



## LESSONS LEARNT FROM RESPONSE AND RECONSTRUCTION ACTIVITIES AFTER THE 2011 GREAT EAST JAPAN EARTHQUAKE

K. Meguro<sup>(1)</sup>

(1) Director/Professor, International Center for Urban Safety Engineering (ICUS), Institute of Industrial Science (IIS), The University of Tokyo (UTokyo), [meguro@iis.u-tokyo.ac.jp](mailto:meguro@iis.u-tokyo.ac.jp)

### **Abstract**

Nine years have passed since the 2011 Great East Japan Earthquake (GEJ Earthquake) and many recovery activities have been undertaken in affected areas. In some of them, recovery activities are completed, but in many areas, especially in Fukushima Prefecture, people are still in the process of recovery, and they are facing many issues. This earthquake revealed that the highly dependent concentration and dispersion of the cities and industrial systems we have developed increase disaster vulnerability, contrary to the efficiency achieved in normal times. Tokyo Metropolitan Inland Earthquake (TMI Earthquake) and Gigantic Earthquakes along the Nankai Trough (NTG Earthquakes: Tokai, To-nankai, Nankai, and their interlocking earthquakes), which might happen by the middle of the 21st century, are likely to cause much more severe damage than the GEJ Earthquake. The reason is not only due to the magnitude of the earthquake but also due to the characteristics of the potentially affected areas. For example, the Tokai, To-nankai, and Nankai earthquakes are expected to happen closer to land than the GEJ Earthquake, and large cities in the Pacific coast are located in low-lying areas with a high risk of strong ground motion and Tsunami. In addition to these cities, in the Tokyo Metropolitan region, there are many areas with densely distributed wooden houses, where there is high risk of spread of fires. Moreover, in the Gulf region, besides high potential of soil liquefaction, there are many facilities, such as thermal power stations and various plants including oil complexes, which are vulnerable to long-period ground motion. In this paper, I would like to introduce the lessons and issues that I consider important to establish better disaster management measures for these mega earthquakes, based on the response and reconstruction activities after the 2011 GEJ Earthquake.

*Keywords: the 2011 Great East Japan Earthquake and Tsunami, response and reconstruction activity, issue and lesson*



## 1. Introduction

Nine years have passed since the Great East-Japan Earthquake (GEJ Earthquake) that occurred at 14:46 (local time) on March 11, 2011. This was the largest earthquake scientifically observed in Japan, with a moment magnitude of 9.0. The earthquake caused devastating damage called "Great East Japan Earthquake and Tsunami Disaster" that spread widely in Japan, especially in East Japan. In particular, a Tsunami with a maximum run-up height of over 40 meters hit the coastal area of East Japan, killing more than 18,000 people shortly after. Tsunami countermeasures, especially structural measures constructed based on the past experiences, such as breakwaters and seawalls prepared in the stricken area could not stop the Tsunami attack. Showing footage of these collapsed facilities, mass media had explained that these time-consuming and expensive Tsunami facilities did not perform as expected, and many people believed their explanation. However, I reported in a 16WCEE paper [1] that these were incorrect based on quantitative analysis.

Lots of recovery and reconstruction activities have been carried out in the affected areas, and in some areas these activities were already completed. However, there are still some areas under the process of recovery. Especially in Fukushima Prefecture, where the accident involving Tokyo Electric Power Company's Fukushima Daiichi (First) Nuclear Power Station happened, there have been facing many problems.

This earthquake revealed that the highly interdependent relationships of the cities and industrial systems that we have developed increase the vulnerability of disasters despite the efficiency in peaceful times. Tokyo Metropolitan Inland Earthquake (TMI Earthquake) and gigantic earthquakes along the Nankai Trough (NTG Earthquakes), which may occur by the middle of the 21st century, can cause damage far more severe than the GEJ Earthquake. The reason is not only due to the magnitude of the earthquake, but also due to the characteristics of the region that may be affected. For example, the NTG Earthquakes are expected to occur closer to land than the GEJ Earthquake, and large cities along the Pacific coast are located in lowlands where the risk of severe ground motion, soil liquefaction and Tsunami is very high. In addition to these cities, in the Tokyo Metropolitan area, there are many densely distributed wooden houses, resulting in high risk of fire spreading. Moreover, in the Gulf region, besides the high potential for soil liquefaction, there are many facilities that are susceptible to long-period ground motion, such as thermal power stations and various plants, including petroleum complexes. In this paper, I would like to introduce lessons and issues that I consider important for establishing better disaster preparedness for these earthquakes based on the response and reconstruction activities after the 2011 GEJ Earthquake.

## 2. My proposed vision of reconstruction and four principles

On March 12, the next day of the GEJ Earthquake, I was asked come to the Cabinet Office's National Strategy Office through an acquaintance, and I joined the meeting held on March 13, two days after the quake. I was asked give them my opinion on how the disaster would progress in the future and on how the government should respond to it. At that time, I talked about various things as described in the next chapter, but based on the second meeting three days later (March 16), I summarized the vision of reconstruction as shown in Fig. 1.

