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Improvement Programs for Earthquake Disaster Management

- Cases of Gyeongju and Pohang in Korea -

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Abstract

In order to build up a quick and unified nationwide earthquake disaster management system in the event of an earthquake disaster, it is necessary to analyze the current state of earthquakes in South Korea and find the problems of the current disaster management system through earthquake cases. The purpose of this study is to investigate the basic concepts of earthquake and disaster management, largely focusing on the Gyeongju earthquake of September 12, 2017 and the Pohang Earthquake of November 15, 2017, and to suggest by comparing and analyzing the research data and previous studies which are describing the need for improvement of current diasaster management system and what its problems are.

Key words: Gyeongju earthquake, Pohang earthquake, disaster management

Ⅰ. Introduction

In worse cases, these occur in areas where populations are highly condensed and lead to secondary damages on the top of natural disasters(Jeong, 2017: 1). In the case of South Korea, there are high chances of damage due to tidal waves that are caused by earthquakes happening in Japan, close to Korea. Considering that ashore areas keep attracting people with a lot of values in terms of socioeconomic utilization, landscape, and environment, there is no doubt that there will be severe damage to human lives and properties when the tidal wave from an earthquake hits(Kang, *et. al.*, 2011; Bae, *et. al.*, 2018: 114).

Recently, a magnitude 9.0 earthquake happened east of Japan. It is assumed that it caused 18,455 casualties east of Japan near the Pacific Ocean, especially in Iwate, Miyagi, Fukushima, Ibaraki Prefecture and etc. It recorded the 3rd highest casualties following the great Kanto earthquake in 1923 with 154,000 casualties and Meiji Sanriku earthquake in 1896 with 21,959 casualties. It caused property damage worth 16-25 trillion Yen.

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Japan is well equipped with disaster prevention systems and facilities, and people are well trained and prepared for countermeasures in case of natural disasters, but they undergo a great deal of damage in the face of enormous natural forces(Jeong, 2017: 1).

The Gyeongju earthquake with magnitude of 5.8, which happened on September 12 in 2016 can be mentioned as the case of South Korea. This caused injuries to 26 people, about 11 billion Won worth of property damage, roughly 5.8 billion Won worth of public facilities damage and nearly 5 billion worth of damage to cultural heritage. Another case is the Pohang earthquake with a magnitude of 5.4 that happened on November 15, 2017. This caused 53.2 billion Won worth of public facilities and 43.9 billion Won worth of private properties as well as injuring 92 people and 1,197 people lost their houses. Since South Korea started to record earthquakes in 1978, the Pohang earthquake is recorded as the 2nd largest earthquake following the Gyeongju earthquake but it caused the most damage. A lot of buildings or structures were damaged. Fortunately, no one lost their lives(Kim, 2017: 14).

The Gyeongju Earthquake in September 2016 and the Pohang Earthquake in November 2017 are record-breaking disasters that are astonishing enough to change the perception of an earthquake that people have not experienced so far. Since the 1978 earthquake was observed, the number of earthquakes has started to increase drastically recently. The total frequency of earthquakes in the last two years(2016~2017) is 474, which contributes 30% of the total frequency of earthquakes since 1978(Nam, 2017: 1; Ha, 2018: 65).

In summary, The Gyeongju earthquake and the Pohang earthquake have made people agree on the necessity of disaster prevention at the national level for earthquakes. changed their perception that South Korea is relatively safe from earthquakes, have a sense of alert and realized that better policies and research for earthquakes are required(Ha, 2018: 66).

Therefore, In order to build up a quick and unified nationwide earthquake disaster management system in the event of an earthquake disaster, it is necessary to analyze the current state of earthquakes in South Korea and find the problems of the current disaster management system through earthquake cases.

The purpose of this study is to investigate the basic concepts of earthquake and disaster management, largely focusing on the Gyeongju earthquake of September 12, 2017 and the Pohang Earthquake of November 15, 2017, and to suggest by comparing and analyzing the research data and previous studies which are describing the need for improvement of current disaster management system and what its problems are.

II. Earthquake and Disaster Management

1. Definition of an Earthquake

An earthquake is one of the most dangerous natural disasters and causes damage to property. About 46% of human lives damage(Death tolls) were caused by earthquakes among the natural disasters that occurred in Asia from 1999 to 2008. Of the estimated property losses due to disasters, 43.4% were reported to stem from earthquakes(Kung & Chen, 2012; Kim, 2017: 59).

