DEVELOPMENT OF INTEGRATDE SITUATION BOARD SYSTEM (e-DRiMSS) FOR DECISION SUPPORT IN EARTHQUAKE DISASTER REPONSE ASIAN CONFERENCE ON REMOTE SENSING ACRS 2020

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ABSTRACT: Damage cases from earthquake disasters are occurring worldwide and South Korea, which is considered relatively safe from earthquakes, has also suffered many losses due to earthquakes recently. In September 2016, an earthquake of 5.8 on the Richter scale occurred in Gyeongju City. In November 2017, an earthquake of 5.4 on the Richter scale occurred in Pohang City, and a liquefaction phenomenon was observed in the Heunghae-eup area for the first time in South Korea. With the rising intensity of earthquakes, the anxiety of local residents is rising due to insufficient preparation and countermeasures, and people are requiring more preparations for earthquake disasters.

This study developed a system to provide reference data for decision making of managers to minimize damage in the event of earthquakes. The Earthquake-Disaster Risk Management Support System (e-DRiMSS) provides earthquake disaster stages, basic information about earthquakes, information about facilities, importance, shake map/liquefaction map, emergency action plan (EAP) information, and EAP information based on shake map. The e-DRiMSS system is expected to be a useful tool for providing reference data for the decision making of managers.

1. INTRODUCTION

1.1 Sheets for Papers and Typing

In recent years, there has been an increasing need for effective disaster management using information and communications technology (ICT) for early detection of the dangers caused by disasters and calamities and to minimize the corresponding damage.

As the 2017 Pohang earthquake in South Korea turned out to have been caused by human factors, damage recovery and restoration measures are still ongoing. The importance of disaster management is receiving fresh attention due to poor disaster response measures. Because of the extensive damage, studies have been conducted on the stability of the domestic earthquake response systems and on active faults.

In addition, in the Heunghae-eup area of Pohang, the soil liquefaction phenomenon was observed for the first time in Korea. The anxiety of the local residents increased due to the inadequate preparation of the relevant authorities for, and response to, such disasters.

Disaster management is a group of activities aimed at minimizing uncertainties about disasters in order to minimize the corresponding damage. Due to the escalating occurrence of natural disasters, citizens' fears are rising, concerns about countermeasures are growing, and the national and local governments are being increasingly required to implement effective disaster management policies and strategies.

Natural disasters from extreme weather conditions, including typhoons, floods, heavy rains, and landslides, account for the largest portion of natural calamities. Earthquakes are relatively neglected in disaster management. In South Korea, seismic design standards were introduced into the design of buildings in the 1980s. Although excellent research results are being published mainly in the field of seismic analysis, compared to theoretical studies, experimental data or earthquake damage observation data that can predict the degree of earthquake damage are insufficient. In the case of high-rise buildings, a certain level of damage standards can be established through existing studies, but in the case of low-rise brick constructions, the research is insufficient. In the Gyeongju and Pohang earthquakes in South Korea, many cases of damage occurred in low-rise buildings and structures.

2. DISCUSSION

2.1 Establishment of Facilities Distribution Information Sharing Inventory

In this paper, to develop a seismic disaster decision support system, a facility distribution sharing-type seismic inventory based on the importance of facilities was constructed. In Heunghae-eup, Pohang, Sinae-dong in Buk-gu, Sinae-dong in Nam-gu, etc. were selected as testbeds to collect information on facilities such as social overhead capital facilities, energy/industrial facilities, and buildings, and factors for determining the importance of facilities were examined. In addition, evaluation criteria for each detailed facility, such as road bridges, railroad bridges, water and sewage facilities, communication/broadcasting facilities, power generation/electricity facilities, transmission and substation facilities, industrial facilities, apartments, multi-use community facilities, evacuation facilities, etc., were determined. To select facilities in the target area, information on 28,862 facilities in Buk-gu, Pohang City from their building ledgers was collected and classified using the importance evaluation method. For 584 facilities in the entire Pohang and 195 facilities in Buk-gu, Pohang, information on FMS facility safety grades and 118 civil defense evacuation facilities, 409 outdoor evacuation facilities, 119 indoor relief centers, and 119 temporary housing facilities was collected. The name, classification, type, category, safety level, location, and model of the collected facilities were classified, and the evaluation items were determined by reflecting the opinions of facility management experts.