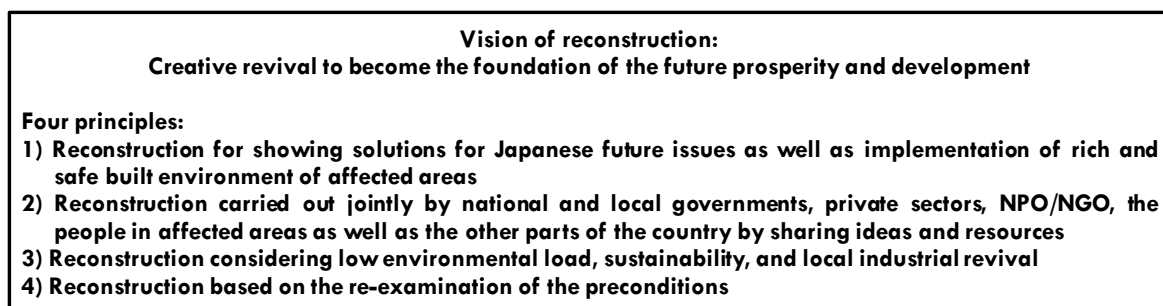


Fig. 1 My proposed vision of reconstruction from the 2011 GEJ Earthquake and Tsunami disaster



I will explain the contents briefly. First of all, as the social environment and the situation are changing drastically, I set "creative reconstruction, that can be the foundation of future prosperity and development," as the goal of reconstruction. And below that I outlined the four principles. The meaning of each is as follows. The first is that the affected area is far more ahead of the Japanese average in various issues, including the declining birthrate and aging population, etc. Therefore, of course, the first priority is to restore the safe and good living environment in the area, but at the same time it should propose a solution to improve future issues in other areas of Japan. In addition, a large-scale disaster makes the problems that the affected area had before the disaster more evident in a shorter amount of time. Therefore, a disaster is a very unfortunate event that no one wants to have, but if it does happen, we should consider a disaster as an important opportunity and use it to solve the problems that the affected area had. This is the same meaning as the Sendai Declaration "Build Back Better" of the 3rd United Nations World Conference on Disaster Risk Reduction, which will be introduced later. Its meaning is that we should aim at "reconstruction, with the understanding of the problems in advance, and aim to solve them."

The meaning of the second principle is that normal disasters can be managed and recovered by the affected local governments and people, and the national government, but this disaster is not of that scale, therefore, the entire country of Japan should cooperate to provide wisdom and money for support. Needless to say, this is for the disaster-stricken area, but at the same time, it is important for those who provide assistance. Through this assistance, those who are not damaged can have an opportunity to learn about disaster management and response at the actual disaster site. A good example is Nishihara Village in the 2016 Kumamoto Earthquake. Staff dispatched to Higashi-Matsushima City during the 2011 GEJ Earthquake have been actively and efficiently responding to the Kumamoto Earthquake. They were engaged in disaster response in Higashi-Matsushima City and built a network with the local government and people. When the Kumamoto Earthquake struck, the Mayor of Nishihara Village returned them from other departments to the disaster management department and they started disaster management. Also, support staff rushed from Higashi-Matsushima City, and they worked together. The third is the literal meaning. The fourth principle is in regret of the fact that the attitude of not examining the assumptions represented by "outside of expectations", and unconditional acceptance of premise and the inability to think about situations different from preconditions, have exacerbated the damage.

### 3. At the Office of National Strategy

At the two meetings of the National Strategy Office immediately after the earthquake, I advised on various points. Specifically, in order to promptly respond to the disaster-stricken areas that have suffered extensive damage and to restore and rebuild, I explained about the Special Office for Reconstruction from the 1923 Great Kanto Earthquake and Mr. Shinpei GOTO's Imperial Capital Reconstruction Plan, Pairing Support System during the recovery from the 2008 Sichuan Earthquake in China, limitations and issues of the Disaster Basic Act of Japan, resetting the mind of survived victims after a large-scale disaster, countermeasures for many people who have difficulty to return home, how to respond to the media and ideal way of information dissemination by media, and how to establish a system for tackling the TMI Earthquake and the NTG Earthquake, among others. This chapter introduces "Pairing Support System" and "Plan of Build Back Better of Capital City Tokyo from the 1923 Great Kanto Earthquake."

#### 3.1 Pairing Support System

Pairing Support System was adopted by the Chinese government in response to the 2008 Sichuan Earthquake. This system was a scheme in which the affected area is divided and for each divided area, responsible municipality for support is determined, and this municipality has responsibility for the long-term recovery and reconstruction of the divided affected area. The advantage of "Pairing Support System" is that the municipality in charge does not need to support multiple areas, but can concentrate on supporting one area. In addition, it becomes easy to create a sense of responsibility in recovery and reconstruction support activities, and a good sense of competition is introduced, and it is easy to improve the quality and shorten the time of recovery and reconstruction activities. Furthermore, municipality that has not been actually damaged,



can gain practical experience in disaster response and management, and this experience will have great significance in future disaster response and management measures.

### 3.2 Plan of Build Back Better of Capital City Tokyo from the 1923 Great Kanto Earthquake

The person who was mainly involved in drafting the reconstruction plan of Capital City Tokyo from the Great Kanto Earthquake disaster was Mr. Shinpei Goto. Mr. Goto was the Minister of the Interior of the Second Yamamoto Cabinet, which was launched on September 2, the day after the earthquake. He started working out a plan from the day after the quake, and first summarized the "Fundamental Measures of Reconstruction of Capital City Tokyo." Among them, he stated followings; "1) do not relocate the capital city, 2) spend 3 billion yen on reconstruction costs (annual budget of the country of Japan at the time was 1.5 billion yen), 3) to create a new city suitable for Japan, adopt the latest urban planning methodology in Europe and United States, and 4) implement new city planning by taking a strong attitude towards the landowners for this purpose."

Based on this idea, by September 9, several proposals were made ranging from 4.1 billion yen to 1 billion yen. Mr. Goto became the Chair of the Special Committee for Reconstruction of Capital City Tokyo from the 1923 Great Kanto Earthquake, which was launched on September 27, reviewed the reconstruction plans, and compiled a plan with the budget of 1.3 billion yen (five-year project), in which construction of underground facilities and high-speed rail were removed. This revised plan was submitted to the Cabinet and it was approved.