An earthquake is a phenomenon in which large rocks in the ground are split or the crust fluctuates, accompanying the movement of the stratum, and waves, so called, seismic waves propagate to the earth's surface and cause the ground to vibrate and cause buildings to tremor. In other words, an earthquake occurs when plates that appear in various forms move, like volcanic activity. However, earthquakes are occasionally caused by other sources of energy(Naver Knowledge Encyclopedia, 2018. 05. 09.).

Generally, earthquakes can be detected simultaneously in large areas. The extent of the tremor, or seismic intensity, in each region is as follows: from the epicenter where cracking originally happened, the vicinity is the most shaky and the vibration is transmitted to all sides, as the distance increases, however, the progress becomes weaker(Jeong, 2017: 3; Busan Safety Homepage, 2018. 05. 09).

Earthquakes that occurred within 600km from epicenter are called 'near-earthquakes', otherwise they are called 'far-off earthquakes'. If they occur at depths of less than 70 km from the surface, it is called a shallow-focus earthquake. If they occur at depths of 70-300km, they are called intermediate earthquakes. If they occur at depths of more than 300km, they are called deep-focus earthquakes. On the premises that it is limited to a certain space and time and depending on the depth of seismic area, an earthquake can be categorized into one of three categories(Busan Safety Homepage, 2018. 05. 09).

The three categories and definitions are as follows:

a. A main shock: The biggest earthquake

b. A foreshock: An earthquake that occurs prior to main shock

c. An aftershock: an earthquake that occurs after a previous large earthquake

2. The causes of an earthquake

The cause of the earthquake has not been clarified yet, but it is known to occur by the energy generated when the plates move or collide with each other. After then, this energy shakes the surface or destroys a part of other plates, the energy stored in it suddenly emits, causing an earthquake(Yang, 2018: 7). Earthquakes can be classified into two types: artificial earthquakes and natural earthquakes

1) Natural causes

This has nothing to do with human being's act but something to do with natural phenomena and can cause earthquakes in 3 main forms as follows:

① Tectonic earthquakes

These are the most common type of earthquakes and are caused when elastic energy accumulated inside of the earth is being released at once.

② Volcanic earthquakes

These happen due to a volcanic eruption.

③ Collapse earthquakes

These occur when a soft ground or cavity falls from inside of the plates(Lee, 2006: 25; Jeong, 2017: 4).

Most natural earthquakes are associated with plate tectonics that explain continental drift. On the basis of the motion of the underground magma, which can cause earthquakes, it is possible to predict the eruption timing and observe the volcanic activity by observing these earthquakes(Yang, 2018: 7).

2) Artificial causes

Explosion of explosives under the ground, underground nuclear tests, etc can be reasons, which can cause artificial earthquakes. Remotely triggered earthquakes can be addressed as a similar term to "Artificial earthquakes" (Lee, 2006: 25; Jeong, 2017: 4).

In some cases, earthquakes occur by human beings. The reason for this is that humans mine fossil fuels, artificially collapse or demolish buildings, and develop reservoirs or ground water. At this time, earthquakes may occur when water is filled or disappears in the gaps between the rocks, and then, the rocks are weakened. An example is the 6.3 magnitude earthquake which occurred by the reservoir on December 10, 1967, in the Koinah region of western Maharashtra, India. Another is the explosion observed in the 1961 "Tsarubaba" nuclear test, equivalent to the power of 50 megatons of nuclear weapons(Yang, 2018: 8).

3. Disaster Management

A disaster conceives danger and danger means the possibility of damage. However, the scale or extent of damage always remains unknown, therefore, uncertainty of damage is the key point in terms of 'danger'. In other words, disaster management can be regarded as managing these risks and uncertainties because disasters have inherent attributes of risk and uncertainty(Lee & Yang, 2004: 56).

The Basic Law on Disaster and Safety Management establishes disaster and safety management systems for the nation, and specify what is required for the disaster and safety management for the federal government or local governments in order to preserve the homeland from various disasters and protect lives(Lim, 1996: 22; Lee, 2012: 348-349).

In this viewpoint, disaster management is one of the policy instruments that can be defined by the concept from being an approach of law or institution, and in a broad sense, it includes all activities to remove the risk of disaster and to arrest and restore damage in the event of a disaster(Byun, 2018: 13).

Disaster management system is to prevent occurrences of disasters in advance and minimize danger of disasters after it happened. So to speak, its purpose is to protect human's lives and their properties and it is performed under the organic cooperation system with related organizations (Byun, 2018: 13).

