Disaster Management & Mitigation in Japan in the Wake of the Great East Japan Earthquake

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Introduction

1. Characteristics of the Earthquake & Tsunami

The Great East Japan Earthquake of 3.11, 2011 and accompanying tsunami were enormous. Centered off the coast of Miyagi Prefecture, the earthquake struck a little further offshore than it had been presumed one might occur. Initially centered along the coasts of Fukushima, Miyagi, and Iwate prefectures, activity almost immediately spread north toward Aomori and south toward Ibaraki and Chiba; the distribution of aftershocks now covers a broad swath of the Pacific Ocean off the Tohoku and Kanto regions. The area of the principal fault is estimated to extend 500 km north-south and 200 km east-west. Slip on the fault is said to have exceeded 30 meters; the resulting movement of the seafloor changed sea levels, causing a great tsunami estimated to have reached more than 7 meters in height at the point of generation, which could be amplified near shore and on land *(Chart (A, B & C))*.

Earthquakes and tsunami have occurred repeatedly in the past along eastern Japan's Pacific coast. The Sanriku coast has been particularly active, suffering earthquake and tsunami damage again and again. Historical data and information had been used to evaluate individual areas including the sea regions off Sanriku, Miyagi Prefecture, and Fukushima Prefecture, and along undersea trenches, but the 3.11 earthquake was so massive it struck all of these at once. Depending on location, the tsunami took one of two forms. In the first, the scope of inundation in Sanriku was roughly comparable to that of tsunami caused by previous earthquakes during the Meiji and Showa periods, with a maximum run-up height of more than 39 meters along the Sanriku coast. Here, the backwash as well as the run-up exerted enormous destructive force. In the second, as on the Sendai Plain, the tsunami reached a maximum run-up height of about 15 meters. This greatly exceeded the assumptions that had been made for a tsunami triggered by an earthquake off Miyagi Prefecture. The area inundated was more than 10 times that anticipated, with broad areas remaining flooded for an extended period of time.

