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Recent Trends in Earthquake Disaster Management in Japan

KATSUTOSHI SUGANUMA
General Unit

1 Introduction

Despite the fact that Japan and the seas around it account for only about 1 percent of the Earth's surface, approximately 10 percent of the world's earthquakes of magnitude 8.0 or greater during the 20th century occurred in Japan or its vicinity, it shows Japan is one of the most earthquake-prone countries in the world. Japan is also a leader in earthquake disaster management.

Since the Great Hanshin-Awaji Earthquake of January 1995, various technologies for earthquake disaster management have been developed.

In March 2005, the Central Disaster Management Council established an "Earthquake Disaster Management Reduction" that sets concrete goals for disaster mitigation by strategically and intensively promoting steps that include making housing and public facilities earthquake-resistant and tsunami countermeasures.

The strategy sets a clear goal of reducing by half over the next 10 years the probable deaths and economic damage from a Tokai Earthquake, which is possible at any time, or a Tohnankai/Nankai Earthquake, which appears likely during the first half of the 21st century.

We will now turn our attention to recent trends and future issues in earthquake disaster management in Japan.

2 What has been learned from the Great Hanshin-Awaji Earthquake and subsequent earthquakes

From the Great Kanto Earthquake of 1923 until the Great Hanshin-Awaji Earthquake of 1995, no major earthquake directly struck a large city in Japan. With advances in construction technology and so on, it was widely believed that major destruction would not occur in the event of an earthquake.

The Great Hanshin-Awaji Earthquake, however, caused the collapse of expressway overpasses and other damage that had been unanticipated and not thought possible.

2-1 Earthquakes with a seismic intensity of 6 or greater occur in various parts of Japan

The Niigata-ken-chuetsu Earthquake occurred in October 2004. It was the first major earthquake since the Great Hanshin-Awaji Earthquake with a maximum seismic intensity of 7 on the Japanese scale. In addition, the Fukuoka-ken Seiho-oki Earthquake occurred in March 2005 in northern Kyushu, a site of little previous seismic activity. That earthquake registered a maximum seismic intensity of 6−. In addition, there is deep concern that a Tokai Earthquake, a Tohnankai/Nankai Earthquake, or an earthquake centered under Tokyo could be imminent.

The source regions of earthquakes and massive ocean trench earthquakes during the past 30 years are depicted in Figure 1.

They have occurred throughout the country outside the probable source regions for a Tokai Earthquake, a Tohnankai/Nankai Earthquake or an earthquake directly under Tokyo.

There are approximately 2,000 active earthquake faults in Japan's inland and coastal areas. The Headquarters for Earthquake Research Promotion has selected 98 fault zones where a major earthquake would cause serious social and economic effects. It promotes research on active faults.

There are about 2,000 confirmed active faults, but several times that many unknown active faults may also exist. A major earthquake could occur almost anywhere, not only in the Tokai and Tohnankai/Nankai regions or directly under Tokyo.

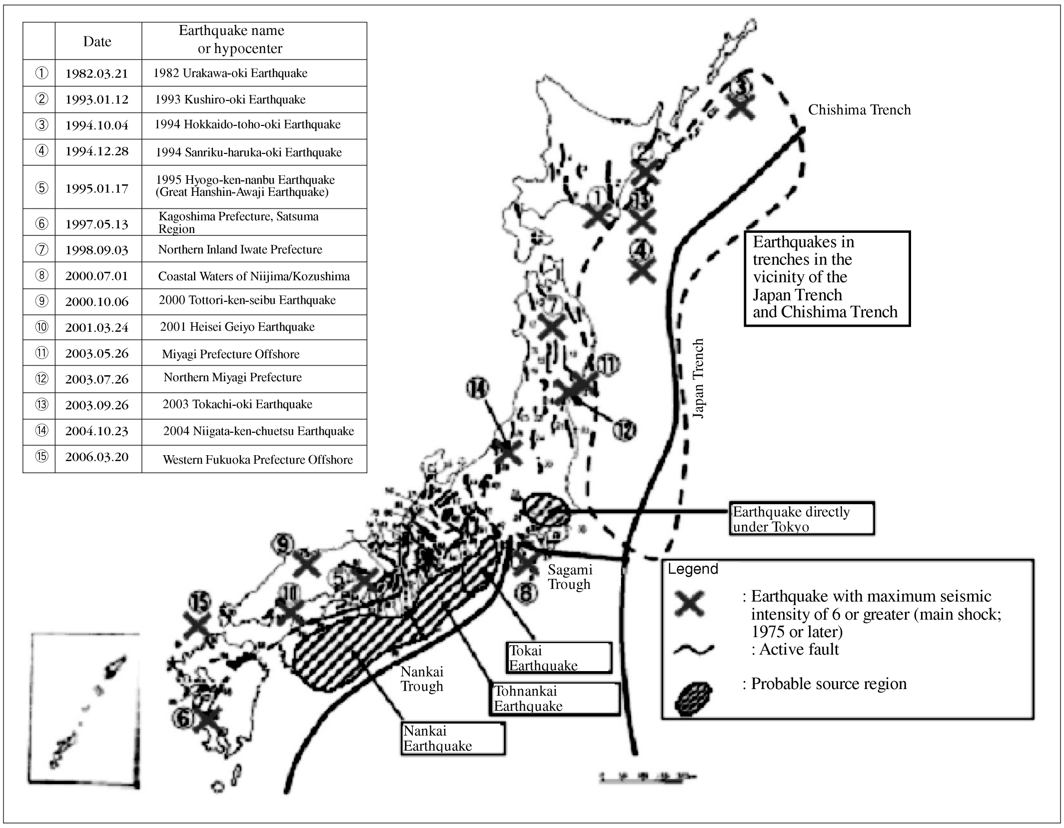
2-2 Declining awareness of disaster preparedness

According to surveys of about 3,000 people aged 20 and older carried out by the Cabinet Office of Japan regarding disaster prevention, a high percentage took measures to prepare for a major earthquake immediately after the Great Hanshin-Awaji Earthquake, but awareness of disaster preparedness has declined with the passage of time. (See Figure 2.)

In addition, as shown in Figure 3, people's greatest concerns in the event of a major earthquake are fire and collapsing buildings, followed by securing food and drinking water in the aftermath, road and bridge damage and congestion, and tsunamis, inundations, and broken levees, and so on.

The percentage that has secured furniture to

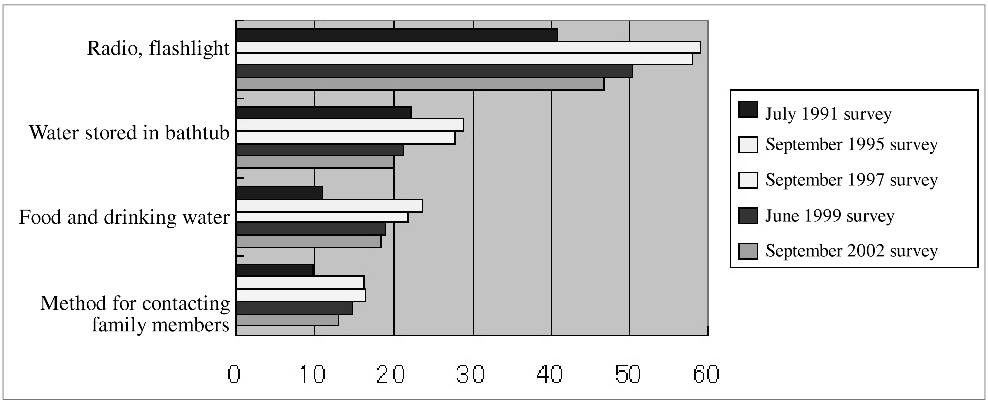
Figure 1 : Source regions of earthquakes and massive ocean trench earthquakes during the past 30 years



