Efforts to Estimate and Provide Information on Damage to Infrastructure Facilities Immediately After an Earthquake

(Research period: FY1992-)

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1. Introduction

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and other organizations that manage public infrastructure need to grasp the status of their facilities in the event of an earthquake, and promptly conduct inspections of the facilities under their control. However, when a disaster impacts a wide area, as in the case of the 2011 Tohoku Earthquake off the Pacific Coast , or when an earthquake occurs at night, as in the case of the 2016 Kumamoto Earthquake, it may take several hours or more to grasp the state of damage.

NILIM has been continuously conducting activities to estimate damage to infrastructure using seismic observation records and provide the information obtained, in order to support disaster response in the information vacuum immediately after the occurrence of an earthquake. This paper introduces the transition and current status of these activities.

2. Development of a "Real-time Earthquake Damage Estimation System" (from 1992)

At the time of the 1995 Southern Hyogo Earthquake, which gave rise to the importance of organizational systems immediately after an earthquake, seismic intensity information was shifting from sensory perception at two or three meteorological offices in each prefecture to mechanical measurement using seismic intensity meters.

Accordingly, in order to support the decision-making process of road administrators responsible for the initial response in the information vacuum immediately after an earthquake, MLIT's seismograph network was established by networking about 700 locations along national highways and rivers nationwide under its direct control, and the "Real-time Earthquake Damage Estimation System," which uses earthquake observation information to predict liquefaction of the ground and damage to infrastructure such as bridges, was developed. Damage prediction is made about 15 minutes after an earthquake and made available to disaster response personnel online. Damage prediction methods for infrastructure are based on estimated seismic motion distribution and damage functions of infrastructure, and we are still working to improve the accuracy of prediction.

3. "Reference Earthquake Information" based on comparison with previous earthquakes (2009 - 2015)

Since the Technical Emergency Control FORCE (TEC-FORCE) was established in 2008 to support local governments in disaster areas in the event of a large-scale disaster, it has been necessary, at the time of an earthquake, to grasp the state of damage to not only facilities under the control of MLIT but also to infrastructure and housing in the affected areas, as well as human damage, in order to consider the scale of the support system.

Accordingly, we created a database of various types of information on earthquakes that have caused damage in recent years (seismic observation data and numerical information on the distribution of seismic motions and damage) and established a system to extract from the database earthquakes (reference earthquakes) with similar distribution and maximum values of SI values and regional characteristics (urban areas, mountainous areas, etc.) observed and collected by the seismograph network, and then provided the information obtained to the relevant departments of MLIT as "Reference Earthquake Information" (**Fig.1**). Thus, having this reference earthquake information has made it easier to imagine the extent of damage and the scale of the disaster response.

Then, we automated the data collection and information comparison, and improved the accuracy of the estimated seismic motion distribution by adding the observation records of K-NET of the National Research Institute for Earth Science and Disaster Resilience (NIED), which consists of strong-motion seismographs installed in about 1,000 locations nationwide, to the observation records of the seismograph network.

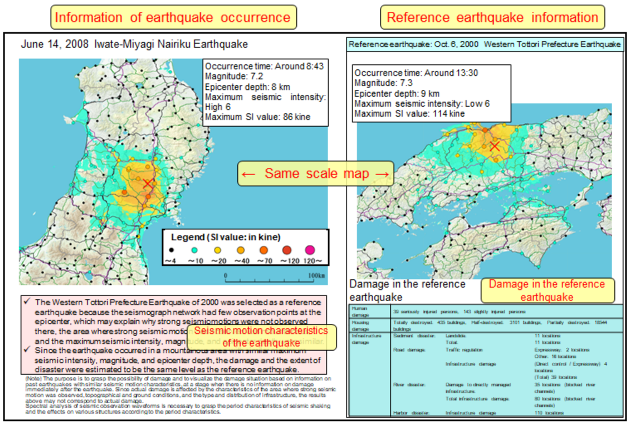

Fig. 1: Reference earthquake information

4. "Spectral analysis information" by comparison with damage occurrence lines (2009-)