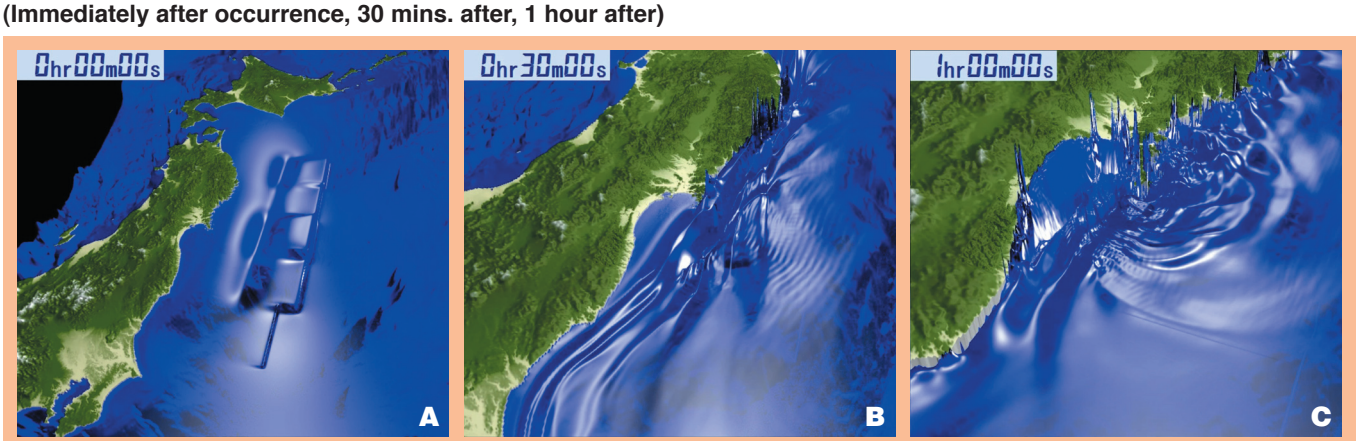
2. Scope of Damage

Although much remains unclear about the scale of the 3.11 tsunami, it appears to have been the largest, and most destructive, in the history of Japan. The tsunami seems to have triggered nearly every imaginable kind of tsunami damage: destruction of coastal structures, tide/tsunami control forests, houses, buildings, and infrastructure due to flooding *(Photos 1 & 2);* topographical change due to erosion and sedimentation; rubble, offshore aquaculture rafts, and ships sent adrift; flammable materials spilled and on fire; damage to transportation networks such as roads and rail (including rolling stock); and even the impact on facilities such as nuclear and thermal power plants.

Of particular note are the seawalls and other protective works that had been implemented along the coast. Although the level of such preparation differed by region, we need to evaluate what role these works played in reducing damage from the tsunami. In addition, some very robust works such as reinforced concrete buildings

CHART

Occurrence & spread of tsunami caused by 2011 Great East Japan Earthquake
(Immediately after occurrence, 30 mins. after, 1 hour after)



Source: Author

suffered damage. We need to investigate in detail at what point in time after the onslaught of the tsunami these were damaged, and in what way.

The degree of damage to buildings and civil infrastructure differed even within inundated areas, with damage increasing beyond a certain inundation depth (or hydrodynamic force). According to the Ministry of Land, Infrastructure, Transport and Tourism's Housing Bureau and Tohoku University (Associate Professor Shunichi Koshimura), the damage rate changed dramatically at an inundation depth of around 2 meters. This finding will act as a guideline that must be considered when rebuilding homes and a variety of other buildings and civil infrastructure projects in the region.

Seeking to Build Safe, Secure Communities

1. Comprehensive Tsunami Disaster Management Grounded in Community

Although reconstruction plans have been drawn up for the areas affected by the disaster, many local issues remain unresolved; vigorous debate continues regarding specific issues and about which projects should be implemented. Previous measures to address tsunami have been based on a comprehensive approach involving physical infrastructure to protect existing communities combined with evacuation systems and community-building efforts to address situations when such physical infrastructure is overcome. Although these three elements (physical infrastructure, intangible systems, and community building) remain unchanged, I hope the first step this time can be to reach consensus on an approach toward disaster mitigation (safety level) that can then be applied to a review of residential and other land use (building restrictions) that fosters the development of disaster-resilient communities. Under the Basic Guidelines for the Promotion of Local Tsunami Disaster Management, established in December 2012, each community is supposed to estimate the extent of tsunami inundation as a baseline for drawing up plans for comprehensive local disaster management, and is able to designate tsunami disaster precaution and special precaution zones. They may also introduce approval schemes for development activity and building construction within such special precaution zones.

It is best for each community to set things up as intensively as possible, taking into account its population dynamics and change of community, the administration of local society, harmonization with agriculture, forestry, and fisheries, and the local natural environment, climate and scenery. Plans should also consider trends in and progress made by reconstruction efforts in which the private sector and young people have taken part.

2. Establishing Safety Levels

A community consensus must be built that takes into account (1) the scale and frequency of (or interval between) earthquakes and tsunami and (2) their impact (damage) when establishing a safety level based on (3) the living and topographical conditions of each community or settlement and an evaluation of (4) the cost and effectiveness of disaster management measures. The first step in securing community safety is for residents and local governments to develop goals (what level of tsunami to address) based on a rational evaluation of factors 1–4.

Today there are two levels discussed in defining how powerful a tsunami to address – Level 1 (concerning the degree of coastal tsunami protection) and Level 2 (concerning the degree of tsunami disaster mitigation) – but local communities should consider Level 2 first.

Level 2 (tsunami disaster mitigation) defines how powerful a tsunami to address, based on the experience of 3.11, in order to prevent a repeat of such devastation (related to the tsunami measures section of local disaster management plans and Article 40 of the Basic Act on Disaster Control Measures). More powerful than the tsunami defined under Level 1 below, this level suggests the most extensive steps needed to protect human life even in the event of a tsunami that exceeds the limits addressed through infrastructure. Massive tsunami of the same class as the 869 Jogan Tsunami are believed to occur once every 500 to 1,000 years.

