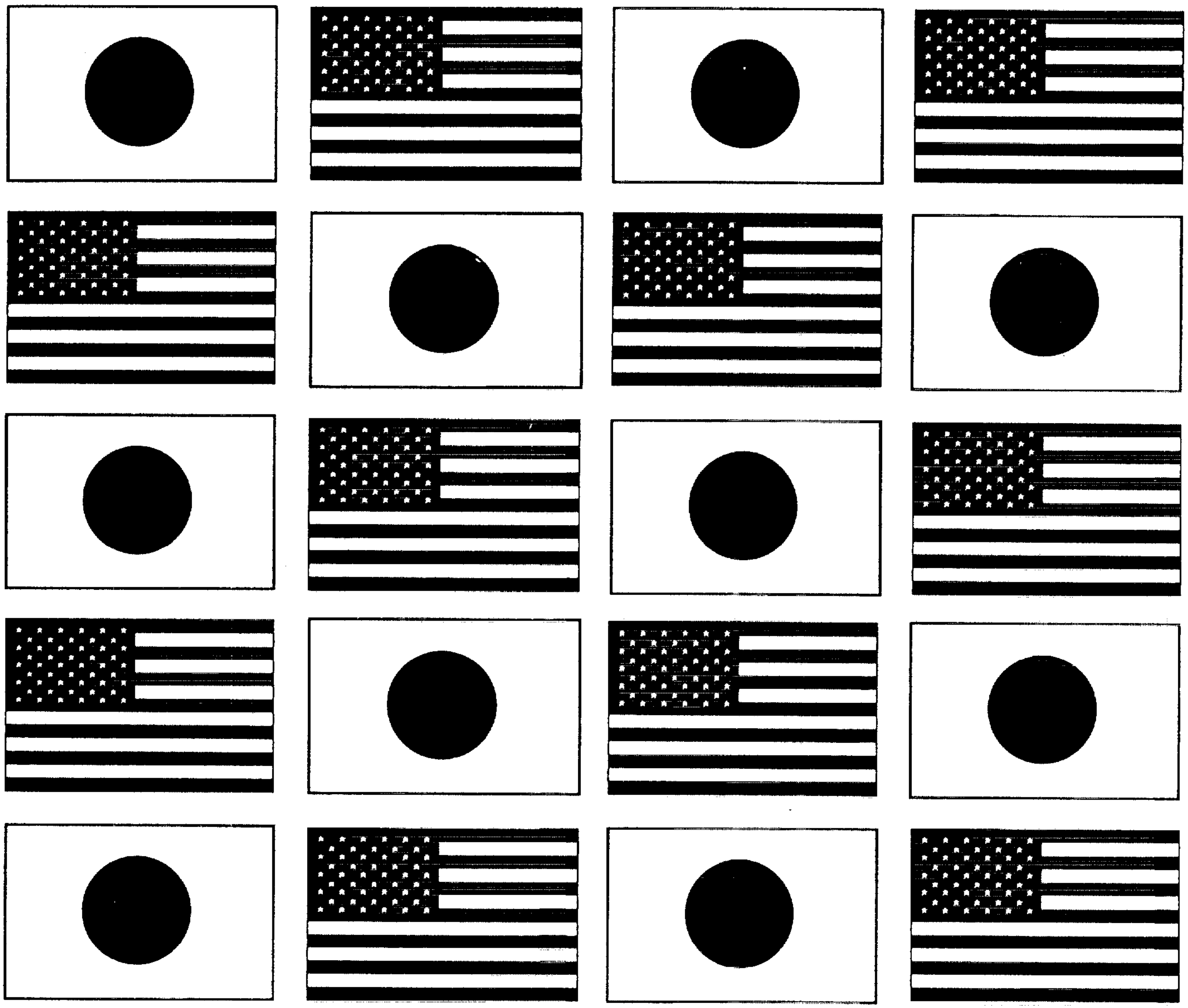

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Wind and Seismic Effects

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PROCEEDINGS OF THE 30TH JOINT MEETING OF THE U.S.-JAPAN COOPERATIVE PROGRAM IN NATURAL RESOURCES PANEL ON WIND AND SEISMIC EFFECTS

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Natural Disasters and Protective Measures in Japan

by

Yasutake Inoue*

ABSTRACT

As a country that suffers frequent natural disasters, Japan applies lessons learned from these experiences to the tasks of providing disaster protection facilities and improving the disaster resistance of infrastructures, but the Hanshin - Awaji Earthquake Disaster (January 1995) taught that because it is difficult to prevent all disasters from occurring, it is essential to accept that disasters will occur and to provide crisis management type disaster protection measures that minimize the damage that they cause. This report describes measures and technological research undertaken in order to supplement existing hardware measures involving the construction of disaster protection facilities with new software measures: those intended to provide crisis management capabilities.

