INVESTIGATION ON HISTORICAL RECORDS OF MAJOR MAN-CAUSED DISASTERS IN KOREA

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For the purpose of comparing the individual risks from nuclear accidents to the individual risks from other man-caused accidents, the frequencies from explosions, structural collapses, and hazardous chemical releases were estimated based on historic accident data. The frequencies of explosions and dam failures in Korea are found to be smaller than those provided in WASH-1400 but comparable with consideration of the time difference and the size difference between the two societies. Continued effort to collect historic accident data will be important for more accurate estimation of individual risks from non-nuclear man-caused accidents.

I. INTRODUCTION

The estimation of Korean individual risks from Korean nuclear power plants (NPPs) is currently ongoing. For the purpose of comparing the individual risks from nuclear accidents to the individual risks from other man-caused accidents, the frequencies of explosions, structural collapses, and hazardous chemical releases in Korea were estimated.

In Reactor Safety Study (Ref. 1), which is also known as WASH-1400, four types of natural disasters (hurricanes, tornados, earthquakes, and meteorites) and five types of man-made disasters (airplane crashes, explosions, dam failures, fires, and hazardous chemical releases) were considered. This paper considers three of the five types of man-made disasters, which are explosions, structural collapses, and hazardous chemical releases.

Because the individual risks from large consequence events were of interest, historical accident events of explosions, structural collapses, and hazardous chemical releases with fatalities more than five were searched, analyzed, and collected from various sources such as literatures, publications, and news articles. The accidents with fatalities up to 40 could be found for explosions and structural collapses, while few accidents with fatalities more than 5 were found for hazardous chemical releases.

II. INDIVIDUAL RISK FROM NON-NUCLEAR ACCIDENTS

II.A. Explosions

The frequency of explosion consequences provided in WASH-1400 was calculated based on 44 major explosions throughout the world with the fatalities greater than 9 during the 1925-1971. Among the major explosions, 22 occurred in the U. S. The frequency of explosion consequences was first calculated based on 44 major explosions throughout the world, and then shifted down by a factor of 2.

The biggest explosion accident in Korea was Daegu gas explosions in 1995 (Ref. 2) which resulted in at least 101 fatalities and 202 injuries, followed by Iri station explosion in 1977(Ref. 3) which resulted in at least 59 fatalities and 185 injuries. However, explosions with fatalities more than 5 were not frequent. The number of explosions with fatalities more than 9 during 1972-2014 is 7, compared to 22 in the U. S. during 1925-1971.

Fig. 1 shows the frequency of explosion consequences in Korea with that provided in WASH-1400 for comparison purposes.

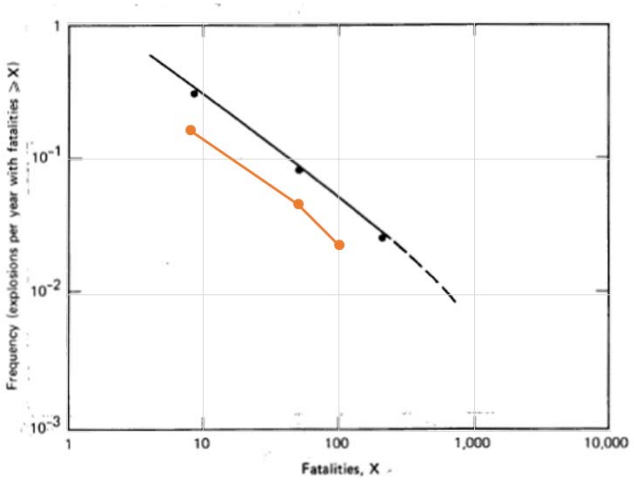

Fig. 1. Frequency of explosion consequences provided in WASH-1400 with comparison to that in Korea.

TABLE I shows the statistics on the number of explosions and their associated casualties (fatalities and injuries) in Korea during 2003-2014. While most of the explosions resulted in zero or one fatalities, TABLE 1 includes one explosion in 2011 which resulted in five fatalities and two injuries and another explosion in 2013 which resulted in six fatalities and eleven injuries.

TABLE I. Explosion Accidents in Korea

Year	Occurrences	Fatalities	Injuries
2003	100	20	19
2004	67	14	11
2005	67	12	92
2006	86	5	152
2007	90	9	157
2008	60	8	123
2009	46	6	67
2010	41	1	64
2011	49	5	95
2012	48	4	82
2013	61	13	105
2014	48	6	67

II.B. Structural Collapses

The frequency of dam failures provided in WASH-1400 was calculated based on the 8 major dam failures that occurred in the U. S. during 1889-1972. The fatalities of those dam failures range from 5 to up to 2,000. Also, the frequency of dam failures with fatalities up to 10,000 was estimated based on researches at that time such as Gast (Ref. 4) and Okrent et al.(Ref. 5).

