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Theoretical research on the Fire-Fighting Dynamics and Countermeasures against Seismic Occurrence in South Korea

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Abstract:
The purpose of this study was to examine the earthquake occurrence situation and earthquake disaster response system in Korea, identify the difficulties and problems experienced by firefighting organizations in the event of an earthquake, and propose countermeasures that can be used by firefighting organizations when an earthquake occurs. In the event of an earthquake, firefighting activities in Korea can be divided into fire, rescue, and first aid. In the event of an earthquake, fires that can occur simultaneously can be suppressed and rescued and rescued. In carrying out such activities, there are some problems. First, in Korea, there are not enough fire-fighting facilities with seismic design, so the firefighting organization, which should be the first to be input when an earthquake occurs, may be damaged and unable to perform proper activities. have. Second, it was found that the propagation system for notifying the earthquake disaster was not operating effectively, third, the firefighting facilities were having difficulty in operating the emergency rescue control team, and fourth, there was a shortage of firefighters. To solve this problem, this study suggested the following measures. First, the scope of seismic design of firefighting facilities should be expanded. Second, strengthen the cooperation system for information exchange in the event of an earthquake and reinforce firefighting observation facilities. Third, it is necessary to supplement related laws and institutional aspects. Fourth, it recruits related experts. Fifth, concrete action plans should be prepared at the national level in the event of an earthquake, such as howto act and recover training.

Key Word*: Fire-fighting Dynamics; Seismic Occurrence; Seismic Design; Propagation System.*

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I. Introduction

In South Korea, there was a consciousness of relatively safety against earthquakes, but the magnitude 5.8 earthquake in Gyeongju in September 2016 and the magnitude 5.4 earthquake in Pohang in November 2017 present that South Korea is no longer safe from earthquakes. In addition, the number of earthquakes has been increasing recently, with an average of 16 times in the 1980s, 26 times in the 1990s, 44 times in the 2000s, and 59 times between 2010 and 2015. In particular, experts have also mentioned the possibility of large-scale earthquakes, raising the need for government-level seismic measures due to uncertainties over the occurrence of earthquakes. Ministry of Public Safety and Security(2016), Earthquake prevention. p.1.Also, South Korea is not located in the Circum-Pacific belt, so the Ring of Fire. However, it is convinced that Korea as a safe zone from earthquakes. Sichuan Province in China is also located in the same Eurasian plate as Korea, but around 70,000 people died due to an 8.0-magnitude earthquake. In other words, major earthquakes can occur not only in countries located on the boundary of the tectonic plate but also in countries located on the tectonic plate, which can be seen as a testament to the fact that Korea is not safe from earthquakes.

In Korea, it was a tragic experience of missing the golden time due to the absence of a disaster management control tower and lack of systematic countermeasures when a major disaster occurred. Although the government has constantly made efforts to prevent disasters and minimize damage, such as the reorganization of related legal systems, the creation and integration of related departments, the problem of failing to create an environment in which skilled professionals cannot be deployed at disaster sites is emerging. Kim, S.C(2018). A study on the problems and countermeasures of fire station in earthquak. The doctoral degree. Wonkwang Univ.

This study aims to examine the current status of earthquakes in South Korea and the fire-fighting response system related to seismic and to deduce problems accordingly. Also, based on the problems related to fire-fighting related to seismic disaster in South Korea, this study suggest practical improvement measures that may be necessary for fire-fighting activities. Through this, the government intends to contributes to creating a safe environment, including the safety of the people and the protection of property.

The aim of this research is to identify the difficulties and problems that fire organizations face in the event of earthquake disasters in South Korea, and to make practical suggestions for countermeasures. To achieve the aim, this study conducted a literature review using previous research and publications, and the detail objectives are as follows: i) Summarize the concepts and characteristics of earthquakes through the literature study. ii) Discuss the current status of earthquakes in South Korea and countermeasures to cope with seismic disaster, iii) Examine how fire-fighting activities are carried out in the event of an earthquake in South Korea and figured out the problems. iv) Suggest countermeasures that can be used by fire-fighting organizations in the event of an earthquake in South Korea.

