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Seismic Fragility Variations of Twin Units Based on the Separation Distance

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1. Introduction

The magnitude 9.1 Great East Japan Earthquake that occurred in 2011 caused a nuclear accident at the Fukushima nuclear power plant. As a result of this accident, a hydrogen explosion occurred in Units 1, 3, and 4, and a core meltdown occurred in Unit 2. This incident emphasized the need for multi-unit seismic safety studies. Seismic events affect a wide area, and when a nuclear power plant is built on the same site, there is a high probability that there will be seismic failure correlations between structures, systems, and components (SSCs). Therefore, when performing a multi-unit seismic probabilistic risk assessment, the evaluation should be conducted by considering the seismic failure correlation between structures, systems, and components [1]. In this study, as one of the studies considering the seismic failure correlation between structures, systems, and components, seismic fragility curves were derived according to distance for the twin units of a nuclear power plant by considering the seismic failure correlation of SSCs.

2. Methods and Results

2.1 Methods

The target nuclear power plant was a twin unit, and a seismic probabilistic risk assessment was performed for a loss of essential power event. The fault tree for the loss of essential power event of the first unit is shown in Fig. 1. The fault tree for the loss of essential power event of the second unit was structured in the same way as the first unit. The top event consists of the loss of essential power events of the two units under OR conditions. In other words, the failure condition was set when a loss of essential power event occurred in one or more units. The loss of essential power event consisted of nine events, and the parameters of the seismic fragility curve for each event are shown in Table 1 [2]. The seismic failure correlation coefficient of SSCs was calculated by Eem et al. It was derived through probabilistic seismic response analysis using the method proposed by Eem et al. 2021[1].

2.2 Results

Fig 2 shows the seismic fragility curves when the twin units are separated by 100m, 500m, and 1,000m, considering the seismic failure correlation coefficient of the SSCs. The seismic failure correlation between SSCs

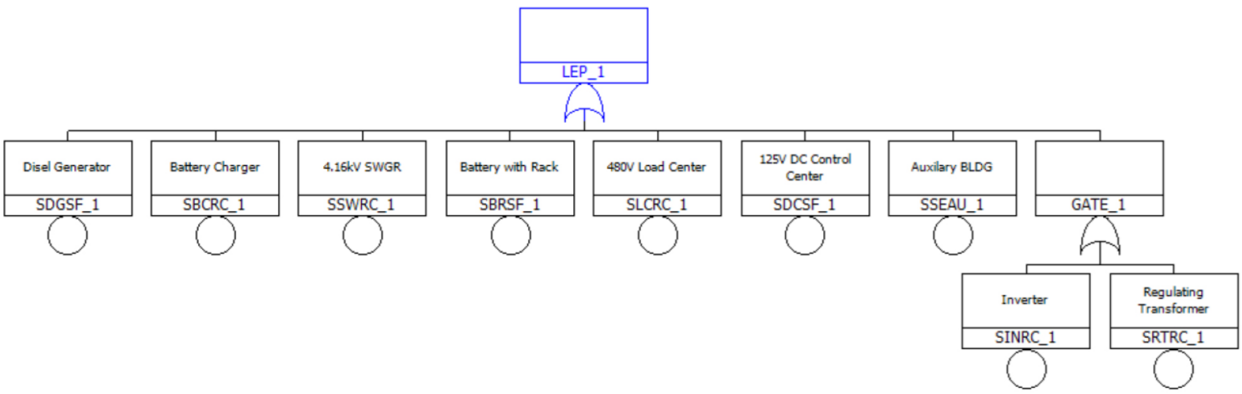

Fig. 1. Loss of essential power event for 1st unit [3]

was considered independent and entirely dependent for comparative analysis. The seismic fragility curves when the twin units are separated by 100m, 500m, and 1,000m are almost identical. The high confidence and low probability failure (HCLPF) when the twin units separated 100m, 500m, and 1,000m are 0.29g, 0.30g, and 0.29g, similar to the seismic fragility cases.

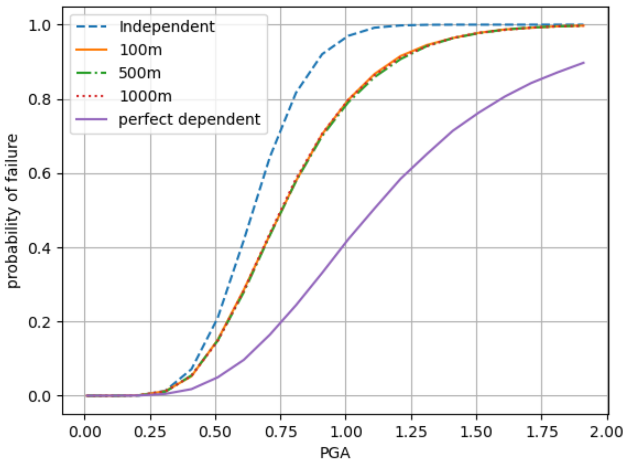

Fig. 2. Seismic fragility curve of loss of essential power event with 100m, 500m, 1000m distance

3. Conclusions

This study confirmed variations in the seismic fragility curve according to the distance between the twin units. Twin units were assumed to be 100m, 500m, and 1,000m apart, and the seismic fragility curve was derived by combining OR conditions for each unit for loss of essential power events. The seismic failure correlation between the SSCs of the twin units was derived through probabilistic seismic response analysis. As a result, it was confirmed that the seismic fragility curves when the twin units are apart 100m, 500m, and 1,000m were similar. Therefore, it is believed that when the distance between twin units is less than 1,000 m, there is little change in the seismic fragility curve and seismic risk.

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