Mr. Goto stated "reconstruction (building a better city than before) rather than restoration (recovery to what it used to be)" as the priorities in these series of plans. This was meant to express a sense of drastic city remodeling. He also said that he would adopt the latest methodology of city planning, and that this was very important in reconstruction efforts after a large-scale disaster.

Disaster is not an event that we want to have, but if it does happen, we must take advantage of that opportunity to solve the problems in the affected area and aim for better reconstruction (Build Back Better). Crisis management should not be considered as an extension of normal response. It is important to define what should not be done even in an emergency, and to do everything else in a response. In case of critical situations, considering what can be done by utilizing the current system cannot drastically solve problems, and also becomes inefficient. Furthermore, when the social situation is different from the era when the existing system was established, bigger problems may arise. When we see the reconstruction activities following the GEJ Earthquake, the importance of these ideas can be heartfelt.

By the way, the reason behind Goto's ability to launch the Imperial Capital Reconstruction Plan shortly after the earthquake was the existence of the Tokyo Municipal Government Renewal Outline (Improvement Plan for Capital City Tokyo). While he was the mayor of Tokyo (current Governor of Tokyo, he served until about three months before the earthquake), Tokyo was much less developed than those of Europe and the US. Then, he created a special team composed of most advanced civil engineers, architects, city planners, and economists, etc. and developed several improvement plans for Capital City Tokyo. Just after the 1923 Great Kanto Earthquake, by adding information about the damage due to this earthquake to the plan, he proposed the Imperial Capital Reconstruction Plan. Without prior preparation of a plan, it was impossible to do this and it illustrates the importance of prior discussion and preparation of recovery and reconstruction planning.

Financial resources of reconstruction from the Great Kanto Earthquake disaster depended on the issuance of government bonds and foreign bonds, and the expansion of public finance from the Ministry of Finance's Deposit Department. As relief for the affected people, tax reduction and exemption and postponement of collection were implemented. Financial measures for damaged companies included measures such as re-discounting of bills of the earthquake by the Bank of Japan, but these measures were postponed the reorganization of companies and banks, which were in poor financial condition irrespective of the earthquake, and led to the Showa Financial Depression and the Showa Depression [2]. It is necessary to



pay close attention to the possibility of similar problems that may occur in future catastrophic earthquake disasters and their reconstruction.

## 4. Lessons learned from the response and reconstruction activities after the 2011 GEJ Earthquake

### 4.1 Mind reset of the survived victims

In Japan, when there are missing persons due to a natural disaster, the search and rescue activities are basically continued until the last person is found. However, in the GEJ Earthquake and Tsunami disaster, many victims are washed away to the ocean by the Tsunami, so there is a high possibility that thousands of victims will not be found. In such case, resetting the mind of the survived victim becomes very important. In disaster-affected areas overseas, where a large number of missing people have occurred, people try to search hard for about one week to ten days. But if they still can't find missing victims, a respected person in the community (mostly religious person) gathers survivors and say; "God is thanking you for your hard work in searching for missing victims to date and as the God has already taken them to heaven who have not been found to date. Therefore, you don't have to worry about them anymore. From now, you had better use your energy for you and your children, and for disaster reconstruction." This is a ceremony for resetting the mind of survived victims and it is quite important to change their mind for actively working for recovery and reconstruction. But at the time, I was aware of this importance, but I had no idea who could do it in our country. After that, researchers, politicians, entertainers, athletes, and others entered the stricken area for support and comfort, and developed various activities. Based on my observation of these supporting activities and victims' response, I felt that the people who could do this in a wide area of Japan were His Majesty the Emperor and Empress.

The resetting of the minds of the survived victims is an important issue even in the TMI Earthquake and the NTG Earthquake, where many people are expected to lose their lives, and it is quite necessary to consider how to deal with this problem before the occurrence of these mega earthquakes [3].

### 4.2 Problems for people who have difficulty to return home

After the GEJ Earthquake, as the earthquake occurred at 2:46 pm on a Friday, a working day, many people faced difficulty to return home in the Tokyo Metropolitan area. The media often calls them returning home refugees, but this should be avoided. "Refugees" are those who have been displaced to escape from natural disasters, illness or conflict, and political reasons, and are subject to protection. They are quite different from the people who have difficulty in returning home.

There were no major fires spreading or major power outages in the Tokyo Metropolitan area during the GEJ Earthquake disaster. Also, building damage was minor, and no roads became impassable due to structural damage or collapse of surrounding buildings. Still, a large number of people trying to return home faced difficulty. The situation foreseen at the time of the TMI Earthquake is completely different. The current estimated 6-7 million people who may face difficulty returning home are those who are more than 20 kilometers away from their homes. We should fully understand the danger of walking home long distances under the following conditions. Immediately after the earthquake, there will be many dangerously damaged buildings in the city, and fires will be spreading, roads are cut off here and there, blackouts occur due to power outage at night. As it is difficult to keep in touch due to congestions in communications, families will also be worried. It would be much more constructive to stay in the city center and contribute to improving the disaster situation, rather than dare to go home in a dangerous situation, if the safety of family members and loved ones can be confirmed. However, when they are called refugees, it gives the impression that they cannot become independent without the protection and support of others.

It is impossible to take care of 6-7 million people at once. We should no longer call them "refugees", and establish countermeasures regarding them as "human resources in the affected area." That way, those



who were the target of protection and support will have the role of mitigating the damage. In order to achieve this, it is important to enhance the safety confirmation system in the event of a disaster.