4. Preliminary Studies on Disaster Management

Lee chose each case of natural disasters that happened in South Korea, USA and Japan, analyzed them and conducted an AHP questionnaire to find out the causes of natural disasters and method to cope with them. Through this, it turned out that disaster management systems works properly with general and small-scale disasters, but it still had its limits to deal with large-scale natural disasters. In conclusion, to build a desirable national disaster management strategy, as members that consist of the central government, local government, private sector, and community, it is necessary for people to fully recognize disaster preparedness and to develop an ability to cope. It is argued that the supreme decision maker's solid leadership and disaster management system should be supported to make all that possible.

Park, Yang, and Ryu(2012) insisted that the most important thing in disaster management be the initial response, and local governments play the most important role in responding to the emergency. However, they also found that local governments have limited ability to play a key role in disaster response, and this is due to the problems of the local self-government disaster management system after analyzing the legal, institutional, manpower, financial, and cooperative aspects of disaster management systems of local governments. According to what they said, it is said that even in local governments, it is also necessary to build up integrating management systems by clarifying the roles among departments, establishing guidelines for disaster response responders, raising morale for disaster officers and training them through proper education, Securing budget, strengthening joint response system and etc.

Jang & Chun(2015) considered that nowadays, it is timely to establish a systematic earthquake disaster response system, considering that the frequency and impact scale of earthquakes are gradually increasing. In addition, to improve the earthquake disaster response system, they analyzed the domestic and overseas earthquake disaster response system and how it is utilized, and suggested ways to help the earthquake disaster response system in South Korea.

Byun(2018) empirically identified what factors affect the operation and effectiveness of disaster management in order to find ways to improve disaster management. After that, he/she divided them into cognitive factors, administrative factors, and environmental factors. Firstly, the cognitive factors included earthquake risk awareness and earthquake interest. Secondly, the administrative capacity of the government for disaster response and the appropriateness of laws and systems related to earthquakes were mentioned. Thirdly, environmental factors consisted of the type of buildings, the age of buildings, and the size of buildings. In other words, he/she analyzed the effects of these factors on the operation and effectiveness of earthquake to disaster management.

Yu & Shim(2018) have found that the domestic earthquake disaster countermeasures and information sharing systems do need working on, and that the distributed response among the different departments is made differently depending on the type of disaster, and the cooperation is not done closely, thus, this is the reason it is difficult to systematically support disaster response. Therefore, it was suggested to integrate informal information (disaster manuals used significantly in disaster management duty, the related laws or etc.,) and formal information in the disaster related system operated by the disaster information in order to construct an efficient disaster management system.

Jeong(2007) pointed out that the damage caused by earthquakes in natural disasters is relatively small, but the frequency and intensity are increasing and there is no prediction system to cope with them. After that, Jeong collected GIS data, processed it into data suitable for earthquake response, and implemented it as a program. Plus, he/she collected information on past seismic data and measurement points by using a program consisting of a geographic city information system called "anyguide" and a Java application, at the same time, by collecting alarm systems that can be handled by the local government at the time of

actual earthquake, the ratio of human injury or property damage could be found.

Jeong(2017) has proven that South Korea is not a safe zone for earthquakes, and conducted a survey on citizens' perception of the dangers of earthquakes, and compared it with how researchers perceived earthquake damage. People were aware of the Gyeongju earthquake through various mass media, however, in the survey, many of them responded to the question that the central government and local governments have not done well in response when coping with aftermath of an earthquake.

Moreover, people's perception of danger towards earthquakes were higher than their one obtained by training or education. Through this, the researcher believed that the agility or technique of evacuation provided by the effects of education are proportional to the quality and frequency of the education, which means they should acquire earthquake evacuation techniques that can be used without forgetfulness, recognize the seriousness, and focus on education for earthquakes. In addition, it is absolutely necessary to train specialists, and that the building law claims it is necessary to review and improve the relevant laws and standards urgently in order to systematize seismic design.

Bae, *et. al.*(2018) analyzed the adequacy of a location of emergency evacuation shelters against the tidal wave form earthquakes through the viewpoint of security vulnerable groups. The researcher conducted the study based on the question "Can the vulnerable groups residing in Busan Metropolitan City reach the emergency shelters within 10 minutes?" After analysis of GIS network, he/she conducted an overlay analysis. As a result, it was proven that most of the evacuation shelters in Busan were located where security vulnerable groups could not evacuate immediately. Therefore, when establishing a resident evacuation plan in preparation for the tidal wave from earthquakes, the security vulnerable group should be prioritized before selecting a place for an emergency evacuation site. On the basis of this, it concluded that disaster preparedness and urban planning should be linked with each other.

