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Man-Made Disasters in Korea: Case Histories and Improvement Plans

Sang-Soo Jeon*

* Department of Civil & Urban Engineering, Inje University, Inje-ro 197, Kimhae, Kyungsangnam-do, Republic of Korea 621-749

Abstract- The infrastructure in Korea was built after the significant growth in the economy after 1960. Today, this aged infrastructure has been inappropriately maintained and managed without awareness of man-made disasters. Even though the Korean government established complementary laws and regulations to prevent man-made disasters, these disasters have occurred in various locations and have been presented as social problems, they have also resulted in large social and economic losses. This paper examines both historical reviews and damage assessments and provides improvement to plans for typical man-made disasters including fire, collapse, explosion, traffic accidents, and environmental pollution. The problems caused by man-made disasters showed that disaster responses were not properly carried out because of the lack of prevention systems or appropriate equipment and facilities and there were no regular safety inspections or appropriate maintenance or repairs of the infrastructure. It is found that the laws related to man-made disasters are very broad, and they overlap across different government organizations. This paper proposes improvement plans to prevent or minimize damages against man-made disasters.

Index Terms- Disasters, Man-made disasters, Damage, Republic of Korea

I. INTRODUCTION

As the technology for human life has developed, the damage by traditional natural disasters such as droughts and floods has been reduced; in contrast, however, man-made disaster catastrophic events resulting from human decisions including both sudden and long term disasters and unexpected risks of damage to intelligent infrastructure have increased. Sudden man-made disasters include structural, building, and mine collapses that occur independently with no outside force. Long-term man-made disasters resulting from both human error and natural forces tend to refer to national and international conflicts. Man-made disasters such as nuclear disasters, oil spills, and terrorist attacks have caused major losses of human lives and livelihoods and can be defined in different ways according to researchers and by the law.

In Korea, man-made disasters are defined by the Federal act on the Disaster and Safety Management and comprise large-scale accident defined by the presidential decree, including fire, collapse, explosion, traffic accidents, and environmental pollution. Large-scale accidents such as the fires in Sealand, a restaurant, and subways in Hwaseong, Incheon, and Daegoo city, respectively; the collapse of the Sinhegju and Seongsoo Grand Bridge, the Sampoong Grocery Store, and the Wawoo Apartments; a gas explosion in the Ahyun-dong, in Daegoo subways, and in Bucheon as well as traffic accidents related to a derailed train in Gupo; the crash landing of an Asiana Airplanes flight, the sinking of a Family Ship in the West Sea; phenol leaking into the Nakdong River resulted from not having prepared disaster systems. These disasters were being administrated by several government organizations (National Disaster Management Institute, 2007) [1].

India experienced 480 man-made disasters during the period of 1990─2009. Man-made disasters constituted 62.2% of the total (Purohit & Suthar, 2012) [2]. These disasters seriously disrupt a society's economy, agriculture and health-care sectors, typically producing long-lasting effects that perpetuate underdevelopment (Harding, 2007) [3]. One example regarding a society's health-care sector is the effects of using asbestos for industrial and domestic applications (David & Russell, 2013) [4].

How to assess the damages caused by man-made disasters has been an important issue. A rigorous damage assessment methodology for building owners and managers to assess the vulnerability of their facilities and these improved damage assessment skills provide reasonable remediation for reducing the loss of life and property during a disaster. A spatial analysis of their impacts on people and physical assets has been developed (Kemp, 2007) [5]. There are several methods for addressing disasters through response and recovery systems. Improving mobile computing support for disaster response and recovery facilitates better assessment of the damage caused to buildings and expedites safe, efficient, and effective disaster response (Aziz et al., 1997) [6].