#### 4.3 For continuous and comprehensive support for affected areas

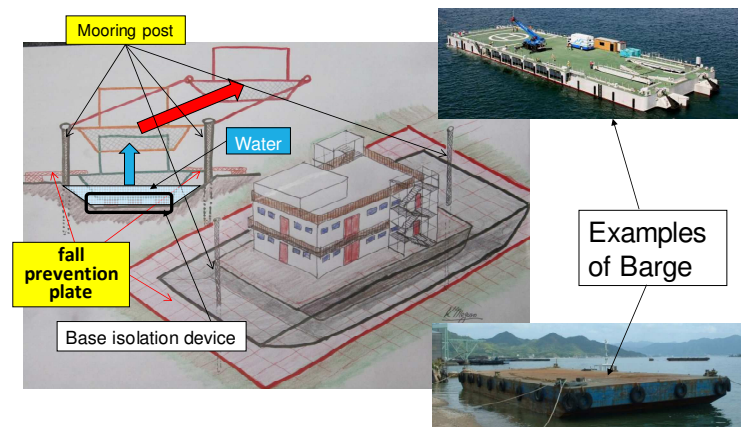
When a large-scale disaster occurs, not only the affected countries but also other countries pay attention to the disaster. Therefore, as part of disaster response, it is important to keep financial measures and economic activities to maintain international trust in the affected countries. This is also important for continuously supporting the affected area in various ways.

In Japan, after disasters, due to feelings of mourning towards stricken areas, people often cancel various ceremonies and events, and stop airing commercials, but this is not good for the stricken area. It is better to ask the stakeholders for assistance in the disaster affected areas after conducting events as usual, and deliver the assistance to the affected areas in the form of like a donation. TV commercials, could be better utilized by saying XX% of the sales will be donated to the disaster-stricken area for their support. We also often refrain from traveling to the stricken area for sightseeing, but this also reduces income for the stricken area and is not helping them. It is important to prevent reputational damages by actively visiting the affected areas and conducting campaigns to purchase crops and products from the affected areas. The mass media should also focus on guiding people to take disaster reducing behavior based on proper predictions by good imagination about the disaster situation, and also prepare programs that give hopes and motivation for life to the affected people.

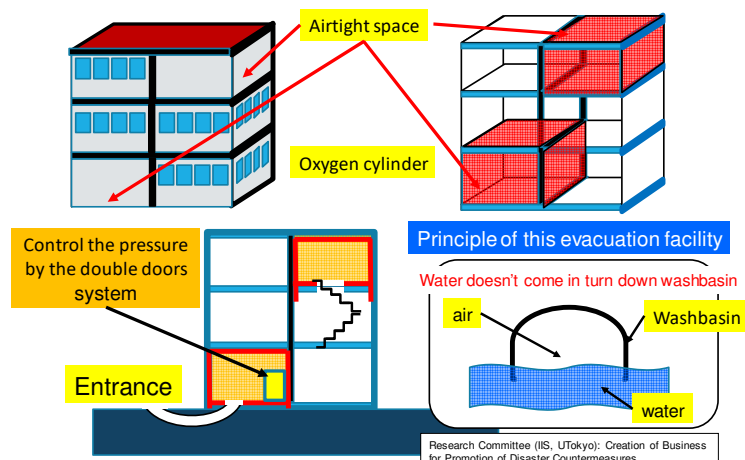
#### 4.4 Reconstruction in times with and without technology

What do you think is the reason why local residents affected by the 2011 GEJ earthquake induced tsunami moved to high land after the past tsunami disaster? I think that the main reason for securing living space, with an altitude of 20m or 30m to escape from the tsunami, was only to relocate to a hill at that time as they didn't have technology. If there was a simpler and more economical way to do this, I believe that they would have adopted the other way.

With the reconstruction measures implemented in the stricken area by the GEJ Earthquake and Tsunami were that large hills and mountains were broken down and vast flat hill lands were constructed, and built all new infrastructure there to create new towns. In the lowlands, artificially raised lands of 8 to 10 m in height were constructed to create industrial areas. These are reconstruction measures based on enormous civil engineering works, but are the same measures as in the past, except using advanced technology. Such a reconstruction policy may raise the following problems. In new vast flat hill lands, there will be a problem of improper use of developed lands since there are not enough people to populate the new areas



(a) Self-Floating evacuation center



(b) Evacuation facility using airtight space in building

Fig. 2 Newly proposed Tsunami evacuation systems



because of depopulation. In artificially raised lands with huge height, there will be problems of uneven land subsidence of different areas and amplification of seismic ground motion.

Assuming current technology, a method of economically realizing a living space at a place high enough to avoid tsunami waves is to build a high-rise apartment building with a number of rooms according to the number of residents. This method eliminates the need for large-scale mountain excavation and embankment construction and new infrastructure development. So it would be more advantageous if some of these costs could be used for maintenance of high-rise apartments. The complaints from fishermen that they cannot see the sea due to Tsunami breakwaters can be solved by providing ocean view rooms to all households. Daily environmental load can be reduced and energy efficiency can be increased. Because elderly people can live together, they can also improve medical issues compared to when they live in scattered areas. As the population is expected to decrease in the future, it is possible to create a new business model in which vacant rooms can be used as accommodation to enjoy the seafood and seaside resort.