II. Earthquake and Disaster Protection

Conception and Characteristics of Earthquake

Earthquake is a phenomenon in which the surface of earth, or ground, is shaken by the impact of rocks in the ground by natural or artificial causes. In particular, as the energy accumulated for a long time inside the earth explodes momentarily, part of it appears to be the shape of the seismic wave, which is called the hypocenter and the surface point above hypocenter the is called epicenter. The direct cause of the earthquake cannot be disclosed, but it is believed to be caused by an earthquake or a sudden release of energy accumulated in it when a plate located on the rock source of earth moves and collides with other plates. There is Plate tectonics to support occurrence of earthquake, this is the natural cause of earthquakes, which is called a structural earthquake. Inside the Earth, it is divided into a rock sphere consisting of solid rock, a lower mantle consisting of mantles and an outer and inner core (see figure 1). The plate means the lithosphere from the surface to about 100km inside the earth.

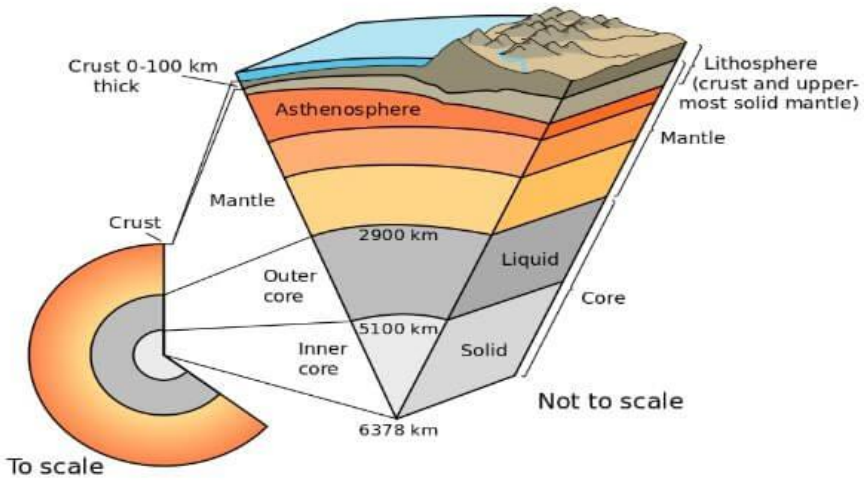

Figure no 1: The Inner Structure of the Earth

Most of earthquakes occur on this plate boundary, in earth, and even inside the plate, small earthquake are consistently occurring. There are more than one 8.0-magnitude earthquake worldwide, an average of 17 times earthquakes with magnitude of 7.0 to 7.9 or below, 134 times earthquakes with a magnitude of 6.0 to 6.9 or below, 1,319 times earthquakes with a magnitude of 5.0 or lower, about 13,000 times earthquakes with a magnitude of 4.0 to 4.9 or below, and more than 130,000 times earthquakes with a magnitude of 3.0 to 3.9 or below. In addition to the natural causes, earthquakes can occur due to artificial causes such as nuclear tests or artificial explosions for fossil fuel extraction, collapse of large buildings and development of underground water. The risk of earthquakes originated from predictive uncertainty. Various methodologies are discussed in predicting earthquakes but predictive uncertainty is inherent because they are not yet applied in practice. This results in expert consultation, and in some cases, the difference in measuring ground acceleration in the eastern part of the U.S. is more than double depending on the actual professional level. South Korea also lacks geological research based on the record system, and considering the risks associated with nuclear power plants, measures related to earthquake prediction and fire prevention are necessarily need. Also, the risk of earthquake is characterized by complexity. If an earthquake occurs, it may cause other historical and economic risks involved depending on the strength and magnitude of the earthquake. For instance, after an earthquake, the complex problem can be occurred such as traffic jams, water supply, electricity outages or outbreaks of infectious diseases. This causes secondary damage to local residents and increase the risk with various factors.

Status of Earthquakes Internal and External

Earthquakes that occurred in South Korea generally happened on the border of fault or fault lines located on the Korean Peninsula. Especially in South Korea, earthquake activity has been relatively low compared to neighboring countries since it is located inside the Eurasian Plate (Table no1).

Table no 1: Shows Earthquake Occurrence 1978~2015.

