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Countermeasure against Fire Disaster in Regional Heritage Villages on the Concept of ICT-Based Disaster Prevention Design

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ABSTRACT

Many severe earthquakes have occurred along the main fault lines in the world. In recent years, there has been a high incidence of small- and large-scale earthquakes in our country. These occurrences of earthquakes have become increasingly serious, owing to a degrading earth environment. An earthquake, in general, causes far more serious damages like disruptions in electricity or gas facilities, and fire disasters from its annexed effects than by its vibrations or the shock itself. In this paper, we present a countermeasure and its necessity in safeguarding against fire disasters in regional heritage villages such as "Asan Oeam," "Jeonju Hanok," and "Andong Hahoe." A more systematic and effective strategy for prevention systems against severe fire disasters is proposed after performing various related investigations and analyses of existing domestic and international systems. We investigated the existing fire security systems and their historical records with the tendency of earthquake occurrences in these three folk villages. In this proposal, we present a strategic approach for safeguarding against fire damages in our regional heritage villages derived from ICT (*information communication technology*)*-based DPD* (*disaster prevention design*), *after examining the laws and regulations of fire-prevention strategies in Japan, America, and Europe..*

Key words *: Disaster Prevention, Fire Disaster, Evacuation Route, Heritage, ICT, DPD, Residents, Evacuation Planning Database, Fire Prevention Strategy.*

1. INTRODUCTION

There have been frequently occurring big earthquakes along the major fault lines in the world like the Haitian case in January 2010. In recent, a very big earthquake which hit Fukushima Japan was followed by a gigantic harmful accident on an atomic power plant, and a lot of aftershocks with their serious side effects continued in a long term period.

On the other hand, we can hardly find examples a good bit of earthquake occurred in Korean peninsula, nevertheless public concerning about danger of earthquake gradually increases, in recent, because there has been a lot more symptoms of earthquake year after year in the peninsula. According to the historical registration of earthquake in Korea,

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they mainly occurred during 16~18 centuries and were distributed all over the Korean peninsula without concentration on some specific areas [1]. Although seismic activity in Korean peninsula is in a period of dormancy, there are a lot of active fault lines or areas in the peninsula so that we can always have possible suffering from danger of earthquake.

When an earthquake occurs, one of the most serious possible side effects is fire disaster caused by damaging facilities of gas and electricity. Fire can always be occurred and give serious harms on human life in all cases of earthquake even though any construction structure has not been collapsed down. In this case we can have far more serious injury of human life and/or damage of property by these annexed effects rather than earthquake itself. If we can hardly put the fire under our control smoothly for some reasons, the amount of damages can be unexpectedly increased. For an actual example, the most harmful damage on human life and property was just caused by fire disaster when the big earthquake hit Kobe Japan in 1995.

In the case of Korean regional heritage villages possessing a lot of timber structured houses between narrow alleys, we can easily expect far more serious damages when an earthquake and/or fire disaster caused from it. Moreover, the major part of residents who live in these folk villages consists of the aged people. We need some realistic strategy with sophisticated design for these folk village areas against the possible earthquake and its side effects like fire disasters.

In this paper, we propose a countermeasure against the secondary effects from earthquake, especially like fire disasters, in regional heritage villages of Korea such as 'Asan Oeam (abbreviated by AO)', 'Jeonju Hanok(JH)', and 'Andong Hahoe(AH)' villages. In general, when there is an earthquake, fire easily occurs from breakages of gas and/or electricity facilities. Injuries of human life and damages of property caused by these secondary harms can be far more serious than the effects of vibration and collapse themselves [2]. First we select 3 regional heritage villages in which residents are living such as AO, JH, and AH as mentioned above. They have their own specific characteristics as far as disaster prevention is concerned because of their different natural and/or artificial environments. The common condition of 3 folk villages is that there are actually residents currently living in. We investigate adequate countermeasure against fire disaster for each folk village referring to their specific conditions. After reviewing the tendency of earthquake occurrences in Korean peninsula, we visit these 3 folk villages and investigate their facilities for fire prevention in Aug.~Sep. 2014. We compare regulations of fire extinguishment facilities in foreign countries with Korean strategy in order to analyze and propose an adequate countermeasure against earthquake and its secondary effects focused on fire disaster in these folk villages.