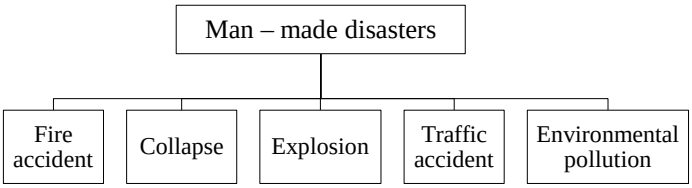
The design of reliable and scalable communication and information management systems is necessary for coordinated responses. Strategic disaster planning using geo-coding and information distribution make it much easier to visualize loss, analyze requirements, plan the efficient distribution of resources, and provide necessary infrastructure for a coordinated response to disaster (Banipal, 2006) [7]. Data interoperability, data integration and data sharing between different emergency management agencies can be utilized by integrating geographic information system (GIS) and simulation models combined with suitable databases and expert systems (Vijayaraghavan et al., 2012) [8].

Partnership frameworks should be established to implement the sequential phases of prevention, preparedness, response, and recovery for disaster management (Kim, 1993) [9]. Communities' being aware of their surroundings, available resources, and help, and listening to their concerns are important during emergencies. More community participation will lead to stronger and more resilient cities. However, there are two

common barriers to learning from disasters: information difficulties and blame and organizational politics (Nirupama & Maula, 2013; Pidgeon & O'Leary, 2000) [10-11].

In the United States, the Federal Emergency Management System (FEMA) and the Department of Homeland Security have been well established to control natural and man-made disasters (Lee, 2005) [12]. In Korea, the industrialized and urbanized areas were developed following the economic growth from the 1960s. Large-scale, underground, and high-rise structures were built in areas all around the country in a very short period of time with no strategic safety plans. The National Emergency Management Agency (NEMA) [13], one of government institutions in Korea, was established in 2003 and initiated a database obtained from the historical damage data on previous natural and man-made disasters. In this study, typical damages and accidents caused by the increased numbers of man-made disasters in Korea as listed in Table 1 were investigated, and improvement plans to prevent or minimize damages are suggested.

Table 1: Man-made disasters in Korea



II. CAUSES OF MAN-MADE DISASTERS

Fire Accident

Fire accidents including Sealand in Hwaseong, the subway in Daekoo, and Hof and Restaurant in Incheon resulted in life and property losses. The Sealand fires in June 1994 were caused when the fires to kill the mosquitoes came in contacted with combustible materials. This fire resulted in twenty-three deaths with six injured, and property losses of roughly $65,000. After this accident, periodic safety checks were conducted in Korea, especially for child care centers and kindergartens, and education policies were developed to increase expertise in the field of safety inspections.

Subway fire accidents in Daekoo in February 2003 resulted in the loss of 192 lives, injuries to 148 people, and property damages of $40 million. The criminal in this accident, a fifty-year old man, ignited a plastic bottle filled with oil, and the twelve-passenger train was burned to its frame. On the day after the accident, Daekoo was proclaimed a special disaster area. After the accident, the safety issues concerning heat insulating material for the interiors of subway trains, fire shutters, and train seats; an education program for the crew and passengers; a risk management manual; and the subway response system were examined to establish safety policies.

The fire accident at the restaurant located on the fourth floor of a building in Incheon on October 30, 1999, resulted in 57 deaths and 80 injuries. Most of the victims were high school students. The lessons learned from this accident were that fire insurance and safety management for building facilities are important social issues. Figure 1 shows number of disasters, fatalities, injuries, and property loss induced by fire accident for recent seventeen years.

