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Preliminary study on tsunami vulnerability assessment in south coast of Korean Peninsula

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1. Introduction

In March 2011, the earthquake of magnitude 9.0 that occurred and it generated a huge tsunami. According Japanese National Police Agency, the number of casualties is about 25,000. The economic damage was estimated US$235 billion, which the World Bank presented it the costliest natural disaster in world history. The tsunami propagated to the Korea coast. After earthquake, the generated waves would reach Masan City (Korea) in approximation 6 hour with 0.1 to 0.2 meter wave heights. The two earthquake scenarios discussed, the first was March 2011 Tohoku earthquake and second was hypothetical Nankai trough earthquake. The Nankai trough is a submarine trough located south of Japan’s island of Honshu, extending approximately 900km offshore. The potential impact on the coast by the Nankai trough earthquake has been reviewed in 2003 by the Japanese government. However, the magnitude-9.0 earthquake that occurred in March 2011, the Japanese government has decided to re-evaluation the event and extensive studies revealed that the occurrence of a magnitude-9.0 earthquake in the Nankai Trough. In this revealed result, the tsunami waves have been estimated approximately 50% bigger than previous results [1]. Even more Nankai trough close to the South Korea compared to the epicenter of the Tohoku Earthquake. Thus, the Nankai trough was carefully examined in this paper. As you many know tsunami is one of the most destructive natural disasters that take very strenuous, costly and time consuming to recovery.

Korea is not free from tsunami, with Nankai trough. And therefore it is just imperative for Korea to pursue a policy against tsunami. This study can provide useful approach for tsunami vulnerability assessment.

2. Methodology

2.1.FUNWAVE

Boussinesq models have been widely used to model ocean wave processes [2, 3]. One major advantage of using these equations over the NSW equations is that they are valid in deeper water than the NSW equations. Numerical models of these equations have been shown to be able to accurately predict wave evolution, decay in wave heights due to breaking induced dissipation, wave run-up, and wave induced currents and other processes. Since these equations can efficiently and accurately model wave propagation, FUNWAVE [2] which is a finite difference model is chosen for the Boussinesq modeling part of this research.

2.2.TOPIS

The TOPSIS technique was developed to solve MCDM problems in which there is no articulation of preference information [4]. The technique is based on the concept that the ideal alternative has the best level for all attributes, whereas the negative ideal is the alternative with all of the worst attribute values. A TOPS IS solution is defined as the alternative that is simultaneously farthest from the negative ideal and closest to the ideal alternative [5, 6, 7].

2.3.VIKOR

The VIKOR method is another MCDM method that employs aggregating functions; it focuses on compromising solutions for a prioritization problem with conflicting criteria, which can help decision makers obtain final solutions [8].

2.4. Vulnerability Factor with Delphi Technique

The Delphi method as a method for structuring a group communication process is accomplished by some feedback of individual contributions of information and knowledge, some assessment of the group judgment or view, some opportunity for individuals to revise views and some degree of anonymity in individual responses [9].

A series of questionnaires with controlled opinion feedback is typically used for collecting and distilling knowledge from a group of experts [7, 10, 11, 12]. The process that experts reply to questionnaires, subsequently receive feedback, and modify their opinion is repeated until arriving at the most reliable consensus. In the present study, we tried to compose assessment criteria using simple 3-round Delphi surveying technique.

Firstly, we selected a group of experts in tsunami and social vulnerability of Korea. Then we created the candidates of criteria after examining literature and brainstorming in Delphi 1st round.

After collecting and analyzing the judgments of a group of experts, the evaluation framework consisting of criteria and their weights can be determined if the consensus of the group emerged.