In order to describe our contributions in the rest of this paper, we first investigate earthquake occurrences in a row and their magnitudes in Korea since 1978 when systematic observation of earthquake has started in our country throughout Section 2. We then present a comparison of fire disaster prevention strategies between foreign countries and Korea, especially focused on heritage villages in Section 3. In Section 4, we analyze and propose fire prevention facilities in these folk villages based on the concept of DPD(disaster prevention design) [3]. Finally in Section 5, we arrange the concluding remarks of this study and some tips for future works.

2. EARTHQUAKE OCCURRENCES AND THEIR MAGNITUDES IN KOREA

We investigate frequency rate and magnitude of earthquake occurrences in the influenced area of Korean Peninsula. Fig.1 shows the present state of seismic activities around Korean Peninsula since 1978 when systematic observation of earthquake has started in the country. As mentioned above, earthquakes in the influenced area of Korean Peninsula do not concentrated on some specific fault lines or areas but spread almost evenly over all the areas of concerned, which can be confirmed from the distributions of dots shown in Fig.1 [4].

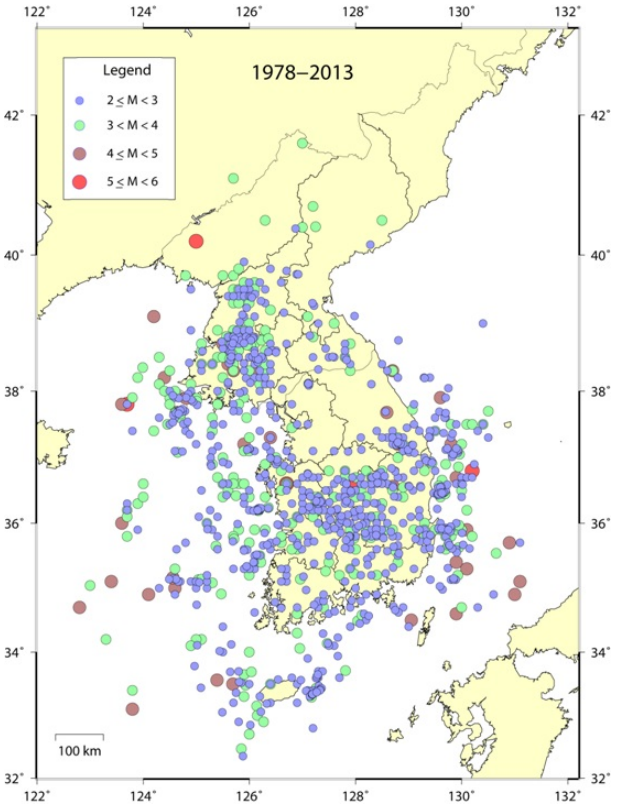


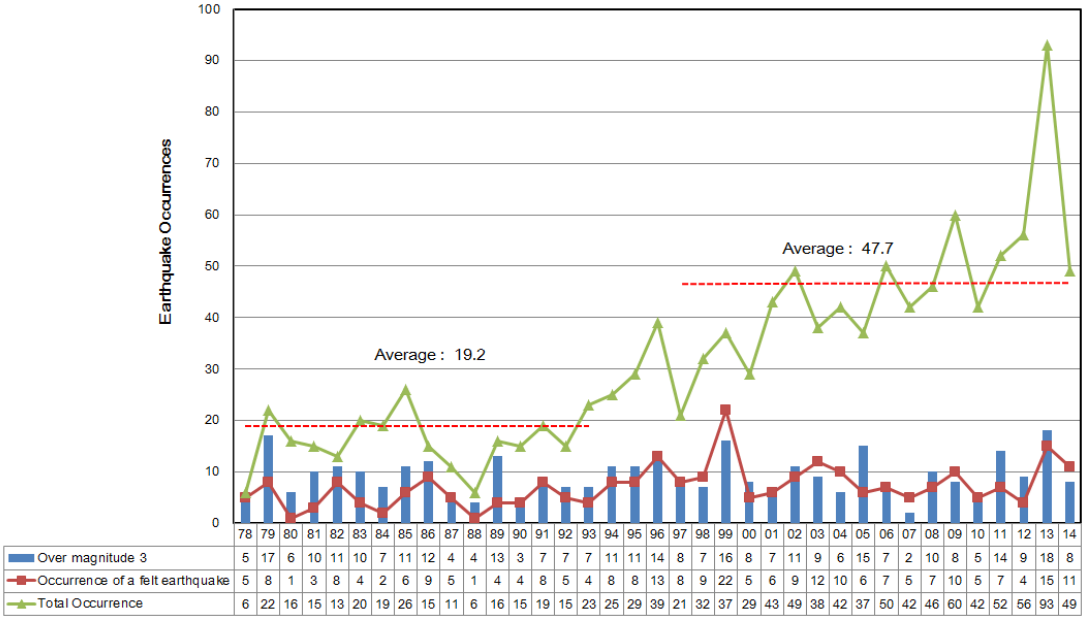
Fig. 1. Frequency Rate and Magnitude of Earthquake Occurrences in the Influenced Area of Korea