	Date	Earthquake name or hypocenter
①	1982.03.21	1982 Urakawa-oki Earthquake
②	1993.01.12	1993 Kushiro-oki Earthquake
③	1994.10.04	1994 Hokkaido-toho-oki Earthquake
④	1994.12.28	1994 Sanriku-haruka-oki Earthquake
⑤	1995.01.17	1995 Hyogo-ken-nanbu Earthquake (Great Hanshin-Awaji Earthquake)
⑥	1997.05.13	Kagoshima Prefecture, Satsuma Region
⑦	1998.09.03	Northern Inland Iwate Prefecture
⑧	2000.07.01	Coastal Waters of Niijima/Kozushima
⑨	2000.10.06	2000 Tottori-ken-seibu Earthquake
⑩	2001.03.24	2001 Heisei Geiyo Earthquake
⑪	2003.05.26	Miyagi Prefecture Offshore
⑫	2003.07.26	Northern Miyagi Prefecture
⑬	2003.09.26	2003 Tokachi-oki Earthquake
⑭	2004.10.23	2004 Niigata-ken-chuetsu Earthquake
⑮	2006.03.20	Western Fukuoka Prefecture Offshore

source : 2005 White Paper on Disaster Management [1]

Figure 2 : Measures taken in preparation for a major earthquake (multiple responses) Unit: %



Source: Prepared by the STFC from "Survey on Disaster Preparedness", Cabinet Office, Government of Japan [2] prevent it from toppling or falling is also low, with respondents citing concern for appearance and lack of awareness of the need as reasons.

2-3 Evacuation of residents

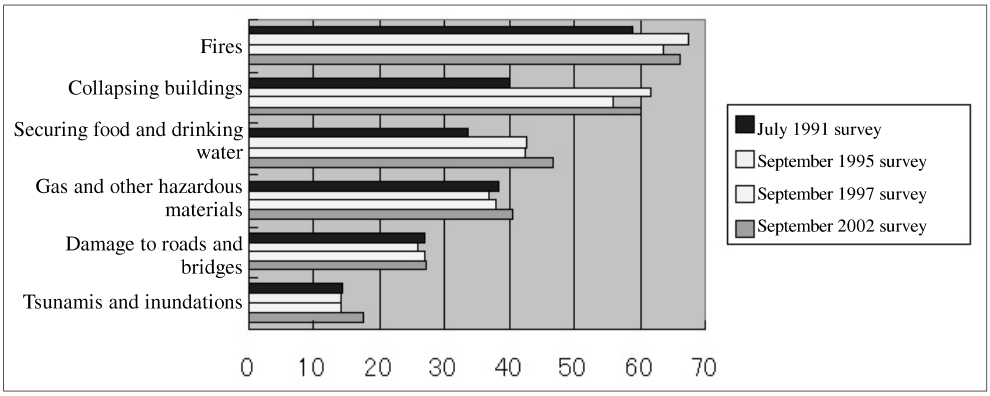
The Pacific Plate subducts beneath the continental plate in Offshore Sanriku. The Sanriku coastline is a ria coast, so it is considered a tsunami-prone area where tsunamis tend to be large.

There were many dead and missing in past tsunamis such as that generated by the Meiji Sanriku Earthquake of 1896, the Showa Sanriku Earthquake of 1933, and the Chile Earthquake of 1960.

In the May 2003 earthquake offshore from Miyagi Prefecture, seismic intensity levels of 4 to 6– were registered along the Sanriku coast, but no tsunami occurred.

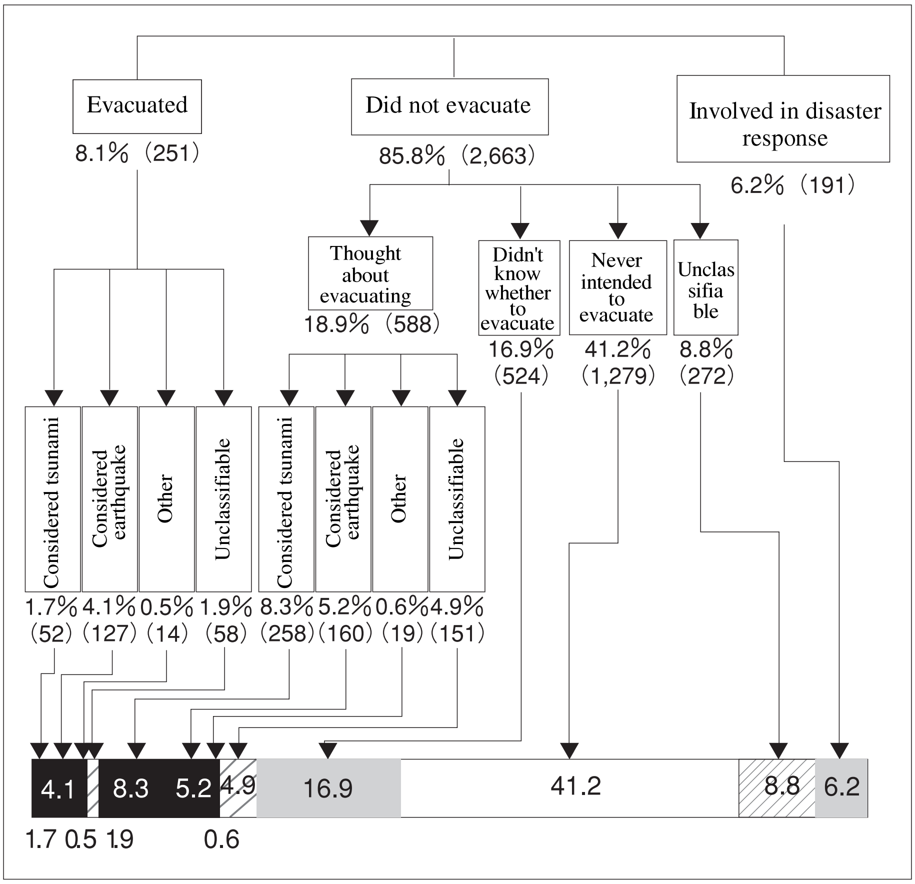
Figure 4 depicts the results of a survey on

Figure 3 : Concerns in the event of a major earthquake (multiple responses) Unit: %



Source: Prepared by the STFC from “Survey on Disaster Preparedness”, Cabinet Office, Government of Japan [2]

Figure 4 : Evacuation behavior of residents of Kesennuma City during the 2003 Miyagi-ken-oki Earthquake



Source: “Current conditions and issues in tsunami disaster management as seen in the evacuation behavior of residents: Awareness survey of Kesennuma City residents regarding the 2003 Miyagi-ken-oki Earthquake” [3] evacuation in an administrative area that includes the tsunami danger zone in Kesennuma City, Miyagi Prefecture. Three thousand six hundred questionnaires, about 30 percent of those sent, were returned.

Referring to the earthquake, about 8 percent evacuated, while 40 percent responded that they never intended to evacuate. Even in a tsunami-prone area, few people evacuated voluntarily.

Furthermore, a September 2004 earthquake with a hypocenter offshore from Tokaido registered a maximum seismic intensity of 5−. Within four to six minutes of the earthquake, the Japan Meteorological Agency issued a tsunami warning for 42 municipalities in Aichi, Mie, and Wakayama Prefectures. Twelve municipalities issued evacuation advisories, but few people actually got out.