Key words: Natural Disaster, Crisis Management, Disaster Protection Measure, Minimization of Damage, Seismic Safety Level, Seismic Information System.

1. INTRODUCTION

Hardly a year passes without a disaster occurring somewhere in Japan as a consequence of harsh natural conditions that make it one of the world's most disaster prone nations along with the high concentration of land use in a few small regions of the country. This report introduces examples of some recent disasters. It also discusses issues that construction administrators must address in response to the Hanshin - Awaji Earthquake Disaster (January 1995), and topics that will be the object of future technological research as an example of earthquake resistance measures.

2. NATURAL CONDITIONS, NATIONAL LAND USE PATTERNS AND NATURAL DISASTERS IN JAPAN

(1) Natural Conditions and National Land Use Patterns in Japan

Japan is a nation with many hills and mountains and generally precipitous topography, is drained by rivers that are shorter and steeper than those in other nations, and has an extremely long coastline in relation to its total land area. And geographically, it is part of the circum-pan Pacific volcanic and earthquake zones and one of the most volcanic and earthquake activity prone nations in the world. Its geology features large faults and fracture zones and many places with weak geological structures. Climatic features of Japan include its position in the path of numerous typhoons and heavy winter snow accumulation in large areas of the country.

In addition to the harsh topographical, geographical, geological, and meteorological natural conditions found in Japan, about 50% of its population and 75% of its total productive activities are concentrated in inundation zones (regions lower than the river water level during the flood period) on alluvial planes covering no more than about 10% of the total national land. On top of this, advancing urbanization has been accompanied by the growing residential use of regions consisting of low swampy land, alluvial fans, precipitous slopes, and other ground with a high latent risk of natural disasters.

In addition to these natural conditions and this pattern of national land use, hardly a year passes without a natural disaster occurring somewhere in Japan as a result of typhoons,

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extremely heavy rainfall, earthquakes, or volcanic eruptions.

(2) Natural Disasters

Figure 1 shows the numbers of fatalities and missing persons caused by natural disasters in recent years organized by the cause of the disasters. It reveals that frequent storm and flood damage caused by typhoons and heavy rainfalls are the cause of fatalities etc. almost every year, and that many people died or disappeared as a result of the Hokkaido Nansei-oki Earthquake (1993) and the Hanshin - Awaji Earthquake Disaster (Hyogo-ken Nanbu Earthquake: 1995).

Table 1 presents representative examples of each of the wide variety of disasters that occur in Japan.

3. LESSONS TAUGHT BY THE HANSHIN - AWAJI EARTHQUAKE DISASTER

To prepare for natural disasters that occur almost every year, we have systematically and continually carried out river improvement, dam construction, coastline preservation, landslide disaster prevention, road disaster prevention, and urban disaster protection projects in an effort to make Japan a safer place to live. To take changes to bridge technology standards as an example of earthquake resistance measures, as shown in Table 2, the Kanto Earthquake was followed by the introduction of design accounting for earthquakes so that it would be possible to design bridges able to withstand a similar earthquake. These standards were reassessed again following the later Niigata Earthquake and Miyagi-ken-oki Earthquake. In this way, we have continually taken advantage of our experiences with natural disasters to provide the capacity required to protect bridges from their effects.

But the Hanshin - Awaji Earthquake Disaster that struck the Kinki Region of Japan, a part of the country spared serious earthquakes for many decades and one believed to be relatively safe, resulted in damage on a scale that exceeded our expectations. By starting fires in districts with highly concentrated wooden housing and by cutting off lines supplying essential services, it dealt a severe blow to the lives of the residents of the disaster region. It also cut traffic networks, with severe repercussions on productive activities both within and outside of Japan.

These events have taught us not only that present science can not necessarily be used to predict the exact time and location of a powerful earthquake, particularly a shallow intraplate earthquake under the land, but that the power of an earthquake can exceed any experienced in the past and that changes both in urban environments and in transportation and other features of the socioeconomic environments both within and outside of Japan mean there is a risk that a powerful earthquake can inflict terrible harm on human society.