On the other hand, if a Tsunami evacuation facility that can absolutely protect life even if an unexpectedly high tsunami attacks can be constructed without raising land significantly, that would leave the lowlands to many facilities, such as a fish market, that can be operated advantageously there. Therefore, my research group has developed a new Tsunami evacuation facility that achieve this purpose as shown in Fig. 2. They are "self-floating Tsunami evacuation facility" and "highly airtight indoor evacuation facility." They don't have the problems that the current general Tsunami evacuation tower facilities have, such as the problem of use in peaceful times, the problem of the need for people requiring assistance during a disaster to climb up the facility during a disaster, the problem of unexpected wave height, and height restrictions due to landscape problems, etc.

As one of the various reconstruction measures, it could have been advantageous to adopt a reconstruction measure that combines evacuation facilities to protect lives from the Tsunami with certainty, and high-rise apartment. But the consensus of local people who had never lived in high-rise apartment could not be obtained and resulted in that this proposal was not implemented. The important point that we should understand is that people cannot answer when they are asked questions beyond their imagination. The more cautious people are, the more they hesitate to get into situations they have not experienced.

#### 4.5 Reconstruction to fulfill future responsibility

I have repeatedly explained that large-scale disasters are an important opportunity to solve potential issues in the affected areas. To properly utilize these opportunities, imagination for the future of the affected areas is indispensable.

In the former Yamakoshi Village (with the population of 2,200 at the time, it is now a part of Nagaoka City by merger of municipalities.), which was the worst affected by the 2004 Niigata Chuetsu Earthquake, the village mayor made a promise with village people that he would enable all villagers to return to the same place as before the earthquake. And he exerted strong leadership in cooperation with the national and prefectural governments. He implemented various construction projects, including measures for collapsed slopes and the development of detour roads, and fulfilled his promises. The cost for this was tens of millions of yen per villager, but 10 years later, the population in 2014 was 1,100, half of the population immediately after the earthquake and it is now about 900. Despite the reduction in the population in the affected area, it costs to maintain the infrastructure. It is necessary to review the reconstruction activities done after the earthquake from the view point of whether they were "fulfilling future responsibilities" in affected area. Periodic reviews are also necessary for reconstruction measures implemented in areas affected by the 2011 GEJ Earthquake.

#### 4.6 Lessons on basic thinking and systems

Since the issues that arise in a disaster response are required to be resolved within the constraints of time and resources, they are often resolved by measures that can be handled by coordination within a limited organization. In the context of the national system, it is rare that this is done based on sufficient coordination and discussions among the concerned ministries and agencies. This is a major cause of difficulty in obtaining



an overall optimal solution. This solution requires the creation of a system with strong authority on decision making and coordination in disaster countermeasures, but the current Cabinet Office, which has no limbs, does not have enough authority.

"Because it is their future and their problem, get the victims and affected municipalities who have the least mental and physical reserve, and who are not highly specialized, to think about restoring and rebuilding of the affected area within a short period of time." Current above mentioned basic policy should be revised. This also causes the affected people to often say, "I want to recover the affected area to what it used to be." Expert contributions are important in resolving this problem, but there are also problems here. The word "snuggle up the victim or the affected area" is beautiful, but experts must be careful not to lose the opportunity to solve problems by excessive snuggling. In many situations, it is important to respond with an appropriate sense of distance.

I express my deepest appreciation and deep appreciation for the efforts of many stakeholders involved in the restoration and reconstruction of the GEJ Earthquake and Tsunami disaster, and for the many ideas conceived and implemented to solve the issues. However, there are many issues left.

What is required in the future response to the mega earthquake disaster is not a "system that can be done if various measures are devised", but a "system that can be easily understood and smoothly implemented."

## 5. What we should do till the next mega earthquake disaster

### 5.1 Understanding the next mega earthquake disaster as a national critical disaster

On June 7, 2018, the Japan Society of Civil Engineers (JSCE) announced the estimated amount of long-term (20-year long effect) economic loss of large-scale natural disasters, such as due to the TMI Earthquake and the NTG Earthquake. Most of the conventional damage estimations are for damages immediately after the disaster, including the damage estimation by the Central Disaster Management Council, Cabinet Office of Japanese Government. The amount is about 95 trillion yen by the TMI Earthquake and about 220 trillion yen by a M9 class NTG Earthquake. However, the long-term economic loss estimated by the JSCE was much bigger and 778 trillion yen in case of TMI Earthquake and 1,410 trillion yen in case of NTG Earthquake [4]. Compared with Japan's general annual budget (about 100 trillion yen) and GDP (about 500 trillion yen), everyone can understand easily that these losses are quite huge. Disasters with a scale that threatens the survival of the country are called "national critical disasters", but it is necessary to understand that these disasters are of that level.

### 5.2 What we should do till the next mega earthquake disaster

(1) Understanding that response for next mega earthquake disaster is an "all-out fight in the process of becoming poor" and change of awareness in "from cost to value" and "phase-free"

Considering Japan's declining birthrate and aging population, and financial constraints, Japan's response to a mega earthquake disaster in the future can be termed an "all-out fight in the process of becoming poor." The expected damage is of a scale that is extremely difficult to recover / reconstruct by only post disaster countermeasures. Therefore, it is important to reduce damage up to the extent that we can recover/reconstruct from the disaster by pre-disaster countermeasures, such as damage mitigation and preparedness. And it is important to understand that research on dealing with such disasters is not sufficient only by linking specific disciplines and a small number of related disciplines.

Besides the deepening of conventional earthquake engineering researches, a combination of structural and non-structural measures based on the research results of natural science including engineering, and social science as well as biological and medical research fields are necessary. And establishment of a comprehensive disaster management system and its social implementation, by cooperation of mass media and financial organizations in addition to Industry-government-academia are also important.





