Fire Risk Assessment on the Land Use Zoning in Korea

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KEY WORDS: Artificial disasters, National Emergency Management, Information of fire occurrence, Fire risk, Maps of fire risk

ABSTRACT: A wide range of Facilities and complicated facilities are concentrated in urban space due to the rapid urban growth. Therefore, urban areas cannot help being vulnerable to all sorts of disasters. Especially, damage caused by fire accident among artificial disasters has been sharply increasing. Therefore, South Korea operates the national fire information system led by the National Emergency Management(NEMA),(http://www.nfds.go.kr) to provide the information of fire occurrence in cities. This organization has offered the information of fire occurrence since 2007. In this regard, this study analyzed fire risk targeting Jinju-si, which is a local city, located in the southern area by using data. It classified fire information over the last seven years, and analyzed the frequency of fire occurrence in facilities. Subsequently, it suggested measures to prevent fire in urban areas effectively by producing the maps of fire risk according to areas.

1. Research Background and Purpose

Since urbanization has been growing at an alarming rate so that a large number of people became concentrated in cities and the size of cities has become larger. As a lot of people reside in urban areas, fire gives a big threat to urban citizens. Disaster is divided into natural disaster and artificial disaster. The former includes the disaster of hurricanes, droughts, floods, tsunami disaster. These kinds of disaster can predict in advance, but it is difficult to prevent. The latter is the artificial disasters like fire, building collapse, which can be reduced due to the awareness of citizens or the advancement of technology.

According to the survey conducted by the Research World in 2009, the degree of safety ignorance was 73.8%, and there was an announcement that this is at a serious level. In fact, the mortality rate of fire in South Korea was the highest among 30 OECD nations. 40,932 fire cases occurred in 2013 in South Korea. In those cases, there were 2,184 casualties along with the property damage of 434,4 billion won. In this regard, this study classified facilities according to the types targeting Jinju-si, a southern province of South Korea, and evaluated fire risk according to facilities by analyzing the data of fire occurrence. Lastly, it manufactured the fire risk based on the research analysis.

2. The Method of Material Analysis

Figure 1. Location of Jinju, Korea

This study calculated the fire risk of Jinju-si located in the southern province of South Korea (Fig.1), identified the occurrence cases, personal injury, and property damage between 2007 and 2013 through the national fire information system of the National Emergency Management(NEMA) (http://nfds.go.kr) for the production of the fire risk maps according to the land use zoning, and collected the facilities of Jinju-si by utilizing the statistical yearbook in Jinju-si(http://stat.nongae.net) and business research reports.

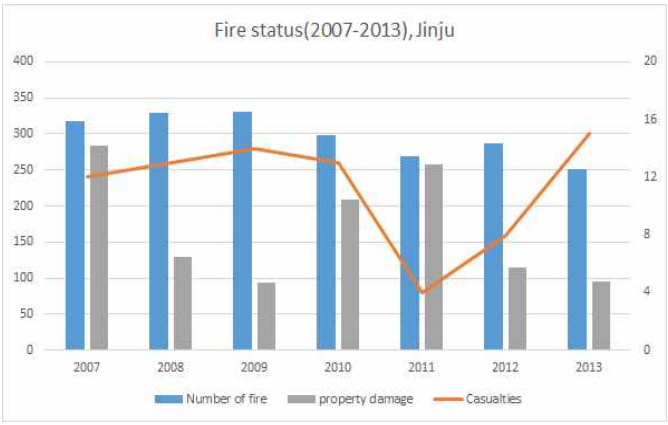

Figure 2. Fire Assesment Analysis of Jinju

Table 1. The Fire Cases According to Districts in Jinju (2007-2013)

	Name	Case/㎢	Name	Case/No.
1	Seongbuk	97.4	Seongbuk	8.7
2	Sangdae	48.3	Sangpyeong	7.2
3	Jungang	47.5	Jungang	6.6
4	Hadae	33.6	Sangdae	5.6
5	Sangpyeong	32.3	Chojang	5.3
6	Shinan	Gaho	Gaho	3.8
7	Pyeonggeo	21.0	Shinan	3.7
8	Cheonjeon	18.6	Cheonjeon	3.3
9	Sangbong	18.3	Hadae	3.3
10	Gaho	11.9	Pyeonggeo	2.7
11	Yihyeon	7.6	Yihyeon	2.7
12	Chojang	5.9	Sangbong	2.5
13	Panmun	1.5	Panmun	2.3
	Average	28.4	Average	4.4

Figure 2 is the actual condition of Jinju-si between 2007 and 2013. Table 1 is the data about the condition of the fire occurrence according to districts (dongs) in Jinju-si. The fire occurrence in Jinju-si had a tendency of increasing until 2009 but it has steadily decreased since 2010. 298 cases of fire on average occurred during the target period and 12 casualties and 1.7billion won property damage occurred. The fire occurrence was the least in 2013, but the number of casualties was the highest.