4. ISSUES IN FUTURE CONSTRUCTION ADMINISTRATION

With the "creation of national land where people can be safe and secure" as one of the principal themes of construction administration in Japan, we have continually striven to reduce nature's ferocity by, for example, improving flood control and erosion prevention measures along with urban disaster protection measures, and strengthening the earthquake resistance of public works structures, homes, and buildings. But the Hanshin - Awaji Earthquake Disaster has taught us that in addition to improving disaster prevention facilities intended to keep such disasters from occurring, it is also important that we accept that it is impossible to prevent all disasters, and assuming that they will eventually occur, prepare for them by providing measures to minimize the damage they inflict. So as described below, it is essential that hardware measures be accompanied by efforts to create crisis management type disaster protection measures: software measures such as the provision of systems to provide information concerning disasters and strengthened coordination between concerned administrative bodies.

(1) Establishment of Regionally Managed Crisis Management Systems

To minimize the damage that disasters cause, the provision of disaster prevention facilities will be accompanied by risk management measures implemented at normal times in preparation for disasters: the clarification of the distribution of roles between concerned organizations, private companies, and residents (regional government bodies, fire fighting and flood response teams), and the complete distribution of hazard maps (Figure 2) etc. In addition, crisis management measures including the distribution of disaster information and the implementation by volunteers and others of various support activities will be carried out to reduce the damage after a disaster occurs.

(2) Switch-over to Facility Improvement for Damage Reduction

Taking levees as an example of this change in the basic concept guiding disaster protection facility provision, rather than being considered to be structures that must prevent flooding from ever occurring, it will be assumed that disasters are inevitable and levees will be treated as structures intended to minimize damage by, for example, emphasizing the prevention of extremely severe damage when a levee does break.

And past hardware measures to prevent landslides and debris flows that cause frequent fatal disasters, will be supplemented by software measures: providing belts of trees as buffer zones, strengthening regulations governing risk areas, and so on (Figure 3).

(3) Provision of Comprehensive Disaster Protection Measures for Urban Areas

With a large proportion of Japanese population and assets and most of its economic and social activities concentrated in its cities, in order to prevent the paralysis of the economic and public functions of the country, and to improve safety during large scale disasters, comprehensive large scale damage prevention measures will be undertaken by both the hardware and software sides: reinforcing the disaster resistance of housing and infrastructures and improving over-concentrated urban districts.

And to permit the rapid and smooth restoration of the daily lives of the people along with economic and public life following a disaster, emergency roadways to replace wide area arterial roads, wide area disaster protection bases, emergency transport routes, etc. will be provided at the same time as multiutility tunnels are constructed to improve the disaster resistance of lifelines used to supply city dwellers with essential services (Figure 4).

5. TOPICS FOR FUTURE TECHNOLOGICAL RESEARCH

To minimize the damage caused by natural disasters, research on a number of technologies must be undertaken. This section of this report describes a number of technological research areas related to protection from earthquake disaster. The concepts on which this selection is based also apply to other types of disasters.

(1) Improving the Earthquake Resistance of Structures

The most basic category of technological research that is required is the search for ways to improve the earthquake resistance of civil infrastructures. Large scale centrifuge and large scale three-dimensional shaking table (Photograph 1) that have been recently installed will be used to conduct research into seismic design and retrofit technology.

(2) Earthquake Disaster Loss Estimation Methodology

In order to more efficiently conduct projects to increase the earthquake resistance of civil infrastructures, research will be conducted to find ways to quantitatively assess the loss caused by credible earthquakes and the effects of earthquake resistance improvement projects. These will enable to set the seismic safety level rationally, and to prioritize economical projects based on the cost - benefits analysis (Figure 5).

(3) Coordination of Seismic Safety Levels of Urban Infrastructures

Research to achieve coordination of seismic safety levels for the various kinds of infrastructures that constitute an urban area will be carried out. The results will, by reflecting the role of infrastructures in each region and the effects of earthquake resistance improvement projects, enable to improve the seismic safety of overall cities (Photograph 2).

(4) Seismic Information Systems

In addition to providing structures with appropriate earthquake resistance, it is necessary to develop technology needed to implement efficient crisis management. Research to develop seismic information systems including early damage estimation technology, damage monitoring technology, and data communication technology will allow facility managers to take effective emergency action such as the temporary repair works on arterial roads immediately after the disaster (Figure 6).

6. SUMMARY

At the same time as the needs for infrastructures are diversifying, finding ways to skillfully utilize the nation's resources including its limited budget, housing stock, and infrastructures stock, has become a serious problem in the face of severe financial conditions, the aging of the population, the falling birth rate, the growing value attached to the natural environment and to the global environment, and other problems. In the future, the provision of hardware, new protective structures and the like, is sure to take longer than it does now, and it will be essential to adopt comprehensive measures that emphasize the software approach. This is a switch from "national land construction" to "national land management (improvement, use, preservation)." It will also be necessary to introduce more and better software measures to deal with the threat of natural disasters.