Level 1 (coastal tsunami protection) defines how powerful a tsunami to address through protective works on the coast (related to Article 2 of the Seacoast Law, seacoast preservation plans, and basic

PHOTO 1 Photo: Author

Tsunami damage to buildings along the coast (Sendai).

PHOTO 2 Photo: Author

Local tsunami damage on the coast (Minamisanriku).

guidelines). This level should indicate a tsunami height to be used to design facilities sufficient to protect life, property, and territory from tsunami that occur from once every few decades to a century or more.

3. Land Use & Building Restrictions

A Level 2 mitigation strategy is important both for preventing loss of life and for quickly implementing restoration and reconstruction measures. In looking at how to cope with tsunami, communities should begin by considering how to protect themselves and mitigate disaster through zoning and land use even in the absence of physical infrastructure. We need to consider moving residential areas and important facilities outside inundation zones and, within inundation zones, how to evacuate them before a tsunami arrives.

Where evacuation is difficult (in hard-to-evacuate zones), the adoption of some measure of physical infrastructure is then probably required. Here, because construction of extremely high facilities is unrealistic, measures should address relatively high-frequency tsunami events (Level 1). It is therefore important to consider not only new construction of civil infrastructure but also the effective use of existing facilities and natural forces, as well as multiple lines of response.

Furthermore, some areas probably need to be covered through an appropriate combination of civil infrastructure and intangible measures. That is, even when assuming some impact from a Level 2 tsunami, there will still be a demand for facility preparation and management that considers how to limit or disperse this impact, minimize the loss of human life, and facilitate restoration and reconstruction.

4. Land Use Separation into Residential & Commercial

Residential and commercial areas should be established in accordance with the following concepts:

(i) Because disaster risk is understood to diminish progressively as one moves from the coast toward the interior, residential land used for housing, hospitals, welfare facilities and the like should generally be arranged toward the interior where the risk of tsunami is lowest. In doing so, the availability of public transportation services as well as any risk of landslides or other disasters must also be considered. Even in areas where there is risk of inundation, some combination of requirements related to buildings' wave resistance or evacuation functionality might also be considered.

(ii) When locating commercial-use land, in addition to the degree of safety in the event of a tsunami, convenience and the nature of the work performed should probably also be considered in the interest of quickly rebuilding local industry. With fishery products' processing plants, for example, it would be advisable, having first determined that they should be concentrated in areas near the coast, to then consider measures needed to address tsunami risks (such as improvements to seacoast protective works or tidewater control forests). Furthermore, due consideration should be given to the storage, positioning, and management of fuels, chemicals, and other hazardous materials that can cause secondary damage when a tsunami strikes, and measures taken to ensure spills are prevented.

(iii) With respect to housing, laws concerning special national financing measures to promote "collective relocation projects" were established in 1972. This program can be used to relocate in the wake of a disaster, and also prior to a disaster if the area has been designated an at-risk zone. The program further requires that at least 10 households (lowered to five after 3.11) be relocated and that at least half of them are relocated to residential areas.

5. Evacuation Planning

The general rule for protecting lives in a tsunami is an evacuation to a safe location and refuge place. In order to evacuate quickly and appropriately, it is critical to know where to go, what route to take, and how much time will be required. Note should be taken of the time available between occurrence of the earthquake and arrival of

PHOTO 3 *Photo: Author*

Ship lifted by the tsunami in Kesennuma

PHOTO 4 *Photo: Author*

Damage on the tsunami control forest in Natori

the tsunami, and estimates made for whether it will be possible to take refuge outside the inundated area. Measures such as establishing emergency refuge buildings will then need to be taken for areas that are difficult to evacuate. It is worth noting that multiple coastal defenses reduce the scope of inundation and therefore the extent of hard-to-evacuate areas. By delaying the arrival of the tsunami, they also leave more time for evacuation.