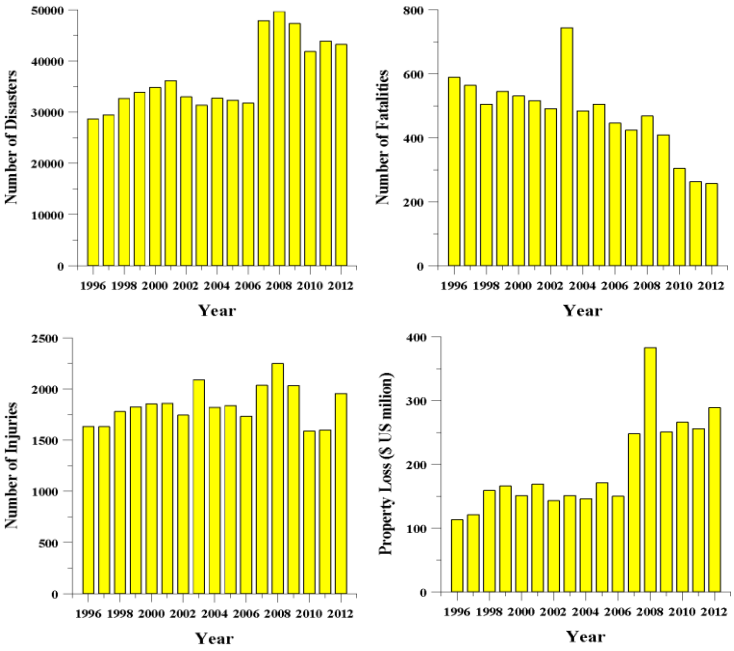


Figure 1. Number of disasters, fatalities, injuries, and property loss induced by fire accident during 1996-2012

Collapse

Collapses of infrastructure including buildings, pedestrian overpasses, bridges, and dams were caused by inappropriate design and construction, low-level technology, aging, inappropriate maintenance and management, ground softening, insufficient periodic safety checks, fires, a gas explosion, and overload. Typical cases were the collapses of the Sinhengju and Seongsoo Grand Bridge, the Sampoong Grocery Store, and the Wawoo Apartments.

The Sinhengju Grand Bridge collapsed owing to inappropriate design, construction, and supervision on July 31, 1992. The bridge was designed with incorrect spans of piers between two towers and constructed with incorrect connections between the cable-stayed bridge and the continuous bridge. The collapse was also induced by the inappropriate number and location of piers between the two towers (Khan & Rahman, 2007) [14]. The collapse occurred at the almost completed stage of construction. This accident provided lessons on how the bridge needed to be very carefully designed and constructed with allowable safety levels.

The collapse of the Seongsoo Grand Bridge resulted in the losses of 32 lives and injuries to 17 on October 21, 1994. It was caused by the collapse of a truss at the upper level located in the middle of the piers. There were also substantially high social and economic losses such as traffic congestion and property damages of $600 million. After this accident, a diagnostic assessment of the bridges was conducted, especially for those over the Han River; Dangsan railway bridge was replaced, and the Hannam, Yanghwa, and Jamsil grand bridges were reinforced.

The collapse of the Sampoong grocery store was caused by the multiple reasons such as inappropriate design, construction, supervision, and maintenance, and it resulted in 502 deaths and injuries to 938 people on June 29, 1995. This accident directly brought to light issues that resulted in establishing an emergency management law in Korea. This was the first place to be declared a special disaster area. During the accident response and recovery, an insufficient number of rescue members and equipment in addition to nonsystematic command systems were found. Hence, after this accident, the necessary prevention and recovery systems for disasters were emphasized.

The Wawoo Apartments collapsed within four months after the completion of construction on April 8, 1970. An investigation was conducted to determine the causes of the collapse. The investigation results showed that the foundation columns were not resistant to the self-weight of the apartments. An insufficient amount of rebar in the foundation constructed along the mountain slopes was the direct reason for the collapse. After this accident, the mayor of Seoul, who was responsible for this accident, resigned, and the residential problems of the urban poor led to social issues. Figure 2 shows number of disasters, fatalities, injuries, and property loss induced by collapse for recent seventeen years.