Table 1. Facility importance evaluation criteria

Classification		Earthquake importance evaluation criteria				
		1st priority	2nd priority	3rd priority	4th priority	5th priority
Social overhead capital facilities	Bridges (Roads, railways)	Seismic design	Structure type (Main span length)	Facility location (Class of track)	Deterioration level	Ground and topographic characteristics
	Tunnels (Roads, railways)		Tunnel length	Facility location (Class of track)	Ground and topographic characteristics	Deterioration level
	Dams		Model	Deterioration level	Ground and topographic characteristics	Ease of restoration
	River facilities (Dammed pools and embankments)		Watershed and classification	Deterioration level	Ground and topographic characteristics	Ease of restoration
	Water and sewage facilities		Supply and intake capacity	Deterioration level	Ease of restoration	Ground and topographic characteristics
Energy/industrial facilities	Power generation / electricity facilities		Location	Deterioration level	Ease of restoration	Ground and topographic characteristics
	Transmission and substation facilities		Location	Deterioration level	Ground and topographic characteristics	Ease of restoration
	Major industrial facilities		Location	Structure material	Deterioration level	Ground and topographic characteristics
Buildings	Apartments		Structure material	Height	Deterioration level	Ground and topographic characteristics
	Multi-use community facilities		Structure material	Height	Deterioration level	Ground and topographic characteristics
	Retaining walls and cut slopes		Height	Type	Ground and topographic characteristics	Deterioration level

An inventory database was designed and constructed by determining the facility importance level results and reflecting on them according to the determined evaluation items, as well as by considering linked use of the collected information in the e-DRiMSS system and modules.

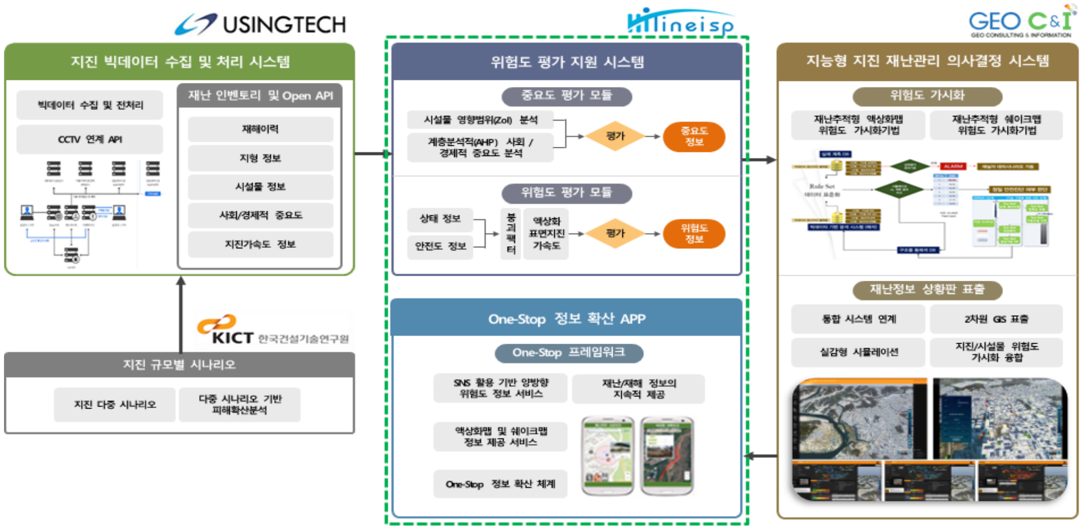

Figure 1. Inventory database linkage plan

2.2 Design and Construction of Decision-Making Support System

To develop the e-DRiMSS system to which the established inventory database will be applied, the function of and display plan for the integrated situation board were defined, and a screen design was prepared. The earthquake disaster stages were set according to the crisis warning system in the Basic Guidelines for National Crisis Management. When the analysis of events (earthquakes) indicates a disaster stage, the system displays the data as blinking, etc. When displaying basic information on earthquakes, the system reviews the linkage of the earthquake acceleration information with the epicenter location information [administrative district (epicenter), bearing, and distance information] provided by the Meteorological Agency. In addition, the facility name, classification, type, and category are displayed.

The system also displays the dependence (level of criticality) of the activities of communities (residents, hospitals, government offices, etc.) and industrial society (agricultural and industrial clusters, textile factories, manufacturing industry, etc.) on major infrastructure (embankments, power, telecommunications, etc.) in terms of quantitative indicators, which are the grades of importance that were determined based on the opinions of experts on the social and economic contribution rate and weight of such activities, and on the support level of each facility.

The LPI information is divided and expressed according to the hard-hit Heunghae area and other areas. Then it is mathematically analyzed based on the dynamic model of the quantitative fluctuations of the vibrometer reacting over time to vibrations generated in the ground when an earthquake occurs. The risk of soil liquefaction is determined by determining the basic EAP of the facility using the probability of liquefaction (the ratio of the vibration shear stress to the shear resistance stress) and the LPI index.