This area is one where tremendous damage is feared in the event of a Tokai or Tohnankai/Nankai Earthquake, so promotion of disaster preparedness there is considered particularly necessary.

In recent years, many people have been getting their earthquake and evacuation information from television, government, and other sources, so disaster management measures that can be quickly translated into action without depending on receiving such information are an urgent task.

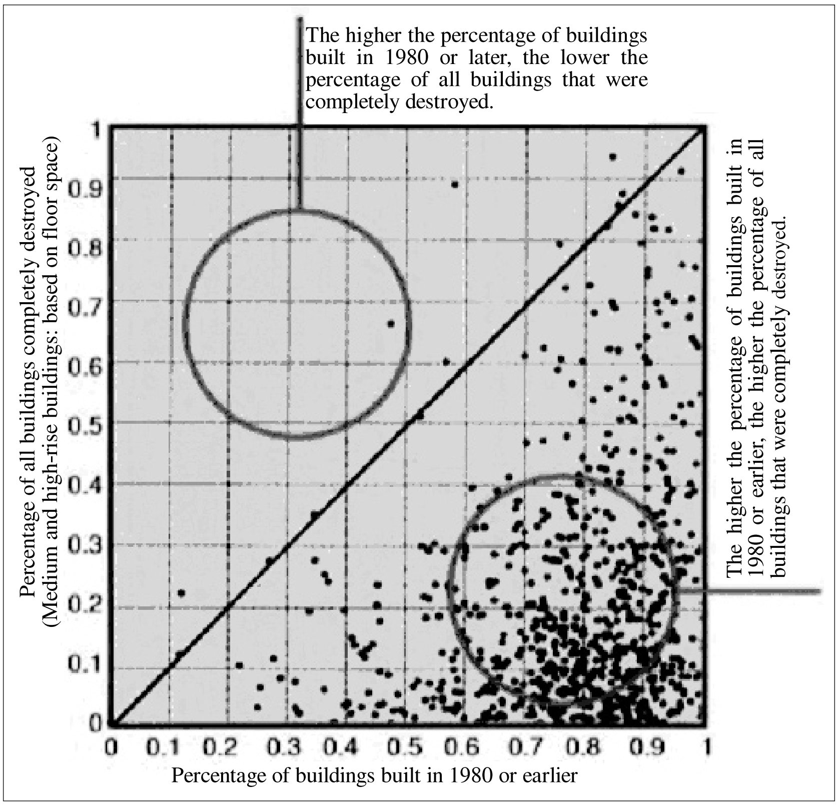
2-4 The effects of the new 1981 earthquake-resistance design code

Over 6,400 people died in the Great Hanshin-Awaji Earthquake. The cause of death in most cases was collapsed buildings or toppled furniture.

Figure 5 shows the relationship between the percentage of pre-1981 structures according to block-by-block data collected from the City of Kobe's property tax rolls, and the percentage of all buildings completely destroyed based on a survey by the City Planning Institute of Japan, and so on.

The percentage of buildings damaged that were built before 1981 was extremely high, demonstrating the effectiveness of the new earthquake-resistance design code implemented

Figure 5 : Block-by-block comparison of the percentage of all buildings completely destroyed and the percentage of buildings built before 1981



The higher the percentage of buildings built in 1980 or later, the lower the percentage of all buildings that were completely destroyed.

The higher the percentage of buildings built in 1980 or earlier, the higher the percentage of all buildings that were completely destroyed.

Source: Building Research Institute, "Damage to buildings from the Hyogo-ken-nanbu Earthquake and subsequent response"[4] in 1981.

Of Japan's approximately 47 million households, 17.5 million were built before 1982. Of these, an estimated 11.5 million are not sufficiently resistant to earthquakes.

Making homes and buildings earthquake-resistant is effective not only in terms of saving lives, but also in mitigating fire damage and the number of fires, reducing the need for rescue and first-aid activities related to collapsed structures, and preventing impediments to recovery and reconstruction.

In addition, in the September 2003 Tokachi-oki Earthquake, no damage was found at locations where measures such as equipment to prevent bridge collapses, soil stabilization to prevent liquefaction, and earthquake retrofitting of wood and reinforced concrete structures had been carried out following the 1993 Kushiro-oki Earthquake and the 1994 Hokkaido-toho-oki Earthquake. This demonstrated the effectiveness of earthquake retrofitting.

2-5 Recovery and reconstruction following the Great Hanshin-Awaji Earthquake

Figure 6 depicts recovery and reconstruction following the Great Hanshin-Awaji Earthquake.

Recovery of lifelines and other urban functions was accomplished relatively quickly (electricity, 6 days; telephones, 14 days; gas, 84 days; water, 90 days; sewers, 93 days), but reconstruction of industry and housing took longer.

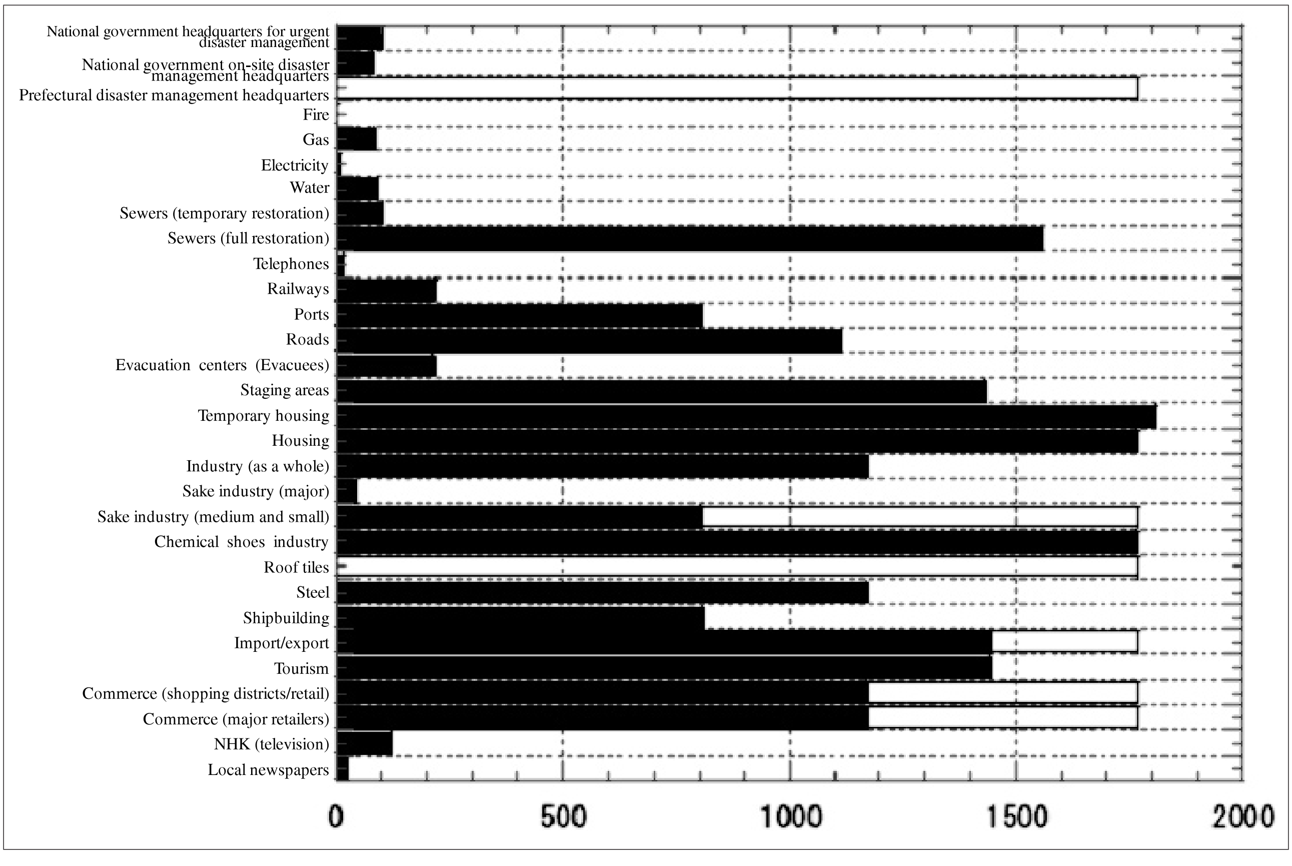
The Chuetsu Earthquake occurred after the floods of July 13 and the heavy rains of Typhoon No. 23 had loosened the ground, and aftershocks continued for a long time afterwards.