Scale	5.0~5.9	6.0~6.9	7.0~7.9	Above 8.0	Total number	Annual average
The world	57,376	4,413	536	33	62,358	1,641
South Korea	6	-	-	-	6	0.16
Japan	3,440	617	81	6	4,144	109

Table no2: Average Seismic Status

Scale	Average number of earthquakes			
	1978~2016	1978~1998 (Analogue observation)	1999~2016 (Digital observation)	2017
2.0~2.9	37.5	19.2	58.9	223
Above 3.0	9.7	8.8	10.8	19
Felt earthquake	8.4	5.9	11.3	98

However, earthquakes occurring inside the plate appear irregularly, it cannot be optimistic that the country is a safe area from earthquakes. Earthquake with magnitude 2.0 and below 3.0 have occurred approximately 59 times from 1999 to 2016, but are presenting a rapid growth trend with approximately 223 occurrences in 2017 (see Table 2). In particular, Korea is no longer safe from earthquake with a 5.8 magnitude earthquake in Gyeongju in 2016 and a 5.4 magnitude earthquake in Pohang a year late in 2017.

Countermeasures of Earthquake Disaster in South Korea

Disaster management means all activities performed to prevent, respond and recover disaster. South Korea intended to prevent and prepared for disasters by introducing a disaster management system and to protect the people from the dangers of disasters. In addition, 58 detailed tasks were prepared in eight field by establishing comprehensive earthquake prevention measures and plans for seismic reinforcement of existing public facilities under the Earthquake Disaster Countermeasures Act. In other words, a comprehensive earthquake prevention countermeasure system was established by creating standards for seismic design by agency and by year, and related goals for reinforcing existing facilities, so that seismic observation system, education, and training could be applied sequentially (Figure no2).

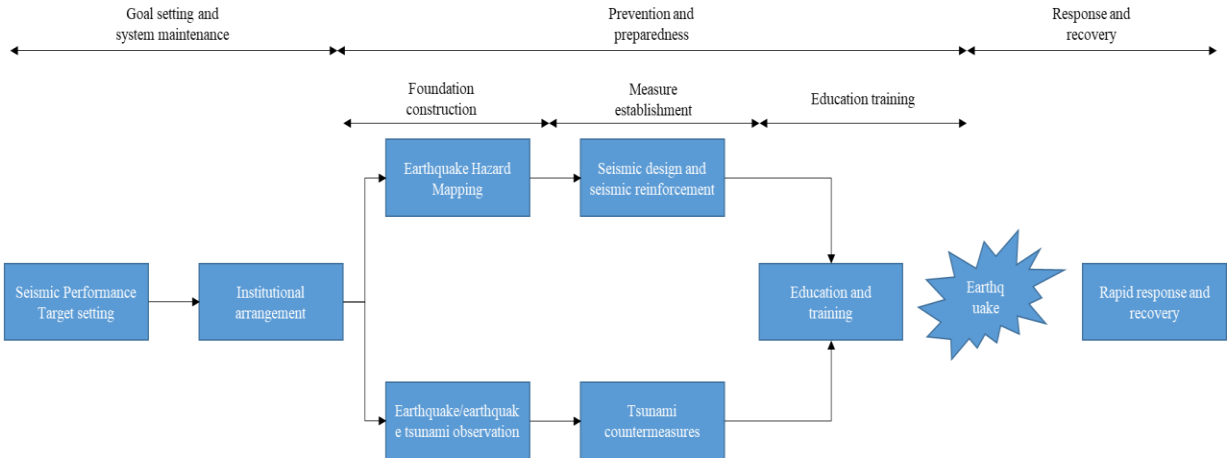

Figure no 2: Comprehensive Earthquake Disaster Prevention System Diagram

Meanwhile, South Korea revised the "Earthquake Disaster Countermeasures Act" in 2016 to the "Earthquake and Volcanic Disaster Prevention Measures Act" to comprehensively specify prevention and

preparedness for earthquakes, earthquake authorities, seismic measures, and research and technology development to reduce earthquakes and disasters. The Ministry of Public Administration and Security announced measures to improve earthquake-resistant materials so that the seismic reinforcement of existing buildings could be completed, along with expanding investment support and strengthening safety regulations to improve the earthquake-resistant rate. Furthermore, the government was required reinforced confrontational ability of seismic disaster by improving safety measurement system, conducting earthquake evacuation training twice a year and supplementing the national action guidelines. For this purpose, fire-fighting forces should be secured to prevent combustion expansion, save lives, and concentrate on response activities such as first aid.

Seismic fire-fighting can be categorized into fire, rescue and first aid. In terms of Fire, in the event of an earthquake, fires occur simultaneously and the extent of the damage increases rapidly over time. Further, not only is traffic paralyzed, but the road is limited, so that there are difficulties until arriving at the disaster site. Combustion is highly likely to expand and lead to large-scale fires. In this case, the purpose of fire-fighting activities is to save lives and the principles to such activities are as follows.

