Earthquake Disaster Management in Japan

by

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ABSTRACT

This paper presents the earthquake disaster management in Japan. General disaster management has been promoted in an integrated and well-planned manner by the central, prefectural and municipal governments, and public utilities in their capacity according to Disaster Countermeasures Basic Act. In addition, building and improvement of facilities of high priority which help reduce damage by earthquakes have been promoted according to 5 year plans based on Act on Special Measures for Earthquake Disaster Countermeasures to prepare for earthquakes that occur anywhere at anytime. On the other hand, countermeasures have been formulated individually against devastating large-scale earthquakes. One of the examples is Tokyo Inland Earthquakes, which is outlined in detail. There have been some developments in earthquake disaster management policy for Tokyo Inland Earthquakes. Following, "Policy Framework", "Earthquake Disaster Reduction Strategy" and "Guidelines for Emergency Response Activities", "Specific Plan for Emergency Response Activities" was formulated by "Central Disaster Management Council (CDMC)" chaired by the prime minister. Specific measures for massive evacuees and the stranded generated by Tokyo Inland Earthquakes were also formulated and proposed measures have been further considered and pursued.

Current situation of several other initiatives are also outlined in this paper such as building quake-proofing, Early Earthquake Warning (EEW) and Disaster Management Information Systems.

KEYWORDS: Building quake-proofing, Early Earthquake Warning (EEW), Large-scale earthquakes, Measures for evacuees and the stranded, Tokyo Inland Earthquakes

1. INTRODUCTION

Japan has suffered from frequent natural disasters of almost all kinds due to its geographical, topological and meteorological conditions and has undergone losses of human lives and properties in years. Protecting lives and properties from natural disasters is a high priority and one of the most important responsibilities of the central government.

This paper presents the earthquake disaster management in Japan. Section 2 summarizes the earthquake proneness of Japan. Section 3 outlines policy frameworks for earthquake disaster countermeasures, Disaster Countermeasures Basic Act, Act on Special Measures for Earthquake Disaster Countermeasures and framework for countermeasures against devastating large-scale earthquakes. The Disaster Countermeasures Basic Act sets a general framework for disaster management to be organized and implemented in an integrated and well-planned manner, and the Act on Special Measures for Earthquake Disaster Countermeasures is to encourage local governments to build and/or improve facilities of high priority while countermeasures against devastating large-scale earthquakes have been considered and formulated individually. Section 4 and Section 5 detail countermeasures against Tokyo Inland Earthquakes and measures for evacuees and the stranded as a result of Tokyo Inland Earthquakes respectively. Section 6 details current situation of building quake-proofing. Section 7 outlines the Early Earthquake Warning and lessons learnt from recent earthquakes. Section 8 presents Disaster Management Information Systems, IT systems developed to estimate damage using only data

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which are available beforehand or readily available when earthquakes occur and, streamline information flow and strengthen information sharing.

2. EARTHQUAKES IN JAPAN

Japan is located on and near plate boundaries of the North American plate, Eurasian plate, Philippine Sea plate and Pacific plate as illustrated in Fig.1 [1]. This explains why Japan is one of the most earthquake-prone countries in the world. Fig. 2 [2] shows the distribution of focuses of earthquakes measuring 5.0 or greater from 1996 to 2005, which illustrates that a large number of earthquakes have occurred around Japan. In addition, Japan accounts for 20% of earthquakes with magnitude of 6.0 or greater from 1996 to 2005.

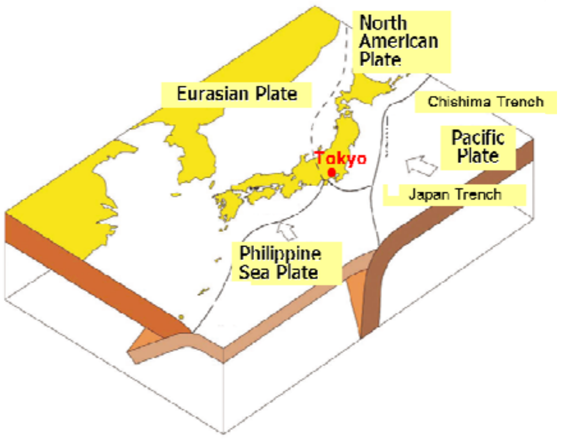

Fig.1 Plates around Japan

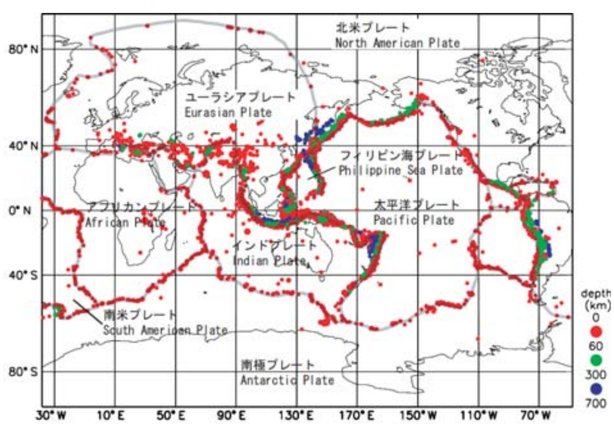

Fig.2 Earthquake Focus Distribution Magnitude 6.0 or Greater

There are mainly two different mechanisms that cause earthquakes in Japan;

1) Earthquakes generated near convergent boundaries

Earthquakes occur when the continental plates, i.e.) Eurasian Plate or North American Plate bounce back from the tension by the subduction of oceanic plates, i.e.) Philippine Sea Plate or Pacific Plate.

2)Earthquakes generated by active faults

Should these earthquakes occur right under cities, they cause enormous damage even if their magnitudes are insignificant.

3. FRAMEWORKS OF EARTHQUAKE DISASTER COUNTERMEASURES

3.1 Disaster Countermeasures Basic Act

The act was enacted in 1961 and has reflected lessons learnt in earthquakes since then. It states obligations, authorities and/or responsibilities of the central government, local governments, public utilities and citizens. It mandates that central government should establish CDMC comprising the prime minister as chairperson, other ministers and several other members, and that local governments should establish similar councils so that disaster management is organized in an integrated manner. Furthermore, it requires CDMC to formulate Basic Disaster Management Plan and disaster management entities such as central government ministries and agencies, local governments and public utilities to formulate Disaster Management Operation Plan or Local Disaster Management Plan to promote disaster management in a well-planned manner.