Immediately after the earthquake, some communities were cut off due to damaged roads. Evacuation of victims was therefore difficult, and delivery of emergency supplies and lifeline services were delayed.

Repair of roads used to supply daily necessities was therefore prioritized in order to quickly reestablish lifelines.

A July 2005 earthquake with its hypocenter in northwestern Chiba Prefecture was the first in

Figure 6 : Days to repair and recovery following the Great Hanshin-Awaji Earthquake



Source: National Research Institute for Earth Science and Disaster Prevention, "Reflecting earthquake research in earthquake response measures"[5]

13 years to register a seismic intensity of 5 within Tokyo's 23 wards. Partly because the earthquake occurred on a Saturday evening, it took some time to gather personnel, and repairs and inspections were delayed.

Approximately 64,000 elevators in Tokyo stopped running. In almost every case, earthquake control operation equipment functioned and the elevators went to the nearest floor, stopped, and opened their doors. Except for buildings that could not be entered for security reasons, expert technicians confirmed safety in order to prevent secondary accidents, and service was restored the following day. There were 78 cases of people trapped in elevators, with an average time of about 50 minutes between receipt of notification and rescue. Apparently, emergency stop equipment engaged when door abnormalities were detected.

Elevators should be equipped on the inside with devices for manually opening doors, similar to the emergency doors on trains, so that people can escape safely.

In addition, considerable time was required before resuming railway operation. Japan Railway and subway lines were stopped for up to seven hours, affecting over 1 million people. Ways of reducing time until service resumption and providing information to passengers in the event of service disruptions are therefore being studied.

2-6 Earthquake prediction

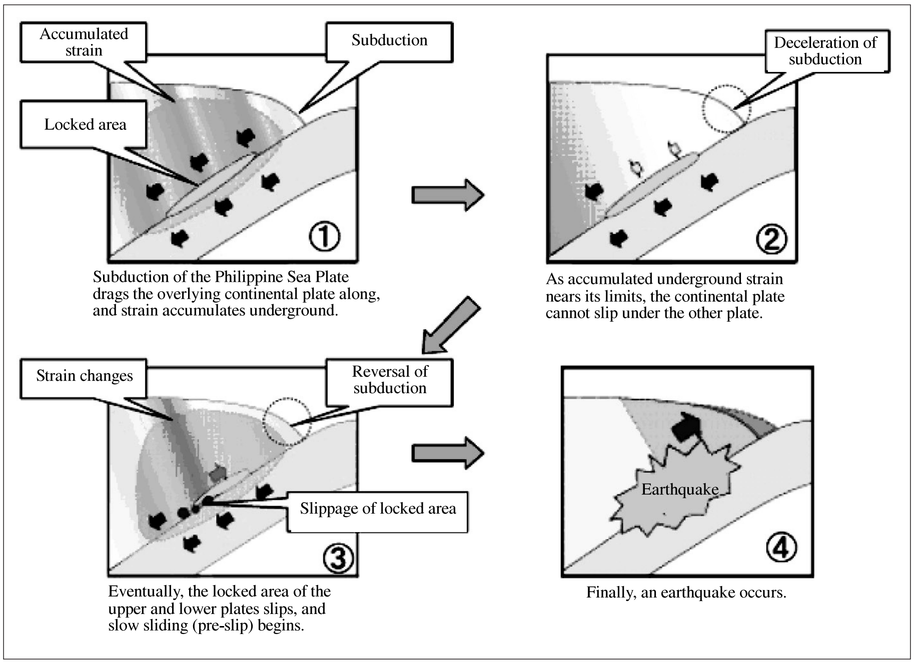
Earthquake prediction is the forecasting of the time, location, and size (magnitude) of earthquakes before they occur. Forty years have passed since Japan's Earthquake Prediction Plan began as a national project in 1965. Currently, the Headquarters for Earthquake Research Promotion carries out long-term probability forecasting whereby it attempts to predict the probability of an earthquake occurring in the next 30 years. This is based on data such as intervals between occurrences, most recent activity, and so on.

For the crustal deformation observation that is fundamental to earthquake prediction, nationwide installation of GPS continuous observation facilities at mesh of approximately 20 kilometers has proceeded, enabling timely and accurate information to be obtained.

Earthquakes are considered to be associated with earthquake precursor phenomena, which are anomalous phenomena that precede earthquakes.

The Japan Meteorological Agency believes that short-term prediction of a Tokai Earthquake is possible because, as shown in Figure 7, (1) there is a high likelihood it will be accompanied by precursor phenomena, (2) a measuring and

Figure 7 : Model of the generation of a Tokai Earthquake



Source: Japan Meteorological Agency, "Information on Tokai Earthquake"[6] observation system that can detect precursor phenomena is in place directly above the source region, and (3) the “pre-slip model” provides standards for judging whether anomalies are true precursor phenomena.

In the September 2003 Tokachi-oki Earthquake, however, no pre-slip occurred.

Before a magnitude 7.3 Haicheng Earthquake that struck China’s Liaoning Province in February 1975, precursor phenomena such as abnormal animal behavior and water gushing from underground were observed. An evacuation order was issued just before the earthquake struck, enabling damage to be minimized.

When anomalous phenomena occur, however, it is difficult to determine if they are indeed earthquake precursor phenomena, and there are few other examples of successful short-term prediction.

3 Status of measures since the Great Hanshin-Awaji Earthquake

Learning from the Great Hanshin-Awaji Earthquake, Japan has undertaken new measures and strengthened and improved existing ones in order to mitigate earthquake damage.

3-1 Preparation of a seismic observation network

In the wake of the Great Hanshin-Awaji Earthquake, the legislator-initiated Earthquake Disaster Management Special Measures Act was passed in July 1995 to promote comprehensive measures for earthquake disaster management.

The Headquarters for Earthquake Research Promotion set forth “Basic Earthquakes Survey and Observation Plan” in August 1997.

For earthquake observation, a system to centralize and process data to the Japan Meteorological Agency was prepared. As shown in Table 1, a highly-sensitive broadband seismic observation network covers the entire country with a high degree of accuracy.

Setup of terrestrial high-sensitivity seismographs (seismographs that detect very small vibrations that cannot be sensed by human beings) in 1,228 locations, at mesh of approximately 20 km, is nearly complete.

Placement of terrestrial broadband seismographs (seismographs that record surface vibrations over a wide range of frequencies, from fast vibrations to very slow ones) in 112 locations, at mesh of about 100 km, is almost complete.