In addition, because it is impossible to know at the time of a tsunami what kind will arrive, there is a need to prepare systems and devise measures to ensure that residents take appropriate action to evacuate. This requires observing and monitoring the tsunami, issuing tsunami warnings, relaying tsunami warnings, leading evacuations, and preparing evacuation routes and places of refuge. In order to enhance future efforts in this regard, we also need to research the 3.11 tsunami to analyze how residents obtained information, what they decided to do, and how they actually behaved.

Efforts to Remember: Building Civic Systems & Strength to Live

In order to convey to the next generation the massive scale of the damage from the 3.11 earthquake – both the experience and the lessons learned – it will be important to leave behind not only written materials but also a variety of physical sites and objects. We must, with local consent, preserve damaged buildings and bridges that immediately convey the destructive force of a tsunami. There is surely also a need to pass on individual experiences and lessons learned. Many local shrines and stone monuments had survived for many years without being swept away by tsunamis, proof that those who experienced great disasters in the distant past tried to leave behind signs that showed how far the tsunami had reached. Although we must put the pain of the past behind us and move forward, I believe it is also important to keep our experiences alive in memory and to overcome tragedy together.

With disaster education, it is important not only to give students an understanding of natural disasters and to encourage them to learn about causal factors for themselves, but also to raise their awareness of disaster management and mitigation schemes and the role they play in putting them into action. Particularly in the school environment, we need to strengthen the relationship to ordinary coursework and implement plans in a way that combines them organically with integrated learning and other special programs. If disaster education is to foster an accumulation of practical knowledge and experience, it also needs to take place across a range of opportunities and forums in addition to schools and communities. We need to pursue it as a matter of social education and lifelong learning, training people to be able to actively engage in disaster management by cultivating the strength to live.

There is a long tradition of disaster education in schools in Japan that has drawn a measure of praise from overseas, but the content is unsystematic, often either limited to training and drills or slanted toward knowledge and information. Issues of survival, of keeping oneself alive, are often not addressed. The following, based on the work of Professor Emeritus Yoshiaki Nihei of Tohoku University, can be raised as key points in cultivating the strength to survive and recover.

- Having faith that one can succeed in solving problems by believing in oneself and working hard without giving up [Self-confidence]
- Believing that, even though there may be periods of difficulty, the future is sure to be better than today [Future orientation, optimism]
- Believing that one's presence in the world has meaning, that life has significance, and in taking care of oneself [Self-esteem, meaningfulness]
- Enhancing one's ability to love oneself even while recognizing some shortcomings and failures [Self-acceptance]
- Believing that people are fundamentally good [Positive view of people]
- Belief that one is always being watched out for, and the ability to ask for help in times of need [Ability to rely on and make use of others]
- Ability, even in difficult situations or times of crisis, to see things with a measure of objectivity [Composure]
- Seeking out the information needed to resolve difficult situations [Information gathering]
- Enhancing one's ability to take risks when required [Risk-taking]
- Increasing one's awareness that one's life is one's own, and needs to be faced independently [Existential solitude]

I believe all of these points need to be incorporated into current disaster education.

Because it is a reminder of the dreadful suffering wrought by disasters, many people see disaster management as something dark and frightening. But this merely focuses on one aspect of disaster management activities. In order to approach disaster management positively and remain conscious of the role such efforts play in protecting our lives and the lives of those around us, we must make effective use of other fields such as environmental education and welfare education in addition to examples of successful risk education. It is critical that people recognize the importance of disaster management and take the initiative in actively pursuing disaster education efforts. It will also be essential to nurture people's ability to coexist with nature, focusing in some cases not only on the damage wrought by natural disasters but also on a deeper understanding of the benefits they can bring. We must also understand how they compare and relate to various everyday risks. JS

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http://www.irides.tohoku.ac.jp/eng/index.html