Editorial

Promotion of Disaster Prevention and Reduction to Overcome Earthquake Disaster and Co-create Future

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1. Introduction

Nankai Trough Earthquake is said to occur with a probability of around 70% over the next 30 years. In the worst-case scenario, the Central Disaster Management Council predicts a death toll of 320,000, near three million of completely destroyed houses, and economic damage worth 220 trillion yen which represents 40% of our GDP. The reasons for such tremendous damage are described as follows.

(1) A large-scale earthquake of which epicenter area extends into land could result in about 60 million of disaster victims,
(2) Cities and towns are expanding over coastal lowlands, and
(3) Many buildings with low earthquake resistance remain without exposure to strong shaking as long as 70 years,

and others.

Inspecting the past earthquakes occurred in the areas along Nankai Trough, we can see that every earthquake occurred at a turning point in the history of Japan. If the above-mentioned worst-case scenario happens, it is likely to disrupt the society and lead to a national-level crisis. Since the Nankai Trough Earthquake is an earthquake that will certainly occur, we must make every effort to prevent damage from it.

I, the author of this paper, was born in Nagoya and has been engaged in education and research in the fields of earthquake-resistant engineering and earthquake engineering at the Nagoya University. As one of researchers who live in possible quake-hit areas, I would like to work hard as much as I can to reduce earthquake damage.

Earthquake engineering researchers are basically striving to minimize earthquake damage and maintain social calm through their research into natural disasters including earthquakes and tsunamis. The following four action items are required to reduce earthquake damage.

(1) Avoiding disaster risks: Create an urban structure less vulnerable to disaster in areas with low disaster risk.
(2) Increasing resistance: Enhance structural strength of buildings in urban areas as well as improving infrastructure that can help prevent disasters from occurring.
(3) Enhancing disaster response capabilities: Prevent damage from spreading by accurately understanding damage information and making effective use of resources in the case of disaster.
(4) Becoming resilient: Foster "ability to survive" of community and individuals to recover and reconstruct the community quickly after a disaster.

Promotion of the first two actions can reduce structural damage and the number of casualties, and the remaining two are effective to minimize chances of expanding damage. To move forward with these action items, we need to conduct researches into hazard prediction, urban planning, earthquake-resistant engineering, disaster information, disaster prevention education, and so on.

However, those researches alone are not sufficient to reduce disasters. Various kinds of capabilities should be combined to put this disaster mitigation approach into practice. With this hope in my mind, I have been involved in establishment of the Disaster Mitigation Research Center (DMRC), Nagoya University and the construction of the Disaster Mitigation Research Building (Gensai-kan). This paper introduces a part of the project.

2. Vulnerabilities to earthquake disasters of urban areas in Japan

During the years of high economic growth since World War II, Japan has promoted the development of national land focusing on convenience and efficiency while concentrating population into urban areas. This made Japan one of the world's top economic powers, realizing an affluent and mature society. However, concentration of population into urban areas resulted in the expansion of cities and towns into dangerous areas and the density of houses. Additionally, excessive pursuit of efficiency and high functionality made the society less redundant and vulnerable to disaster. On the other hand, population shrinking and aging in rural areas weakened the society.

Table 1 shows changes in Japanese society over the past two decades. All items for comparison between 1993

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and 2013 are derived from the 20th anniversary special website of NHK Close Up Gendai (http://www.nhk.or.jp/gendai/20th/). From this table, we can see how Japanese society has been weakened. Amid the sluggish economic growth, the national debt tripled, the number of young people decreased by 20%, and the number of full-time housewives who defended their communities and homes during the daytime became fewer. Rapid proliferation of convenience stores and family restaurants has led to decrease in amount of food stockpiled in communities and individual households. Furthermore, our society became dependent on logistics services such as home-delivery service. There is an abundance of electrical appliances in every house, and dependence on cell phone or Internet has been increasing. While our life is becoming more and more convenient, traffic disruption or blackout is having an increasing influence on society.

As shown in the example on Fig. 1, large cities in Japan expanded their areas into alluvial lowlands as a result of population concentration. Thermal power plants and refineries are located on landfills in bay areas where the earthquake hazard is high. On the other hand, on soft ground in lowlands protected by dikes, houses are densely packed and high-rise buildings stand side by side. Therefore, there are concerns about damage to electric power equipment or refineries caused by strong shaking, liquefaction-related disruptions of gas supply or water supply and sewerage systems, long-term flood due to collapsed dikes, earthquake fires caused by the density of houses or insufficient fire-fighting resources, strong shaking of high-rise buildings produced by long-period ground motion for long duration of time, and so on.

Japan is about to enter the active period of earthquakes while having a problem of shrinking labor force because of the falling birth rate and the aging population. Now is the time to address the urgent issue of building a resilient society. To create a disaster-resistant, autonomous, decentralized, and cooperative society, the importance of robustness improvement of society and regional revitalization has been stressed in recent years.