Underground strong-motion seismographs (seismographs that monitor strong vibrations too great to be recorded by high-sensitivity seismographs) are in place at 975 locations, generally at the same sites as high-sensitivity seismographs. There are also 3,564 in surface locations, with an additional 2,800 belonging to local governments.

Placement of GPS continuous observation facilities (a system using satellites to monitor plate and crustal deformation) in 1,456 locations, at approximately 20-km mesh, is almost finished.

For seismic observation using cable-type seafloor seismographs, existing facilities are being used, and work to select major areas in sequence and emplace new seismographs is underway.

Along with the replacement of the seafloor seismograph off Omaezaki, placement of cable-type seafloor seismographs is necessary because of the urgency of the situation in the Tokai and Tohnankai/Nankai Earthquake regions.

3-2 Prompt communication of data obtained through seismic observation

Currently, data from seismic intensity indicators in every prefecture are connected to the Japan Meteorological Agency, which broadcasts a range of information to the public should a seismic event occur. The prefectures begin transmission of seismic intensity data within four minutes after an earthquake. Transmission from all observatories is to be completed within nine minutes.

When large-scale damage is expected, a headquarters is formed in the Prime Minister’s Office and an emergency assembly team is convened.

During the July 2005 earthquake centered in northwestern Chiba Prefecture, the extra time taken due to slow processing by the Tokyo regional server that transmits data to the Japan Meteorological Agency led to delays in initial response. In the Niigata-ken-chuetsu Earthquake as well, a breakdown in the seismic intensity data network occurred, making some of the transmissions to the Japan Meteorological Agency impossible.

3-3 *Earthquake warning bulletins*

As illustrated in Figure 8, earthquake warning bulletins work by detecting P waves (preliminary tremors), which have a high propagation velocity, at observatories near the hypocenter before the S waves (principal shock) that cause major shaking arrive, and estimating the hypocenter and scale of the earthquake, when the S waves will arrive, and the seismic intensity. This helps to prevent and reduce damage from earthquakes and tsunamis.

The Japan Meteorological Agency began testing earthquake warning bulletins in February 2004. Currently, bulletins are being provided to about

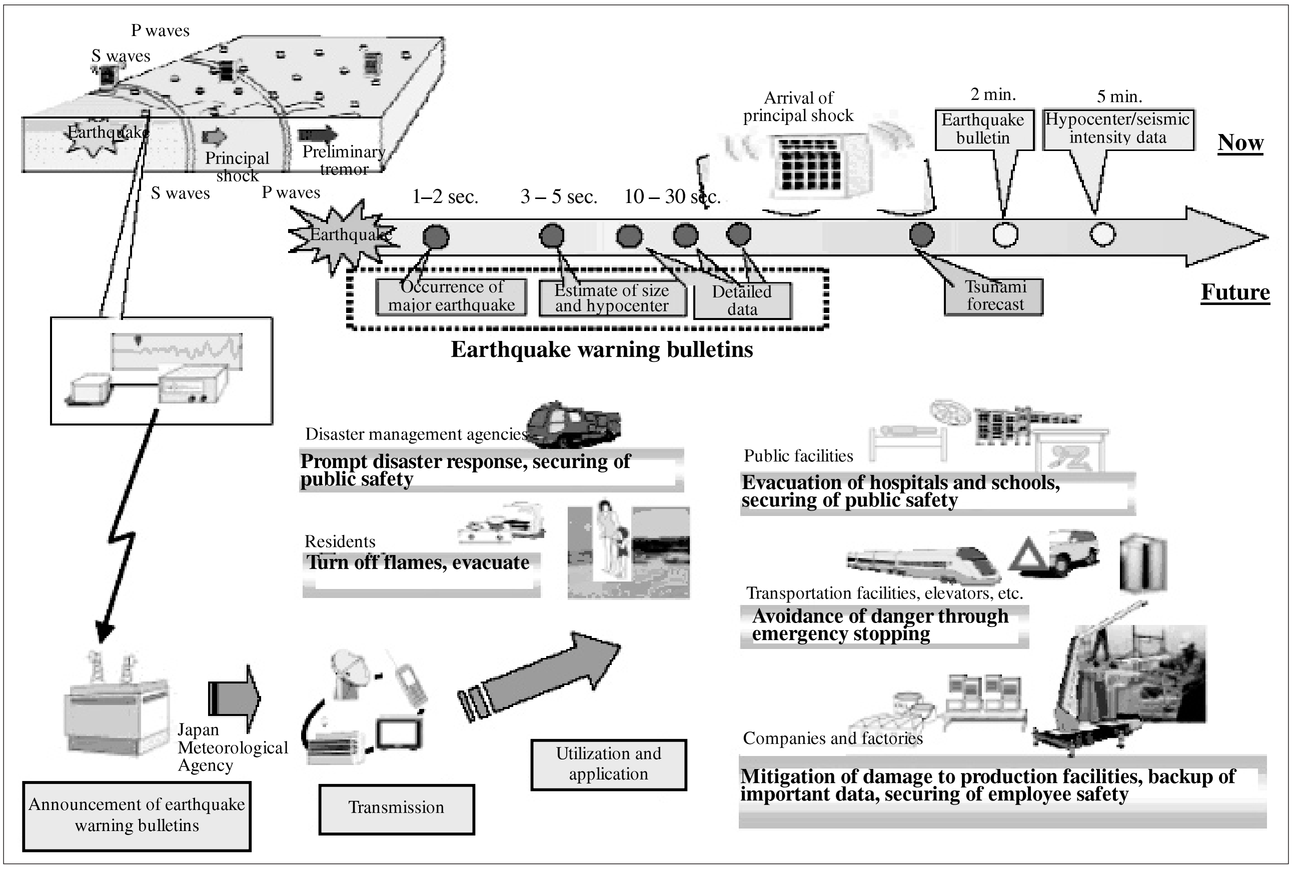
Table 1 : List of seismic observation facilities (as of March 31, 2004)

Type	High-sensitivity seismograph		Broadband seismograph		Strong-motion seismograph		Crustal deformation			Ocean floor crustal deformation (ocean floor geodetics)		Ground water	Geo magnetic	Gravity	Tide / tsunami
Supervising authority	Land	Seafloor[*1]	TYPE1[*2]	TYPE2[*3]	Above-ground	Under-ground	GPS	SLR	VLBI	Strainmeters, etc.[*4]					
Ministry of Education, Culture, Sports, Science and Technology							41								
National universities	273	6 (2)	10	26	116	9	59			104		42	42	3	5
National Research Institute for Earth Science and Disaster Prevention	755	6 (1)	22	51	1700	672	3			55		7	15		6
Japan Agency for Marine-Earth Science and Technology		5 (1)													4
Ministry of Land Infrastructure and Transport					1158	285									76
Geographical Survey Institute							1311		4	5			15	2	27
Japan Meteorological Agency	186[*5]	8 (2)			585					36			6		84[*6]
Hydrographic and Oceanographic Department, Japan Coast Guard							39	1			16		1		28
National Institute of Advanced Industrial Science and Technology	14			4	5	9	3			15		42	20		
Total	1228	25 (7)	31[*7]	81	3564[*8]	975	1456	1	4	215	16	91	99	5	230[*6]

(*1) Number of cables is shown in parentheses.
(*2) Broadband seismographs that cover frequency bands enabling analysis from free vibration to minor earthquakes (e.g., STS1 and CMG1T).
(*3) Broadband seismographs that cover frequency bands enabling analysis of a range of seismic events from micro-earthquakes to tsunami earthquakes that have relatively short predominant periods (e.g., STS2 and CMG3T).
(*4) Includes strainmeters, volume strainmeters, three-component strainmeters, tiltmeters, extensometers, etc.
(*5) Among the Japan Meteorological Agency's high-sensitivity seismographs, there are 20 locations where seismographs with Type 2 broadband performance are installed. Includes three at Ministry of Education, Culture, Sports, Science and Technology facilities.
(*6) Includes 10 observation points relying on other agencies (local governments, etc.) and 2 utilizing facilities belonging to other agencies.
(*7) The Nemuro observatory is a joint facility of the National Research Institute for Earth Science and Disaster Prevention and national universities.
(*8) In addition, local public agencies have approximately 2,800 aboveground strong-motion seismographs.