Yang(2018) presented a few methods to improve the earthquake preparedness plans and disaster safety management system in South Korea, in order to establish natural disaster prevention measures and minimize damage when disasters occurred. First, expand the roles and functions of relevant departments at the national level and establish a network of integrated information centers. Second, develop a crisis management program for natural disasters that can happen frequently in South Korea, and services for people to get information online.

Ⅲ. Analysis of Gyeongju earthquake and Pohang earthquake

1. The occurrence of the Gyeongju earthquake and the Pohang earthquake

1) The gyeongju earthquake

A series of earthquakes, including the 5.8 magnitude mainshock in Gyeongju on September 12, 2016, were detected in a wide area of the Korean Peninsula. The magnitude of this earthquake was the largest in the southern Korean Peninsula since the first earthquake observation on the Korean

Peninsula began in 1905(Lee, 2017: 190).

All Koreans have thought that the Korean Peninsula is a safe earthquake zone. However, the biggest earthquake ever happened in Gyeongju. On September 12, 2016, a 5.1 magnitude foreshock occurred in 8.2 km southwest of Gyeongju City, followed by a 5.8-magnitude earthquake in 8.7km southwest of Gyeongju at 20:32:54, which was the largest one on the Korean peninsula

When the Gyeongju earthquake occurred, buildings was severely shaken, some glass, roofs and tiles were destroyed in Daegu, which is only about 55km(About 35miles) away from Gyeongju by a straight line. Vibration was also detected in most parts of the country including the metropolitan areas. Most people experienced an earthquake for the first time and 23 people were injured as a result of falling into psychological and physical fear, from falling, falling off of household furniture, vases, or household appliances. As a result of the earthquake damage, small buildings that were not designed for seismic activity, had their roofs and fences damaged or destroyed, resulting in 5,367 cases of damage, totaling 11 billion Won.

Disaster notification text messages were sent after a long time when the earthquake occurred, and the Korean's messenger "Kakao Talk", which is used by over 40 million people, was not functioning smoothly in receiving or sending messages. The anxiety grew because of mobile phones malfunctioning due to the earthquake.

A few days later, a magnitude 4.5 earthquake occurred at 8:33pm in the southwest, 11kms away from Gyeongju on September 19. It had the largest aftershocks out of 300 that occurred after the 5.8 magnitude earthquake on September 12, and it was strong enough to feel the vibration in the whole country. At the time of the second earthquake, the disaster notification text messages were sent 12 minutes after the earthquake, and aftershocks over 1.5 magnitude occurred 554 times until December 31, 2016(Earthquake Year Book, 2016: 206).

In the Gyeongju earthquake that occurred on September 12, the most common damage were roof damages, accounting for about 42% of total damages. Followed by building cracks and fence damage. According to the analyzed distribution of the magnitude, most of the large damage appeared within a radius of about 25 kms from the epicenter. Especially, as most of the damage types are roof breaks, building cracks, and wall breakage, most of the damages caused by the earthquake largely occurred in small houses and structures(Earthquake Year Book, 2016: 210).

2) The Pohang Earthquake

A magnitude 2.2 earthquake occurred at 2:22:32 PM on November 15, 2017 in the 7km north part of Buk-gu, Pohang, followed by a 2.6 magnitude earthquake at 2:22:44pm. These two earthquakes were foreshocks, a magnitude 5.4 earthquake occurred at 2:29:31 PM. At 2:32:59pm, a magnitude 3.6 earthquake occurred 7km north of Buk-gu, Pohang-si. Thereafter, there were several additional aftershocks of a magnitude between 2 and 3. At 4:49pm, a magnitude 4.3 aftershock occurred. The aftershock continuously occurred, and at 4:19:22 pm on December 25, a magnitude 3.5 aftershock occurred in 8 km north of the Buk-gu, Pohang. A total of 70 additional aftershocks occurred during this period, and earthquakes of magnitude 3.0 or greater totally

happened 6 times(Naver Knowledge Encyclopedia, 2018. 04. 27).

The Pohang Earthquake was smaller than the Gyeongju Earthquake in terms of scale, but the seismic intensity was shallower and the magnitude of the sensation was greater and it was strong enough to be detected in the whole of South Korea. After the mainshocks, aftershocks of magnitude between 2.4 to 4.3 followed. These earthquakes affected 1,400 people, injured 135, and property damages worth 67.2 billion Won(Better Tomorrow with Sharing, 2017. 12. 27.).

Roads were cracked in Pohang and the outer walls of buildings collapsed. Some apartment residents were also evacuated urgently. Some companies had employees leave early due to the earthquake. Detected even in Seoul were vibrations, let alone Gyeongju, Daegu and Busan.

