Development of Strategy Assessment Emergency Preparedness Plans Using Level 3 PSA

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1. Introduction

In 2011 March, nuclear accident at Fukushima has become a worldwide issue. After its accident, environment organizations not only exaggeratedly assert that riskiness of the nuclear power plant, but also suspect the danger of our nuclear power plant. To solve this problem, we use Level 3 PSA to set up scenario of power plant accident including reference plant, and carry out its sensitivity analysis.

2. Methods and Results

2.1 MACCS2 code

MACCS2 code (MELCOR Accident Consequence Code System code) is representative code of Level 3 PSA that can evaluate effects, such as economic damage, early fatality and cancer fatality when power plant accident is occurred[1]. This code considers region, population, geographical features, weather, release of radioactivity, and emergency respond plan. With the use of MACCS2 code, we can analyze fatality, risk, and sensitivity according to accident scenario of nuclear power plant including UCN 3&4, YKN 1&2. This consequence can be used not only as evaluate the safety of each nuclear power plant, but also as develop emergency respond scenario.

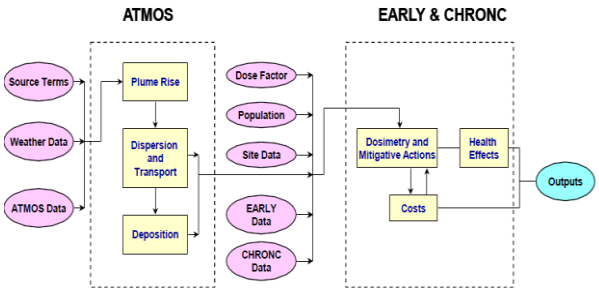

Fig.1. Progression of a MACCS Consequence Calculation

2.2 Emergency Preparedness plans

Emergency preparedness plans are made of on-site and off-site plans. On-site emergency plans consist of reporting flowchart, crisis management organization, institutional duty and role. Likewise off-site emergency plans include prevention plans for residents (evacuation, sheltering and relocation) and the emergency disaster drill[2]. This research evaluates qualitative and quantitative consequences about these plans.

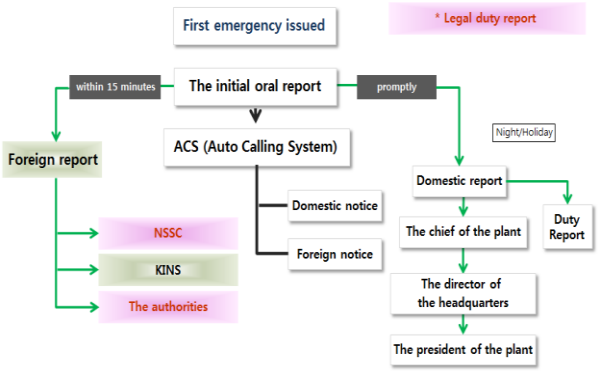

Fig.2. Reporting flowchart

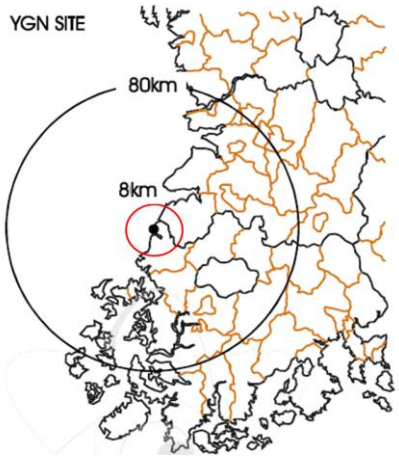

Fig.3. Emergency Planning Zone of the YGN site

2.3 Risk Assessment

With the result of analysis MACCS2 code, we can get individual fatality risk, such as early fatality risk and cancer fatality risk, of an nuclear power plant. Risk can be regarded as one single person passes away by the accident of an nuclear power plant. This is the equation of the risk.

$$Risk = \frac{\sum_{STC(i)} Fatality_i \times Frequency}{Population} \quad (1)$$

Each STC, we calculate risk in order to evaluate the safety of the nuclear power plants. Furthermore, with the result, we can set up emergency preparedness plan.