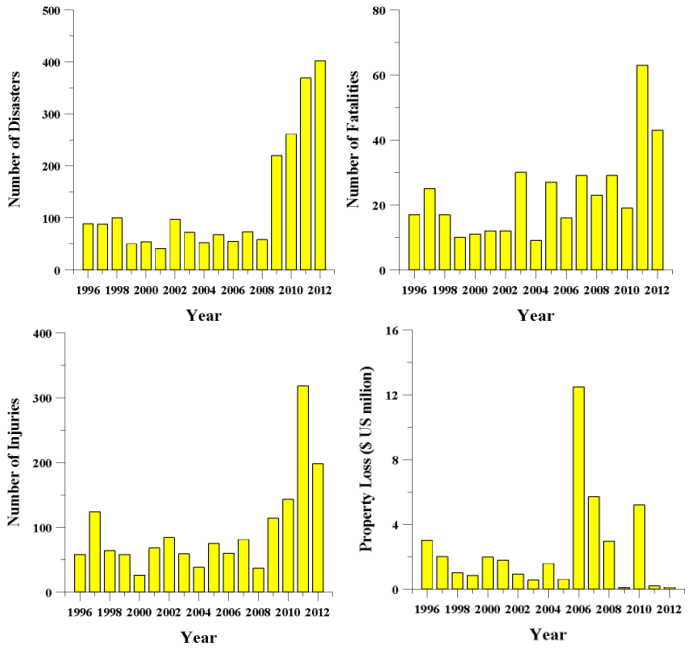


Figure 2. Number of disasters, fatalities, injuries, and property loss induced by collapse during 1996-2012

Explosion

Explosions caused by the explosion of phosphide gas, explosives, and energy resulted in life and property losses. Physical models were developed to calculate the physical effects of explosion and fire from Liquefied Petroleum Gas (LPG) accidents and also to predict the affected areas. The areas affected by LPG tank accident were estimated through the integration of a chemical explosions and fire models with a GIS database. Theoretical investigations of various methods for calculation, the physical effects of explosions, and fire events on vessels containing 120 tons of LPG were carried out with many physical models (El-Harbawi et al., 2004) [15]. Typical gas explosions in Korea were occurred in Seoul, Daekoo, and Bucheon city.

A gas explosion on December 7, 1994, occurred at Ahyun-dong in Seoul following the ignition of a fire from spread gas leaking from a motor-operated valve during the inspection of the gas meter at the Korea Gas Corporation gas governor station. The accident resulted in the losses of 12 lives, injuries to 170 people, and 366 refugees from 127 residential buildings. After the accident, an immediate response was not appropriately and systematically carried out because of low-level of technology and insufficient equipment (Lee, 2002) [16].

The excavation work on roadways in Daegoo took place with the permission of the government administration office. However, the excavation damaged the gas pipelines buried at this site and resulted in a gas explosion that caused 101 deaths and injuries to 202 more on April 28, 1995. Great losses directly resulted from the passive, lackadaisical responses of the related government organizations. Subsequently, the roadways in which urban gas pipelines were buried were required by law to have special maintenance for the safety of gas pipelines.

An explosion at the LPG station in Bucheon occurred on September 11, 1998. Leaked gas ignited by unknown sources resulted in the explosion. At that time, the vent valve on the underground LPG tank was the vent valve was opened and emitted gaseous nitrogen. The accident resulted in the death of one, 96 injuries, and property damages of $11 million. After the accident, a comprehensive management system for the LPG station with respect to safety was established, and a new contract form for a safe supply of LPG was introduced, both to fully compensate victims for damages and possible mistreatments by the poor retail businessman who managed the LPG station. Figure 3 shows number of disasters, fatalities, injuries, and property loss induced by explosion for recent seventeen years.