According to the Central Disaster Prevention Headquarters of the Ministry of Public Administration and Security, the Pohang earthquake was smaller than the Gyeongju earthquake that happened last year, but it caused 1,797 victims and 55.1 billion Won worth of property damages while the earthquake caused 111 victims and 11 billion Won worth of property damage(News Post, 2018. 04. 26).

2. Discovery of Issues through Analysis of both Earthquakes

First, it turned out that there were problems in facility inspection process, maintenance and management and building seismic design, which are

Table 1. Comparison of Gyeongju and Pohang earthquake

	The Gyeongju earthquake	The Pohang earthquake
Occurrence date	• 2017.09.12	• 2017.11.15
Type	• Spontaneous	• Both spontaneous and artificial
The hightest magnitude	• 5.8	• 5.4
Human lives damages	• 23	• 92
Amount of property damages(Won)	• 11 billion	• 55.1 billion
Amount of private property damages(Won)	• 3.5 billion	• 24.9 billion
Damage recovery cost(Won)	• 14.5 billion	• 145.5 billion
Frequency of aftershocks	• 124	• 68
An emergency notification text message	• Sent 9 minutes after the earthquake	• Sent 19 seconds after the earthquake(faster than seismic wave)
Action of the central-government and provincial governments on the day	• No official meeting held • Officials visited from the central government on the following day	• Operation of the Central Disaster Safety Measures Headquarters Phase 1 at 2:43pm • Officials visited quickly damaged spot from central government at 6:10pm
Features	• The largest scale since the observation of earthquakes in South Korea • Caused 1000 cases of cultural heritages	• Epicenter was shallow and feeling power was greater
Common issues	• Lack of shelters • Insufficient earthquake response manual distribution • Absence of systems to predict damages • Inadequate laws and regulations for improving earthquake disaster prevention • Insufficient training or education to prepare for disasters • Absence of communication • deficient seismic design	

※ Source: Revised from Yeongnamilbo(2018.01.11.); Revised from Kyongbukilbo(2017. 11.22).

preventive steps of disaster management. The Heunghae Indoor Gymnasium, which was used as a shelter for the local residents during the Pohang Earthquake, was designated as a place to evacuate without confirming whether the building was anti-earthquake or not. Not only did the building lose its qualification as a space for tired and uneasy people to rest comfortably due to the earthquake, but caused additional anxiety and fear to people. This means that disaster management and prevention plans did not prepare thoroughly for disaster management in advance, and it is an example clearly showing the problems of policies and systems for disaster management (Kyongbukilbo, 2017. 12. 13).

The representative types of damage caused in the Gyeongju and Pohang earthquakes are the collapse, tilting or collapse of the pillars of the building, which means that domestic building's seismic design is less than 33% of the standard. In South Korea, seismic design was introduced in the construction law since 1988. Since then, it has been known that the structures built after that year are safe from earthquakes, but it has been revealed that there are serious problems in seismic design through the Gyeongju and Pohang earthquakes (Yonhap News, 2016. 09. 12).

Piloti structures in South Korea are mainly applied to multi-family houses and town houses. It is a structure that supports the building by installing only the pillars on the first floor of the building without the outer wall. The first floor is mainly used as a parking area. It is regarded as a favorite way to build a school or a public office building because it can save construction cost compared to installing a parking space in a basement floor in a narrow site and provides an aesthetic effect that gives a visual opening feeling to the first floor. However, the piloti structure has the disadvantage that it is vulnerable to earthquakes because it supports the weight of the whole building on the second floor only by the pillars, and it does not have a bearing wall. Therefore, a new building law was enacted in 2015, and the earthquake-resistant design was applied to the piloti structure. Having said that, it was applied only to the building that was newly built more than two stories, and the existing buildings were not covered by this law. Buildings constructed with piloti structures have difficulty withstanding earthquakes due to the structural limitations of the buildings, especially with vertical earthquakes (Jeonbukilbo, 2017. 12. 05).

The seismic design ratio of buildings in South Korea varies by region: Sejong (50.8%), Ulsan (41%) and Gyeongsangnam-do (40.8%), which is near Kyungju, had comparatively high ratios of the anti-earthquake buildings, but the big cities built a long time ago like Busan (25.8%), Daegu (27.2%) and Seoul(27.2%) had low ratios. The low seismic design ratio can be a problem, however, it is worse that a seismic design that cannot be relied on even in buildings with a seismic design. Experts also pointed out that the application of a seismic design was limited by the type of building, and that there was no countermeasure for structures built before 1988 (Kukjeilbo, 2016.09.13).

