Chapter 51

Cooperation with Industries

Field of expertise: Tsunami Engineering, Coastal Engineering

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Summary

The Great East Japan Earthquake highlighted the issues of disaster prevention and mitigation in coastal areas. In this chapter, we introduce the comprehensive activities of the industry-academia collaboration between Tohoku University and Tokio Marine & Nichido Fire Insurance Co., Ltd. in the areas of risk reduction, including risk assessment of earthquake and tsunami disasters, investigation of practical disaster prevention and mitigation systems, as well as efforts to solve social issues such as disaster prevention education and awareness.

Keywords: industry-academia collaboration, earthquake and tsunami risk assessment research, Eco-DRR, tsunami evacuation research, disaster prevention education and awareness

Introduction

Since the Great East Japan Earthquake, research on disaster prevention and risk reduction against earthquakes and tsunamis has been recognized as a challenge in high demand by society. It is expected to contribute to the development of science and technology as well as to the solution of social issues. This will be done through effectively collaborating with industries on matters such as related research and development as well as human resource development.

1: Problems Revealed by the Great East Japan Earthquake

What happened?

The Great East Japan Earthquake (hereafter referred to as the "earthquake") ruptured the faults along the Japan Trench from Iwate Prefecture to the coast of Ibaraki Prefecture. The tsunami generated by the 9.0 magnitude earthquake, the fourth largest in recorded history, hit a large area along the coast of eastern Japan with a height of over 10 meters. The tsunami reached a maximum run-up height of 40 meters and inundated an area of 561 km^2. The damage caused by this massive earthquake and tsunami was extensive and far beyond what the government expected. There was more than just building damage from tremors and liquefaction, and flooding caused by the tsunami. Other problems occurred, such as sediment movement, drifting debris, tsunami fires, and other vulnerabilities that had not been fully considered until then, such as urban tsunamis.

The reality of the damage

The strong currents of the giant tsunami carved the ground and changed the topography of the area, resulting in a black tsunami with a large amount of sediment that hit the coastal regions. Similar damage was recorded in the 1960 Chile tsunami in the Ofunato area of Iwate Prefecture, but the details are still unclear, and the reality of the black tsunami is gradually becoming clear from this experience and records. It has been pointed out that the effects of the black tsunami may have increased the extent of inundation and destructive power. Tsunami lung, caused by breathing in toxic substances or bacteria that exist in the seawater and sediment, has also been confirmed. In addition, the dust from dried sediment left on land after the tsunami subsided caused health hazards to nearby residents, and the leaching of heavy metals such as arsenic from contaminated soil and groundwater systems. Drifting debris increased the destructive power of the tsunami by engulfing everything from houses to cars and ships, and also made it more difficult for people caught in the tsunami to escape or survive it, thus worsening the damage. Tsunami fires ignited by debris in the inundation area were difficult to extinguish and caused secondary damage. In urban areas with sturdy buildings, these buildings may have blocked people's views, which may have delayed detection and evacuation. In addition to accelerating the flow between buildings, urban tsunamis hit people from multiple directions - from the sea and from around the buildings - making it more difficult to evacuate. This was the reality of the urban tsunami. During the tsunami evacuation, traffic congestion occurred due to people evacuating by car, and many people were killed by the tsunami while they were in their cars. In principle, evacuation on foot is recommended in the event of a tsunami, but it is true that there are people and areas where evacuation on foot is a challenge.

The total economic damage caused by the series of massive earthquakes and tsunamis amounted to approximately 16.9 trillion yen (Office of the Director-General for Policy Analysis, 2011) or about 146 billion US dollars. As a result of this damage, a total of about 1.2 trillion yen (about 10.4 billion US dollars) was paid in property insurance claims for about 770,000 cases (Kuriyama, 2012). The earthquake insurance system played a major role in helping the victims to rebuild their lives, and this was highly evaluated by all sides. On the other hand, in order to maintain a sound insurance system that supports people's safety and security, it has become essential to assess the impact and risk of earthquakes and tsunamis for a more appropriate insurance design.