Table 1 Changes in Japanese society over past 20 years

	1993	2013
Population aged less than 15 years [million persons]	20.84	16.59
National and local government debt [trillion yen]	333	977
Gross Domestic Product (GDP) [trillion yen]	467	520
Convenience store [stores]	23,000	47,000
Restaurant [stores]	3,876	12,429
Household with full-time housewife [families]	9,150,000	7,730,000
Cell-phone penetration [%]	1.70	106.80
Internet penetration [%]	-	79.10
Home-delivered parcel [billion pieces]	1.19	3.40

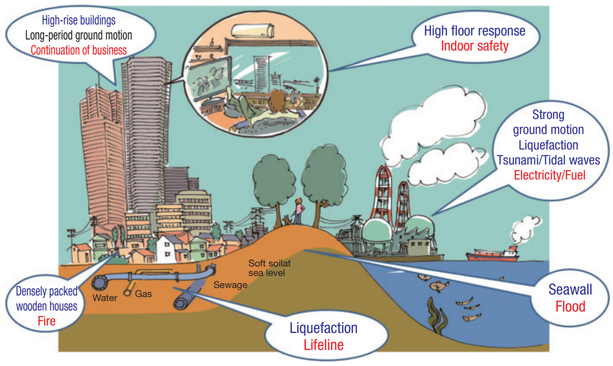

Fig. 1 Vulnerability of urban area to earthquake disaster

3. Mobilization of all social capabilities

In preparation for the Nankai Trough Earthquake that will definitely occur and turn into a catastrophe, we need to make maximum efforts to reduce disaster damage. Since resources available after the occurrence of an earthquake are limited, advance efforts to reduce damage is required.

Earthquake disaster related researches include the following three fields.

(1) Physical research addressing the natural phenomenon of an earthquake occurrence (e.g. seismology).
(2) Engineering research aiming to build earthquake-safe structures (e.g. civil engineering/architecture).
(3) Social scientific research exploring society or individuals that can respond to earthquakes appropriately.

Collaboration between these research fields is necessary to increase the effect of damage reduction.

The following researches are also required to reduce earthquake damage.

(1) Research to predict seismogenic behavior or damage by observing various phenomena triggered by an earthquake and converting them into physical models.
(2) Research to prevent damage from anticipated events by taking necessary measures such as infrastructure development or construction of earthquake-resistant structures.
(3) Research to restore the community by taking recovery and reconstruction measures quickly as well as respond to disaster appropriately by grasping the disaster situation early and utilizing available resources effectively.

Additionally, the results of these researches should be used to help with disaster mitigation; we need to generalize the results, make standards or laws, and then formulate measures to be taken. Specifically, it is necessary to encourage people to take actions actively in industry or families. In other words, collaboration between academia, government, industry, and citizens is essential to promote researches, measures, and implementation of the measures.

As I have discussed, all social capabilities need to be mobilized to accomplish disaster mitigation; collaboration between different research fields (physical/engineering/social scientific), comprehensive approach to prediction, prevention, and response, and industry-academia-government-citizens collaboration (See Fig. 2).

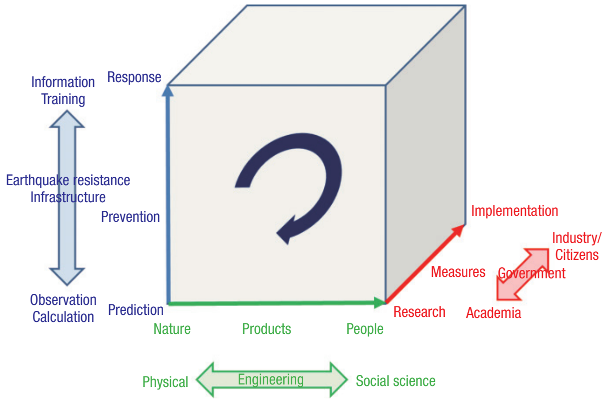

Fig. 2 Mobilization of all capabilities

A viewpoint of "Think Globally, Act Locally," which means "looking at an issue from a higher perspective and implement a solution in your local community," is important in resolving a comprehensive issue such as earthquake disaster mitigation. A way in which various issues are resolved individually and put together in each of segmentalized fields or organizations is barely effective enough for partial optimization, but not effective for total optimization. In the event of a large-scale disaster, the scale of damage will be too large for available resources. Therefore, we need prioritize action items to be implemented from a higher perspective. We also need to accept social diversity, add bottom-up approach to top-down approach, combine capabilities of national and local governments, and mobilize capabilities of public and private sectors. In short, all types of capabilities, self-help, mutual-help, and public-help, are necessary. On the premise that communities and organizations have been autonomous and decentralized, we must create a mutual-help system in which unaffected regions or organizations provide support for affected regions or organizations. Autonomous, decentralized, and cooperative mutual-help society is the basis of resilient society.