The fire risk in Jinju-si was calculated by using the scope of fire risk presented by the Society of Fire Protection Engineers(SEPE). As a method of level evaluation conducted by SEPE, there are 4 methods; Checklists method, narrative, indexing, and probabilistic methods. Checklists method and narrative method choose appropriate protection ways by discovering risk and confirming the control method to achieve the goal, so that it may be difficult to quantify and the evaluation criteria of "appropriate" or "Inappropriate" can be used (SEPE, 2002). In probabilistic methods, simulation utilizing the computer modelling is used and the evaluation method of the probabilistic risk level is utilized in the field of nuclear power development in which disaster possibility exists. The fire risk index according to the indexing method is a model based on the professional evaluation logic and the past experience in the fire safety field. In terms of the fire risk index, the comparison of the relative risk rather than the absolute risk is possible, so that the comparative risk about a variety of population can be calculated.

This study used a relative evaluation method through the fire occurrence matrix by SEPE. The values of F=fire occurrence cases/facility numbers, personal damage=casualties/the cases of fire occurrence, and property damage=damage amount/the cases of fire occurrence were sought and risk through the fire occurrence matrix was calculated. Accordingly, risk maps in Pyeonggeo-dong, which is a residential area, and Sangdae-dong, where a lot of facilities are combined, were produced (Jindong, S.,2008).

3. The Calculation of Fire Risk

There are qualitative risk analysis method, quantitative risk analysis and relative ranking method as Domestic evaluation methods of fire risk. The qualitative risk analysis is a method of identifying the presence of risk, in which there is a limit to quantify risk, even though it is easy to interpret and classify the occurrence mechanism of hazards. The quantitative risk analysis is a way of evaluating the size of the effect and the analysis of scope according to a analysis of the probability of accident. This has the advantage in providing measures against risk by expressing the risk concretely, even though it requires a lot of expertise and materials. The relative ranking method is a way to calculate the size of the risk with index, in which the identification of risk attributes and the calculation of size are possible, so that it is high in practicality. This focuses on the relative evaluation rather than the absolute evaluation, which evaluates risk levels by ranking the levels.

To calculate fire risk, facilities were classified according to types and the occurrence cases of fire, personal injury, and damage amount were organized by utilizing the business research reports of 2013, offered by the Statistical Yearbook and the enforcement of the Building Act by the Ministry of Land, Infrastructure and Transport (Uisu, J.,2008)(Table 2).

Table 2. The Actual Condition of Fire Damage in Jinju/Number of Facilities

Division	Occurrence cases	Personal injury	Damage amount (1000won)	Facility number
Detached house	325	27	1,653,469	73,701
Public house	99	13	509,307	59,194
Education house	23	6	146,277	987
Sales facility	46	0	663,166	6,998
Public institution	2	1	6,268	145
Accommodation and food facility	110	5	669,563	5,562
Gathering facility	20	1	559,129	795
Medical facility	20	0	25,591	970
Factory facility	66	1	3,273,994	2,388
Warehouse facility	58	2	287,254	217
Sanitary facility	3	0	31,768	44
Cultural property facility	1	0	43,358	150
Recreational facility	12	0	99,516	847
Daily service facility	38	0	360,260	3,306
Transportation facility	310	7	893,247	2,189
Manufacturing facility of dangerous materials	1	3	44	26

Table 3. The Matrix of Personal Injury

occurrence frequency	1	2	3	4	5
5	Sanitary facility	Warehouse facility Transportation facility			
4		Factory facility	Gathering facility	Education facility	Manufacturing facility of dangerous materials
3	Medical facility Entertainment facility	Accommodation and food facility			
2	Cultural property facility Daily service facility			Public institution	
1	Sales facility		Detached house Public house		

Personal injury

Table 4. Property Damage Matrix

occurrence frequency	1	2	3	4	5
5		Warehouse facility Transportation facility		Sanitary facility	
4	Manufacturing facility of dangerous materials		Education facility	Gathering facility	Factory facility
3		Medical facility	Accommodation & food facility Entertainment facility		
2		Public institution	Daily service facility		Cultural property facility
1		Detached house Public house		Sales facility	

Property damage

In terms of the classification of fire according to facilities, fire in a detached house accounted for the highest, which was followed by transportation facilities, accommodation and food facilities, factory, and warehouse facilities. Table 3 and Table 4 based on Table 2 constituted the matrix of occurrence frequency, personal damage, occurrence frequency and property damage. The occurrence frequency is the value of dividing fire occurrence cases into facility cases, personal injury is the value of dividing personal damages into the occurrence cases, and property damage is the value of dividing the damage amount into the occurrence cases. The values above are divided into 1~5 stages to construct the matrix of fire occurrence. The facilities that have a high risk in the personal injury include the manufacturing facility of dangerous material, warehouse facility, transportation and automotive facility, gathering facility, and education facility. In terms of the property damage, facilities that have a high risk include sanitary facility, factory facility, warehouse facility, transportation facility, education facility, gathering facility, and cultural property facility. Warehouse facility, transportation and automotive facility, education facility, and gathering facility appeared to have a high risk in both personal injury and property damage.