3.2 Act on Special Measures for Earthquake Disaster Countermeasures

In 1995, the Great Hanshin-Awaji Earthquake occurred and caused devastating damage. As a result, the Act on Special Measures for Earthquake Disaster Countermeasures was enacted to promote preparation for earthquakes that occur anywhere in Japan. The act encourages governors of local prefectural governments, in consultation with mayors of municipal governments to formulate a 5 year plan of building and/or improving facilities of urgent priority in view of earthquake disaster management. All prefectural governments have been pursuing further improvements since 2006, the beginning of 3rd 5 year plan. Financial assistance from the central government is available to certain types of facilities scheduled in the 5 year plans.

3.3 Countermeasures against Large-scale Earthquakes

Measures against devastating large-scale earthquakes are considered individually by the CDMC according to the flowchart depicted in Fig.3 [3]. Measures against the following earthquakes, illustrated in Fig.4 [3] were or have been considered;

- Tokai Earthquake
- Tonankai and Nankai Earthquakes
- Trench type Earthquakes in the Vicinity of the Japan and Chisima Trenches
- Tokyo Inland Earthquakes
- Chubu and Kinki Inland Earthquakes

Firstly, things that determine characteristics of earthquakes are determined, such as earthquake focuses and earthquake models. Then, seismic intensity distribution is estimated. With the seismic intensity distribution as an input, the number of collapsed buildings, death toll and economic loss are estimated. Based on the damage estimates, Policy Framework which serves as a master-plan covering disaster preparedness, emergency response and recovery is formulated. Following the Policy Framework, Earthquake Disaster Reduction Strategy and Guidelines for Emergency Response Activities are formulated. The former stipulates quantitative disaster reduction objectives and specific measures to achieve them. The latter is a set of guidelines for emergency response activities by organizations concerned. Specific Plan for Emergency Response Activities specifies emergency response activities such as dispatch of search and rescue units, and shipment of emergency goods of predetermined quantity region by region based on the damage estimates. This enables emergency response activities to be implemented as soon as devastating earthquakes occur even when no detailed information on the damage is available. The emergency response activities will be adjusted as more information becomes available.

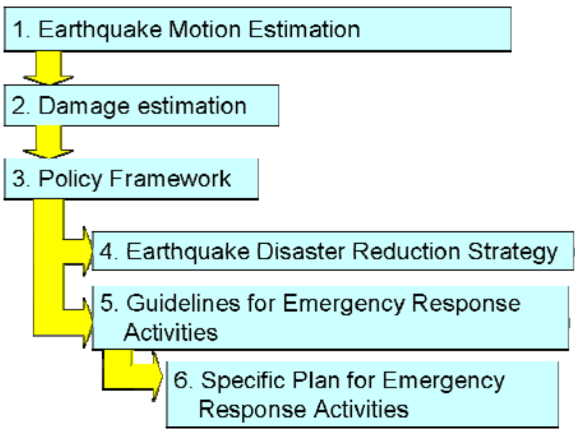

Fig.3 Flowchart of Formulation of Countermeasures against Large-scale Earthquakes

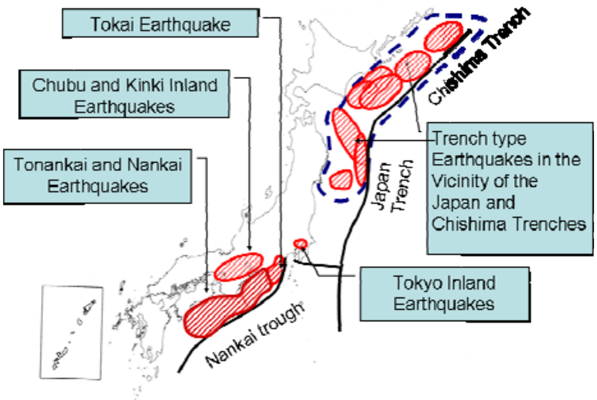

Fig.4 Large-scale Earthquakes

4. COUNTERMEASURES AGAINST TOKYO INLAND EARTHQUAKES

The largest earthquake which struck Tokyo metropolitan area within a century is the Great Kanto Earthquake in 1923 measuring 7.9 magnitude. This caused tremendous damage, totaling more than 100,000 deaths and missing persons combined. Earthquakes with magnitude of around 8 occur periodically at intervals of 200 to 300 years in the area. It is unlikely that an earthquake of this magnitude will occur in 100 years however inland earthquakes of magnitude 7 class occur several times between two magnitude 8 class earthquakes. Therefore, countermeasures against Tokyo Inland Earthquakes of magnitude 7 class have been considered according to the flowchart outlined in 3.2.

An earthquake was selected, out of 18 simulated earthquakes as a target to consider countermeasures against because it is relatively imminent, it strikes central Tokyo heavily and the impacts widespread as illustrated in Fig. 5 [4]. As a result of the earthquake, it is estimated that 850,000 buildings could collapse or burn down, and that 11,000 people could die in the disaster. Economic loss is estimated to reach 112 trillion yen (approximately 1.12 trillion US dollars).

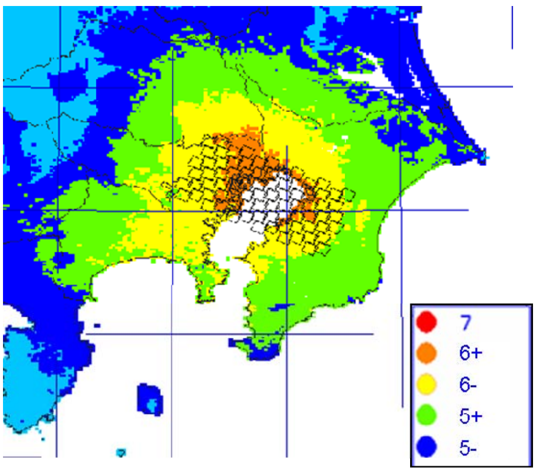

Fig.5 Seismic Intensity Distribution
Tokyo Inland Earthquake

Policy Framework which serves as a master-plan covering disaster preparedness, emergency response and recovery was formulated in 2005 and sets policy direction to reduce the influence of the disruption of functions as the political, administrative and economic center, and the influence of enormous damage. Earthquake Disaster Reduction Strategy was formulated in 2006 and stipulates quantitative disaster reduction objectives, which are to reduce the estimated death toll by 50% and economic loss by 40% in 10 years. It also stipulates specific measures to achieve the disaster reduction objectives.