4. Disaster Mitigation Research Center and Building

4.1 Disaster Mitigation Research Center (DMRC)

In December 2010, the Disaster Mitigation Research Center (DMRC), Nagoya University, was founded under the slogan of "disaster mitigation" and "collaboration," aiming at being a regional think-tank to formulate strategies for disaster damage mitigation. Thanks to donations from companies and external funds for research, the center employed professors who had lots of hands-on experience in disaster prevention and accepted many contracted researchers from local governments and private companies (Fig. 3). Many of the researchers have been involved in Earthquake Resistant Building Engineering in design offices, general contractors, home builders, etc.

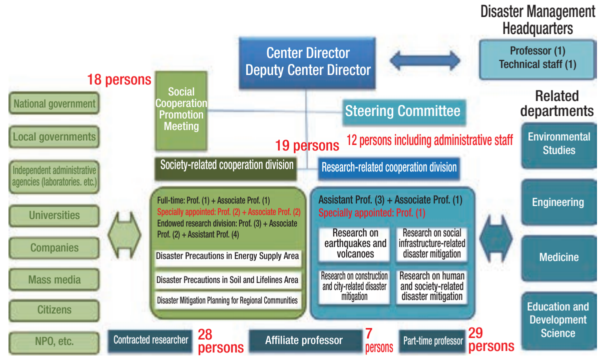

Fig. 3 Disaster Mitigation Research Center (DMRC), Nagoya University

We have enhanced collaborations between different research fields, between academia, government, industry, and citizens, and with research institutions inside and outside the region for five years after the launch of the center. A system to address disaster damage reduction in collaboration with all capabilities is being established. As well as promoting research programs to reduce disaster damage, development of human resources for disaster prevention, awareness raising among citizens, cooperation towards realization of a cooperative society for disaster prevention, the center is carrying out practical activities related to disaster response and disaster risk prevention.

4.2 Disaster Mitigation Research Building (Gensai-kan)

The Disaster Mitigation Research Building called "Gensai-kan was completed in March 2014. This building serves as a hub for disaster prevention and mitigation research, for disaster response, and for education and awareness raising during ordinary times.

It is a base-isolated reinforced concrete building of five stories above the ground and one underground story, amounting to 2,898m^2 in total floor space, shaped like a triangle shortcake. An elastic base isolation system has been installed in the basement, which is comprised of a laminated rubber bearing, a direct-operated rolling bearing, and oil dampers. The system is designed so that the natural period is 5.2 seconds to avoid coinciding with the predominant period of the ground motion of about 2.6 seconds. There is 90cm clearance to ensure sufficient design margin. In addition to the underground base isolation system, the rooftop laboratory for disaster mitigation and experimentation on the 5th floor also has a base isolation structure with a natural period of 5.2 seconds – the Gensai-kan is a dual base-isolated building. The underground gallery is designed for visitors to learn the technological history of earthquake resistance/isolation and vibration suppression of structures while observing the base isolation device from outside of the gallery. There are "Gensai Gallery" for oscillation experience and "Gensai Hall" for holding seminars on the 1st floor, "Gensai Library" where visitors can browse relevant information and the Disaster Management Headquarters on the 2nd floor, and space for research projects on the 3rd to 4th floors.

4.2.1 Hub for research into disaster mitigation

The Gensai-kan building itself is a subject of research on earthquake resistance as well as a field of experiment. The rooftop laboratory weighing 410 tons has a base isolation structure with 5.2 seconds of natural period and can shake with a half amplitude of about 70cm by applying sympathetic vibration with an actuator. Since there is a virtual reality system comprising a stereoscopic image display and audio equipment in the laboratory to simulate an earthquake situation while shaking the room, visitors can test their states of mind during earthquake or experience disaster response drills. The use of the laboratory's shaking as vibratory force generates an inertia force of about 40 tons, enabling a whole building weighing 5600 tons to shake with an amplitude of about 5cm.

With the newly developed pulling jack installed on the underground base isolation layer, free vibration experiment can be conducted by causing forced displacement of about 10cm. Assuming that the rooftop laboratory is a building standing on the ground (= the entire building of the Gensai-kan), since the natural periods of the entire building and the rooftop laboratory are both 5.2 seconds, it is possible to reproduce resonant response of a multi-story building. This can be used for research and development of vibration suppression techniques of construction to avoid resonance.