REFERENCES

1) Ministry of Construction : Construction White Paper , 1995
2) National Land Agency : Disaster Prevention White Paper , 1993,1994,1997

Table 1. Representative Disasters

Disaster Category	Location	Time	Description
Volcanic Disaster	Unzen Fugendake Mountsain in Nagasaki Prefecture	June 3, 1991	The eruption and increasing level of activity of Fugendake resulted in the repeated formation of lava domes that grew and collapsed, causing a series of pyroclastic flows followed by the formation of another lava dome and so on. A pyroclastic flow that occurred on June 3 killed 40 people and 3 more people went missing and have never been found.
Windblown tree disaster	In 30 prefectures, but mainly in those in Kyushu	September, 1991	Storm generated by typhoons 17, 18, and 19 knocked down and damaged trees. The damage to privately owned woodlots covered 60,000 hectares.
Earthquake disaster (Hanshin - Awaji Earthquake Disaster)	Centered in the Hanshin Region	January 17, 1995	A magnitude 7.2 earthquake (Hyogo-ken Nanbu Earthquake) occurred with its hypocenter 14 kilometers below the northern part of Awaji Island. A total of 6,425 people were killed, 2 went missing, and 43,772 people were injured. A total of 110,457 homes were totally destroyed and 147,433 more were partially damaged. Transportation routes, harbor facilities, and other infrastructure items were damaged along with lines carrying essential services such as water, communication lines, electricity, etc.
Rock Failure	The Toyohama Tunnel at Furubira in Hokkaido	March 20, 1996	A massive rock (about 11,000 m^3) collapsed on top of the portal of the Toyohama Tunnel. One bus and two passenger cars were destroyed. A total of 20 people were killed and 1 injured.
Debris Flow Disaster	The Harihara River at Izumi City in Kagoshima Prefecture	July 10, 1997	A stationary early summer rain front caused the a debris flow (about 200,000 m^3). A total of 21 people died, 13 were injured, and 16 buildings were damaged.

Note. These are representative examples of recent disasters of various kinds. Many other disasters have actually occurred, but they are not listed on this table.

Table 2. Reflection of Earthquake Disasters in Technical Standards for Bridges

Earthquake	Principal Damage	Reflection in Technical Standards for Bridges and Elevated Highways
1923 Kanto Earthquake Disaster (M 7.9)	Fatalities: 99,331 Injuries: 103,733 Buildings destroyed: 128,266	Details of Road Structure (draft) "Stipulated that design should account for earthquake" (1926)
"Based on surveys and research concerning design earthquake force"		Design Specifications of Steel Highway Bridges "Specifically stipulated design seismic coefficients" (1939)
1964 Niigata Earthquake (M 7.5)	Fatalities: 26 Injuries: 447 Buildings destroyed: 1,960	Specifications for Seismic Design of Highway Bridges "Stipulated the installation of falling-off prevention systems" "Stipulated the assessment of soil liquefaction" (1971)
1978 Miyagi-ken-oki Earthquake (M 7.4)	Fatalities: 28 Injuries: 11,208 Buildings destroyed: 1,383	"Part V: Seismic Design" in "Design Specifications of Highway Bridges" "Stipulated the design of the terminal point of longitudinal reinforcement (elongation of the anchor length of steel reinforcing rods) "Expansion of the quantity of hoop tie reinforcement (minimum hoop tie steel diameter from 6 mm to 13 mm)" (1980)
"Based on surveys and research concerning the dynamic bearing strength and deformation performance of reinforced concrete bridge piers"		"Part V: Seismic Design" in "Design Specifications of Highway Bridges" "Stipulated an examination of the ultimate horizontal strength during an earthquake for reinforced concrete bridge piers" (1990)
1995 Hanshin - Awaji Earthquake Disaster (Hyogo-ken Nanbu Earthquake: M 7.2)	Fatalities: 6,425 Missing: 2 Injuries: 43,772 Buildings destroyed: 110,457	"Part V: Seismic Design" in "Design Specifications of Highway Bridges" "Stipulated design earthquake force accounting for earthquake motion caused by the Hyogo-ken Nanbu Earthquake" "Stipulated seismic design based on the ultimate horizontal strength during an earthquake method for structural members strongly effected by earthquakes" (1996)