Specific Plan for Emergency Response Activities was recently formulated in 2008 following Guidelines for Emergency Response Activities formulated in 2006 which is a set of guidelines for emergency response activities by organizations concerned.
Specific Plan for Emergency Response Activities specifies emergency response activities such as the dispatch of search and rescue units, and the shipment of emergency goods of predetermined quantity, region by region based on the damage estimates. This enables emergency response activities to be implemented as soon as devastating earthquakes occur even when no detailed information on the damage is available. The emergency response activities will be adjusted as more information becomes available. Fig. 6 and 7 [5] show the Specific Plan for Emergency Response Activities.

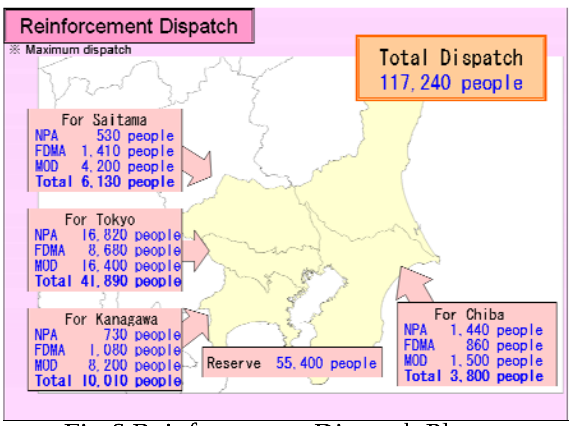

Fig.6 Reinforcement Dispatch Plan, Specific Plan for Emergency Response Activities

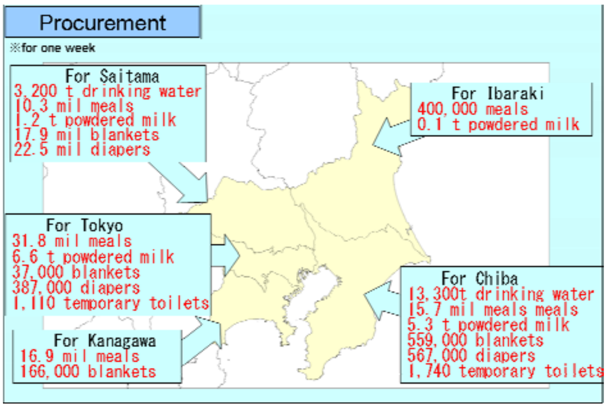

Fig.7 Procurement Plan,
Specific Plan for Emergency Response Activities

5. MEASURES FOR EVACUEES AND THE STRANDED

The Tokyo Inland Earthquake is estimated to devastate the area forcing up to 7 million people to evacuate home, 4.6 million of them need shelters, and affecting 14 million people certain distance away from home, 6.5 million of them would find it difficult to walk such a long distance home. The Policy Framework for Tokyo Inland Earthquakes referes to this problem leaving specific measurs for evacuees and the stranded to be considered. A committee to work on problems as a result of the massive evacuees and the stranded was established and produced a report which anylizes problems quantitatively and proposes measures.

5.1 Measures for Evacuees

There will be shortage of shelters for 600,000 evacuees in total provided that each Ward of Tokyo needs to accommodate evacuees from its residents. A first thing to be considered to cope with the shelter shortage is to reduce the number of evacuees needing shelters. One of the proposed measure is to examine promptly if the buildings are safe from collapse by aftershocks and to encourage evacuees to return home whose housing is proved to be safe. It is also proposed that evacuees be encouraged to find shelters at parents', relatives' or places offered outside of the area if possible. For the supply side, it is proposed that each Ward make use of public and private facilities to ensure capacity in its district and to coordinate evacuation with other Wards. Furthermore, measures related to the supply of essentials, operation of shelters and provision of useful information for evacuees are referred to in the Policy Framework.

5.2 Measures Concerning Temporary Emergency Dwellings

If the Tokyo Inland Earthquake occurs, it is estimated that up to 1.62 million temporary emergency dwellings is demanded in the region. It is estimated that housing for about 1.35 million households can be arranged 6 months after the earthquake, 120,000 of them by temporary housing, 310,000 by repairing damaged dwellings, 2,000 by public housing, and 920,000 by undamaged private houses and apartments for let in the region, which falls short

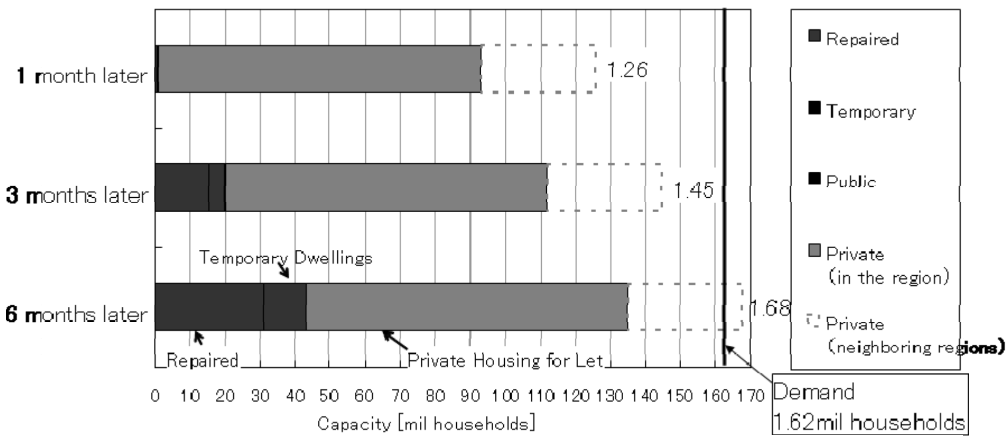

Fig.8 Supply of Temporary Emergency Dwellings

of the demand by 270,000 households. Thus, it seems difficult to meet the demand in the region alone. Capacity for 330,000 households found in the neighboring regions could fill the gap as illustrated in Fig. 8 [6]. Thus, it is important to make arrangements such that damaged dwellings will be repaired promptly, provisionally or permanently so that evacuees could return home, vacant capacity, public or private will be made available, and emergency temporary housing will be provided.