Table 5 is the value of calculating fire risk class(rating) based on the mean value of matrix constructed

above. Risk class is calculated based on the mean value of the matrix in personal injury and property damage. This study expressed the classes of fire risk into 4 classes by using the mean value of facility's fire risk. The class of facility's fire risk as shown in Table 5 was calculated based on the data of fire occurrence over the last seven years, which shows an essential indicator in evaluating the possibility of fire occurrence about facilities which are located in urban space in Jinju-si.

Table 5. Risk Rating (Class)

Division	Dangerous stages (5 stages)			Matrix (5 classes)		Risk class
	Fire occurrence	Personal injury	Property damage	X=b	X=c	
	(a)	(b)	(c)	Y=a	Y=a	
Detached house	1	3	2	2	1	I
Public house	1	3	2	2	1	I
Daily service facility	2	1	3	1	2	I
Sales facility	1	1	4	1	3	II
Medical facility	3	1	2	2	2	II
Public institution	2	4	2	3	2	III
Accommodation and food facility	3	2	3	2	3	III
Cultural property facility	2	1	5	1	4	III
Recreational facility	3	1	3	2	3	III
Education facility	4	4	3	4	4	IV
Gathering facility	4	3	4	4	4	IV
Factory facility	4	2	5	3	5	IV
Warehouse facility	5	2	2	4	4	IV
Sanitary facility	5	1	4	3	5	IV
Transportation and automative facility	5	2	2	4	4	IV
The manufacturing facility of dangerous material	4	5	1	5	3	IV

4. The Production of the Fire Risk Map

Based on classes of fire risk according to facilities, which were analyzed above, this study selected Sangdae-dong which is an area, where industrial complex and residential area are intermingled based on the classes of fire risk according to facilities, and Pyeonggeo-dong, where residential area and neighborhood commercial area are intermingled, thanks to the new land development. Subsequently, it designated fire risk of facilities according to the land use and manufactured fire risk, classified as 4 classes (Fig. 3-6).

Figure 3. Sangdae-dong Zoning Map

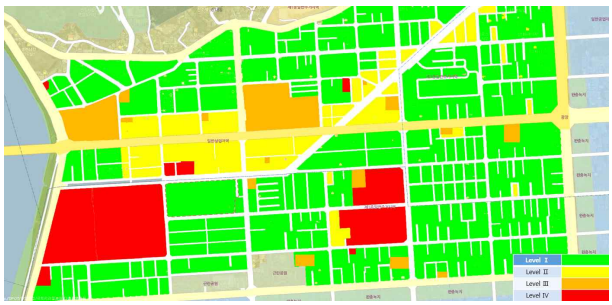

Figure 4. Sangdae-dong Fire Risk Map

Figure 5. Pyeonggeo-dong Zoning Map

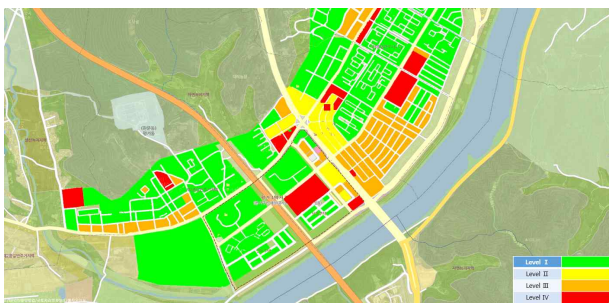

Figure 6. Pyeonggeo-dong Fire Risk Map

As shown in Fig.3~Fig.6, detached houses, adjacent to an industrial area and commercial areas, adjacent to the apartment zones, developed as high-density residential areas are marked as areas, vulnerable to the fire. Like this, in terms of the fire management, effective prevention and measures can be established by dividing fire risk class according to facilities, and manufacturing the map of fire risk, distributed in urban areas.

5. Conclusion

In this study, fire risk in Jinju-si was analyzed and risk maps were manufactured by applying the fire risk calculation method presented by the Society of Fire Protection Engineers(SEPE) based on the fire occurrence data in Jinju-si. The summarization of the study results is as follows:

First, facilities were classified according to types by using the business research reports of 2013 presented by the Building Act, enforced by the Ministry of Land, Infrastructure and Transport and Jinju-si Statistics Yearbook. After that, it organized the cases of fire occurrence, personal injury, and damage amount and calculated the class of fire risk according to facilities. The rankings (class) of fire risk according to facilities located in Jinju-si are as follows: The fire risk of detached houses, public houses, and daily service facilities belonged to the first class, the risk of sales facilities and medical facilities was subject to second class, the fire risk of public institutions, accommodation and food facilities, cultural Facilities, and recreational facilities was third class, and the fire risk of education facilities, gathering facilities, factory facilities, warehouse facilities, sanitary facilities, transportation and automotive facilities, and the manufacturing facilities of dangerous materials was evaluated fourth class.

Second, this study divided the fire risk of facilities as rankings and suggested the basis which can set up the effective preventive measures in terms of fire management by manufacturing fire risk maps of facilities, distributed in urban areas. The fire in urban areas in South Korea is the highest disaster next to traffic accidents. Therefore, as a way to cope with such fire effectively, the manufacturing of fire risk map and the establishment of measures which can help fire stations manage risk zones specially is required.

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