Disaster countermeasures have three main players, "self-help effort, mutual-assistance, and public-support." However, given the current human and financial constraints in Japan, "public-support" will continue to shrink. Therefore, it is necessary to make up for the shortfall with "self-help effort and mutual-assistance." But, implementation of disaster countermeasures as before by appealing to the "conscience" of individuals, corporations, NPOs and NGOs, and local communities who are responsible for it is no longer possible. It is important to create an environment that provides financial and mental benefits to them that are active in activities, beyond the scope of social contribution. What is important here is a change in awareness of disaster countermeasures, and the keywords are "from cost to value" and "phase-free". Conventional disaster countermeasures, which are considered as costs, and are "one-time, without continuity, and the effect cannot be understood unless a disaster occurs." But, new value-type countermeasures bring value and brand power to organizations and regions with countermeasures even during normal times, and the benefits continue. "Phase-free disaster countermeasures" do not separate the phases of disasters from those of peaceful times, improve the quality of life during peace time, and can also work effectively in case of a disaster.

Through such businesses for disaster management, an appropriate disaster management business market will be fostered in various markets including overseas markets. This would result in the development and maintenance of high level of disaster management capabilities to compensate for the shortage of "public-support." This creates an environment that will reduce damage due to future major catastrophe in Japan as well as world and realize appropriate reconstruction.

## (2) Secure of the electric power after major earthquake

Prior to the 2011 GEJ Earthquake, much of the electricity used in the Tokyo Metropolitan area was generated by nuclear power plants located far outside the Tokyo Metropolitan area. However, following the shutdown of the nuclear power plants after the GEJ Earthquake, much of the electricity used in the Tokyo Metropolitan area is now being generated by thermal power plants around Tokyo Bay. In other words, since the power is in the "local production for local consumption" state, the consumption area and the production area will be damaged at the same time due to the potential TMI Earthquake. In addition, as these thermal power plants are operated based on the premise that fuel is supplied smoothly, their fuel reserves are small. Therefore, even if there are no equipment problems, full operation is not possible unless the operation of Tokyo Bay becomes normal.

By the way, in the Tokyo Metropolitan area, when a large magnitude earthquake occurs, it is known that a long period ground motion with predominant period of about 4 to 10 seconds will be generated. Since these periods coincide with the natural periods of skyscrapers and long bridges, and the sloshing period of fuel in the storage tanks around Tokyo Bay, there is a high risk of liquid leakage from the storage tanks and fire. Moreover, liquefaction-induced damage to port facilities can be considered, making operation of Tokyo Bay more difficult. Under such circumstances, disaster response in an environment of extreme power shortage may be required.

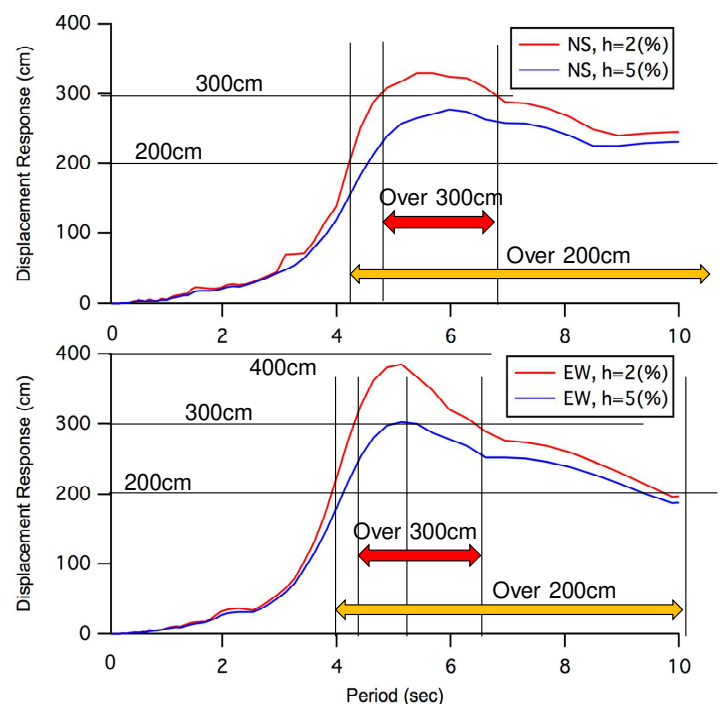


Fig. 3 Displacement Response Spectrum of the 2015 Kathmandu, Nepal earthquake ground motion (Upper: NS, Bottom: EW component)



The problem of long-period ground motions has been pointed out since the 1995 Kobe Earthquake, but with some exceptions, we have not experienced any earthquakes or ground motions that would actually be a major problem. However, as shown in Fig. 3, the ground motion due to the Kathmandu Earthquake in Nepal in April 2015 is an intense long-period ground motion. The upper part of a skyscraper with a natural period of 4 seconds or more vibrates with 6 to 8-meter displacement (both amplitudes), with the natural period of each building. If this earthquake ground motion hits the Tokyo Metropolitan area, it will cause enormous damage to skyscrapers, long bridges, fuel storage facilities, etc., and it will cause a major obstacle to supplying power.

(3) Population relocation guidance and bold land policy

In a society with a declining birthrate and an aging population, as a disaster precautionary measure, following measures are required. Instead of leaving the number and distribution of towns and villages as they are, and the population is allowed to change naturally, it is important to direct people living in high disaster risk areas to low risk areas. This measure can be implemented effectively in a society with a declining population, and it will create a happy environment for both migrating and welcoming people. At this time, as both the government and the citizens have a financial limitation, it is important to use the opportunity of the citizen's life plan, such as, at the timing of moving or rebuilding houses. Namely, using that timing, people should be guided to move to the space, which becomes vacant by depopulation, in low disaster risk areas. In this way, the future disaster risk and damage of the municipality as a whole will be significantly reduced, and the environment for disaster response will be greatly improved, even if there are no special costs or budgetary measures.