5.3 Measures for the Stranded

As for the stranded, simulations were implemented to understand their behaviors, degree of road congestion caused by the stranded, time it takes for the stranded to return home on foot, and the like. The simulation model was developed using a random utility model and road network model. The random utility function assumes that people choose the option which gives the highest expected utility, i.e.) either to stay where they are, to go home on foot, to take a rest at a shelter, or to keep walking. The model also incorporates factors such as the availability of information about the family and their safety, distance to home, and degree of congestion. The utility function was derived from answers to 24,500 questions from 200 examinees.

The simulation was implemented to see the effects of the following factors;

- types of available roads, trunk roads with/without semi-trunk roads
- weather
- bottlenecks of roads
- building collapse
- fire
- availability of information on road congestion
- time taken to obtain information on family
- time to commence returning home

The simulation suggests that without any measures to alleviate, roads will be terribly crowded (more than 6 people / ㎡ which is almost as crowded as trains during rush hours in Japan) as illustrated in Fig. 9, 10 [6] and as many as 2 million people will have to undergo this terrible congestion for more than 3 hours. This naturally leads to concerns that not a few people may need medical attention and that there will be huge demand for rest rooms and places for rest on their way home. Some policy implications are also derived from the simulations. The number of people stranded in a heavy congestion for more than 3 hours is reduced to;

-50% or 25% respectively if 1/3 or half of the stranded commence returning home next day,

-80% or 2/3 respectively if staggered return is arranged within 3 hours or 6 hours,

- 90% if the information on the family is available in 6 hours instead of 24 hours,
- 40% if the information on the road congestion is available,
- 30% if there is no fire or building collapse.

Based on the findings, measures for the stranded are proposed. It is extremely dangerous for the stranded to head home at once as this overcrowds roads and places near railway stations, and increases chances of being involved in mass falling and of dying from fire and falling objects. Also, this clogs roads and impedes emergency response such as search and rescue, fire fighting, emergency shipment and medical transfer. It should become widely known that it is important that people refrain from heading home immediately and things be arranged so that family safety could be confirmed promptly when disasters occur. It is also proposed that companies and schools be prepared for and arrange things for their employees and students to stay there for a while to allow for their return on the following day and staggered return. It should be arranged such that information on roads is readily available for the stranded.

In addition, assistance for the stranded returning home on foot is proposed including traffic restricting and directing at dangerous and/or congested areas, provision of information on roads, medical assistance, and places for rest on their way home. Local authorities are encouraged to coordinate the assistance.

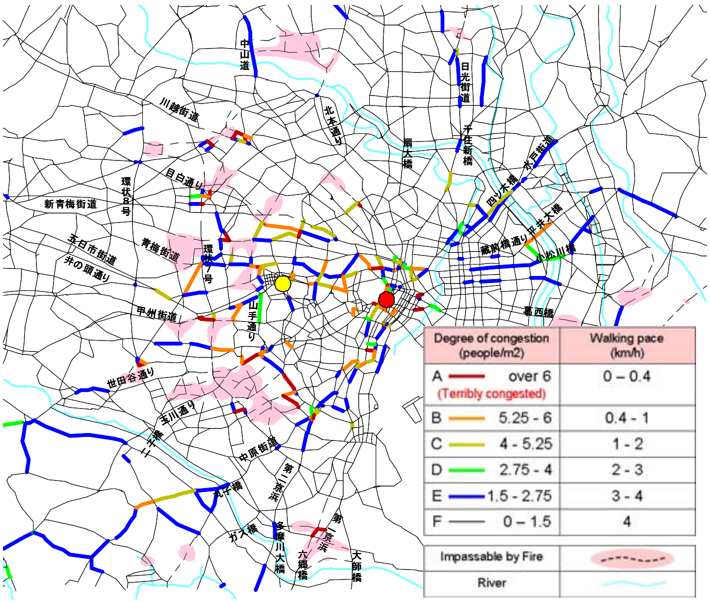

Fig.9 Road Network and its Congestion (3 hours after the earthquake)

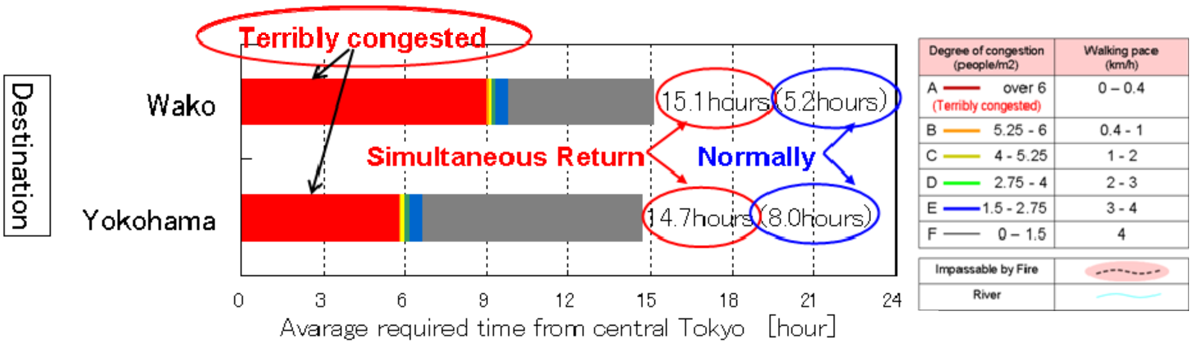

Fig.10 Degree of Congestion and its Duration to Destinations

5.4 Measures for Shortage of Rest Rooms

Demand for rest rooms and places for rest will be enormous as both evacuees and the stranded need them.