As shown in the legend of the map, the largest dots reveal a magnitude of 5~6, and the smallest dots indicate 2~3 on the Richter scale.

According to the result of this investigation, relatively big earthquakes over magnitude of 5 have occurred several times at Mt. Songni, Hongsung, Euiju, Baekryung-Do, and Uljin etc. Some of these regions are in less than 100km distance from our focused folk villages like AO, JH, and AH. Although there has not been still reported any serious damage caused by earthquake in our folk villages, the areas of 'Asan Oeam' and 'Jeonju Hanok' villages are investigated to be possible

earthquake occurrence in the near future. We also need to be careful to watch and counterplan against earthquake and its side effects to preserve these heritage villages, even though the past investigations inform us relatively safe situation from natural disasters.

Another serious indication of earthquake in the area of Korean Peninsula in the near future can be proven by the statistics as shown in Fig.2. Annual average number of earthquake occurrences in the area of Korean Peninsula had been about 20 in 1980s, but it has been continuously increased like 30 or more in 1990s and 40 or more in 2000s. And then finally in 2013, there were 93 times of earthquake occurrences in the same area. Moreover, relatively big earthquakes with magnitude 3 or more on the Richter scale, which can be perceived by common people, have been continuously increased and their scales have been getting bigger and bigger. This analysis apparently shows that the Korean Peninsula is no more a safe region from earthquake as well as our heritage villages.



	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14
Over magnitude 3	5	17	6	10	11	10	7	11	12	4	4	13	3	7	7	7	11	11	14	8	7	16	8	7	11	9	6	15	7	2	10	8	5	14	9	18	8
Occurrence of a felt earthquake	5	8	1	3	8	4	2	6	9	5	1	4	4	8	5	4	8	8	13	8	9	22	5	6	9	12	10	6	7	5	7	10	5	7	4	15	11
Total Occurrence	6	22	16	15	13	20	19	26	15	11	6	16	15	19	15	23	25	29	39	21	32	37	29	43	49	38	42	37	50	42	46	60	42	52	56	93	49

Fig. 2 State of Earthquake Occurrence in Korea

3. FOREIGN AND DOMESTIC STRATEGIES AGAINST FIRE DISASTER FOR HERITAGE VILLAGE

3.1 Japan

In Japan, they established 'the Cultural Properties Protection Law' in 1950, and they obligate to install an automatic fire alarm system at any staple cultural heritage of structure in 1961 for their early fire detection and suppression. From 1989, they imported and have been operating a new style of alarm system which directly transfer fire alarms to the nearest fire station when a fire occurs in the area of cultural heritage.

In addition, they prescribed all the main buildings of cultural heritages should be provided with standard Seismic Capacity Evaluation and should obey the corresponding methods and considerations since 1999. According to these national strategies, the Japanese Cabinet has been making diagnosis on seismic performance of cultural heritage buildings scattered over all the national territory since 2005.

3.2 America

They have been thoroughly providing against any kind of fire disaster under the strict control of NFPA(national fire protection association) since it was founded in 1896. In other words, NFPA is preparing detailed guidelines for fire protection or prevention facilities which make people act against possible big fire disasters. In 2010, especially, the Cultural Heritage Technology Committee of NFPA established and announced the 'No.914 Code' (Code for Fire Protection of Historic Structure) so that they can rigidly build up their safety system for historic buildings, structures, and heritages.

3.3 Europe

In Europe, they have organized EFHN(European Fire Heritage Network) as a common fire protection of historical and/or heritage structures since 2000s. Through COST C17 a subordinate of EFHN's headquarter, each nation in Europe participates in this prevention strategy for fire disaster of historic or heritage structures. For example, England, Australia, and some other countries in Europe are commonly providing a prevention strategy against fire disasters on their cultural heritages of constructions. According to their guidelines, all structural heritages should be installed by fire-sensing loop controls, fire-alarm systems, smoke-sensing loop controls, sprinklers, water-spray facilities, and emergence lights etc. as well suited for their places. They commonly considered these guide lines and/or strategies to be a regulation possibly accepted for each country in Europe.