On the other hand, as post-disaster countermeasures, it is necessary to implement a bold land policy. Given the financial constraints in the future, the same measures as those after the 2011 GEJ Earthquake cannot be expected for the recovery and reconstruction after future mega earthquakes, such as TMI Earthquake and NTG Earthquake. Based on the changes of population and industrial characteristics in the future in Japan, it is necessary to take efficient reconstruction measures.

To this end, it is necessary to take measures to efficiently restore affected areas, including restrictions on private rights based on appropriate evaluations and the government's purchase of Tsunami-flooded areas and the development of an environment including a legal system that can achieve this. For this, the putting the cadastral survey in order is indispensable, and this must be done immediately. As shown in Fig. 4, the current cadastral survey rate in Japan is 52% on a national average. The areas affected by the GEJ Earthquake were areas with relatively high cadastral survey rates, but it is necessary to increase the rate in potentially affected areas due to the TMI Earthquake and the NTG Earthquake. In addition, if an earthquake were to occur before sufficient readiness of the cadastral survey, an appropriate budget for land purchase should be deposited with a third-party organization, and an environment in which land can be acquired quickly should be established. This method is equally applicable if the cadastral survey was in place but the landowners are unknown or difficult to contact. Direct negotiations with the landowners should be allowed to take place with a third party, with a grace

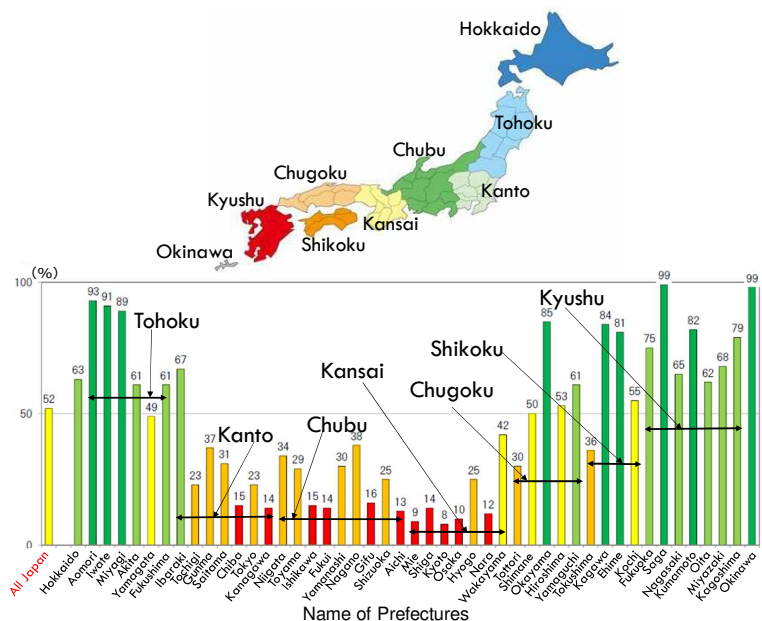


Fig. 4 Cadastral survey rate of all Prefectures in Japan (as of March 2017)



period. By doing so, the government can quickly purchase land and create an environment that facilitates the realization of optimal recovery measures for the affected area as a whole within a short period of time.

(4) Improvement of disaster insurance

Essentially, disaster insurance should have "risk finance" and "risk control" functions. The former is a function for receiving insurance money when an event that you do not want to have happen, while the latter is a function for lowering the possibility of events that you do not want to occur. The problem in Japan is that earthquake insurance for ordinary dwellings only has the former function to a limited extent, but basically does not have the latter function. Figure 5 shows the concept of aseismic design of infrastructure, and insurance premium for earthquake insurance. Basically, both have the same idea that standard insurance premium and standard seismic load are multiplied by coefficients depending on the characteristics of the region and individual structures to determine the final value.

In the aseismic design of infrastructure, in order to take into account of the characteristics of the region, there are two coefficients. One is to consider the seismic activities or the economic situation in the region, and the other is to consider the local site condition affecting ground motion at the site where the infrastructure is constructed. Consideration of local site condition is important as the seismic ground motion becomes quite different by the local soil condition even though the same magnitude and distance of the earthquake, resulting in a large difference in damage. Other parameters are multiplied by a coefficient that takes into account the importance and dynamic characteristics of the target structure.

But in case of earthquake insurance, there is only one coefficient to consider the effect of the target region with prefectures as the unit, and the discount rate due to differences in seismic performance is up to 50%. These coefficients have many problems compared to the actual situation. For example, the risk of a Tsunami is high in areas near the coast, but is zero when entering more than 5 to 10 km inland from the coast. The local ground conditions where the target building is located are not considered. Furthermore, as can be seen from the total collapsed rate (wooden houses) in Fig. 6, the difference in damage caused by the difference in seismic resistance between the old buildings with low earthquake resistance and the latest buildings with high earthquake resistance is about 100 times in a seismic intensity 6- area, about 50 times in seismic intensity 6+ area, and about 10 times in seismic intensity 7. Obviously, the difference is much more than 50%, even if it covers anything other than total loss. These facts indicate that the most important principle in insurance, "principle of fairness" has not been established. This is a significant difference from recent auto insurance policies, which considers past accidents, violations, and annual mileage in detail. It should contribute to risk control by properly assessing the risks of the region and buildings and guiding people from high disaster risk environments to low-risk