Source: The Headquarters for Earthquake Research Promotion [7]

Figure 8 : Earthquake warning bulletins



Source: Japan Meteorological Agency materials [8]

140 organizations, including national disaster management agencies, local governments, universities, schools, and the private sector.

Damage can be reduced by carrying out the following disaster management action before the principal shock arrives:

- Automatic control of trains, elevators, etc.
- Avoidance of dangers by transmission to people in buildings, at local governments, etc.
- Practical application of data transmission systems such as mobile phones and satellite communications
- Damage mitigation by turning off electricity, gas, fuel to factory production lines, and other elements that can cause fires, and backing up important data.

Because of the minimal time lag between the P waves and S waves of an earthquake centered directly under a city, such as the Great Hanshin-Awaji Earthquake, the bulletins are not effective for such earthquakes.

During the August 2005 earthquake offshore from Miyagi Prefecture, time from transmission of the initial earthquake warning bulletin until arrival of S waves was approximately 22 seconds in Kawasakimachi, Miyagi Prefecture, where the seismic intensity reached 6–. In the cities of Sendai and Ishinomaki, where the seismic intensity reached 5+, times from transmission until S wave arrival were 16 seconds and 10 seconds, respectively.

3-4 The Act for Promotion of the Earthquake Proof Retrofit of Buildings (Earthquake Retrofitting Promotion Act)

Based on the lessons of the Great Hanshin-Awaji Earthquake, Japan's Diet passed the Act for Promotion of the Earthquake Proof Retrofit of Buildings (Earthquake Retrofitting Promotion Act) in December 1995 to work towards early retrofitting of buildings that do not meet earthquake-resistance codes.

Owners of designated buildings (schools, hospitals, theaters, department stores, offices, and other buildings of at least three stories and 1,000 m2 where many people gather) must carry out earthquake-resistance inspections and, if necessary, carry out earthquake retrofitting. Ordinary homes are not included.

Almost 10 years have passed since the law went into effect, and although about 10,000 designated buildings have been retrofitted, not enough earthquake retrofitting has been carried out.

In 2004, therefore, parts of the Building Standards Law and the Urban Planning Law were revised in order to ensure the safety of building and proper urban disaster management.

Partial revision of the Building Standards Law (ensuring building safety)

- Enhancement and strengthening of the reporting and inspection systems for buildings
- Issuing of directives to upgrade dangerous substandard buildings
- Rationalization of regulations regarding existing substandard buildings
- Strengthened penalties (corporate tax penalties for not complying with directives to perform upgrades), etc.

Partial revision of the Urban Planning Law

- Countermeasures for earthquakes and major fires in crowded urban areas, etc.

In order to strengthen measures for homes and buildings with insufficient earthquake resistance, designated buildings must undergo earthquake inspection and retrofitting within specified periods. Buildings with insufficient earthquake resistance are to receive not just guidance and advice, but also will receive instructions, be required to make reports, and submit to on-site inspection, and buildings that fail to comply will be publicly identified. Revisions to the Earthquake Retrofitting Promotion Act such as new provisions requiring action to be taken with respect to general housing are also under consideration.

3-5 Earthquake resistant, seismic isolation, and vibration suppression construction

There are three types of construction that raise the earthquake-resistance of buildings: “earthquake resistant construction,” “seismic isolation construction,” and “vibration suppression construction.” Figure 9 explains these categories.

Earthquake resistant construction utilizes studs, walls, and other structural elements to absorb seismic forces through elasticity or elastoplasticity.

Seismic isolation construction utilizes equipment such as bearings in foundations, between stories, and so on to absorb seismic energy and prevent buildings from shaking.

Vibration suppression construction utilizes suppression equipment such as dampers in walls to absorb seismic energy and control shaking of the entire building.

Earthquake resistant construction proved effective in the Great Kanto Earthquake. During Japan’s period of rapid economic growth, buildings became taller, and in the 1980s vibration suppression construction increased mainly as a means of improving livability in high winds. Seismic isolation construction has increased since the Great Hanshin-Awaji Earthquake.

3-6 Making homes and buildings earthquake resistant

The cost of earthquake retrofitting for single-family homes varies by the size of the house and the amount of work needed, but it averages ¥2 million per home.

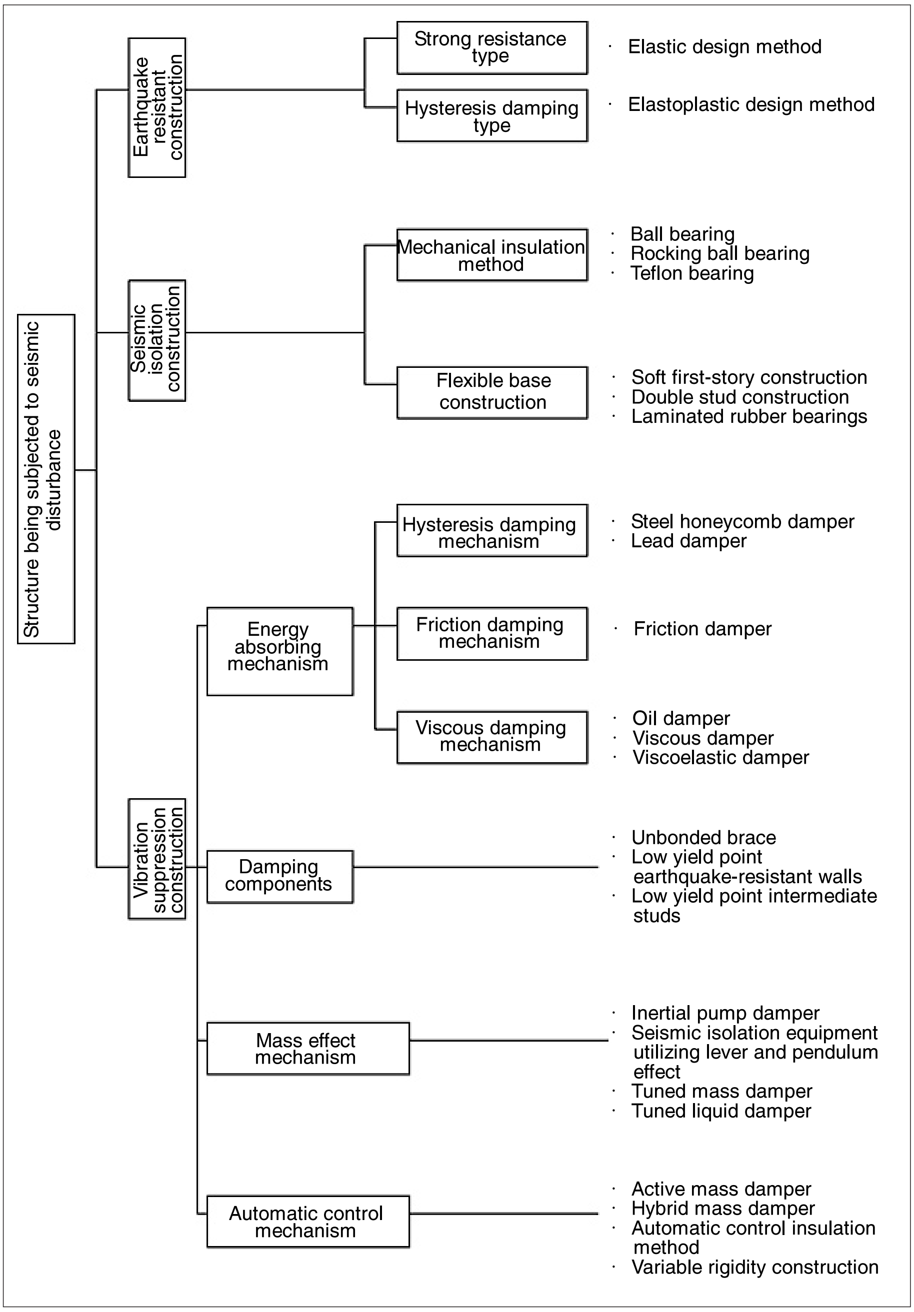
Since the Great Hanshin-Awaji Earthquake, the following support system for earthquake inspections and retrofitting has been implemented to ease the cost burden.