3.4 Domestic Strategy against Fire Disaster

We really need to establish a rigid protection strategy against fire disasters on our cultural heritage because almost all of our historical constructions were built by timber structures [5]. They definitely reveal their weakness or vulnerability especially against fire disasters as they should.

Domestic strategy of fire prevention for our cultural heritage of constructions is legislated by laws 'The Cultural Properties Protection Law' and 'The Law of Installation Maintenance & Safety Management of Fire'.

3.4.1 The Cultural Properties Protection Law

In Korea, fire prevention strategy for constructional heritage is basically regulated by 'The Cultural Properties Protection Law'. This law was enacted on January 1962 and has been partially revised several times in the past. Main contents of this law legislate a necessary process for protecting fire disasters on cultural heritage of constructions and standard installations of extinguishment facilities.

3.4.2 The Law of Installation Maintenance & Safety Management of Fire

As cultural heritage of construction is a kind of building or structure, it should be basically controlled by the law of safety management for constructional structures. Therefore fire safety control for these structures is regulated by 'the Law of Installation Maintenance & Safety Management of Fire' in Korea. In other word, any building nominated by 'the Cultural Properties Protection Law' should be supposed to install extinguishment facilities, alarm facilities, fire escape facilities, and extinguishment water facilities. In addition, specific objectives of fire prevention strategy including folk villages and/or cultural heritages should organize and operate their own fire-fighting group or corps so that they can be possible to be protected against fire even in peacetime.

4. ANALYSIS OF FIRE PREVENTION FACILITIES IN HISTORIC HERITAGE VILLAGES

4.1 Asan Oeam Folk Village (AO)

[Photo 1] shows an overview of Asan Oeam(AO) folk village as a bird's eye view from an aviation. AO is geographically located in ChungcheongNam-Do, and it is generally known to have been established about 500 years ago. Total area of the village is about 198,194m^2, and more than 150 residents are living in the village.

Photo 1. Overview of Asan Oeam Folk Village (ChungNam)

There are totally 78 old style buildings and most of them are constructed by timber structure as shown in Table 1. Only 4 out of 78 houses are made by block, and all the other 74 houses are timber structure and some of them even have their roof of rice straw [6], [7]. Asan Oeam folk village, therefore, has its serious vulnerability of fire for its own construction material when there happen to be an earthquake and a big fire caused by it occurs. Moreover it is investigated that once a house gets fire on its roof, it can be easily transferred to neighboring roofs or houses because thatched roofs of the houses in the village are approximately adjacent with each other.

Table 1. Building Analysis of Asan Oeam Folk Village

House Structure		Roof Style	
Wooden	**74**	Tiled	20
Block	4	Thatched	30
-	-	Others	28
Total	78	Total	78

Totally 274 digestion facilities including outdoor hydrants and chemical extinguishers are installed in Asan Oeam Folk Village. There is also a fire station in less than 1km from the center of the village. But there is no fire-fighting facility at an initial stage like sprinkler in the major part of houses so that we can investigate the village to be a lot dangerous for fire disaster. Also what we can seriously consider about the village is that the major part of residents consists of the elderly who cannot easily evacuate from the place when a fire disaster occurs.

4.2 Jeonju Hanok Village (JH)

An overview of Jeonju Hanok Village is shown in [Photo 2]. JH is geographically located in Kyo-Dong and Pungnam-Dong, Wansan-Ku, Jeonju City, JeolaBuk-Do. It has been started to establish since the era of Chosun Dynasty, present formation is from 1930s. It was nominated as a 'Hanok Conservation Area' in 1977. Total area of the village is about 0.25km^2, and there are more than 700 Hanok houses in the village.

Photo 2. Overview of Jeonju Hanok Village (JoenBuk)

We investigate Jeonju Hanok Village has been formed as a city town so that distance between houses is generally narrow. Moreover, major part of hanok consists of timber structure and roof style is all Kiwa, a kind of Korean traditional roof-tile. Fire, therefore, can easily spread over neighboring hanok houses if there occurs a fire caused by earthquake.

According to our detailed investigation, the major part of hanok houses in JH village do not have inside sprinklers, and fire-fighting facility at the beginning is a Powder Extinguisher. There is a fire station near Jeonju Hanok Village so that they can prepare against big fire disaster. But narrow alleys between hanok houses are preventing the fire trucks from coming inside the fire place as show in [Photo 3].