The most remarkable dam failure occurred in Korea was the Hyokiri dam failure in 1961(Ref. 6) which resulted in 57 fatalities. The failure of Yeoncheon dam in 1996 also received a lot of attention, but no fatalities were involved with the accident. Because one dam failure with 57 fatality occurred during 1961-2015, the frequency of dam failure with fatality greater than 50 in Korea can become estimated to be 0.0185/year. Fig. 2 shows the data points for the calculation result plotted on the frequency-consequence curve for dam failures in WASH-1400.

Due to insufficient dam failure data, the scope of data collection was extended to all structural collapses. Table 2 shows the statistics on the number of structural collapses and their associated casualties (fatalities and injuries) in Korea during 2003-2014. The data includes Mauna Ocean Resort auditorium collapse in 2014 (Ref. 7) which resulted in 10 fatalities and the collapse at a building construction site in Icheon, Korea in 2005 which resulted in 9 fatalities. By comparing the number of occurrences and fatalities in Table 2, the fatalities in most of structural collapses involve less than two fatalities.

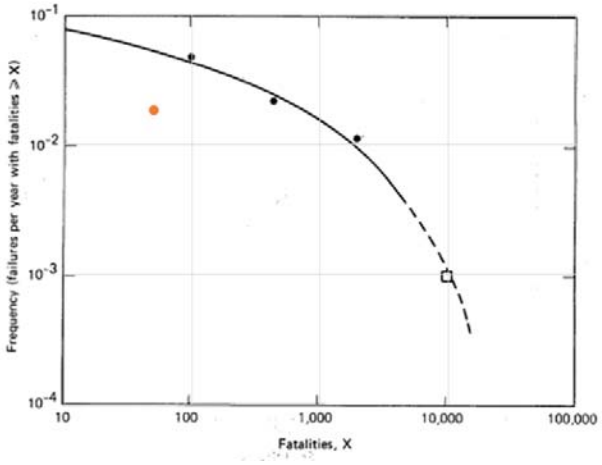

Fig. 2. Comparison of the individual risk provided in WASH-1400 and that in Korea due to dam failures.

TABLE II. Structural collapses in Korea

Year	Occurrences	Fatalities	Injuries
2003	72	30	59
2004	52	9	38
2005	68	27	75
2006	55	16	60
2007	73	29	81
2008	58	23	37
2009	220	29	114
2010	261	19	143
2011	369	63	324
2012	402	43	198
2013	401	26	223
2014	396	22	152

II.C. Hazardous Chemical Releases

The individual risk from hazardous chemical releases provided in WASH-1400 was provided based on the study by Simmons et al.(Ref. 8), with the evacuation model by Hans and Sell (Ref. 9). The study assumed that the frequency of substantial release of chlorine while being transported by railroad tank car was at least once every ten years. Because such type of accidents only resulted in one fatality in 50 years, the actual data were not clearly reflected in the frequency-consequence curve.

One of the most remarkable hazardous chemical releases occurred in 2012 (Ref. 10) while unloading hydrofluoric (HF) acid from a tanker which resulted in 5 fatalities and 18 injuries. Another accident that involves the leakage of HF occurred in 2013 which resulted in 1 fatality and 4 injuries.

Table III shows the statistics on the number of environmental pollution accidents and their associated casualties (fatalities and injuries) in Korea during 2003-2014. Even though the environmental pollution accidents include hazardous chemical releases, it seems that the statistics in Table III before 2012 mainly focus on the oil spill accidents and do not properly reflect casualties associated with hazardous chemical releases. After the HF release accident in 2012, a lot of attention is given to hazardous chemical release accidents, and as a result, significant increase in the number of occurrences and casualties can be observed after 2013.

TABLE III. Environmental pollutions in Korea

Year	Occurrences	Fatalities	Injuries
2003	55	-	-
2004	45	-	-
2005	59	-	-
2006	52	-	-
2007	50	-	-
2008	70	-	-
2009	78	-	-
2010	102	-	-
2011	68	-	-
2012	92	11	56
2013	244	11	70
2014	316	4	178

III. DISCUSSIONS

Because the data on the accidents and associated casualties were collected by various sources, the comprehensiveness of the data cannot be guaranteed, especially when the consequences were relatively small. Even though there are concerns on the possibly missed accident data, the estimated frequencies of explosions, structural collapses, and hazardous chemical releases are considered to be reasonable and can be used as base data in estimating the societal and individual risks from non-nuclear man-caused accidents. For more accurate estimation of individual risks from non-nuclear man-caused accidents, continued collection of accident data and update of the collected accident list will be necessary.

IV. CONCLUSIONS

For the purpose of comparing to the individual risks from nuclear accidents, the frequencies of three types of non-nuclear man-caused accidents were estimated and compared with those provided in WASH-1400. It was found that accidents involving fatalities greater than five are rare compared to total number of occurrences. The frequencies of explosions and dam failures in Korea are found to be smaller than those provided in WASH-1400 but comparable with consideration of the time difference and the size difference between the two societies. Considering the concerns on the comprehensiveness of the historic accident data, continued effort to collect historic accident data will be important for more accurate estimation of individual risks from non-nuclear man-caused accidents.

ACKNOWLEDGMENTS

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