Supply of and demand for rest rooms were estimated based on the results from the simulation to understand the behaviors of the stranded.

Demand was estimated based on the frequency per hour of passersby and evacuees, which are assumed to be 0.5 times /hour/person and 5 times/24 hours/person respectively from literature review.

Supply was estimated based on the number of rest rooms for emergency use and fixed rest rooms at places such as convenience stores, gas stations, restaurants, shelters and public space in 23 Wards of Tokyo under certain assumptions allowing for their capacity and availability/hour, and disruption of water supply.

Fig. 11 illustrates the demand-supply gap of rest rooms along route 246 in Setagaya Ward. Shortage of rest rooms could continue for 17 hours [7].

It is proposed that local authorities stockpile portable rest rooms and make necessary arrangements such that the stranded could use rest rooms of public and private facilities.

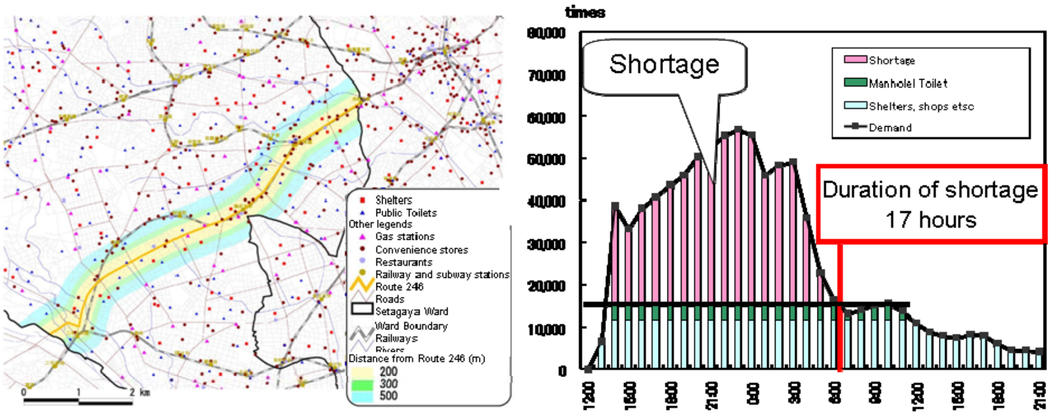

Fig.11 Shortage of Rest Rooms

6. BUILDING QUAKE-PROOFING

In Great Hanshin-Awaji Earthquake, it was reported that 83.3% of 5,500 [8] deaths immediately after the earthquake were caused by building collapse and/or furniture falling. It is estimated that 4,200 people die due to building collapse in a Tokyo Inland Earthquake provided that the earthquake occurs at 5 o'clock in the morning according to damage estimation undertake by CDMC. It became clear from series of damage estimations that building collapse not only causes deaths but also facilitates outbreak and spread of fire, generates evacuees, impedes search and rescue, and generates debris. Thus, building quake-proofing has been considered and promoted as a high priority in earthquake disaster management.
Objectives of building quake-proofing are summarized in table1 [9], [10].

6.1 Acts Related to Earthquake Resistance of Buildings

In addition to the Act on Special Measures for Earthquake Disaster Countermeasures outlined in 3.2, following acts are also related to earthquake resistance of buildings;

a) Building Standard Law
The law stipulates minimum standards on building sites, structures, facilities and use to protect lives, health and properties of the citizens. The law was enacted in 1950 and has been amended. The Earthquake Resistance Standards based on the law have been amended in response to major earthquakes. The epoch-making amendments to the Standards which have served as a basis of the current Standards were introduced in 1981 and have been called "New Earthquake Resistance Standards". Standard was introduced that buildings must be designed so as not to collapse completely after being struck by an earthquake of seismic intensity 6+ to 7, to the then-existing standard that buildings must be designed to maintain sound structure after being struck by an earthquake of seismic intensity 5+.

Table1 Objectives of Quake-proofing

Use	Proportion of buildings with earthquake resistance	Objective
Buildings	75% (2003)	Raising the proportion to 90% by 2015
Public elementary and junior high schools	58.6% (2007)	Quake-proofing 10,000 schools with high possibility of collapse by FY2011
Hospitals	43% (2005)	Quake-proofing 50% of hospitals with insufficient earthquake resistance by FY2010

The law also stipulates that buildings must be examined before the commencement of, during the construction of and after the completion of the buildings to ensure that the buildings are built in conformity with related acts.

b) Housing Quality Assurance Act

This act was enacted in 2000 to assure the quality of housing, to protect the interests of housing purchasers and to settle disputes related to housing swiftly and properly by introducing the following schemes;

-Warranty against defects

Contractors and vendors of new housing are held liable for warranty against defects affecting the structural performance for at least 10 years.

-Housing Performance Indication System

Housing Performance Indication Standards have been introduced to enable would-be purchasers to compare housing performance before contract and third party institutions have been established to evaluate the performance indicators.

-Dispute settlement scheme

c) Act for Execution of Defect Warranty Liability under Housing Quality Assurance Act

This act was enacted to mandate that contractors and vendors of new housing should either deposit the sum according to the number of housing supply or contract insurance to ensure funding necessary to redeem warranty against defects for 10 years stipulated in the Housing Quality Assurance Act.

d) Act on Promotion of the Earthquake-proof Retrofit of Buildings

This act is to enhance building safety by promoting earthquake-proof retrofit of building to protect lives, safety and properties of the citizens from building collapse.

The act was amended in 2006 to promote quake-proofing buildings further. One of the major amendments was the introduction of a scheme that the central government formulates basic guidelines and each local government formulates a plan based on the guidelines to promote the building earthquake resistance evaluation and building quake-proofing. It was also stipulated that local governments may announce that owners of designated buildings instructed to have them examined and/or quake-proofed fail to do so.

6.2 Assistance

Financial assistance available to earthquake resistance evaluation and building quake-proofing has been expanded as in table 2 [11].