III. Problems of Fire-fighting Activities and Response in Earthquake Outbreak

Fire-fighting Activities in Earthquake Outbreak

In the event of an earthquake, fire-fighting activities shall be prioritized in ensuring the safety of human lives and experiencing damage by identifying the scale and damage of earthquake. It is ideal to detect fires early and put them under control to prevent expansion. In addition, in case of simultaneous fires, activities should be carried out to ensure the safety of human lives, and areas with high risk of fire should be prioritized in the event of fire in various areas. Second, as a rescue activity, buildings or soil collapsed due to earthquakes, resulting in simultaneous large-scale rescue situations. In this case, rescue activities are carried out first at the fire site, and the efficiency of rescue activities is increased by identifying the demand of rescue. Third, as a first aid, it is necessary to prepare for the simultaneous and widespread occurrence of many injuries in the event of an earthquake. At this time, life-saving activities are prioritized as well as rescue and information is collected through cooperation with medical institutions and others, while emergency medical centers are installed in the field to conduct first aid activities. Fire-fighting activities can be carried out more smoothly in the event of an earthquake, preventing the spread of fires from earthquake occurrence, and minimizing casualties and minimized infrastructure damage.

Problems of Fire-fighting response in South Korea

First of all, South Korea is lack of seismic-resistant fire-fighting facilities. The seismic design of fire-fighting facilities aims to minimize damage in the earthquake outbreak by deploying fire-fighting facilities with improved seismic performance. According to the Enforcement Decree of the Fire-fighting Facilities Installation, Maintenance, and Safety Control Act, it is required to obligatorily establish fire-fighting facilities in accordance with the seismic design standards prescribed by the head of the National Emergency Management Agency so that fire-fighting facilities can operate properly in the event of an earthquake such as fire-fighting systems, fire-fighting water facilities, and fire-fighting facilities. However, there are only those criteria, but no specific legal basis or basis for seismic design methods which is yet available.

Second, in earthquake outbreak, the radio system that informs it should be operated more effectively. In case of South Korea, according to Article 38-2 of the Framework Act on Disaster and Safety Management (Establishment and Operation of Warning System), forecasts and alarms caused by earthquakes can be displayed on mobile phones. Accordingly, the National Disaster and Safety Portal operates a text system to prepare the public for disasters in the event of disasters. However, in case of an earthquake in Pohang in 2018, text messages were not sent until about seven minutes after the earthquake.

Third, there are difficulties in operating the Emergency Rescue Control Group. In the event of a disaster, the emergency rescue control team performs the command and control of rescue measures, rescue activities, and the authority of command is overlapped. In other words, each person in charge in not only different from the Minister of Public Administration and Security in the case of the head of the Disaster and Safety Countermeasures Headquarters and the head of Central Emergency Rescue Control Group, but among the authority of the Disaster and Safety Countermeasures Headquarters, there is a overlap with the authority of the Emergency Rescue Control Group (limits to traffic, orders for preparedness, and measures for forced evacuation), so clear regulation are needed.

Fourth, shortage of manpower is problematic. As of 31th December, 2016, the current status of on-site manpower shortage compared to the standard of firepower in South Korea shows a total of 19,254 fire-fighting personnel in short supply (32,460) compared to the required workforce (51,714) (Table no3).

Table no 3: Status of on-site shortage in comparison to fire personnel standard (unit: person)

Division	Limit	Standard	Lack	Division	Limit	Standard	Lack
Seoul	4848	5176	318	Sejong	202	419	217
Busan	2055	2700	645	Gyeonggi	5505	9067	3562
Daegu	1649	2224	575	Gangwon	1997	3635	1638
Incheon	1738	2367	629	Chyngcheong	2924	5919	2995
Gwangju	842	1140	298	Jeolla	3596	6581	2985
Daejeon	969	1218	249	Gyeongsang	4413	8463	4050
Ulsan	674	923	249	Jeju	527	1009	482

If a major disaster such as earthquake occurs in the country, the problem of fire-fighter will become problematic, and it is urgent to add more manpower to prepare for it. In addition, it is necessary to strength internal stability by securing fire-fighter with expertise in earthquakes.