2: Paradigms Destroyed by the Earthquake

Conventional wisdom and necessary responses

The earthquake insurance system in Japan is a completely self-help system, operated solely by insurance premiums paid by insurance subscribers, with no taxation whatsoever. Since the Earthquake Insurance Law was enacted in 1966, two years after the 1964 Niigata Earthquake, 2.4 trillion yen (about 20 billion US dollars) had accumulated by the time of the present earthquake, and 1.2 trillion yen (about 10.4 billion US dollars) has been paid due to the damage caused by it. With an increase in the number of insured people after the earthquake (the percentage of households purchasing earthquake insurance rose from 26.0% to 33.1% between 2011 and 2019), a series of earthquakes have resulted in large insurance payouts. For example, about 386 billion yen (about 3.4 billion US dollars) was paid out for the 2016 Kumamoto earthquake (the second largest in history), and about 107 billion yen (about 932 million US dollars), the third largest amount

in history, was paid out for the 2018 earthquake centered in the northern part of Osaka Prefecture (General Insurance Rating Organization of Japan, 2019). These payouts supported the reconstruction of many victims' lives. The earthquake insurance system has a total payout limit. At the time of the Great East Japan Earthquake, the limit was 5.5 trillion yen (about 48 billion US dollars), but after discussions, the limit was raised to 11.7 trillion yen (about 102 billion US dollars). Based on the latest findings and damage from the earthquake, the Cabinet Office estimated the damage for a massive Nankai Trough earthquake and tsunami. In the worst case scenario, the death toll would exceed 320,000 and the economic damage would be much greater than that of the earthquake. The estimated cost is 220 trillion yen (about 1.9 trillion US dollars), about 2.2 times the size of Japan's annual budget. It is truly a national disaster. In the face of the possibility of a huge earthquake and tsunami, such as the Nankai Trough mega-earthquake and tsunami, which could cause so much damage that the conventional insurance system would not be able to cover the full amount, the question of how to prevent and mitigate disasters without relying solely on insurance or hardware facilities has become a social issue. Based on the actual damage caused by major earthquakes, we need to be prepared to mitigate risks by any means necessary. In addition, there is a strong need to enhance tsunami risk research not only in Japan but also in other countries.

3: A New Approach

On July 26, 2011, Tohoku University and Tokio Marine & Nichido Fire Insurance Co., Ltd. signed a cooperation agreement agreeing to establish the Earthquake and Tsunami Risk Evaluation Endowed Research Division (Tokio Marine & Nichido) (Representative: Prof. Fumihiko Imamura) in our institute to support reconstruction and enhance disaster research, especially tsunami risk. Tohoku University's analytical technology, knowledge and data on tsunami risk assessment, etc., and Tokio Marine & Nichido Fire Insurance Co., Ltd.'s knowledge and data on earthquake and tsunami risk cultivated through its insurance business is combined, and the two organizations are collaborating to strengthen research, development, and human resource development in this field. It also aims to provide the results of its research and knowledge it obtains to society in order to promote disaster prevention education and awareness. Since its inauguration, the division has engaged in comprehensive activities for risk reduction in terms of both physical and non-physical measures, including earthquake and tsunami risk assessment research, as well as disaster prevention education and awareness-raising.

4: Achievements and the Future

A new approach to disaster science

In this section, we'll introduce the results of activities conducted by this research laboratory in collaboration with industry and academia. In the research on risk assessment, it was proposed that we first improve the tsunami hazard assessment method, then construct both a quantifiable tsunami risk based on the probable tsunami height and the possibility of it appearing on the Pacific coast of the Tohoku region, and a tsunami hazard map based on the expected time frame. The relationship between tsunami inundation depths, velocities, and building damages (fragility function) was evaluated more precisely than before by state-of-the-art statistical methods, using the data of damaged buildings in Ishinomaki City, Miyagi Prefecture, during the Tohoku earthquake tsunami. Furthermore, we proposed a method for quantitative evaluation of tsunami risk by combining the results of probabilistic tsunami hazard evaluation and tsunami fragility research.

