Development of External Flooding Hazard Assessment Methodology for Korea Nuclear Power Plants

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1. Introduction

Typhoons annually occur several times in Korea because of a physical geography of the Korean peninsula. The regions located in the typhoon track have been damaged owing to high wind, heavy rain, storm surge, external flooding and wind-borne missile. In particular, the coastal region has been damaged by typhoon, such as collapse/washing out of various structures.

A probabilistic external flooding risk assessment in NPPs has not been conducted because the sites are selected by considering the probable maximum precipitation (PMP) and past storm surge height during the design stage. It has been predicted by many researchers that a super typhoon (maximum sustained surface winds of at least 65m/s) will occur in Korea because the intensity and frequency of typhoons have been increasing as a result of global warming [1, 2]. Studies on the typhoon risk of Korea NPPs located in coastal regions have received little attention compared with other external events, despite recent strong typhoon landfalls near NPPs. Therefore a typhoon risk assessment is needed to establish a response system and predict the damage of NPPs from a typhoon.

In this study, the external flooding hazard assessment method was proposed. In addition, the external flood height of KORI NPPs was calculated by using the method under 10^{-6} annual occurrence frequency.

2. External flooding hazard assessment method

2.1 Factors causing external flooding

According to the past typhoon data, typhoon lead to high wind and heavy rain. A wind pressure of structure created by high wind. Furthermore, high wind develops a storm surge. When a storm surge height exceed the site level of NPPs and a heavy rain continuously hit the region, an external flooding can be occur.

The drain systems of NPPs are divided by a drainage and surface drainage. A drainage system of NPPs are designed based on the probabilistic maximum precipitation (PMP) of 50 years return period.

The effects of external flooding for NPPs contains below contents.

- Loss of offsite power
- Malfunction of electrical devices due to a water leak
- Water pressure of external facilities (structures, tanks etc.)

2.2 External flooding hazard assessment procedure

Because external flooding occurs by storm surge and precipitation, Figure 1 shows the flow chart of external flooding hazard assessment of NPPs.

It is needed to develop the wind field model for simulating a storm surge. The property of long period wave with nonlinearity, bottom friction effect of coastal waters are considered to simulate the storm surge. In this study, the storm surge height was calculated by using the MIKE 21 and ADCIRC code. From the storm surge simulation, the time history of surge height can be calculated.

The hydrologic model was developed by using a precipitation data and analysis results of basin. The Huff rainfall distribution was used to analysis a rainfall-runoff. Then site topography and structure modeling create to simulate the flooding of NPPs. Flood discharge was calculated by the Clark method.

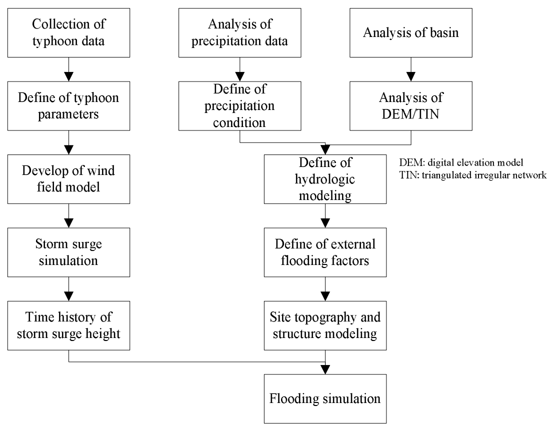

Fig. 1. Flow chart of external flooding hazard assessment

3. Flood height calculation example

From the track data of past typhoon, the southeast region was affected by typhoon. Therefore, the KORI NPPs was selected to calculate the external flood height by typhoon. It was assumed that the site slope was to zero and the site dose not drain due to a lack of site information.

3.1 Storm surge height

From the preliminary analysis, it was showed that the highest storm surge was measured when the typhoon passed the KORI site. In this study, the probable maximum sea level was calculated by the sum of the increase of sea level due to RCP 6.0 scenario (136 cm), approximate highest high water (AHHW) (40.9 cm), annual tide (12.0 cm) and storm surge tide by annual occurrence frequency.

Figure 2 showed the analysis model and storm surge tide. From the analysis results, the storm surge tide of this study did not consider wave run-up effect.

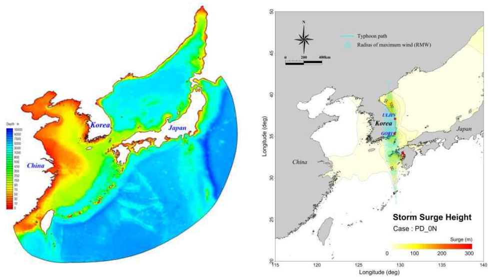

Fig. 2. Analysis model and storm surge tide

3.2 External flood height

In order to analyze the extreme rainfall of the domestic nuclear power site, stationary point frequency analysis, non-stationary point frequency analysis, regional frequency analysis considering R2 and R4 regions, experiential frequency analysis, frequency analysis applying the Bootstrap method, FORGEX technique POT method were applied. DEM and TIN were generated from 1/5,000 scale digital contour maps using ArcGIS and HEC-HMS[3] for hydrologic modeling in the study site and The Huff rainfall distribution and Clark method were applied to estimate the extreme flood. The combination condition of rainfall and typhoon surge at the study site is composed to consider the extreme flood condition and external causes of flooding, and then these conditions are applied to 2D hydrodynamic model.

Figure 3 shows the maximum flood height of KORI NPPs. The surface water of unit 3&4 flows to the site of unit 1&2 because the site of unit 1&2 was lower than that of unit 3&4. In addition, the surface water does not drain well due to the sea wall to protect NPPs from tsunami.

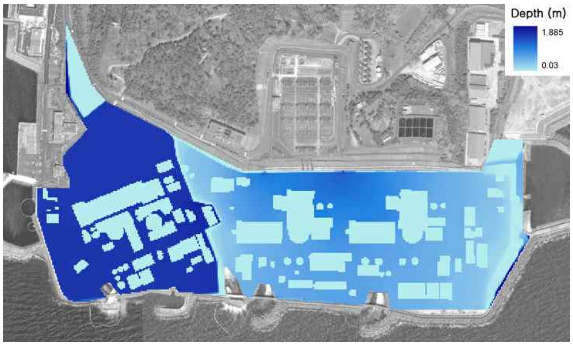

Fig. 3. Maximum flood height by precipitation

4. Conclusion

To develop the external flooding hazard assessment methodology a hydrodynamic analysis is conducted considering the storm surge and extreme rainfall condition and the flood height of KORI NPPs was calculated by using the developed method in this study.

The protection system of flooding according to the scenarios can be established from the result of this study. The internal and external flooding factors are identified so that the flood risk can be analyzed at the nuclear plant site, In addition, the results of this study can be used as the reference to set up the structural and nonstructural flooding countermeasures.

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