Second, in preparation for disaster management, evacuation education and training were insufficient. Given that everyone is affected by disaster in different ways and responds to disasters, the opportunity for disaster education should be given equally to all people, and in the case a disaster

has actually occurred, no one should fail to cope with it due to lack of training or education (Lee, 2012: 153)

However, when the Gyeongju Earthquake and the Pohang Earthquake occurred, the lack of basic knowledge of people, inexperienced response, and the safety indifference in which they thought they were safe from for the earthquake made the citizens incapable of doing anything. After the earthquakes, people rushed out to the streets. However, they didn't know what to do but acted distractively because they had not been informed about the place of evacuation. This means that most of people have been indifferent from where to be evacuated under a disaster as well as that public officials were not adequately trained in disaster preparedness or well trained in response manuals either.

According to the Ministry of Public Administration and Security, there were 160 people who visited the hospital due to the earthquake. In the case of hospitalized patients, only 4 people were injured because of TV, shoe box, etc falling on them. However, there are more than 10 patients injured while being unprepared when the earthquake happened. Elderly people in their 70s were often injured as they rolled down the stairs or got hit by stuff falling on them in the house. On the other hand, in the case of young people in their 20s and 40s, most of them are injured by being thoughtless. Some people jumped out of the window on the second floor in a hurry and they got their teeth broken or ankle fractured. This indicates that people lacked basic cognitive and response skills for earthquakes. It would have been safer for people if they had been thoroughly prepared for earthquakes and had a good knowledge of their behavior (Seoul Economy, 2016. 09. 18).

Third, information delivery, which is the most significant in the case of disaster, was not fast. Agility matters the most in the disaster response steps. At this stage, promptness and appropriateness must be ensured. However, when the Pohang Earthquake occurred, the emergency notification message was sent out 8 minutes after the earthquake and in some cases, it was not sent at all. This was a failure of information transmission which was a part of the initial response. Not only did it increase anxiety for many citizens, but it lowered the credibility of public institutions with prolonged response. Even when an earthquake of magnitude 4.5 occurred on September 19, as it used to be, the emergency disaster notification messages were sent out 12 minutes after the earthquake. Furthermore, the website of the Ministry of Public Administration and Security was not able to share information quickly with citizens because the server was down for 3 hours on the 12th and 19th when the Gyeongju earthquake occurred. This proved that the disaster control tower, functioning as an alarming means, did not do its role.

Fourth, more careful follow-up on the psychological shock than physical shock is needed. In Gyeongju-si, 1,045 people received counseling treatment at the Mental Health Welfare Center due to mental stress after the disaster, and at the Gyeongju Public Health Center, the number of applications for counseling increased about 10 times compared with the usual cases (Nocut News, 2017. 09. 06). This is the evidence that residents are anxious and physically unwell. After the earthquake in Pohang, the restoration work was still in progress, but regardless of it, the victims

were still feeling uneasy because of additional aftershocks.

Especially, during the Pohang Earthquake, the psychological state of the locals was found to be worse than the psychological state of locals during the Gyeongju earthquake. The reason for this is that the Pohang earthquake was smaller in magnitude than the Gyeongju earthquake, but the depth of the epicenter was so shallow that the impacts on the human body could be felt more. Depression and anxiety are relatively more serious(E-daily, 2017. 11. 21).

Disasters create physical, material and spiritual damages for many people, especially those who have experienced a disaster directly, can have greater psychological wounds, trauma and suffer long-term pain.

For example, in the Hebei Spirit oil spill case(2007), one local committed suicide (2008), or when Seongsu bridge collapsed in Seoul(1994), a person who lost his/her turned into alcoholic(2004), or in Daegu subway fire(2002), a survivor acquired schizophrenia(2004), or when typhoon 'Maemi' hit South Korea(2003), a farmer who had property damage took his life, and etc(NEM, 2010; Lim, 2016: 67).

As can be seen in these examples, these sufferings can appear to survivors, bereaved families, rescue personnel, and can also have a negative impact on society due to suicide, abuse, violence, schizophrenia, family demise, alcoholism or drug addiction. In addition, psychological impacts may develop into acute stress syndrome or post traumatic stress disorder (PTSD), which may cause serious long-term mental problems.

