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Reliability analysis of road network for estimation of public evacuation time around NPPs

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1. Introduction

The most strong protection method of radiation emergency preparedness is the evacuation of the public members when a great deal of radioactivity is released to environment.

After the Three Mile Island (TMI) nuclear power plant meltdown in the United States and Chernobyl nuclear power plant disaster in the U.S.S.R, many advanced countries including the United States and Japan have continued research on estimation of public evacuation time as one of emergency countermeasure technologies. Also in South Korea, "Framework Act on Civil Defense: Radioactive Disaster Preparedness Plan" was established in 1983 and nuclear power plants set up a radiation emergency plan and have regularly carried out radiation emergency preparedness trainings.

Nonetheless, there is still a need to improve technology to estimate public evacuation time by executing precise analysis of traffic flow to prepare practical and efficient ways to protect the public. In this research, road network for Wolsong and Kori NPPs was constructed by CORSIM code and Reliability analysis of this road network was performed.

2. Methods and Results

2.1 Traffic Flow Analysis Code

In the United States, computer codes used to calculate the evacuation time in the area of nuclear power are MASSVAC, NETVACI, DYMOD, and I-DYNEV, and among them the representative computer code developed in the 1980s is I-DYNEV. I-DYNEV code indicates traffic flow for individual vehicles to make it easy to grasp traffic situation at intersections or congested roads. However, since it presumes that traffic situation is fixed, it is difficult to realistically reflect a situation where traffic situation changes by time (e.g. morning and evening rush hours).

Another general code is CORSIM developed by Federal Highway Administration (FHWA). In the CORSIM code, delay time derived from bottleneck at intersections and the number of vehicles leaving emergency planning zone by hour are calculated to estimate total evacuation time. To obtain these results, geometrical structures of roads (e.g. junction or intersection), road condition, distribution of evacuation vehicles by region and hour are needed. The CORSIM uses NETSIM code, which is a micro traffic control system, as a traffic flow model. NETSIM code characterized by precisely simulating inner-city traffic is a model to analyze traffic flow on highway network by calculating each vehicle's movement at intervals of several seconds in accordance with a car-following theory.

Generally, the Traffic Software Integrated System (TSIS) computer program package has been used, which was developed by the University of Florida in the United States as traffic flow analysis tool in assessing traffic influences of cities, road designs, and facilities.

In TSIS, CORSIM which is a micro traffic simulation model of the U.S. FHWA is a core element. CORSIM is a model combining the FREESIM model which is applied to highways or semi-expressway with the NETSIM model widely used for simulation of main street networks. CORSIM reproduces most traffic situations that can be experienced in road networks to a considerably detailed level including traffic signal control, bus operation, obstacles, parking, spillback, and left turn pocket overflow.

2.2 Reliability analysis of constructed road network

Main input data of the NETSIM code include geometrical structure of roads (e.g. the number of lanes, rotating pocket, location of detectors), type of links (main street networks or semi-expressway), traffic volume, intersection-rotating traffic volume, and type of traffic control. Using this input data obtained by field surveys, road network was constructed as follows.

Reliability analysis of this road network was performed by comparison real traffic speed by driving test with traffic speed from this traffic analysis in several spots for application to Korean NPPs.

3. Conclusion

A correlation between the real and the analyzed speeds was presented in Fig 2. The square of R is 0.7659 in Kori and 0.911 in Wolsong respectively. This means this constructed road network is well represented the real surrounding of NPPs in Korea. As a result, the reliability of this road network using CORSIM code for evacuation time estimate would be concluded to be high.

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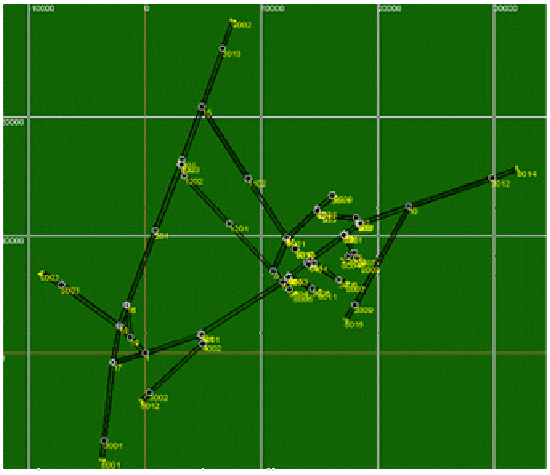
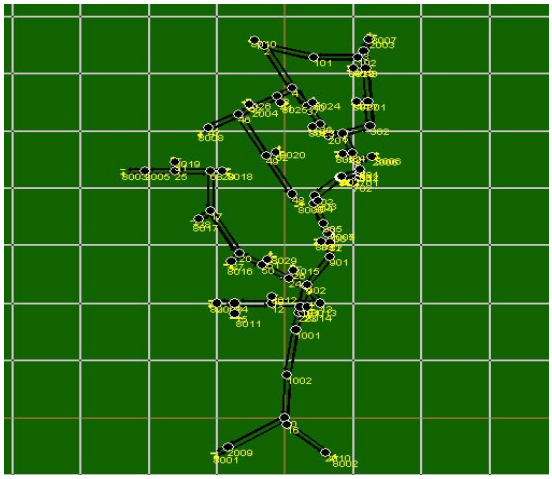
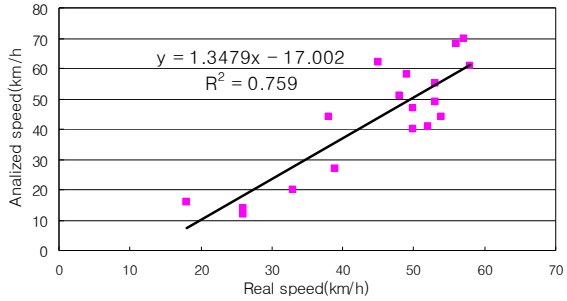


(a) Kori

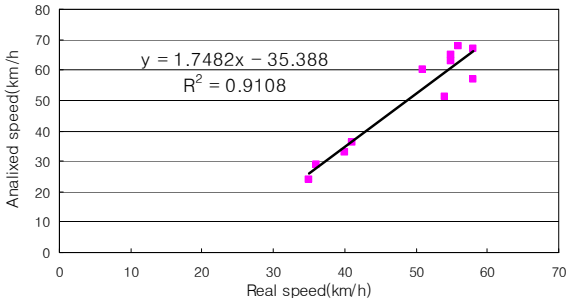


(b) Wolsong

Figure.1. Road networks of Kori and Wolsong NPPs



(a) Kori



(b) Wolsong

Figure.2. Comparison between the real and the analyzed speeds