Table2 Assistance Scheme for Building Quake Proofing

Measures	Subsidy rates and conditions
Evaluation	-Undertaken by private sector 2/3 -Undertaken by public sector Residence 1/2, Others 1/3 (Buildings on emergency transportation roads 1/2)
Quake-proofing	・Entitled buildings -Single family homes in built up areas whose collapse may cause road blocks -Collective housing and non-residential buildings in densely inhabited areas -Single family homes with income less than 40 percentile ・Subsidy rate 15.2% (undertaken by private sector) The rate is increased to -2/3 for buildings on emergency transportation roads -2/3 for buildings used as shelters -1/3 for Collective housing on evacuation routes - 23% for single family homes with income less than 40 percentile

Quake-proofing promotion tax incentives are also in effect [11].

Residential buildings
-10% of expense up to 200,000 yen (approx. 2,000 USD) is deductible from income tax subject to certain conditions
-Real estate tax (up to 120m2 equivalence) is reduced to 50% for the duration of;
3 years if the building is quake-proofed between 2006 and 2009
2 yeas if the building is quake-proofed between 2010 and 2012
1 year if the building is quake-proofed between 2013 and 2015

Commercial buildings
10% of expense for quake-proofing may be added to tax depreciation for the initial year for income and corporate taxes.

6.3 Earthquake Insurance System
Fire insurance does not cover losses by fire caused by earthquakes and losses expanded by earthquakes. Earthquake insurance optional rider to fire insurance is necessary for these losses to be covered. The central government reinsures part of the risk borne by insurers of earthquake insurance and manages funds in a special account to pay insurance in case devastating earthquakes occur which private insurers alone are unable to insure.
Earthquake insurance only covers residential buildings and household goods. Insurance premium is calculated according to the structures and locations of insured buildings and buildings accommodating insured household goods. Insurance premium per insurance payment of 10 million yen is from 5,000 yen (approx. 50 USD) to 31,300 yen (approx. 313 USD) per annum. Discount is available as follows:
-10% for buildings built after June 1st 1981,
-10%, 20%, 30% for buildings of earthquake resistance grade 1, 2 and 3 respectively according to the Housing Performance Indication Standards stipulated in Housing Quality Assurance Act or guidelines for earthquake resistance evaluation formulated by MLITT,
-30% for seismic isolated buildings defined in Housing Quality Assurance Act,
-10% for buildings proved to meet Earthquake Resistance Standards stipulated in Building Standard Law.
Furthermore, insurance premium is deductible from income tax (up to 50,000 yen) and residential tax (up to 25,000 yen) [12].

6.4 Public School Quake-proofing
Act on Special Measures for Earthquake Disaster Countermeasures presented in 3.2 was amended in 2008 and subsidy rates have been raised from 1/2 to 2/3 for reinforcing public schools and from 1/3 to 1/2 for rebuilding public schools if inevitable. It has been mandated that municipalities evaluate the earthquake resistance of schools and announce the results.
In addition, 280 billion yen (approx. 2.8 billion USD) in total was appropriated in the first and second supplementary budgets for FY2008 and initial budget for FY2009. Quake-proofing 10,000 building with high possibility of collapse have been rescheduled to be completed by FY2011, one year earlier than previous schedule [10].

6.5 Hospital Quake-proofing
Financial assistance for hospital quake-proofing has been increased as follows;
- Private hospitals designated as a disaster base hospital: from 1/3 to 1/2
- Other private hospitals scheduled in 5 year plans based on the Act on Special Measures for Earthquake Disaster Countermeasures: from 1/3 to 1/2
- Public hospitals designated as a disaster base hospital: from 60% to 65%
- Other public hospitals scheduled in 5 year plans based on the Act on Special Measures for Earthquake Disaster Countermeasures for earthquake disaster countermeasures: from 30% to 65%

7. EARTHQUAKE EARLY WARNING

7.1 Purpose and Mechanism of EEW
Earthquake Early Warning (EEW) is to provide the public with the warning of earthquakes so that the public could take precautions before the

secondary wave arrives. First, a seismograph near the earthquake focus, out of 1,000 seismographs all over Japan detects quakes by the primary wave. The wave is then analyzed to estimate the location of the earthquake focus and its magnitude. Then, the distribution of seismic intensity is predicted. EEW is issued for the general public if the maximum predicted seismic intensity reaches 5- and more than one seismograph detect the earthquake. EEW is also issued for Specific Users who wish to receive the warning as soon as possible and understand its limitation if the predicted magnitude is greater than or equal to 3.5 or the maximum predicted seismic intensity is greater than or equal to 3.

Fig. 12 illustrates how EEW works [13].

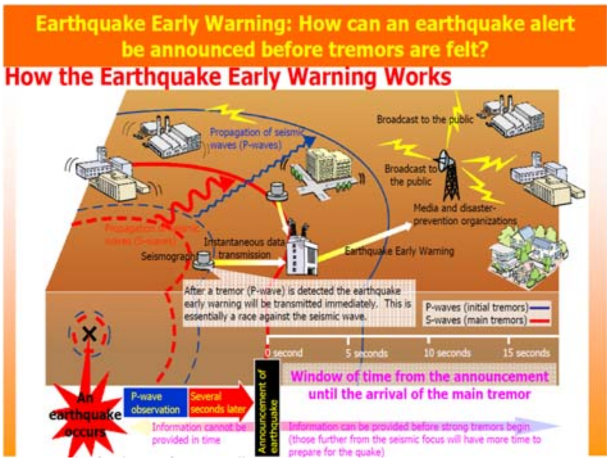

Fig.12 Outline of Earthquake Early Warning

7.2 User Response to EEW in Actual Earthquakes

EEW has been in operation for Specific Users since August 2006 and for the general public since October 2007 respectively. EEW has been issued for the general public against 9 earthquakes and for Specific Users against more than 1,600 earthquakes respectively.

A survey was conducted against offices located in Tohoku area where two large earthquakes struck in 2008, Iwate-Miyagi inland earthquake with magnitude 7.2 and maximum seismic intensity 6+ and Iwate northern coast earthquake with magnitude 6.8 and maximum seismic intensity 6-. This is undertaken to understand the perception of and actual response to EEW.