Photo 3. Narrow Alley between Hanok Houses in JH Village

Among those hanok houses that residents are actually living in are almost half of all the buildings in the village. Therefore we can easily expect that it will be far more dangerous if the fire occurs at night. These days, about 5 million tourists are visiting Jeonju Hanok Village a year. We insist it is urgently necessary to setup a safety precaution against fire disasters.

4.3 Andong Hahoe Folk Village (AH)

[Photo 4] shows a bird's eye view of Andon Hahoe Village and its surroundings. We can see the Nakdong River is turning around the village like English letter 'S' which means the name of the village 'Hahoe(河回)'-'river turns'. AH Village has been established about 600 years ago. There are 125 traditional houses and 232 residents are living in the village. 'Andong Hahoe Village' had been registered in UNESCO 'World Cultural Heritage' on July 31, 2010 at the same time when 'Kyungju Yangdong Village'. These days, more than 1 million tourists are visiting the village a year.

Photo 4. Overview of Andong Hahoe Folk Village (KyungBuk)

AH Village is a representative Korean traditional folk village of which the houses are mainly timber structure. Roof of each house is 'Choga' or 'Kiwa'. Backbone of 'Choga' roof is made by timber structure and it is covered with straw thatch so that we can investigate they have many weak points against fire disasters. 'Kiwa' roof on the other hand has its own fire-resistance so that danger of flying fire from external source can be relatively lower than 'Choga' roof. But there are a lot of small wood sticks inside the 'Kiwa' roof in AH Village as shown in Photo 5. If fire occurs inside the 'Kiwa' roof to attack these timber sticks, we can easily expect much difficulties in fire-fighting process. Narrow alley between houses in the village is another hindrance in case of fire-fighting using fire trucks or other mechanisms [8].

Photo 5. Small Wooden Sticks Used for Kiwa Roof in AH

Digestion facilities installed in AH Village are 414 extinguishment equipment including extinguishers and hydrants. In addition we can investigate 50 fire detectors are distributed over the village [9]. A fire station is located in 0.5km distance from the center of AH Village. But there is no fire-fighting facility for an initial stage like sprinkler in the major part of houses. We can therefore investigate AH Village to be a lot dangerous for fire disaster like AO Village. Also what we can seriously consider about the village is that the major part of residents consists of the elderly who cannot easily evacuate from the place when a fire disaster occurs. This is almost the same situation as we have investigated for Asan Oeam Folk Village. We need a strategy to respond quickly against fire disasters caused by an earthquake or not.

5. CONCLUDING REMARKS

In this paper, we have investigated and analyzed fire prevention systems for local folk villages or cultural heritages in Korea. We have focused on Asan Oeam Folk Village, Jeonju Hanok Village, and Andong Hahoe Folk Village in witch residents are presently living. We conclude all of these 3 folk villages should have a more rigid strategy against fire disasters including initial fire-fighting procedures and evacuation routes for elderly residents as follows;

1) Although possibility of earthquake occurrence is relatively low in Korean Peninsula, the number of occurrences has been continuously increasing since 1990s. Especially in folk villages we focus on, we need a more rigid strategy to prevent against fire disasters for lack of fire-fighting facilities at the beginning status of fire in almost all houses of our 3 folk villages.

2) We find there are a lot of restrictions to install fire detection instruments or extinguishment facilities in our folk villages because they are nominated and protected as cultural heritages as a whole town in our country. In other words, if any kind of modification such as repairing or variation is needed, we should obtain a constructional permission from the Government. These limitations make it hard to modify not only structural facilities but also fire-fighting facilities.

3) We can investigate that almost all houses in the 3 folk villages are very weak for fire disasters because they were constructed by timber structure. Moreover once a fire occurs on a house in the village, it can be easily transferred to other houses because houses are very closely nearby with each other. On the other hand, major part of residents in the folk villages is mainly the aged over 65 so that we should prepare a more rigid strategy for evacuation process and/or safety plans against fire disasters.

4) For the case of house with 'Kiwa' roof, we can expect firing on timber skeleton inside the roof. When the fire is transferring throughout small sticks of timber structure, there can be serious dangers of fallings and/or collapses.

We expect additional research for seismic design and reinforcement of fire disaster prevention in the case of cultural heritage of structures in our folk villages as a future study.

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