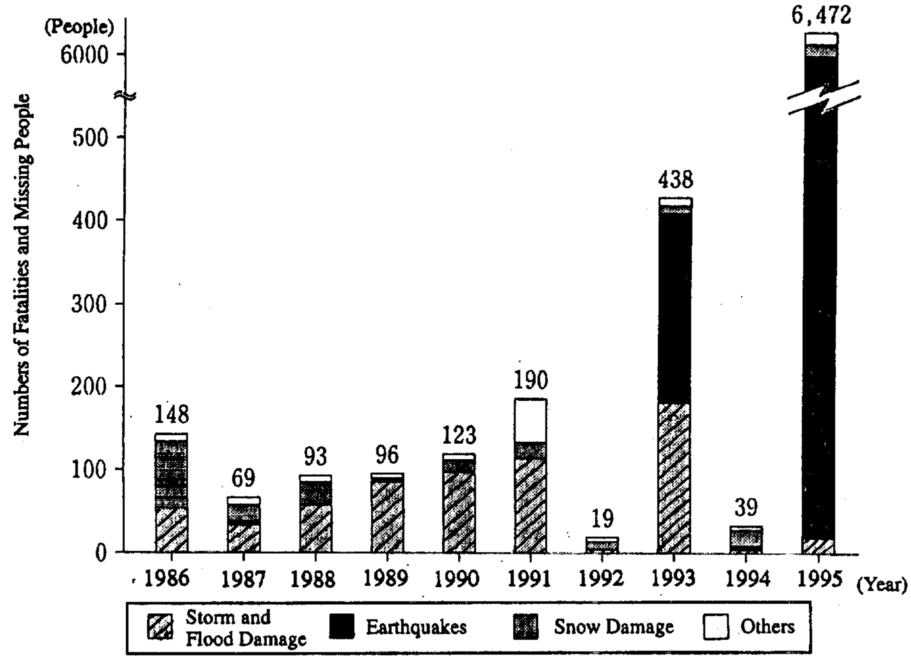


Figure 1. Fatalities and Missing People by Cause of Disaster

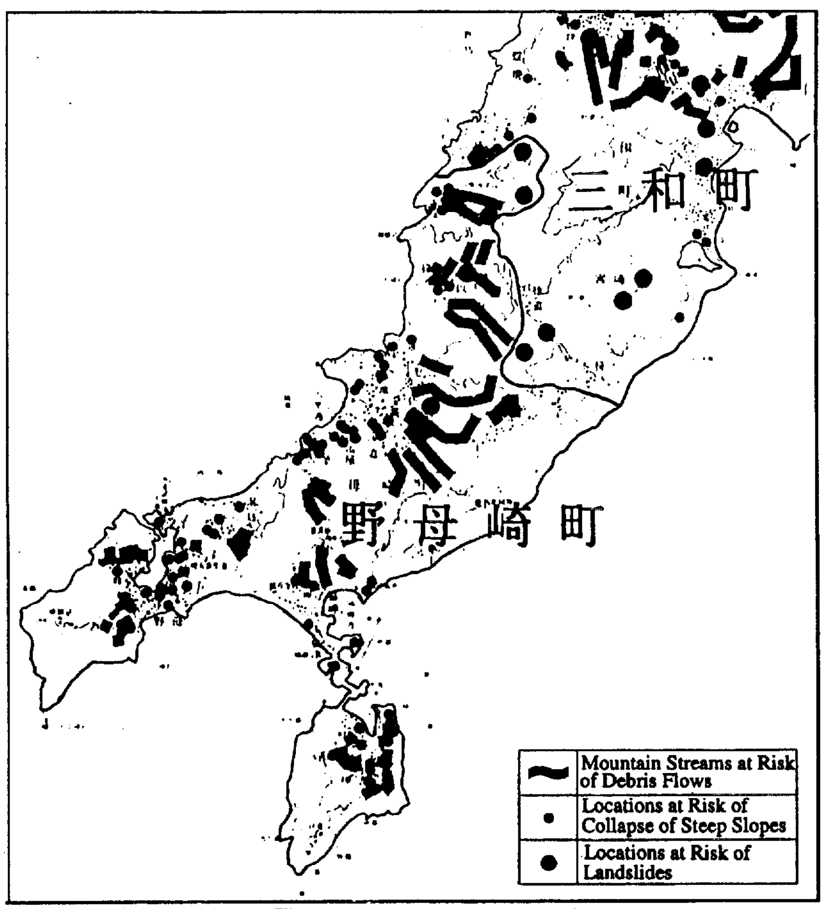


Figure 2. Hazard Map

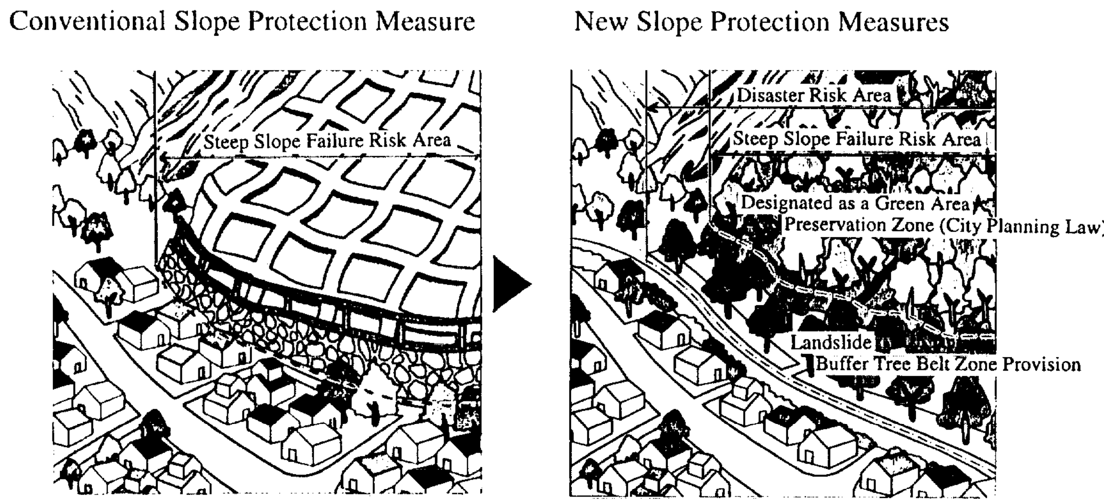