IV. Suggestion of Fire-fighting Response to Seismic Disaster

First, the scope of seismic design of fire-fighting facilities should be expanded for prevention purpose. The damage to private and commercial facilities earthquake occurrence is also great, but if an earthquake damages a fire facility, it could cause life-saving difficulties and the secondary damage caused by the failure to extinguish the fire is likely to be enormous. Therefore, considering the seismic performance of fire-fighting facilities, it is necessary to prevent damage to fire-fighting facilities and minimize damage.

Second, it is necessary to strengthen cooperation of information exchange and fire-fighting observation facilities should be reinforced. In earthquake occurrence, information on it and information related to the damage forecast shall be collected and provided to citizens. Especially since there are a number of earthquake in Japan, which is adjacent to South Korea, the international information system should be strengthened to receive relevant information about the tsunami and earthquake. In addition, effective measures for earthquakes and tsunami should be devised by predicting the time when ta tsunami arrives and assessing the risk level of each region. To achieve this, the government should not only identify information about earthquakes from the Korea Meteorological Administration, video information from affected area, damage situations, and other information provided by Japan, but also focus on reinforcing and operating the system so that the agencies can collect damage information independently in South Korea.

Third, it is required the supplementation of relevant statutes and institutional aspects. According to Article 20, level of 3, the Enforcement Decree of the Fire-fighting Facilities Act in South Korea requires the preparation of a fire safety management target (automatic fire detection facility) which should be prepared to prevent a fire by earthquake.

Fourth, it is desperately need more manpower for fire-fighting. As discussed earlier, the number of fire officials in South Korea is far short. Accordingly, the number of fire officials should be continuously increased while actively considering the use of volunteer workers and volunteer fire team in the event of an earthquake. In other words, the public and private sectors should work together to operate an emergency recovery team while working with professionals to ensure rapid recovery in the event of an earthquake.

Fifth, the government should conduct measures and rehabilitation training for the people to respond to earthquakes. Due to the belief that South Korea is relatively safe from earthquakes, there is a lack of information on people's earthquake response training and behavior knack compared to neighboring countries.

Therefore, the fire organization of South Korea should establish fire-fighting plans for fire, rescue and first aid activities in case of an earthquake, while conducting seismic-causing behavioral knack and training in advance for the safety of the people. In particular, the fire-fighting department should be fully prepared to respond to earthquakes by conducting emergency call training, initial measure training, collecting information, command headquarter operation training, extinguish training caused by earthquake and unit formation training.

V. Conclusion

The aim of this study was to investigate earthquake situation and the earthquake disaster response system in South Korea, identify the difficulties and problems experienced by fire-fighting organizations in the event of earthquake, and suggest countermeasures that can be used by fire-fighting organization in earthquake occurrence. This study determined the concept and characteristics of earthquakes and the causes of earthquakes and examined the national measures to cope with earthquakes. Further, the activities of fire-fighting organization in seismic outbreak were discussed and the corresponding problems were handled. In the earthquake occurrence, fire-fighting activities in South Korea can be divided into fire, rescue and first aid. In the

outbreak of earthquake, it is necessary to extinguish fire first, life-saving and conduct first aid activities. There are several problems in carrying out these activities during seismic outbreak.

First, in case of South Korea, due to the lack of earthquake-resistant fire-fighting facilities, the first fire-fighting organization to be deployed in the earthquake outbreak may be damaged and not be able to carry out proper activities. Second, the radio system that notifies the earthquake disaster is not operating efficiently. Third, the fact that fire-fighting facilities have difficulty operating the group of emergency rescue control. Fourth, there is a lack of fire-fighter manpower.

To solve these problems, the study suggests the following measures; First, the scope of seismic design of fire-fighting facilities is expanded. Second, the cooperation system for information exchange in earthquake outbreak is strengthened and fire observation facilities are reinforced. Third, it is necessary to supplement the relevant statues and system. Fourth, recruit related professionals. Fifth, specific action plans for the people's behavior and restoration training should be prepared at the national level when an earthquake occurs.

This study is significant that it preemptively presented the activities, problems and countermeasures of the fire-fighting organization in the earthquake occurrence. However, it is limited in that if failed to conduct empirical research on whether it was actually effective as a theoretical study. Therefore, it is necessary to conduct empirical research to investigate if the fire-fighting countermeasures presented in this study are effective in actual fire-fighting activities.

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