Ⅳ. Improvement Programs for Earthquake Disaster Management

1. Prevention and/or Mitigation Phase

Preventing disasters begins at home, and all family members must be aware of the severity of the disaster and be able to practice preventive measures. In addition, companies should ensure that they do the best for disaster management, be able to minimize the damage when disasters happened and quickly restore damaged properties. Moreover, it will be desirable for them to make sure all risk factors are identified in advance on the spot to prevent disasters by finding ways to improve the disaster prevention system.

Jeong(2017) surveyed the residents of Busan on the biggest damage types expected in the event of an earthquake. 30 people(12%) mentioned economic damage, 212 people(84.8%) mentioned human injuries, 6 people(2.4%) mentioned psychological damage and 6 people(2.4%) mentioned socio-cultural damage. Most of them were worried about life or death to human body(Byun, 2018: 180).

Therefore, in order to minimize the damage to people, firstly, the seismic performance of the structure should be reinforced, the fire-fighting facilities in the building should be designed to withstand the earthquake as well and it should be mandatory to apply an anti-earthquake design to all structures that will be built.

The reason why the seismic performance in the structure should be reinforced is to minimize the damage to people or property when the building collapses. The reason why the reinforcement of seismic performance of firefighting facilities should be strengthened is to prevent a secondary

fire due to an earthquake. In the case of an earthquake, firefighting equipment such as sprinklers and fire hydrants should be able to work as normal without breaking down. Otherwise, the system that can cope with the fire caused by the collapses will not be working properly and this can lead to larger diasasters. If a fire-fighting facility with a seismic design is imposed on the building law, the building itself will be able to cope with the fire caused by the earthquake more efficiently while improving the seismic ability.

Additionally, with the Gyeongju earthquake and the Pohang Earthquake as a lesson, people need to make sure there should be no more anxiety caused by disaster shelters which are not designed to be earthquake-resistant. Since a disaster occurs without notice, the place evacuated for safety should universally be able to pursue human dignity and respect for human life under any circumstances.

2. Preparedness Phase

On January 17, 1995, a large earthquake struck Kobe, Hanshin and Awaji areas in Hyogo Prefecture in Japan, killing 6,000 people. After the earthquake, people realized how an earthquake is risky and the importance of precautionary measures. They also conducted training for senior executives in organizations to display the importance of disaster prevention projects and the role of policy makers(Ha, 2018: 75).

In order to effectively cope with the earthquake, public officials who must first cope with the earthquake and local residents who are urged to actually evacuate need to change their perception of earthquakes first. Recognition of seismic risk is amplified after experiencing a real earthquake, but it is easily forgotten as time goes by. It is therefore, important to master the evacuation ability for an earthquake through repetitive education and training.

Although it is desirable to regularly perform earthquake disaster prevention education and training for all citizens, considering the cost and time limit, it is necessary to educate key personnel for earthquake disaster evacuation and train them regularly. Educate public agencies and private halls to arrange people who are responsible for earthquake-related disasters and behavioral issues and lead people to evacuate in the event of an earthquake. In the case of an organization that manages and supervises vulnerable groups such as schools, kindergartens, and hospitals, the role of core personnel is very important, so a system is needed to support them in their education and training(Ha, 2018: 79-80). In particular, Korea needs to build a strategy that can respond swiftly to disaster-stricken victims. It is necessary to prepare guidelines for the elderly, the disabled, dementia patients, children, foreigners, etc. to identify the specificities of the vulnerable classes and to guide them on how to evacuate in case of a disaster, and disseminate and educate them(Kim & Lee, 2017: 287).

Kwon(2012) conducted a questionnaire on "Have you ever been educated about how to act when a tsunami-related disaster occurs?". 55.2% of the respondents answered "Absolutely not." This can be indirect evidence that Central and local governments should develop disaster-related education programs for locals and give the public an opportunity to participate in education at any time. Furthermore,

considering that all regions have geographical, natural and industrial characteristics and different types of disasters in each region, appropriate disaster management systems should be established for each region and education and training should be operated in different ways(Kim, *et. al.*, 2014: 388).

3. Response Phase

When a disaster occurred in the past, the disaster management department asked the department responsible for communication and information to send information to people, and it took a lot of time to convey the situation because there was a person in charge for each medium(Asia Economy, 2018. 04. 10).

There should be no people who cannot accept rapid, accurate and public information distributed simultaneously. In particular, it is necessary to distinguish among the elderly, vulnerable groups, ordinary people, and children. In addition, by utilizing the advantages of the Fourth Revolution, a new transmission medium can be uncovered and the damage can be reduced if the external activities are effectively communicated to the public and promptly responded. The Disaster Relief Department should take the time to spend time for each department to identify and deliver the disaster information that is essential for the disaster-related tasks, so that the reporting path can be simplified and unified so that prompt action can be taken.