The reference earthquake information cites the state of damage caused by previous earthquakes. However, in the case of unprecedented widespread earthquake, such as the 2011 Tohoku Earthquake off the Pacific Coast, there are cases where there are no existing earthquakes to refer to in the database. In addition, even if the SI value distribution was presented as a seismic motion index that correlates relatively well with the degree of damage to infrastructure, it is an index with which civil engineers are not familiar, so a more engineering-oriented evaluation method was required.

Therefore, at the time of an earthquake, we are distributing "Spectral analysis information" to estimate the scale of damage by comparing an acceleration response spectrum (**Fig. 2**, colored line) having a natural period of 1 to 2 seconds, which is considered to be highly correlated with damage to infrastructure and medium and low-rise buildings, with the "damage occurrence line" (**Fig. 2**, black line). In Fig. 2, since the acceleration response spectrum of the relevant earthquake is below the damage occurrence line, the damage is estimated to be very limited.

In order to distribute the spectral analysis information, staff had been downloading the data and creating the spectral analysis information themselves until 2016. However, in the 2016 Kumamoto Earthquake, it took 3-4 hours after the earthquake for the spectral analysis information to be distributed partly because it occurred at night, so the information could not be utilized during the information vacuum immediately after the earthquake.

Accordingly, we built a system in 2017, which automatically obtains information necessary for spectral analysis information and automatically distributes it within approx. 15 minutes after an earthquake.

By reviewing the spectral analysis information, the extent of damage to infrastructure can be immediately estimated. Meanwhile, since spectral analysis information is considered to predict damage at the seismic motion observation points, we are making improvements in order to create spectral analysis information that takes into account the records of observation points of the Japan Meteorological Agency, from the viewpoint of observation density improvement.

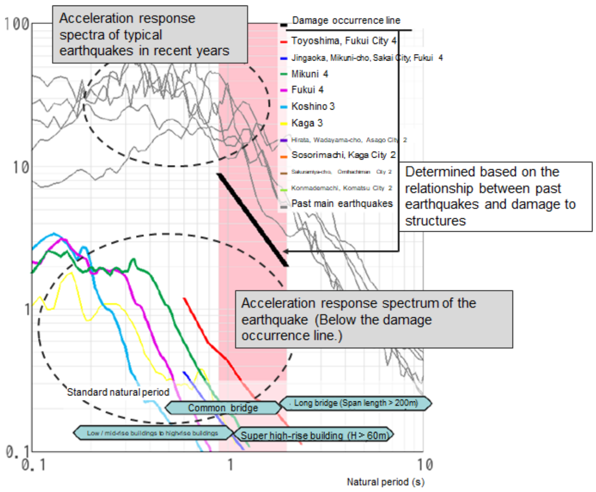

Fig. 2: Spectral analysis information (extract)

5. Conclusion

At present, spectral analysis information is distributed to disaster response personnel at Regional Development Bureaus, etc., and is used as reference information during information vacuums, such as at night. However, the 2021 earthquake off the coast of Fukushima Prefecture exposed the problem that it would take time to obtain the information necessary to create spectral analysis information. We will continue to address these issues as needed and improve the accuracy of our damage prediction.

In addition, as an incidental benefit of distributing spectral analysis information, it will also provide an opportunity for disaster response personnel to think about what an acceleration response spectrum, an engineering index, is. We will continue to work on the distribution of information and promotion of understanding, as the benefits should be important.

☞See the following for details.

1) "Automatic distribution of seismic motion analysis information to reduce the information vacuum immediately after an earthquake," KATAOKA Shojiro, NAKAO Yoshihiro, ISHII Yosuke, OMICHI Kazuho, Proceedings of the 39 JSCE Earthquake Engineering Symposium, p. 8, Oct. 2019