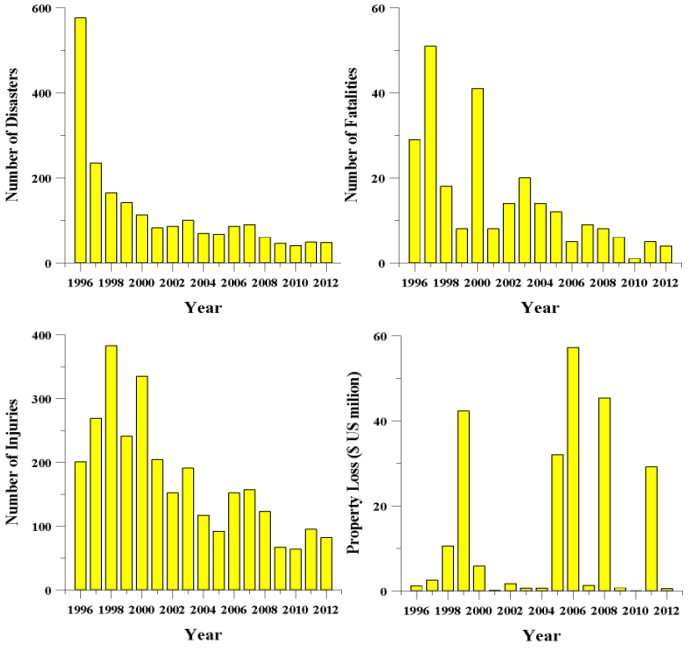


Figure 3. Number of disasters, fatalities, injuries, and property loss induced by explosion during 1996-2012

Traffic Accident

Traffic accidents by car, railway, airplane, and ships have resulted in life and property losses. Typical accidents in Korea include a derailed train at Gupo in Busan, the crash landing of Asiana airlines airplane, and the sinking of Family Ship in the West Sea.

In March 1993, as a train passed the Gupo station, it was derailed because the soft ground settlement caused by blasting loads near the railways during excavation work because the Korea Electric Power Corporation performed the construction work without permission from the National Railroad Administration. The accident resulted in the losses of 78 lives and injuries to 198 people. The lesson learned from the accident was the importance of communication between each government organization.

The crash of the Asiana Airlines flight resulted in 66 deaths and injuries to 46 in July 1993. To save gas and avoid customer complaints, a reckless emergency landing was carried out on the army runway with neither radar supports nor an instrument landing system during heavy rainfall. In general, the number of customers using airplanes has substantially increased; in contrast, the safety facilities were insufficient. After the accident, a systematic rescue system at the airport was developed.

The sinking of Family Ship in the West Sea on October 12, 1993, was caused by reckless navigation in extreme weather conditions, overloads of both passengers and baggage, and only two security members. A half-hour after the accident, the police helicopter departed and the patrol ship arrived after one hour. This accident showed the problem of an inappropriate rescue system. After the accident, strengthening the system arose as an important issue. Figure 4 shows number of disasters, fatalities, injuries, and property loss induced by traffic accident for recent seventeen years

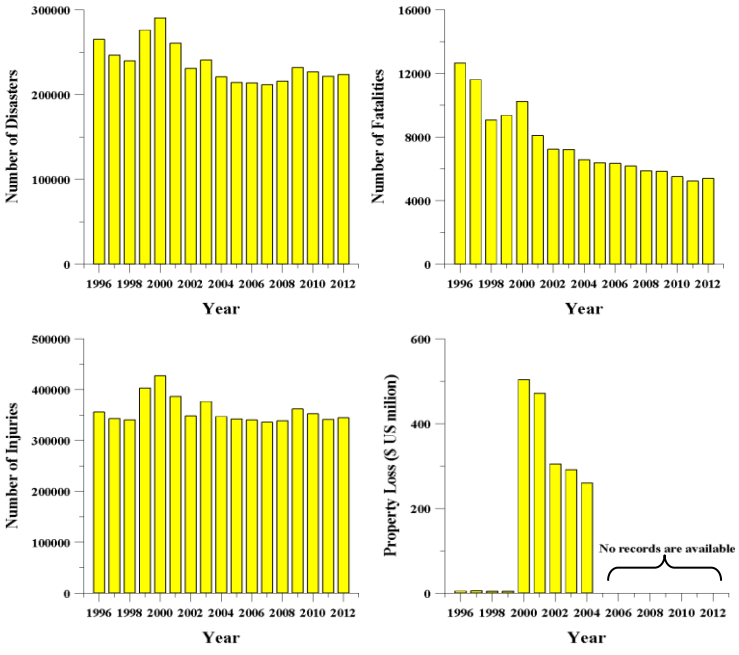


Figure 4. Number of disasters, fatalities, injuries, and property loss induced by traffic accident during 1996-2012