	A	B	C	D	E	F	G	H	I	J
1		Early	Fatality	Cancer	Fatality	STC	Population weighted Risk		Individual Fatality Risk	
2		0-80 km	0-16 km	0-80 km	0-16 km	frequency	Early	Cancer	Early	Cancer
3	STC1	0.00E+00	0.00E+00	2.70E-03	2.31E-03	1.63E-06	0.00E+00	6.47E-08	0.00E+00	1.05E-13
4	STC2	0.00E+00	0.00E+00	3.88E-01	3.28E-01	2.35E-06	0.00E+00	7.96E-06	0.00E+00	1.87E-11
5	STC3	2.91E+01	2.91E+01	1.51E+02	7.87E+01	1.47E-08	2.96E-02	1.86E-03	4.35E-10	2.73E-11
6	STC4	5.66E+01	5.66E+01	4.04E+02	2.46E+02	1.16E-08	4.08E-02	5.75E-03	4.73E-10	6.67E-11
7	STC5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8	STC6	2.59E+01	2.59E+01	1.21E+02	4.90E+01	1.85E-07	2.89E-02	8.60E-04	5.35E-09	1.59E-10
9	STC7	2.53E+01	2.53E+01	8.89E+01	4.21E+01	3.39E-10	2.63E-02	8.81E-04	8.92E-12	2.99E-13
10	STC8	2.46E+01	2.46E+01	1.05E+02	4.27E+01	1.56E-07	2.55E-02	1.00E-03	3.98E-09	1.56E-10
11	STC9	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	STC10	2.47E+01	2.47E+01	1.08E+02	4.37E+01	2.13E-07	2.56E-02	1.02E-03	5.45E-09	2.17E-10
13	STC11	2.56E+01	2.56E+01	1.04E+02	4.18E+01	1.13E-10	2.64E-02	9.90E-04	2.98E-12	1.12E-13
14	STC12	2.40E+01	2.40E+01	9.99E+01	4.03E+01	1.66E-07	2.49E-02	9.67E-04	4.13E-09	1.61E-10
15	STC13	2.67E+01	2.67E+01	1.20E+02	4.74E+01	2.18E-07	2.74E-02	1.09E-03	5.97E-09	2.38E-10
16	STC14	4.33E+02	4.33E+02	2.35E+03	1.50E+03	4.26E-09	7.51E-02	8.78E-03	3.20E-10	3.74E-11
17	STC15	1.84E+02	1.84E+02	1.34E+03	7.86E+02	3.37E-07	6.03E-02	6.64E-03	2.03E-08	2.24E-09
18	STC16	7.27E+00	7.27E+00	1.22E+02	7.10E+01	1.68E-08	7.63E-03	1.87E-03	1.28E-10	3.14E-11
19	STC17	4.11E+01	4.11E+01	2.80E+02	1.54E+02	1.78E-08	3.61E-02	3.17E-03	6.43E-10	5.64E-11
20	STC18	2.30E+02	2.30E+02	1.52E+03	9.10E+02	1.77E-09	6.54E-02	6.46E-03	1.16E-10	1.14E-11
21	STC19	1.52E+02	1.52E+02	9.95E+02	6.33E+02	5.29E-07	5.63E-02	1.05E-02	2.98E-08	5.55E-09
22	Total	**1.31E+03**	**1.31E+03**	**7.91E+03**	**4.69E+03**	**5.84E-06**	**5.56E-01**	**5.18E-02**	Average (without STC5,9)	
23		**100% Evacuation**							**4.54E-09**	**5.28E-10**

Fig.4 UCN5&6 Risk Assessment

2.4 Sensitivity analysis

When nuclear power generation accident occurs, damage on residents can be distinguished from the means of emergency respond. Sensitivity analysis can be defined as setting up accident scenario to find best efficient emergency respond plan by the comparison of the simulated results[3]. Independent variables are evacuation speed, delay time, duration of the emergency phase, and duration of the plume segments. It is crucial to admit these to the feature of the nuclear power plant region.

	Early	**Cancer**		
		~1.6km	**~8km**	**~80km**
95%/5%	3.44E+02	5.70E+02	1.84E+03	3.56E+04
100%/0%	3.39E+02	5.73E+02	1.82E+03	3.56E+04
70%/30%	3.71E+02	5.55E+02	1.91E+03	3.57E+04
50%/50%	3.93E+02	5.44E+02	1.97E+03	3.58E+04
30%/70%	4.14E+02	5.31E+02	2.03E+03	3.58E+04
0%/100%	4.47E+02	5.13E+02	2.12E+03	3.59E+04

Table.1. Table of the Sensitivity Analysis

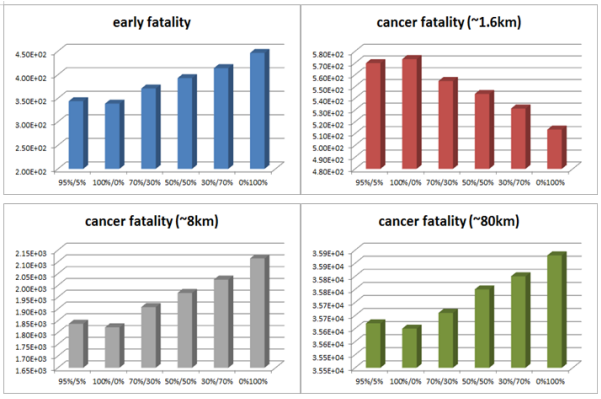

Fig.5 Sensitivity Analysis about Emergency Response

3. Conclusions

Recently, there has been a few accidents in the nuclear power plant, and the problem of the safety evaluation becomes more important. Especially, the mass media demands the suspend of nuclear power plants after the accidents occurred in Fukushima. And because of it, the residents' in Fukushima feel a growing sense of unease. However, through this report, we simulate the actual nuclear power plant accidents. Moreover, as we suggest the results and the evaluation of the safety in the emergency respond plan, we are able to prove effectiveness of the safety and the emergency respond plan in nuclear power plants.

ACKNOWLEDGMENTS

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