Figure 3. Provision of Buffer Tree Belts and Strengthening of Regulations for Risk Areas

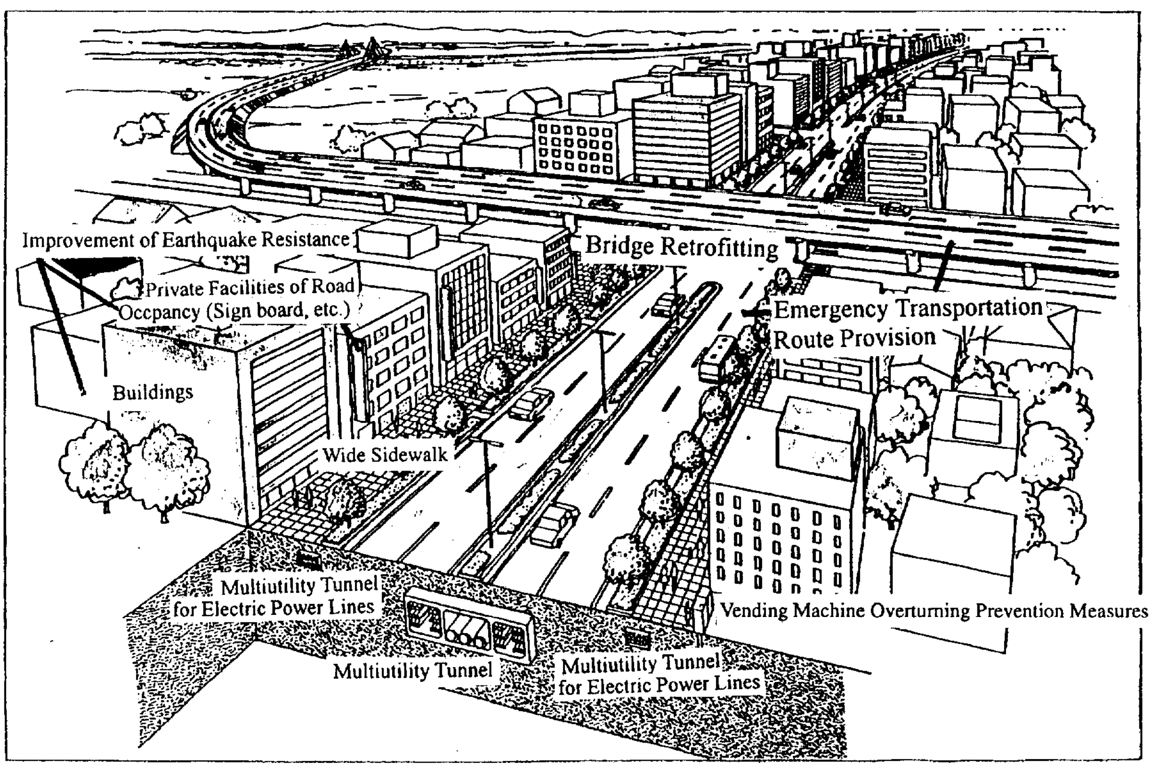


Figure 4. Improvement of Disaster Protection by Providing Emergency Transportation Routes