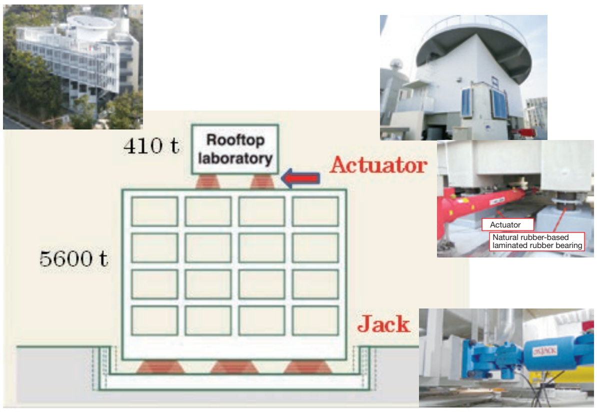

Fig. 4 Shakable building, Gensai-kan

The oil dampers installed at the underground base isolated layer and the actuator on the rooftop laboratory are manufactured by KYB Corporation. The actuator also includes a feedback control function. We plan to install on-off switching type oil dampers on the rooftop by the end of this fiscal year to begin considering the protection effect of TMD (tuned mass damper) with additional dampers during strong wind or the feasibility of AMD (active mass damper) for absolute vibration control.

A lot of seismometers, earth pressure meters, and displacement meters installed in the building are useful to clarify vibration behavior of building, aging of building or base isolation system, earth pressure distribution properties during earthquake, and other issues. Aiming at developing inexpensive vibration monitoring methodologies, we have installed lots of simplified seismometers in the building and be currently studying the effectiveness. I would like to develop a new vibration monitoring technology based on these methodologies in the future.

4.2.2 Hub for disaster response

The Disaster Mitigation Research Building (Gensai-kan) has functions as a disaster response hub in local community and the Nagoya University. The Disaster Management Headquarters of the university on the 2nd floor has a mission to protect the lives of 24,000 people (faculty and students). The 1st floor will be open to municipalities, key companies, and mass media, and the 3rd and 4th floors to domestic and international disaster investigation teams in the event of an earthquake.

The Gensai-kan is equipped with various types of disaster response equipment and stockpiles of necessary

Fig. 5 Base isolated floor of Gensai-kan (Left lower), 1st-floor gallery (Middle lower/Left upper/Middle upper), 2nd-floor library (Right lower/Right upper)

supplies. As well as introducing a high-performance base isolation structure, it has a diesel generator capable of one-week continuous operation, a solar power generation device, 3m^3 drinking water tank and 17m^3 miscellaneous-use water tank for 100 persons × 10 days, a dish antenna for satellite communications with municipalities, a long-distance wireless LAN connected with the national disaster management organizations, etc. on its rooftop. There is lots of other equipment installed in this building; on-campus broadcasting system, drainage tank, city-propane switching type gas-powered air conditioning equipment, power panel capable of connecting to a power supply vehicle, earth tube that utilizes temperature environment in the ground for heat exchange, etc. With the use of all equipment within the building, we intend to keep this building functioning as a disaster response hub even when a large-scale disaster occurs. It also doubles as a model exhibition of disaster response hub.

4.2.3 Hub for preparedness

The Gensai-kan is used as a place of learning or collaboration in ordinary times. The 1st and 2nd floors are open to public on afternoon of Tuesday through Saturday.

In the “Gensai Gallery” and “Gensai Hall” on the 1st floor, visitors can learn about disaster prevention and mitigation through various exhibitions showing fundamental to cutting-edge research information. In addition, diverse seminars are frequently held here.

The 2nd floor has “Gensai Library" where visitors can view or read various disaster-related materials; newspaper, magazines, videos, books, historical materials or hazard maps of municipalities, ground-related data, old maps, etc.

The Gensai-kan is a place of “learning” and “awareness raising” that offers visitors an opportunity to understand natural disasters by contact with various exhibitions or materials firsthand and to think about disaster prevention and mitigation locally. At the same time, it also is a place for cooperation and collaboration where diverse groups of people involved in disaster prevention and mitigation activities, such as researchers, governments, companies, and citizens, join hands with each other.

5. In Closing

The Disaster Mitigation Research Center (DMRC), Nagoya University is playing a role as a region-based disaster mitigation think tank with the support of many people in the local community. By positioning the Gensai-kan as “Gensai Agora” (agora means a square in Greek) to mobilize all capabilities from the community, I hope we can create a society where everyone understands that disasters can happen to them, too, saves their own lives, and cooperates with family and community members. What we should do to achieve this goal is as follows; to learn the region’s history, to grasp the actual state of the region, to analyze charms and challenges of the region, to paint a vision of the future, and to promote and implement regional activities. We would like to learn about the region, help the Gensai-kan grow into a local museum that contributes to the creation of local community in cooperation with the society, and capitalize on earthquake engineering research to reduce earthquake disasters in the region. We call this activity in which we mitigate disasters, overcome them, and then create a society with new values “Disaster Mitigation Renaissance."

Note: Please visit our website at http://www.gensai.nagoya-u.ac.jp/ for up-to-date information on the Disaster Mitigation Research Center and Building (Gensai-kan).