Environmental Pollution

Environmental pollution includes air, water, and soil pollution. Only water pollution has been a critical problem in Korea. One of the typical cases was phenol pollution in the Nakdong River, which occurred on March 14, 1991. Thirty tons of phenol leaked from a damaged phenol pipeline, infiltrated an intake station, and then contaminated the water supply for the residents of Daekoo. This was the first environmental pollution problem for which the organization committee was rebuked. Figure 5 shows number of disasters, fatalities, injuries, and property loss induced by environmental pollution for recent seventeen years

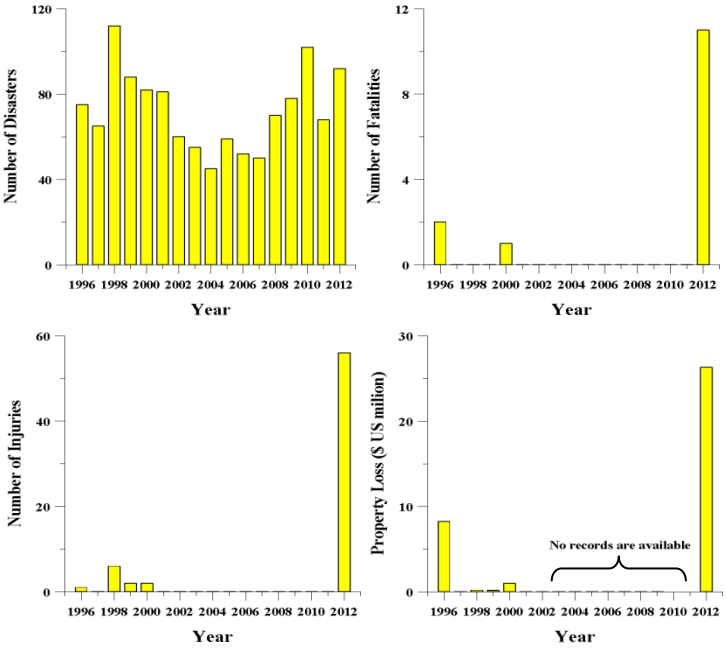


Figure 5. Number of disasters, fatalities, injuries, and property loss induced by environmental pollution during 1996-2012

III. PROPOSED IMPROVEMENTS TO PLANS FOR MAN-MADE DISASTERS

Fire Accident

If anticipated fire-damaged areas are very large or highly condensed areas of buildings have been declared fire boundary zones (National Disaster Management Institute, 2007) [1]. Fireproof design law should be upgraded and should establish new criteria reflecting the new technology and materials.

Law enforcement for the maintenance of fire protection facilities and safety management should be strengthened to improve safety inspections of firefighting equipment. Because the fire safety criteria coded by architecture and firefighting, laws were established by several different government organizations under a lack of systematic co-work systems, inefficient management resulted. The experiment revealed that the fire prediction, estimation, and management capacity in Korea is only 40% to 50% of the level of that in advanced countries, and therefore, new technologies related to these and an efficient interactive system should be developed and established by

combining similar regulations, supplementing regulations, and making new regulations if it is necessary.

Collapse

A safety management system for infrastructure is operated in three sequential steps: design, construction, and maintenance. Design laws are related to construction technology management, roadways, architecture, firefighting, electrics, and gas. In contrast, construction laws are related to construction technology management and both industrial safety health and construction standards. Laws on maintenance and management are related to the special law for the safety management of infrastructure and facilities and for disaster and safety management standards (Lee, 2005) [12]. The special law is prosecuted by the Ministry of Land, Transport, and Maritime Affairs, and safety inspections are conducted based on a precise safety diagnosis manual to investigate structural defects. The safety management standard law is prosecuted by the Ministry of Public Administration and Security. This disaster management institution manages facilities that are at risk of a disaster. Although the law is well classified, it is complicatedly connected to the overlapping duties of different government organizations. Hence, a comprehensive and united law is required, and professional institutions should be established to systematically resolve and manage problems.