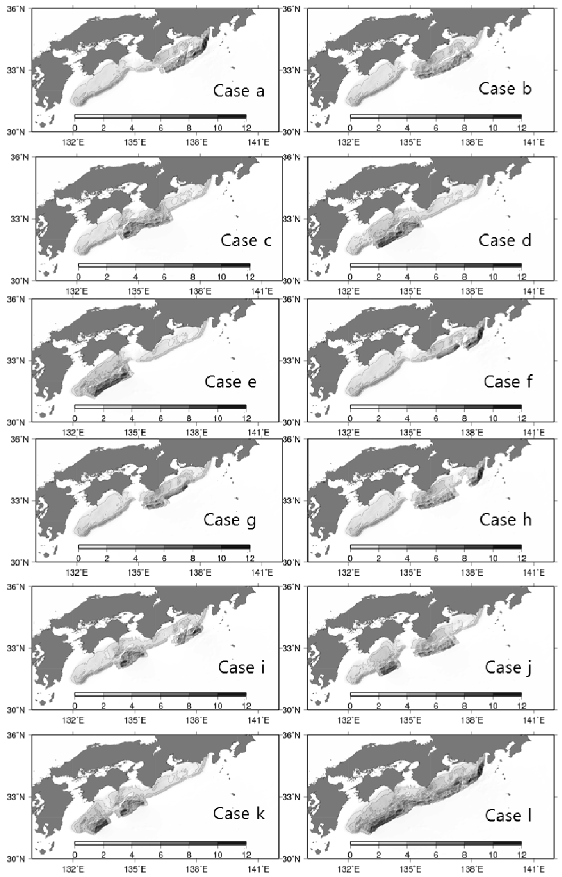

Fig. 1. Eleven scenarios of the hypothetical Nankai Trough tsunami and maximum initial water level.

Delphi procedure needs the active involvement of all experts and takes a lot of patience to complete. This study contacted some experts who make researches about tsunami, costal engineering and natural hazard risk. However, we couldn't finish the surveying process. Thus we supposed criteria sets which are expected the results of survey. Adopted criteria are (1) human life, (2) Urban function, and (3) primary facilities.

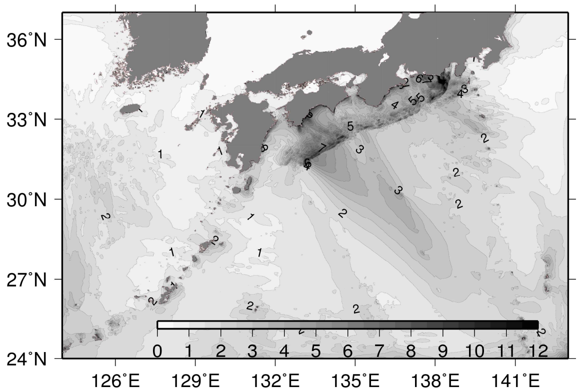

Fig. 2. The distribution of maximum tsunami wave heights

Human life is the most important element that have to be protected against natural disaster. The census report of Statistics Korea provided population, number of households, population density, and population growth ratio. Those could be used to construct quantifiable index for the criteria, human life.

Urban function including various functions of human society is essential for maintaining the community. There are means of transportation, evacuation facilities, medical facilities, agencies against disaster, and etc. In this study, we assume that urban area ratio can be indicated the urban function.

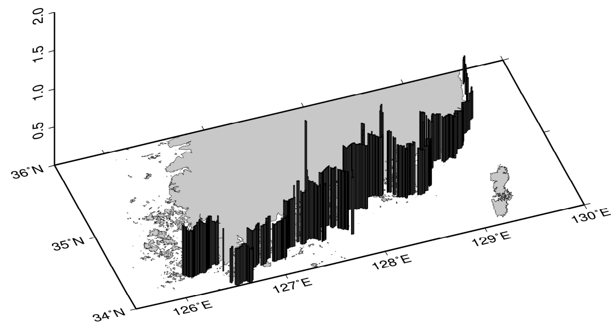

Fig. 3. The maximum tsunami heights at the coastal area of Korean Peninsula

Some facilities are very important to sustain human society. We learned from the painful experience of Fukushima disaster. If facilities as power plant, port and airport were destroyed, it caused massive damage to human society. Thus we considered them primary facilities.

3. Tsunami Risk Analysis

Fig. 1 shows the 12 senarios of initial wave height due to magnitude 9.0 Nankai trough earthquake. Fig. 2 shows the distribution of maximum tsunami wave heights due to Nankai trough earthquake.

