Transactions of the Korean Nuclear Society Autumn Meeting
Changwon, Korea, October 24-25, 2024

Magnitude Homogenization for a South Korean Earthquake Catalog

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Keywords : South Korea, seismicity parameter, earthquakes

1. Introduction

An interest in earthquake engineering increased after the 2017 Pohang and 2016 Gyeongju earthquakes in the southern areas of South Korea, near multiple nuclear power plant complexes, such as Saeul and Wolsong as shown in Figure 1.

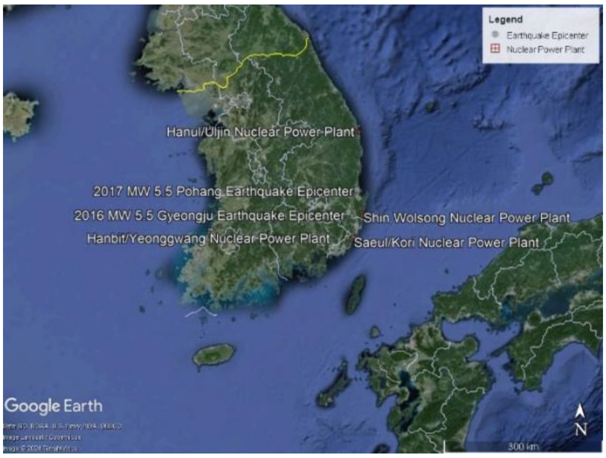

Fig. 1. Map of South Korean nuclear power plant complexes and the epicenters for the 2016 Gyeongju and 2017 Pohang earthquakes. Note the proximity of the earthquakes to Saeul and Wolsong nuclear power plants.

One of the basic procedures in earthquake engineering is seismic hazard analysis. Seismic hazard analysis involves expressing the potential for strong ground shaking at a site of interest and uses many independent parts to calculate an exceedance rate from a probabilistic approach or an intensity measure from a deterministic approach. One of these parts is the recurrence relationship. The most famous earthquake recurrence rule was publicized by Gutenberg-Richter [1]. It describes the relationship between the magnitude and number of earthquakes:

$$\text{Log } N = a - b\, M$$

where N represents the cumulative frequency of earthquakes greater than or equal to the magnitude M, and a-value and b-value represent regressed constants. The a-value is related to the seismic activity. The b-value (the slope of the recurrence relationship) is a measure of the relative number of small to large earthquakes.

However, earthquakes are measured with different magnitudes. These different magnitudes could depend on the seismic network that recorded it or the data available. This work presents several relationships that will relate a variety of magnitudes such as M_S and m_b to the more common moment magnitude form, M_W [2]. The scope of this study is limited to teleseismic magnitudes such as M_s and m_b because it has been noted that local magnitude measurements by South Korean agencies were inconsistent throughout the years [3-4]. Correcting for structural discrepancies is out of the work scope for this study.

2. Methods and Results

An earthquake catalog was compiled by collection data on from the International Seismological Center, ISC [5-7]. The ISC collects data from seismic networks and agencies all over the world and makes them freely available. We collect these data and organize events by their earthquake magnitudes. Events can have multiple magnitudes associated with them. A regression is then made for earthquakes that have a Mw recorded to any other earthquake magnitude.

An example of the regressions between M_W and M_S recorded by ISC, $M_{S,ISC}$, and m_b recorded by the ISC, $m_{b,ISC}$, is shown in Figures 2 and 3, respectively. For $M_{S,ISC}$, the data appear to have a linear relationship and the parameters for a linear equation is shown, with a slope of about 0.729 and an intercept of about 1.632. For $m_{b,ISC}$, the data also appear to have a linear relationship and the parameters for a linear equation is shown, with a slope of about 0.891 and an intercept of about 0.673. Relationships like these can be used to help homogenize an earthquake catalog for further analysis, especially for a South Korean earthquake catalog

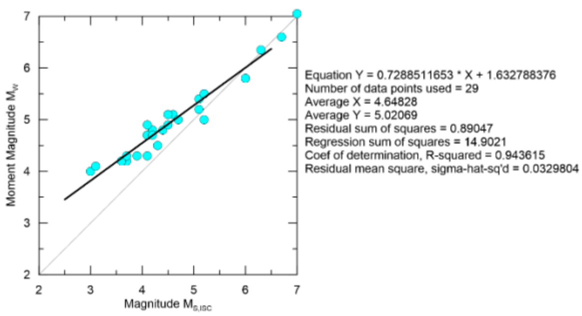

Fig. 2. Correlation between M_W and $M_{S,ISC}$.

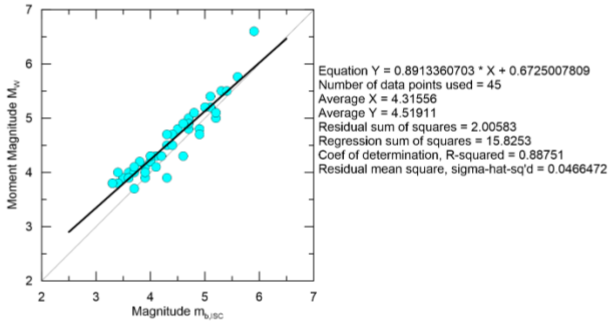

Fig. 3. Correlation between M_W and $m_{b,ISC}$.

Interestingly, as a comparison, some agencies have tremendous scatter in their data. For example, the data from the Experimental International Data Center, EIDC with regards to a local magnitude is shown in Figure 4. Although the data suggest a light linear relationship with a slope of 0.805 and an intercept of 1.514, the variation across the relationship is relatively large. Similar scatter was also shown in data measured by South Korean agencies, although the reason for that scatter is structural rather than seismological.

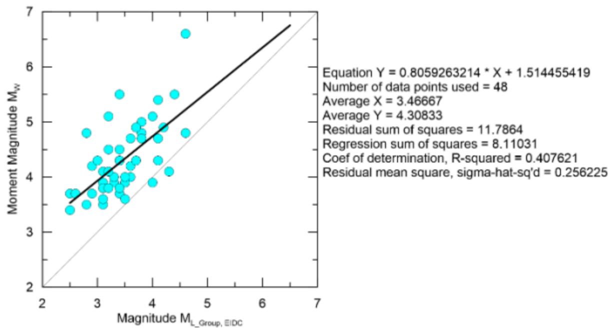

Fig. 4. Correlation between M_W and $M_{L,EIDC}$.

3. Conclusions

This study compiled earthquake event data from ISC for the South Korean region from 1900 to 2020, but many events did not have the same magnitude. To homogenize the events, multiple linear regressions were applied to the data to extract M_W from other magnitudes such as M_S and m_b. None of the relationships showed a one-to-one relationship but did show linearity. These relationships make it useful and easier to compile future catalogs.

Acknowledgement

This research was supported by the 2024 Research Fund of the KEPCO International Nuclear Graduate School (KINGS), the Republic of Korea.

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