

Comparison of Wind Hazard Curves from Observation-Based Extreme Value Analysis and Typhoon Logic-Tree Simulation for Korean Nuclear Power Plant Sites

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1. Introduction

Extreme wind is one of the external hazards that should be addressed in the design and safety assessment of nuclear power plants. The wind hazard at a site can be evaluated by various methods, ranging from statistical analysis of observed wind speeds to probabilistic simulation of storms; among these, two approaches are selected for comparison. The first is a direct extreme value analysis of long-term meteorological observations, which is the basis of the fixed formula adopted in the stress test reports for the operating plants. The second is a probabilistic typhoon wind hazard analysis, in which a large number of synthetic typhoons are generated by Monte Carlo simulation and the resulting site wind speeds are assembled into a hazard curve through a logic tree. The latter approach has been developed for Korean sites in a series of studies [1, 2], but it has remained a research method and has not been used in regulatory assessments.

The two approaches differ in what they represent. The observation-based curve reflects all causes of strong wind at the observing station, but its extrapolation to an annual exceedance probabilities far below the inverse of the record length is uncertain. The typhoon simulation is physically based and can be extended to very low frequencies, but by construction it accounts for typhoon wind only.

In this study, the two approaches are applied to the four operating nuclear power plant sites in Korea and compared on identical hazard-curve axes, together with the fixed-formula values published in the stress test and with an independent typhoon simulation study reported for the Mokpo area near the Hanbit site [3].

2. Methods

2.1. Observation-based extreme value analysis

Annual maxima of the daily maximum 10-minute mean wind speed were extracted from the ASOS records of the Korea Meteorological Administration for the stations adopted in the stress test, and a Gumbel distribution was fitted by the maximum likelihood method, for direct comparability with the fixed formula of the stress test. For each site, the station giving the highest hazard is taken as governing.

2.2. Typhoon logic-tree simulation

The typhoon wind hazard was computed by Monte Carlo simulation with a logic tree, following Choun and Kim [1] and Kim [2]. Typhoons passing within 300 km of each site were extracted from the RSMC Tokyo best-track data, and a twelve-branch logic tree was formed from two distributions of the central pressure deficit, three values of the radius of maximum winds, and two formulations of the Holland B parameter. Ten million synthetic typhoons were generated for each branch, and the annual exceedance probability was obtained from the gradient wind field converted to the 10 m level with a Poisson occurrence model. The implementation reproduces the published hazard curves of [1] at the Hanbit site.

2.3. Basis of comparison

All results are given as 10-minute mean wind speed at a height of 10 m, and the 10,000-year wind speeds published in the stress test are shown as markers. Anemometer heights were not adjusted and the observed annual maxima were not separated by meteorological cause.

3. Results and Discussion

Figs. 1 and 2 compare the results at the Hanbit and the Kori sites, respectively.

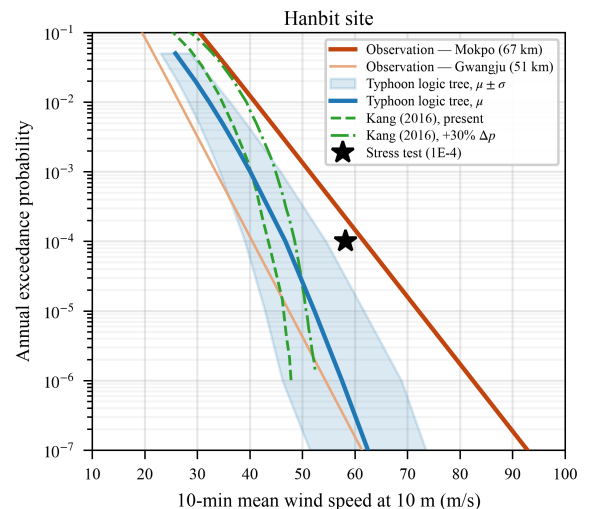


Fig. 1. Wind hazard curves at the Hanbit site.

At both sites the observation-based curve of the governing station lies above the mean curve of the typhoon simulation, and above the upper edge of its one-standard-deviation band, over the whole range considered; the separation widens as the exceedance probability decreases. At the Hanbit site the independent typhoon simulation of Kang et al. [3], reported for the Mokpo area near the site, falls in the same range as the present logic-tree result and likewise below the observation-based curve of the coastal station. The wind speeds published in the stress test lie close to the observation-based curves. The same tendency was obtained at the Hanul and the Wolsong sites.

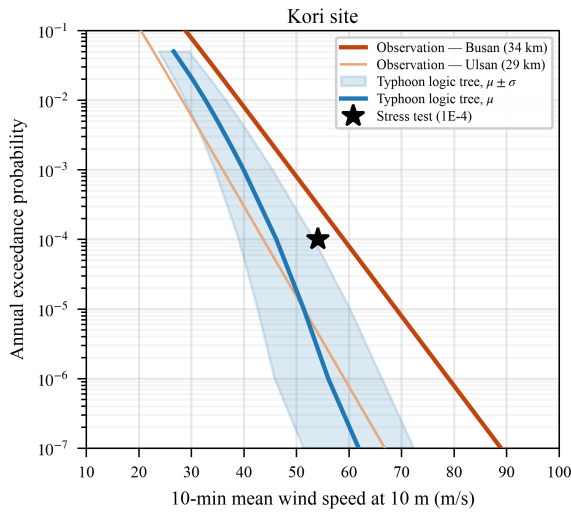


Fig. 2. Wind hazard curves at the Kori site.

Over the range examined the observation-based estimates are therefore generally larger, and in this sense the observation-based analysis, as applied here, provides an upper bound to the typhoon wind hazard curve. This is consistent with the observed annual maxima including strong winds of all causes whereas the simulation represents typhoons only.

The comparison is, however, sensitive to the station selected. At the Hanbit site the inland station falls below the typhoon-based mean over most of the range, reversing the ordering, whereas the coastal station of the same site gives the highest curve; the spread between two stations of one site exceeds the difference between the two methods.

4. Conclusions

Wind hazard curves at the operating nuclear power plant sites in Korea were computed by an observation-based extreme value analysis and by a typhoon logic-tree Monte Carlo simulation, and were compared with the values published in the stress test. Over the range examined the observation-based curves are generally higher, so that the observation-based analysis, as applied here, provides an upper bound to the typhoon wind hazard; the comparison is nevertheless sensitive to the exposure of the station adopted for a site.

Only the Gumbel distribution was used, and the observed annual maxima include both typhoon and non-typhoon events, so that the difference between the two approaches cannot yet be attributed to a single cause. Separating the observed extremes by meteorological cause and correcting for anemometer height remain as further work.

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