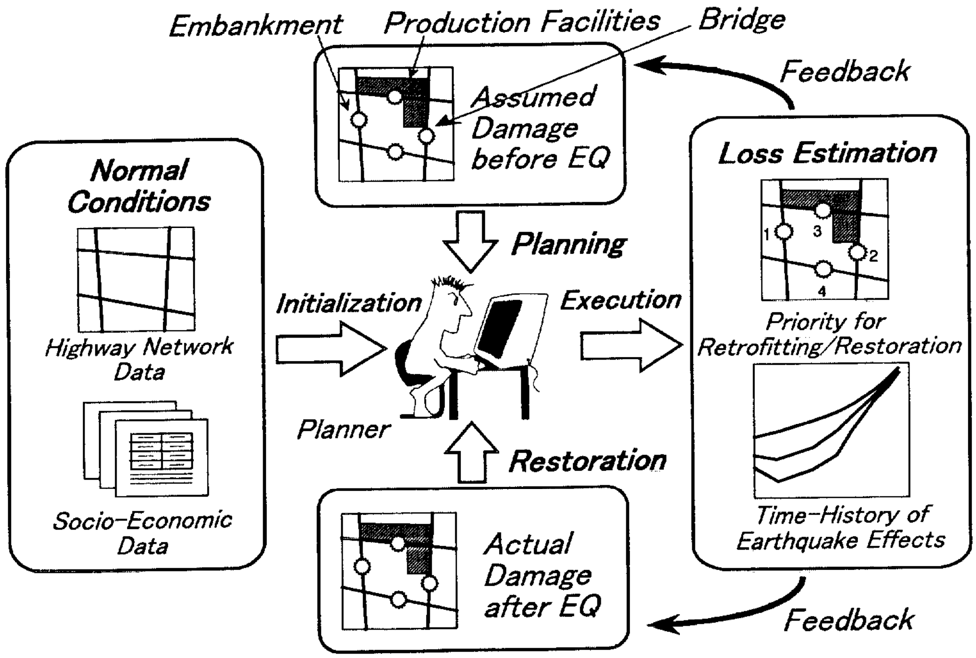


Figure 5. Loss Estimation for Pre-/Post Earthquake Risk Management

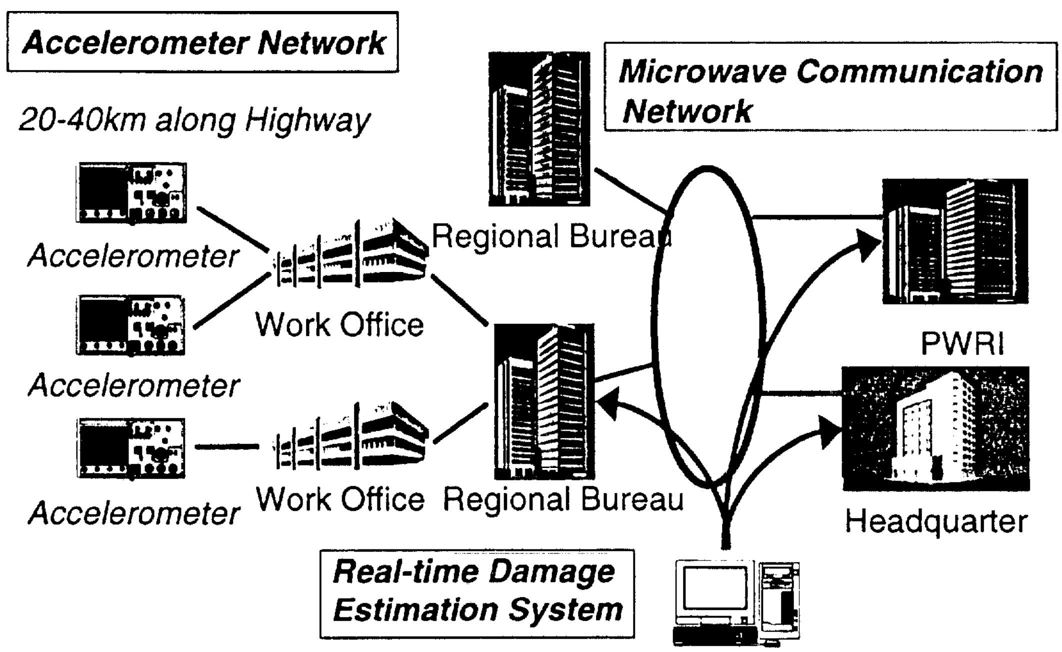
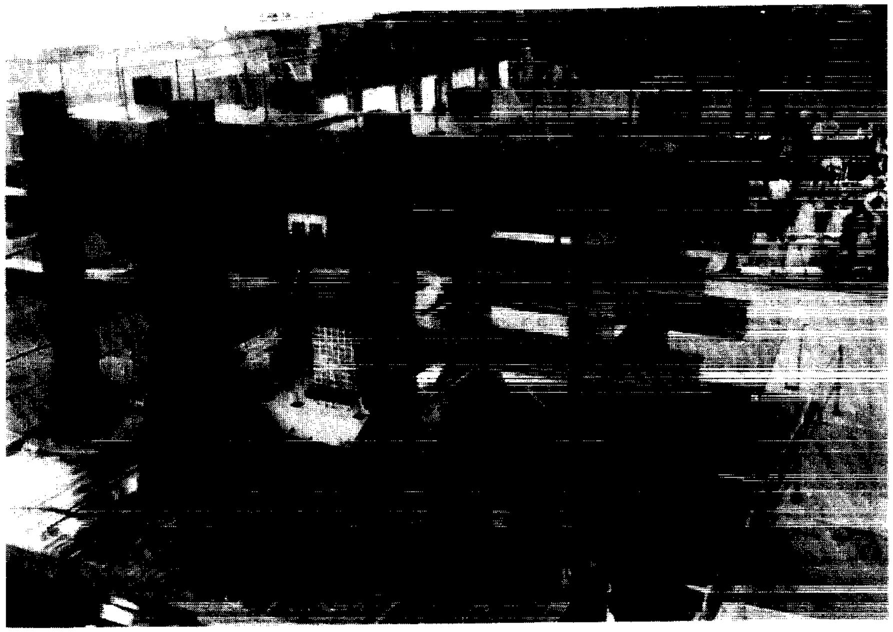