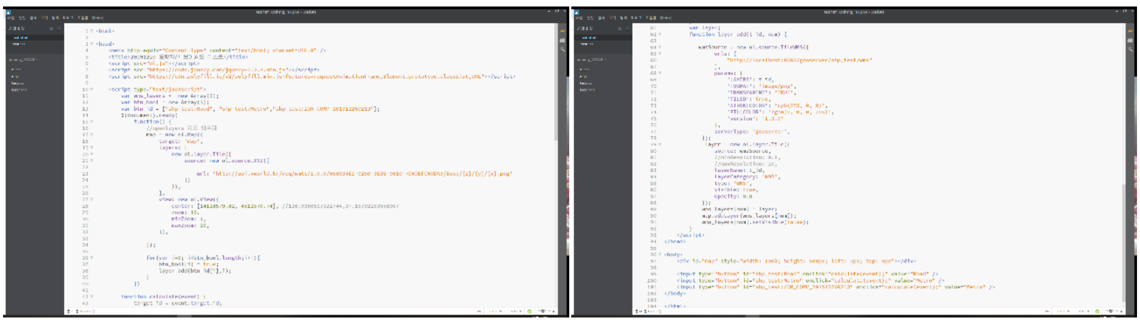
Figure 2. A relation code of V-World

To display map data on an open source web browser, V-World was applied based on OpenLayers of the JavaScript Library. To provide a web-based geographic application API such as Google Map or Bing Map, a code that can be linked on the web was developed and applied. Thus, an e-DRiMSS system was developed that can be used to supply reference data for managerial decision-making in each earthquake disaster stage.

To display earthquake disaster information, a screen design was prepared and the UI was created as shown in Figure 3a. Map information, earthquake disaster stage information, basic earthquake information, facility information, importance information, LPI information, EAP information, and Shake Map-based EAP information are displayed.


a. Integrated situation board (main screen)

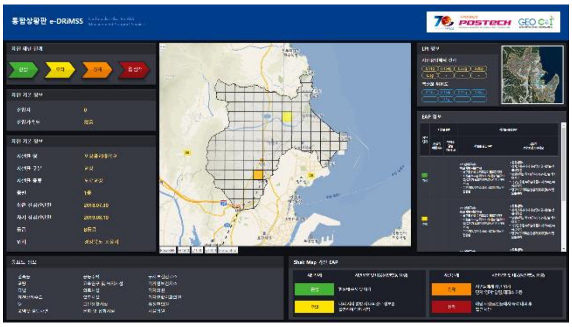
b. Shake Map display

Figure 3. Integrated situation monitoring system

For the map information, 2D- and 3D-based maps were expressed by applying V-World's API to provide facility information. In the earthquake disaster stage, when an earthquake occurs, the seismic information is analyzed; the earthquake is classified by color into one of the four stages of *attention*, *watch*, *alert*, and *severe* according to the crisis warning system of the National Security Agency Guidelines Regulations; and the disaster information is flashed on the screen.

The basic earthquake information was linked to the earthquake acceleration and epicenter location information provided by the Meteorological Agency. In addition, the facility safety management status information provided by the facility integrated information management system was displayed to provide facility information.

The information of importance, which quantitatively displays information on which major infrastructure the activities of local and industrial communities depend on, is classified into four depths in accordance with the standards in Table 1 of the ‘Enforcement Decree of the Special Act on Safety Management of Facilities.’ The information was expressed in the order of the facility classification, type, name, and importance information.

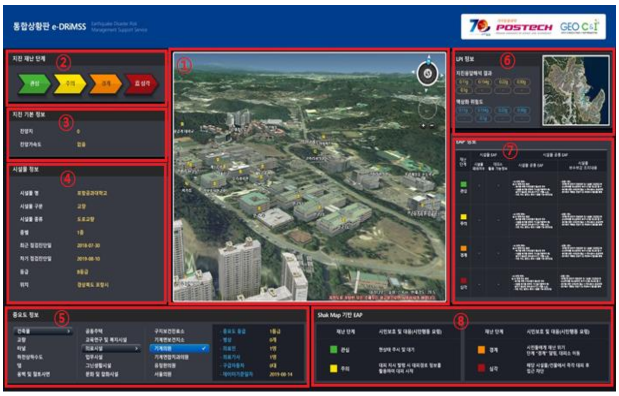
Figure 4. e-DRiMSS

The results of the seismic response analysis, the probability of soil liquefaction, and the LPI index are expressed as shown in Figure 3b. Based on them, the basic EAP of the facility is calculated, and the stage (*attention*, *watch*, *alert*, or *severe*) is provided to enable the manager to take facility maintenance and reinforcement measures. Information on how to protect citizens and how to respond to the disaster is also provided, along with guidelines for citizens' evacuation. Figure 4 shows the functional categories of the e-DRiMSS system to provide the earthquake disaster information described above.

In addition, the average display time was tested to quickly display the earthquake disaster situation information. Based on the web-based system, the driving speed of the system was measured 10 times and then analyzed. The result was 187.74 ms on average, which took an average of 0.19 seconds, ensuring the speed of the system's expression of earthquake information.

3. CONCLUSION

In this study, a decision-making support system was developed to help managers make decisions and respond quickly in case of an earthquake. In the event of an earthquake, a soil liquefaction map derived through simulation is provided. Based on this map, importance-based facility information and attribute information can be provided and utilized. In addition, the system is expected to be used as a reference for selecting evacuation shelters and evacuation routes by providing information on areas with danger of soil liquefaction, etc. In addition, further earthquake-related data will be analyzed. Moreover, the system will be linked to other systems in the other project that is constructing the building safety intelligence information platform based on smart sensors in areas where earthquakes frequently occur.

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