In the case of Iwate-Miyagi inland earthquake, EEW was issued for the Specific Users and for the general public 3.5 seconds and 4.5 seconds after the earthquake was first detected respectively. Fig. 13 illustrates the time between the issue of EEW and the arrival of the secondary wave. The EEW did not arrive before the secondary wave in regions near the earthquake focus however it was in time in other regions. Precautions were taken in response to EEW such as halting machines or elevators in factories, alerting employees, and having children under desks at a kindergarten.

In the case of Iwate northern coast earthquake,

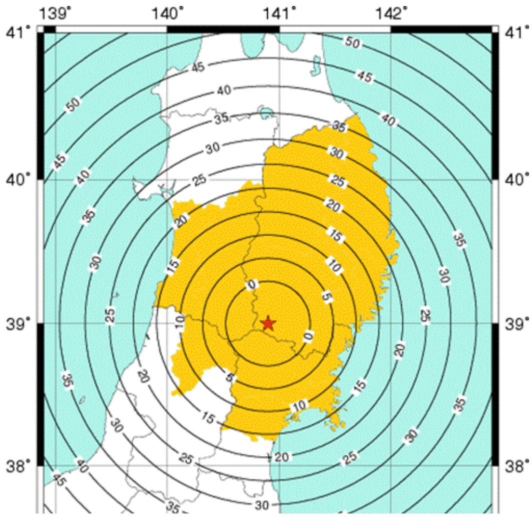

Fig.13 Time between the issue of EEW and the arrival of the secondary wave in Iwate-Miyagi Inland Earthquake

the percentage of people who took precautions was slightly less than Iwate-Miyagi inland earthquake as Iwate northern coast earthquake occurred at midnight. EEW was issued for the Specific Users after 4.1 seconds however EEW was not issued for the general public until 20.8 seconds after the earthquake. This was because maximum predicted seismic intensity did not reach the criterion, seismic intensity of 5- until then.

JMA has established a working group to improve EEW so that EEW would be more accurate and issued sooner.

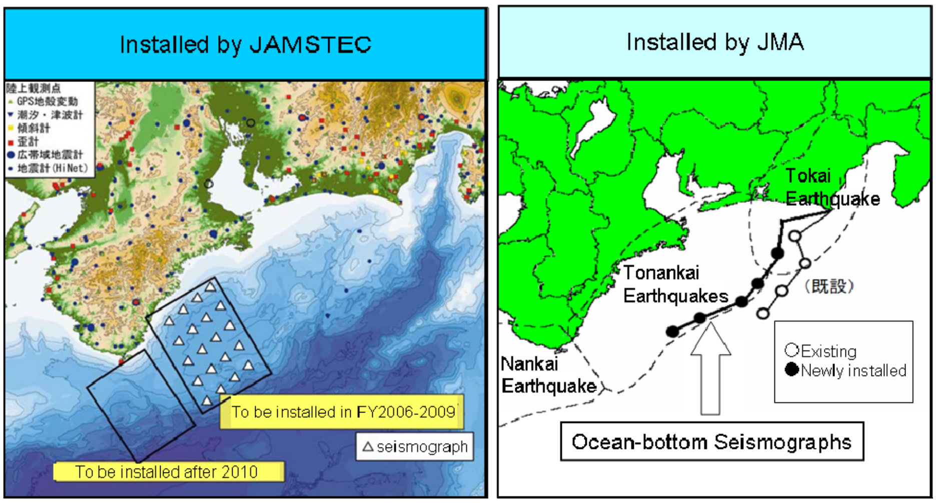

Fig.14 Ocean-bottom Seismographs and Tsunami Gauges

7.3 Ocean-bottom Seismographs and Tsunami Gauges

Ocean-bottom seismographs and tsunami gauges have been installed in assumed focal areas of Tokai Earthquake, and Tokai and Tonankai Earthquakes as in Fig.14. The ocean-bottom seismographs are to detect earthquakes which occur under the ocean at the depth of 1-2 km and the tsunami gauges are to detect tsunamis generated by earthquakes measuring the difference in the water pressure coming from the fluctuation of the ocean surface at the bottom. This is expected to detect earthquakes immediately and facilitate more accurate and prompt EEW against earthquakes under the ocean and tsunami warnings/advisories respectively. Also, this is expected to help understand details of earthquakes under the ocean, enhance the capacity to watch the signs of Tokai Earthquake, and contribute to the understanding of the mechanism of Tokai and Tonankai Earthquakes.

8. DISASTER MANAGEMENT INFORMATION SYSTEMS

8.1 Disaster Information System

The development of Disaster Information System (DIS) dates back to 1995 when the Great Hanshin-Awaji Earthquake struck Japan. In addition to the extensive damage and disrupted means of communication and transportation, the lack of framework to report and share information made it difficult and time-consuming to collect and share information necessary for effective emergency response activities. Various initiatives have been undertaken to improve disaster management since then. One of such initiatives is the development of an IT system to estimate damage with only the data available beforehand and observed seismic intensities transmitted soon after earthquakes occur to help organize and initiate emergency response activities.

When an earthquake occurs, seismic inteinsities observed by seismographs of about 4,300 all over Japan are transmitted to DIS. If the maximum seismic intensity reaches 4, DIS is initiated automatically. Firstly, observed seismic intensities are transformed into velocities of the secondary waves on the surface, which are in turn transformed into velocities at the seismic bedrock with site amplification calculated beforehand from geological data. Then, distribution of velocities at the seismic bedrock are estimated for areas of 1 square kilometers based on the transformed velocities. The distribution of seismic intensities are estimated from the disitributon of velocities at the seismic bedrock backwards. Then, the number of collapsed buildings is estimated from the distribution of seismic intensities and the relation between rate of collapsed buildings and seismic intensity derived from past earthquakes. Lastly, death toll is estimated from the estimated number of collapsed buildings and the relation between the number of collapsed buildings and the death tolls derived from past earthquakes. Although it depends on the scales of earthquakes, the estimation is completed about 10 minutes after the earthquakes occur. The results are then transmitted to central government ministries and agencies.