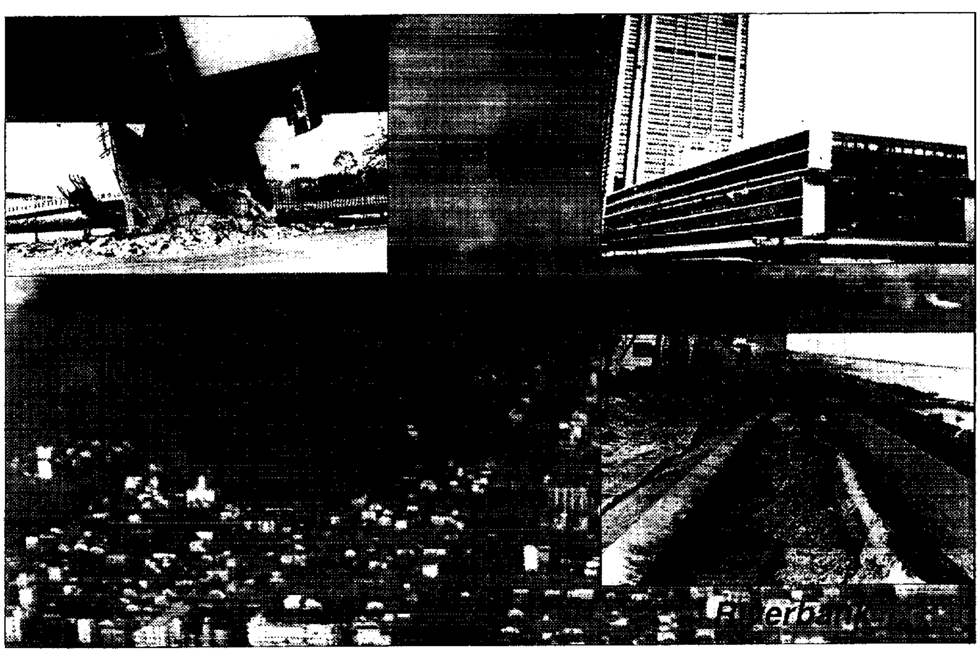


Figure 6. Earthquake Disaster Information System



Photograph 1. Large Scale Three-dimensional Shaking Table



Photograph 2. Upgrading Seismic Safety of Urban Area