- Subsidy for earthquake inspection and retrofitting of condominiums and offices, etc. (FY 1995)
- Subsidy for earthquake inspection of single-family homes (FY 1998)
- Subsidy for earthquake retrofitting of single family homes (FY 2002)

Earthquake inspection and retrofitting of homes through FY 2003 totaled 170,000 inspections (160,000 subsidized), and 3,500 retrofits (40 subsidized). The system is not being sufficiently utilized.

Because the above system was not sufficiently utilized, the earthquake inspection and

Figure 9 : Categories of earthquake resistant, seismic isolation, and vibration suppression construction



Source: Ministry of Land Infrastructure and Transport[9]

retrofitting support systems were unified through the establishment of a home and building earthquake retrofitting program in FY 2005.

The program must be introduced and implemented throughout Japan.

3-7 Earthquake insurance

Because the potential damage from earthquakes is so large, it is difficult for private-sector insurance companies to bear the risk alone.

Following the 1964 Niigata Earthquake, therefore, the Act for Earthquake Insurance was passed in 1966 to establish an insurance system jointly operated by the government and private-sector insurance companies.

When insurance claims for a single earthquake reach a certain level, the government pays a portion of such claims. Since April 2005, the limit per earthquake has been ¥5 trillion (a possibility in an earthquake on the scale of the Great Kanto Earthquake).

Earthquake insurance is incidental to fire insurance, and is limited to ¥50 million for the structure and ¥10 million for household goods, 30-50 percent of fire insurance coverage.

Premiums are decided according to date of construction, wood or non-wood construction, and risk by prefecture (four categories).

As of the end of FY 2003, earthquake insurance was attached to about 35 percent of fire insurance policies.

About 17 percent of households have earthquake insurance. Including Japan Agriculture Cooperatives insurance, the enrollment rate is still only about 30 percent. Promoting the spread of earthquake insurance is a current issue.

3-8 Hazard maps

Hazard maps are intended to keep disaster damage to a minimum. Along with clearly depicting expected damage zones and degrees of damage on maps, they present evacuation information such as shelters and danger zones in an easy-to-understand format.

Earthquake hazard maps have been prepared for Tokyo and six cities including Yokohama and Nagoya. Tsunami hazard maps have been created for only 122 of Japan's coastal municipalities, about 12 percent of the total of 991. The Central Disaster Management Council raised the issue of the creation of tsunami hazard maps within the next five years for all municipalities that need to introduce tsunami disaster management measures.

Most hazard maps created and published to date indicate schools, community centers, and other evacuation points, but few show escape routes or designated evacuation routes.

3-9 Disaster recovery and reconstruction

According to the Basic Disaster Management Plan (July 2005, Central Disaster Management Council), "Recovery and reconstruction of affected areas has the aim of supporting victims in putting their lives back in order, working towards recovery of facilities with the focus on the prevention of repeat disasters, and providing the basic conditions for local development from the perspective of improving safety. In addition, the promptest and smoothest possible recovery and reconstruction should be implemented in light of reduced socioeconomic activity in the community because of the disaster."

Based on the lessons of the Great Hanshin-Awaji Earthquake, the following measures are in place.

(1) Revision of laws and plans

(i) Amendment of the Disaster Countermeasures Basic Act

Revisions enhancing and strengthening the functions and operations of government disaster management headquarters by relaxing the conditions for establishing the Headquarters for Urgent Disaster Management led by the Prime Minister and establishing the On-site Disaster Management Headquarters as a legal entity have been implemented. Local government disaster management has been strengthened by allowing mayors to call upon prefectural governors to ask for the aid of the Self-Defense Forces.

(ii) Revision of the Basic Disaster Management Plan and the Local Disaster Management Plan

The earthquake section of the Basic Disaster Management Plan, the most important plan in the disaster management sector, was completely revised.

In addition, the comprehensive plans for local areas (the Local Disaster Management Plan) were also revised in each prefecture in light of the complete revision of the Basic Disaster Management Plan. As of April 2004, 2,390 municipal governments (76.5 percent of the whole) had completed their revisions.

(iii)The Act Concerning Support for Reconstructing Livelihoods of Disaster Victims

Natural disasters can cause very significant damage to livelihoods. For victims who face difficulties rebuilding their lives and regaining their independence due to economic or other factors, prefectures can use funds contributed from a mutual aid perspective to help the victims regain their independence. The law was passed and implemented in 1998. In 2004, it was revised to relax the conditions for its application and to increase the maximum payment amount.

(2) Securing lifelines

Lifelines are directly related not only to recovery and reconstruction, but also to ending evacuee conditions.

Securing personnel to work on recovery

and reconstruction is important, but for improved earthquake resistance for facilities and quick restoration of function after a disaster, establishment of earthquake inspection technology and retrofitting methods for existing facilities and research and development of technology for prompt discovery of areas damaged in a disaster are also necessary.

In addition, during recovery and reconstruction checks, wiring and pipes must be decentralized through sectioning off, duplicating, or networking.

(i) Electricity

After the Great Hanshin-Awaji Earthquake, 44 electrical fires broke out. Public service announcements urging people to turn off circuit breakers before evacuating are being implemented, but circuit breakers need to be constructed such that they will remain off even after electricity is restored until a confirmation button is pushed.

(ii) Gas

For city gas, microcomputer-equipped meters that shut off when an earthquake is sensed have been required since the Great Hanshin-Awaji Earthquake. They functioned effectively during the Chuetsu Earthquake, preventing secondary damage. An automatic shutoff system linked to earthquake warning bulletins is needed for liquid propane gas as well.

(iii) Water

Many water pipes have been weakened by the use of asbestos-cement materials or have been in place more than 20 years, so pipe connections joints do not withstand earthquakes well. The Great Hanshin-Awaji Earthquake caused about 900,000 homes, mainly in Kobe, to lose water service. Currently, waterlines are being made earthquake resistant with ductile cast-iron pipes with earthquake-resistant joints, steel pipes, polyethylene pipes, and so on.