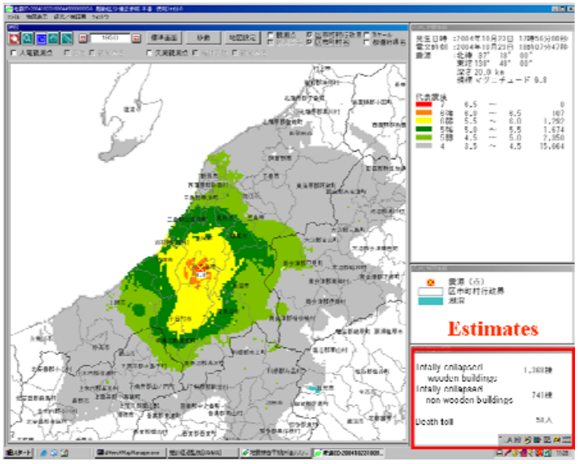

Fig.15 Distribution of seismic intensities estimated by DIS

8.2 Disaster Information Sharing Platform

Disaster Information Sharing Platform is to consolidate disaster informaiton gathered by organizations responsible for disaster management on a base map using Geographical Information System and share the information among central government ministries and agencies. It has been developed since 2005.

Differenct pieces of informaiton from different organizations are stored on different layers. This enables users to choose layers of their interests and have them overlaid and displayed. In this way, information is used and shared easily and graphically.

The information is transmitted to the Platform automatically without data entry by integrating systems wherever possible. Keeping the workload of information transmission such as data entry minimum releases valuable resources for other activities in time of emergency, which is one of the main objectives of the Platform.

Information on the following items is currently available on the Platform.

- Weather
- Estimated distribution of seismic intensities and damage
- Satellite images
- Disruption of electricity and gas supply in certain regions
- Rivers

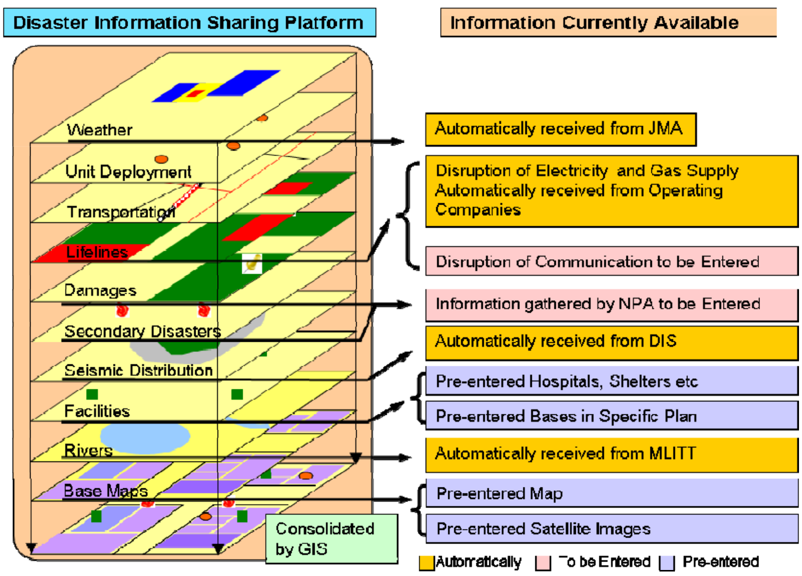

Fig.16 Information currently available on Disaster Information Sharing Platform

In addition, the number of casualties and damaged buildings, and disruption of communication facilities can be entered in the Platform.
Other information will be further consolidated on the Platform automatically by integrating IT systems managed by other organizations as far as possible.

9. CONCLUSION

This paper presented earthquake disaster management in Japan. Japan has suffered from earthquakes as large earthquakes occur anywhere at anytime in Japan. Disaster management has been promoted in an integrated and well-planned manner according to the Disaster Countermeasures Basic Act and facility improvement in preparation for earthquakes has been furthered according to 5 year plans based on the Act on Special Measures for Earthquake Disaster Countermeasures. On the other hand, comprehensive measures have been considered and undertaken against imminent devastating large-scale earthquakes individually. Tokyo Inland Earthquakes above all, striking Tokyo, is estimated to cause tremendous damage. Reducing the damage and maintaining political, administrative and economic functions as the Capital are two pillars of disaster management stated in the Policy Framework. Measures against Tokyo Inland Earthquakes have been promoted according to Earthquake Disaster Reduction Strategy. In addition, continuity of operation plans and business continuity plans, Specific Plan for Emergency Response Activities have been formulated to ensure administrative and business operation, and prompt and efficient emergency response to earthquakes.
The central government has institutionalized building earthquake resistance by legislation, increased subsidy rates appropriating supplementary budget for FY 2008 in addition to initial budget, and has arranged tax incentives to strongly promote building quake-proofing.

In addition to the measures proposed for massive evacuees and the stranded generated by Tokyo Inland Earthquakes, there are still some issues to be worked on. For example, measures should be coordinated by the central government, local governments and media to gather, share and provide information for those who need it such as the evacuees and the stranded. Also, schemes should be arranged for organizations concerned to coordinate wide-area evacuation.

While all levels of governments play important roles in disaster management, the disaster management also requires for every single member of the society to be involved, play its part and help each other for better respond to disasters.
Specifically, each person should prepare for and take actions against disasters by doing things such as quake-proofing the home, fixing furniture to prevent it from falling to avoid being hurt, stockpiling emergency goods, food and water enough for the first few days, and examining ways to shelters.
Actions should be taken to encourage local communities to restore and strengthen the solidarity, to facilitate involvement of volunteers in disaster management, to expand and strengthen voluntary disaster prevention units of local communities, to encourage private companies to provide assistance for local communities and to encourage those individuals and groups to coordinate their initiatives to maximize disaster management capacity.
In addition to its disaster management, the central government has arranged measures to support these activities by arranging things such as various assistance scheme for building quake-proofing and EEW. It is extremely important that these activities should be furthered to strengthen disaster resistance of the country.

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