Explosion

Most explosions in Korea have been caused by gas (National Emergency Management Agency, 2007) [13]. Advanced prevention systems for the risk of explosions were developed, but there were limitations because the analysis was performed for limited specific conditions and the systems were still based on simple introductory procedures and a low level of technology. The system did not satisfactorily reflect all industrial fields. However, prevention systems in advanced countries have been developed and associated with systematic and comprehensive safety policies. Because gas explosions are primarily caused by carelessness and safety insensitivity, a specialized agency should periodically inspect gas facilities and carry out safety education and publicity activities. Government officials should guide and supervise the specialized agency to maintain professionalism. Because the locations of gas pipelines buried underground are not electronically geo-coded in GIS, there is high risk during the excavation work for subway construction and roadway expansion and reinforcement, especially in urban areas. Therefore, the gas pipelines constructed in the past and also newly constructed gas pipelines should be digitized by digitizing in GIS.

Traffic Accident

Traffic policy in Korea needs to be established from good references based on prototype models of well-developed traffic safety policies around the world, and the government should enact an enforcement policy to increase driver awareness of traffic safety through education programs. This may require hiring a professional road safety officer. A database for the areas in which frequent traffic accidents occur should be compiled for traffic analysis to simulate possible traffic accidents. Traffic facilities should be improved especially for high risk accident regions.

The safety criteria established by each organization cannot be enforced by law (Park, 2005) [17]. In advance, criteria especially for railways should be established by law to supplement both signal system equipment and electricity supplies, and rapid response and recovery systems should be improved by utilizing the equipment.

There are only three professional rescue ships in Korea, in contrast, there are 190 in Japan. There are substantially small numbers of rescue ships in Korea. Hence, the government should invest funds in increasing the number of rescue ships for rapid and efficient responses to reduce life and property losses. In England, after Braer Ship accident, 10,000-HP tug boat was deployed near the oil-tanker seaway. In Korea, there are 100-ton rescue ships that are not eligible to rescue the ships. Large-scale of rescue ships that satisfy the high demand efficiency and safety should be deployed in cases of ships that run aground and in high-risk crash zones. Korea's Coast Guard is the only existing organization responsible for the marine accidents.

Environmental Pollution

Air pollutants do not automatically disappear and they harm both the human body and ecology in nature. Most air pollutions in Korea is caused by exhaust fumes generated by the greatly increased numbers of diesel engine automobiles, especially in urban areas. Based on an environment report, sulfite gas contamination is severe, especially in Seoul, at a level that exceeds two times standard recommended by the World Health Organization (WHO). Additionally, acids contained in rain generated by sulfite gas amounted to four to six times more than the 1990 average amount of acids contained in rain. To reduce air pollution mainly induced by traffic, the local government agency should establish a comprehensive strategic plan, and residents may have to actively participate in the education program.

A scientific management system associated with a water pollution remediation policy should be developed to control water quality. The pollution-loading system should be enforced by law, and the central and local government agencies should establish an information system to systematically manage water pollution. A diagnosis of environmental pollution by a professional environmental company should be conducted, and also, contracts for estate businesses should reflect any pollution investigation results because there is a possibility of secondary losses such as groundwater contamination after a certain period of time.

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IV. CONCLUSION

In this study, typical losses induced by man-made disasters in Korea were described, and appropriate improvement plans were suggested. The analyzed results of typical problems caused by man-made disasters showed that disaster responses were not properly carried out because of the lack of prevention systems or appropriate equipment and facilities. There were no regular safety inspections or appropriate maintenance or repairs of the infrastructure.

In the meantime, the laws related to man-made disasters are broad, and they overlap across different government organizations. Therefore, the laws should be clearly modified to avoid the overlapping of multiple organizations and should be

scientifically supplemented. The laws of each government administration should be reexamined and, if necessary, integrated and merged in order to develop efficient co-work systems between different government organizations. When the disasters occur, each organization should be responsible for assigned work and charged with respect to its responsibility. Public activities and citizen education should be carried out in systematic ways with practical exercises.

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AUTHORS

First Author – Sang-Soo Jeon, Ph.D. Associate Professor, Inje University, Inje-ro 197 Kimhae, Kyungsangnam-do, Republic of Korea 621-749
Email Address: ssj@inje.ac.kr