4. Recovery Phase

In order to help those affected by the disaster, it is essential to increase medical support and train more disaster relief specialists. In addition, a comprehensive support policy should be established so that disaster victims can return to their daily lives quickly, and local governments need to revitalize human and material resources to help victims affected by shock and anxiety. Regardless of whether it is a natural disaster or a social disaster, it is appropriate to identify the aftermath of the disaster and the physiological and psychological impacts of the victims, and to continuously monitor the victims of the disaster and the area affected by the disaster(Kim, *et. al.*, 2017: 82).

Currently, the Korean government operates the Disaster Psychology Counseling Center, which helps victims of disasters receive consultation with psychological counseling specialists to treat the effects and provide relief. However, the psychological counselor is training the volunteers to meet the standards of the central government, rather than going through a professional process, and in the event of large-scale disaster, the expertise of the human resources for psychotherapy will be inferior. Therefore, it is necessary to train mental health specialists, social work specialists, disaster response specialists, and volunteers to improve education and training programs and to help victims efficiently in the event of a major disaster(Kim, *et. al.*, 2017: 90).

V. Conclusion

Recently, earthquake activity has been on the rise. The earthquake that occurred in Gyeongju on September 12, 2016 and the earthquake on November 15, 2017 in Pohang are increasing public anxiety. Until now, Koreans have regarded the Korean peninsula as the earthquake safety zone,

even though they were well aware of earthquake damage cases in neighboring countries such as Japan and China. Even now, there is no systematic technology and disaster prevention measures against earthquake. In addition, South Korea has focused on recovering from disasters rather than preparing for natural disasters, which was part of the reason why research on natural disasters is going slow. For this reason, it is difficult to predict the time and extent of natural disasters in South Korea, and there is little awareness of earthquakes in the nation because there is no major damage caused by earthquakes(Jeong, 2017: 1-2).

In conclusion, this study suggests that necessary improvements be made in the prevention process, the preparation process, the response phase and the recovery phase.

First, the preventative process should not only strengthen the seismic performance of building structures and firefighting facilities, but also establish a building law that mandates firefighting facilities with a seismic design to be incorporated into buildings.

Second, in the preparation process, disaster education and training should be done properly. In order to change the perception of disasters, it is necessary to repeatedly train and train civil servants who are in charge of disaster management, civic organizations that can act on the spot when a disaster occurs, and volunteers who are engaged in the field. In order to respond quickly to disasters, it is also necessary to train local residents on a cycle-by-cycle basis. However, it should not be forgotten that due to the different types of disasters in each region, appropriate disaster management systems and education and training guidelines should be developed for each region.

Third, in order to reduce the damage, it is necessary for ordinary citizens to change their perception of earthquakes. Natural disasters, such as earthquakes, are indeed difficult to control. Therefore, it is necessary to thoroughly plan preventive measures before an earthquake occurs, and to prepare measures to cope effectively after an earthquake occurs, to minimize damage. For this to work well, people need to change their perception of earthquakes first(Kim, 2017: 68). According to the US Risk Assessment Study Committee, the first step in establishing risk-related policies is to increase citizens' interest in risk. Therefore, it is necessary for people to recognize that earthquakes are a risk that is close to our daily lives, but that overly biased information can harm people's perception, so it is necessary to provide various earthquake information.

Fourth, disaster information delivery systems should be improved. In the event of a disaster, prompt, accurate and public information should be communicated in order to prevent social disruption and the prevention of the second disaster. When the Gyeongju / Pohang earthquakes occurred, the keyword related to the earthquake came to the top of the search frequency in the real-time search word of an Internet search site. This means that the process of preparing the disaster for the public is scarce, but the speed with which information is gathered to respond immediately in the event of a disaster is accelerated.

Fifth, it is necessary to expand medical support for disaster victims and to train more experts on disaster psychology counseling. In addition, a comprehensive support policy should be set up so

that disaster victims can quickly return to their daily lives(Kim, *et. al.*, 2017: 82), and local governments should revitalize human and material resources to ensure the psychological stability of victims.

Sixth, the manual for foreigners living in Korea and those who are vulnerable to disaster should be reinforced. When an earthquake occurs, publicity about coping tips is not done well, and coping tips are written only in Korean, not in a foreign language. Foreigners living in Korea who do not know Korean can be in even greater danger when an earthquake occurs (Lee & Cho, 2017: 149). Considering these points, we must reinforce the response manual and pay more attention to disaster vulnerable groups in particular.

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