(iv) Sewers

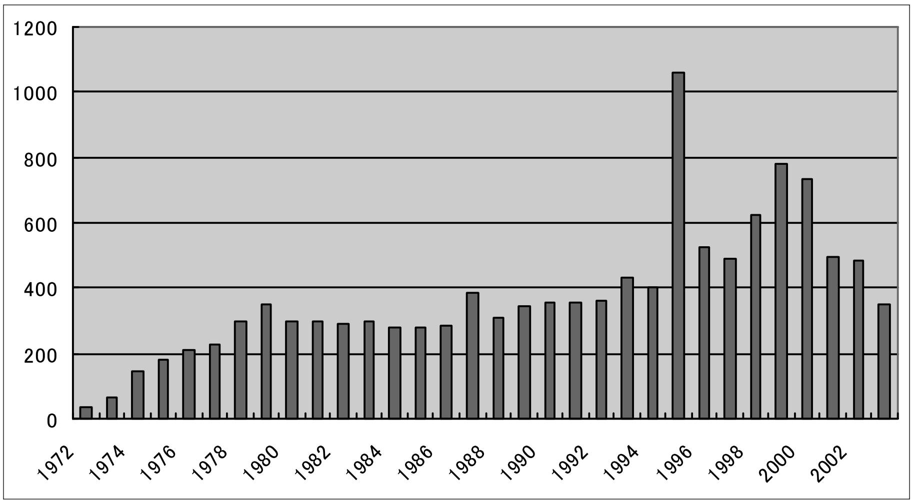
Sewage facilities such as treatment plants, pumping stations, and pipelines constructed since the Great Hanshin-Awaji Earthquake are generally earthquake resistant. For joints, very elastic and watertight expanding and flexible joints are used, and monitoring of sewer damage status through remote-control television cameras is progressing. Sewer services are restored in conjunction with recovery work on waterlines.

3-10 *Research and development budgets for science and technology related to disaster management*

Japan's disaster management countermeasures, including those for natural disasters, are based on the Disaster Countermeasures Basic Act, which was passed in 1961 in the aftermath of the Typhoon Ise-wan of 1959.

In recent years, research and development on technology related to disaster management has

Figure 10 : Research budget for science and technology related to disaster management in Japan (unit: ¥100 million)



Source: Prepared by the STFC from White Paper on Disaster Management [1] proceeded in accordance with the 1993 Basic Plan for Research and Development on Disaster Prevention (December 1993, decided by the Prime Minister).

Following the Great Hanshin-Awaji Earthquake, the Headquarters for Earthquake Research Promotion was established as a special government organ in July 1995. It carries out earthquake-related observation, measurement, surveys, and research.

Changes over time in the budget for science and technology research related to disaster management, including on natural disaster countermeasure technology, are depicted in Figure 10.

The trend has been upward since 1970s. The decline since FY 2001 is due to the shift to independent administrative institutions.

4 Current and future issues

In order to reduce earthquake damage, the following issues should be addressed.

4-1 Completion of a seafloor seismograph network

Development of the seismograph observation network based on the 1997 Basic Earthquakes Survey and Observation Plan is nearly complete.

However, because movement of the earth's crust occurs where it cannot be seen, underground and under the ocean, away from monitoring instruments, analysis of waveforms and scale data by monitoring earthquakes on the sea floor immediately after they happen is essential to reducing earthquake damage.

If seismographs are placed essentially to surround a hypocenter, seismic activity can be monitored with a high degree of accuracy. Because monitoring ocean seismic activity from the land reduces observation accuracy, real-time continuous monitoring at sea is imperative.

Completion of a seafloor seismograph network is necessary not only because direct observations of seismic activity at sea would contribute to collection of earthquake and tsunami data, it would also lead to damage mitigation through earthquake warning bulletins.

4-2 Replacement of seismographs and improvement of the reception system

Seismographs need to be replaced every 10 years, and the instruments emplaced following the Great Hanshin-Awaji Earthquake are now almost 10 years old.

Local governments have set up approximately 2,800 seismic intensity indicators all over Japan. The Chuetsu Earthquake's seismic intensity of 7 was recorded by Kawaguchimachi's seismic intensity indicator. However, the consolidation of municipalities has led to the elimination and consolidation of seismographs, while reduced funding has led to reductions in routine maintenance, possibly lowering the accuracy of measurement.

The seismic intensity indicators of local governments not only collect seismic data, they also are used for the prompt initial responses of relevant government agencies, including the headquarters in the Prime Minister's Office.

In addition, the system must be immediately improved through measures such as increasing the number of network lines, multiplexing and continuous connection, enhanced processing capacity for transmission and reception servers so that municipalities and prefectures can respond to seismic intensity bulletins.

4-3 Establishment of preferential treatment to promote earthquake resistance

The Central Disaster Management Council's Earthquake Disaster Management Reduction sets forth the concrete goal of increasing the percentage of earthquake-resistant housing from the current 75 percent to 90 percent over the next 10 years.

However, the high costs of inspection for earthquake resistance and earthquake retrofitting, as well as the proliferation of unscrupulous contractors, have been obstacles to achieving this goal. Householder's overconfidence in the safety of their homes can also be seen.

Unification of the earthquake inspection and retrofitting systems should help promote earthquake resistance, but earthquake retrofitting can raise property values, leading to higher property taxes.

Preferential treatment for disaster mitigation measures, such as reduced property taxes for earthquake-resistant structures, discounted earthquake insurance premiums, and so on, should be adopted.

Promoting measures to make structures earthquake-resistant should be prioritized according to the degree of danger based on hazard maps, risk by prefecture for earthquake insurance, and so on.

4-4 Creation and distribution of hazard maps

Municipalities are the primary agents for the implementation of disaster management measures. They play a major role that includes ordering the dispatch of fire and police units, issuing evacuation advisories and orders to residents, establishing danger zones.

Hazard maps that not only predict tsunamis and landslides caused by earthquakes, but also indicate possible locations of disrupted transportation networks and collapsed or burning buildings and allow evacuees to be promptly directed to safe locations must be created and distributed.

When revising the Local Disaster Management Plan due to consolidation, some municipalities were unable to undertake the creation of hazard maps.

Hazard maps not only provide information of damage risk, evacuation sites, escape routes, and so on, they are also useful when considering facilities improvements such as preventative and emergency measures.

In addition, at the urban planning stage, roads should be made wide as a measure to prevent fires from spreading.

4-5 Promotion of multipurpose conduits

Inefficiencies in the recovery and reconstruction of lifelines following the Great Hanshin-Awaji Earthquake were noted. These included the digging up of roads to repair gas lines, followed later by the digging up the same roads again to repair water mains.

Methods to share information regarding damage and recovery and to work cooperatively on reconstruction of various lifelines must be established.

Placement of lifelines such as electricity, gas, and water in multipurpose conduits under roads is advancing. By securing sufficient maintenance space in the multipurpose conduits, not only is the safety of lifelines during an earthquake improved, but traffic problems can be reduced because there is no need to dig up roads several times to repair the different lifelines.

Many lifelines suffered heavy damage in the Great Hanshin-Awaji Earthquake, but multipurpose conduits in a certain part of Kobe received only minor damage. Urban renewal that better resists earthquakes should be promoted.

5 Conclusion

Ever since the Great Hanshin-Awaji Earthquake, people have been calling for disaster management that reduces damage.

Promotion of effective action on disaster mitigation issues such as those described above must be promoted.

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Katsutoshi SUGANUMA
General Unit, Science and Technology Foresight Center

He worked for many years in river management, surveying and planning for rivers such as the Tonegawa and the Arakawa. Currently he works in the social infrastructure field in areas such as earthquake and natural disaster management.

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