This method enables us to compare the magnitude of tsunami risk regardless of whether it is domestic or international, and to use this information for decision-making and disaster prevention planning. Starting in 2019, we expanded the scope of our research to include corporate facilities, and develop tsunami fragility functions for corporate assets such as factories, in order to improve tsunami risk assessment methods for industrial facilities.

We have also been working on Eco-DRR (Ecosystem-based Disaster Risk Reduction). In our research on the tsunami mitigation effect of coastal forests, we clarified the relationship between the width of coastal forests and the damage to buildings behind them using big data on building damage in seven cities and towns along the coast of Sendai Bay. In 2020, we also started a trial using a new method called environmental DNA analysis. This research aims to analyze DNA from large organisms that can be detected in the environment, and to understand the spatio-temporal characteristics of ecosystems in order to effectively utilize natural forces for the realization of a sustainable society.

We have also been developing and upgrading an integrated tsunami model that can reproduce tsunamis, including sediment and debris transport, with the aim of establishing methods for predicting, evaluating, and mitigating the complex and compound tsunami damage observed and surveyed in the Great East Japan Earthquake. In this research has continued since it began as part of the national strategic project (HPCI Strategic Area 3, Tsunami Project Leader: Prof. Fumihiko Imamura) which ended in 2015, and we succeeded in reproducing the complex tsunami hazard with sediment movement and drifting objects in Kesennuma City, Miyagi Prefecture, which was a global first. It contributed to elucidating the complex disaster mechanism and damage escalation scenarios. The results of these science-based, realistic tsunami simulations have been computer-generated and are widely used in disaster prevention education and awareness-raising activities. This has increased the momentum to review the future damage assessment in coastal areas which are at high risk for tsunamis from the Nankai Trough and other areas in the world. In fact, specific efforts regarding black tsunamis have started in Kawasaki City, Kanagawa Prefecture, and other coastal areas. This method is expected to contribute to the future strengthening of national land, as it is capable of assessing complex damage risks that have never been assumed before.

In regards to tsunami evacuation drills, we practiced evacuation and training methods based on local needs with Kakeagare! Japan, a collaborative effort within and outside of the institute. For example, in Yamamoto Town, Miyagi Prefecture, we cooperated in the evacuation survey for tsunami evacuation drills using vehicles and confirmed that appropriate guidance at intersections where traffic tends to be concentrated is effective in easing traffic congestion and shortening evacuation time. We also contributed to local disaster prevention by cooperating in the formulation of a tsunami evacuation plan for Kesennuma City, Miyagi Prefecture.

Disaster prevention education was also widely disseminated in Japan and abroad. Awareness-raising activities were conducted on an ongoing basis to explain the mechanisms of natural hazards as science in a way that is easy for children to understand, and to foster children's ability to make their own decisions and take action (as described in detail in Chapter 29). We are also working to promote cooperation between industry, academia, government, and the media, and are striving to create a foundation for the transmission of disaster-related information and disaster awareness. In cooperation with the Tokio Marine & Nichido Group, the department has continued to disseminate information by providing disaster prevention education (visiting classes) and advising and supervising the disaster prevention and mitigation website, For Tomorrow’s Smiles.

In cooperation with the Tokio Marine Group, we have widely disseminated our knowledge and activities in research and disaster prevention education through industry-academia collaboration to contribute to social disaster prevention and disaster mitigation at academic

conferences, in the media, and at various disaster prevention events in Japan and abroad. It is necessary to continue to study comprehensive and effective measures to mitigate risks from both the physical and non-physical perspectives as we support the reconstruction of the affected areas.

Conclusion - from the authors

In order to reduce the risk of a huge tsunami disaster such as the Great East Japan Earthquake, it is necessary to clarify the tsunami behavior and tsunami vulnerability at each stage including sediment movement and drifting objects, and to discuss and come to a consensus on effective tsunami protection and evacuation based on the actual damage from the earthquake and scientific evidence. This will require expertise and technology from diverse stakeholders and multiple perspectives, not only from research institutions. It is important for preparedness against the threat of huge earthquakes and tsunamis to share data and knowledge among industry, government, and academia.

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