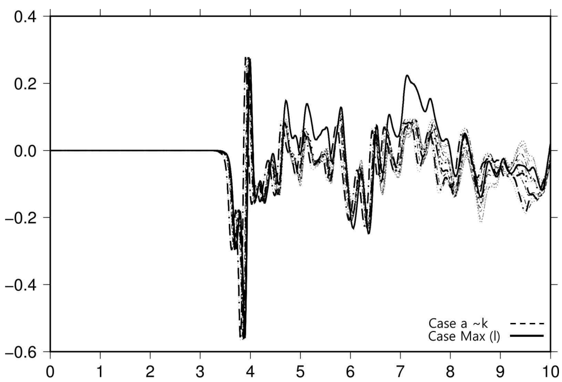

Fig. 4. The time series of water elevation for all tsunamis at the Gori Nuclear Power Plant.

Fig. 3 show the computed maximum tsunami heights predicted at the coastal points in southern Korean Peninsula. Maximum tsunami heights of approximately 1.0 m were computed for the southern coast of. Time series of water elevations for all tsunamis and for a point located in the entrance of the Gori Nuclear Power

Plant is presented in the Fig. 4. We can clearly identify the wave rundown before Tsunami arriving. The first (highest) tsunami wave is about 0.3 m. The spectral signature of tsunami induced waves depends not only on the fault parameters.

4. Vulnerability Assessment

This study tried to identifying vulnerable area using 4 factors such as human life, urban function, primary facilities and 12 scenarios of the Nankai Trough tsunami, including maximum initial water level with TOPSIS and VIKOR methods. Fig. 5 show the results of vulnerability assessment in the case of the scenario of maximum initial water level.

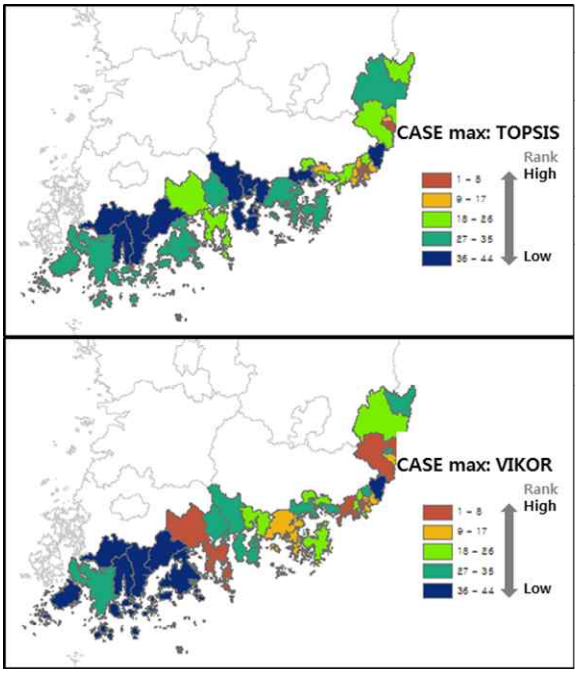

Fig. 5. The vulnerability assessment result

In most case, the big city of Busan is most vulnerable area. Mainly because the level of human life factor is high and it has Gori nuclear power plant. The results of TOPSIS method are quite similar about all scenarios but VIKOR method present different results among each scenario because it considers each factors differences. It seems as though influence of primary facilities factors such as Ulsin nuclear power plants, Wolsung nuclear power plants, and Ysosu thermal power plant.

5. Summary and Further Works

A simulation of the tsunami that would be caused by an earthquake in the Nankai Trough was conducted to determine the effect on the Korean coast. The tsunami waves are simulated to propagate southeastward, diffract clockwise south of Kyushu and head for Cheju Island and the southern coast of Korea. The detailed coastal structures are not included in this research because the computational cost. Further simulation studies are underway to take into account coastal structure. The results of these studies will be reported soon. And the vulnerability factors must be improved to reflect the situation of coastal area.

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