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Seismic Hazard Analysis on Indonesia's Multipurpose Nuclear Research Facility

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1. Introduction

Indonesia houses three specialized research reactors. One of these is the RSG-GAS multipurpose reactor, formerly known as the MPR-30, is a high flux research reactor situated with many irradiation facilities, neutron doping facilities, and several in-pile facilities for research activity on fuels and reactor components as well as radioisotope production.

The reactor is located near Jakarta on the island of Java as shown in Figure 1. This location is surrounded by several faults that have historically produced significant, large magnitude earthquakes, the most famous of which was the December 26, 2004 M9.2 earthquake that caused a massive tsunami resulting in significant damage and over 150,000 fatalities worldwide [1-2]. Although there are many faults surrounding Java, two of the major faults, Sumatra and Sunda, are shown in Figure 1. This is very concerning as the potential for strong ground shaking from earthquakes is high given the historical seismicity of the area. Considering that Indonesia wishes to integrate nuclear power into its energy mix, activities required for the consideration of earthquake loading on such nuclear facilities will be required. This study hopes to estimate a loading parameter, such as response spectra, that can be expected at the RSG-GAS site. This will help in extending the Indonesian experience in activities required for the successful implementation of a civilian nuclear power program.

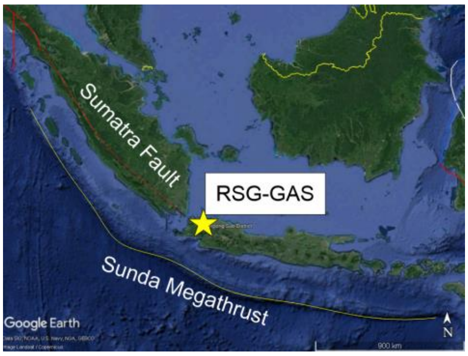

Fig. 1. Location of the RSG-GAS reactor site. Note the surrounding of large faults.

2. Methods and Results

One of the most popular techniques in analyzing the seismic hazard of a location is seismic hazard analysis. The modern version of the technique estimates the annual rate of exceedance for some pre-specified intensity measure given a set of parameters [3-5]. The general equation is given as:

$$\lambda(IM > x) = \sum_{i=1}^{n_{sources}} \lambda(M_i > m_{min}) \times \sum_{j=1}^{n_M} \sum_{k=1}^{n_R} P(IM > x | m_j, r_k) P(M_i = m_j) P(R_i = r_k) \quad (1)$$

where λ = annual rate of exceedance, IM = intensity measure, $n_{sources}$ = number of seismic sources, P[A] = probability of the random variable A indicated in the brackets, M, m = earthquake magnitude, R, r = site to source distance, n_M = number of different magnitudes for the ground motion prediction equation, n_R = number of different site to source distance measures for the ground motion prediction equation, and i, j, and k = indices. The use of this equation is more commonly referred to as probabilistic seismic hazard analysis.

Probabilistic seismic hazard analysis essentially requires a hazard assessment where multiple models used within Eq. (1) can vary. These variations are accounted for in a logic tree as shown in Figure 2. The result theoretically helps reduce uncertainty when properly used.

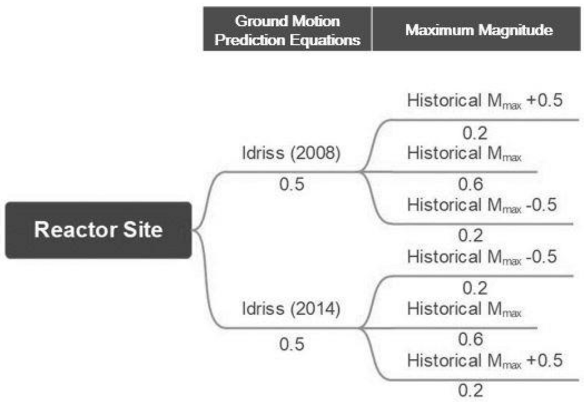

Fig. 2. Logic tree used for seismic hazard analysis.

In this study, only two models will be varied. One is the ground motion prediction equation, which accounts for the $P(IM > x | m_j, r_k)$ term in Eq. (1). The ground motion prediction equations utilized herein are the versions from Idriss [6-7] which are geared more towards rock sites. The results for each ground motion prediction equation is taken from OpenSHA software, which has many built-in components [8]. The other component that was varied was the maximum magnitude for each seismic source. The maximum magnitude was taken from historical data. The variation was allowed to fluctuate between ±0.5 of the historical maximum magnitude.

An example of the results from OpenSHA is shown in Figure 3. The figure shows hazard curves for three spectral accelerations at T = 0, 0.2, and 1 s. As expected, the hazard for spectral acceleration at T = 0.2 s shows the highest hazard levels.

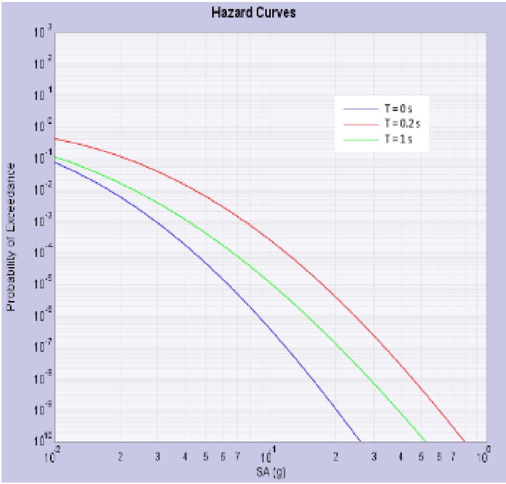

Fig. 3. Hazard curves for RSG-GAS using OpenSHA software.

These hazard curves are used to construct a uniform hazard response spectra. By selecting a hazard value, one can peruse each hazard curve and select the corresponding spectral acceleration associated with the period. The response spectra can be described with period on the x-axis and spectral acceleration on the y-axis. Figure 4 provides the response spectra for the RSG-GAS site.

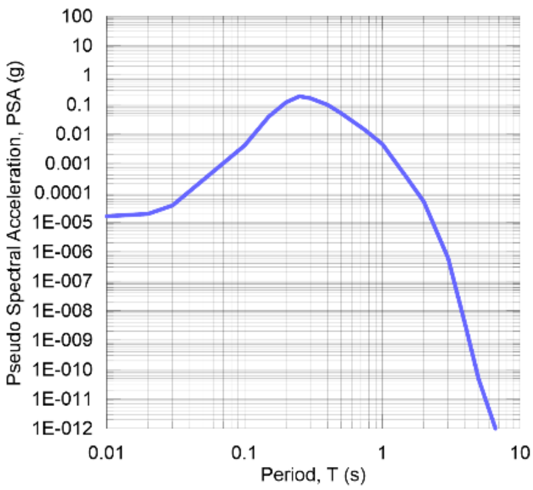

Fig. 4. Hazard spectra RSG-GAS site.

3. Conclusions

A elementary probabilistic seismic hazard analysis was conducted on the RSG-GAS nuclear facility site in Indonesia. Modern ground motion prediction equations and a variation of the maximum magnitude were used to help estimate the hazard curves. These hazard curves were used to derive a uniform hazard response spectra, which shows relatively low spectra accelerations at short periods and relatively high spectral accelerations when T = 0.2 to 0.3 s.

Acknowledgement

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