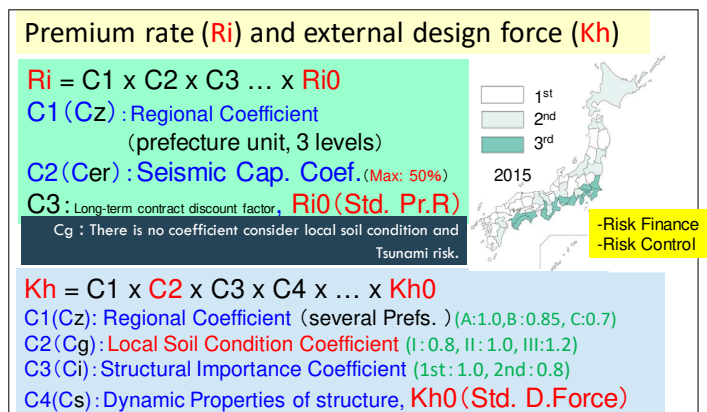


Fig. 5 Comparison of earthquake insurance and aseismic design of infrastructure

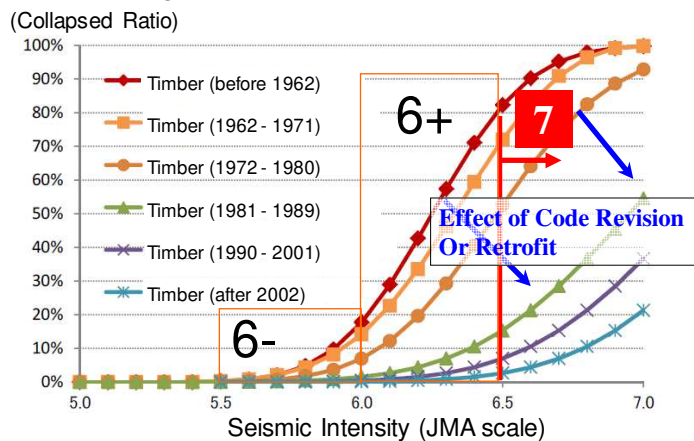


Fig. 6 Fragility function of wooden houses in Japan



environments. However, the current situation is equivalent to saying, "Keep people living in high disaster risk environments. Then, the damage will increase in the future. Therefore, we must secure a large sum of funds."

#### (5) Issues on handling disaster debris

The 2011 GEJ Earthquake and Tsunami disaster caused about 30 million tons of disaster debris, which was a struggle to dispose. At the end of February 2014, the Ministry of the Environment of Japanese Government estimated that up to about 110 million tons of debris would be generated due to the TMI Earthquake and up to about 349 million tons of debris by the NTG Earthquake. The debris caused by the TMI Earthquake is about 16.5 times of the annual waste volume in whole Tokyo, and it takes about four years to incinerate by existing facilities in the Kanto region and 15 to 26 years to landfill. Furthermore, the amount of debris due to the NTG Earthquake is about 11 times of that by the GEJ Earthquake and Tsunami disaster, and it will take about 8 years to incinerate combustible materials at all existing facilities in Japan and 16 to 20 years to landfill noncombustible materials.

The processing of such a large amount of disaster debris is a problem totally unexperienced by Japan. The most important measures are to reduce disaster debris as much as possible by reducing damage by pre-disaster countermeasures. Next, it is necessary to establish a cooperative system among industry, government and academia, and develop a specific treatment plan by involving not only technical issues, but also the identification of issues including laws and regulations, and based on solutions.

## 6. Conclusion

In the history of the world, there has been no such city like Japan's Central metropolitan area with such a large population and concentration of economic activities where earthquakes, typhoons, volcanoes, and various other natural disasters occur frequently.

"In the past, there was a country in the Far East called Japan, which created the world's largest city, Tokyo, with excellent technical and enormous economic power. However, the arrogant attitude and loss of humility due to the very technical ability and economic power touched the wrath of God, and Tokyo was destroyed in one day by the earthquake. This is called 'The Second Tower of Babel'". I really hope that will not be written in future world history textbooks.

There is not enough time left before the TMI Earthquake or the NTG Earthquake occurs. During the process of becoming a poor country, it is essential to reduce the damage by pre-disaster countermeasures to the level that it is possible for Japan to recover and rebuild by itself by effectively using the time until the earthquake occurs. Also, advance preparation of methods and the environment conducive to realizing a smooth recovery and reconstruction after a mega earthquake is important. This is the challenge that we are facing today.

## References

- [1] Kimiro MEGURO (2017): Misunderstood lessons from the 2011 Great East-Japan Earthquake and Tsunami disaster. *Proceedings of the 16th World Conference on Earthquake Engineering*, Paper No. 4193, 10 pages.
- [2] Eiji FUKASAWA (2011): Policy response after the Great Kanto Earthquake —Fiscal and Financial Measures and Medium- to Long-term Impact on the Japanese Economy—, National Diet Library ISSUE BRIEF NUMBER 709 (2011. 4.28.)
- [3] Kimiro MEGURO (2018): Issues and lessons for better management of mega earthquake disaster in future based on the 2011 Great East Japan Earthquake and Tsunami Disaster experiences, *Reconnaissance Survey Report on the 2011 Great East Japan Earthquake and Tsunami Disaster*, Vol. of City Planning (in Japanese).
- [4] President's Special Committee on Securing Resilience, the Japan Society of Civil Engineers (JSCE) (2018): Technical Study Report on Countermeasures against Giant Disasters that Cause 'National Critical Disaster (in Japanese).