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Calculation of Wind Speeds for Return Period Using Weibull Parameter: A Case Study of Hanbit NPP Area

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1. Introduction

Evaluation of the meteorological characteristics at the nuclear power plant and in the surrounding area should be performed in determining the site suitability for safe operation of the nuclear power plant. Under unexpected emergency condition, knowledge of meteorological information on the site area is important to provide the basis for estimating environmental impacts resulting from radioactive materials released in gaseous effluents during the accident condition. In the meteorological information, wind speed and direction are the important meteorological factors for examination of the safety analysis in the nuclear power plant area.

Previous study, Lee and et al. performed the calculation of Weibull parameter on the Barakah NPP area [1]. In this study, meteorological characteristics on Hanbit(Yeonggwang) site area was investigated about the extreme wind speed for return period including the Weibull distribution.

2. Theoretical Methods

2.1 Weibull distribution modeling

The Weibull PDF for wind speed, which is a two-parameter function, is expressed mathematically as follows [2]:

$$f(v) = \left(\frac{k}{c}\right)\left(\frac{v^{k-1}}{c}\right) exp\left[-\left(\frac{v}{c}\right)^{k}\right] \quad (1)$$

For v $\geq$ 0, Where v = wind speed [m/s],
c = scale parameter, k = shape parameter.

The cumulative distribution function is obtained by integrating eq.(1) and take the form:

$$f(v) = 1 - exp\left[-\left(\frac{v}{c}\right)^{k}\right] \quad (2)$$

Shape parameter and scale parameter can be written as a function of the wind speed. In this paper, shape and scale parameters was calculated with a double logarithmic transformation of Eq(2), which can be written as:

$$ln\{-ln[1-f(v)]\} = k \cdot ln(v) - k \cdot lnC \quad (3)$$

Plotting *ln(v)* against *ln{-ln[1-f(v)]}* should yield a straight line. The gradient of the line is *k* and the intercept with the y-axis is *-k·lnC*.

2.2 Calculation of directional wind speed for return period

From the eq. (2), the cumulative distribution probability considering the wind direction *j* can be acquired and expressed as follows:

$$p(v,j) = exp\left\{-\left(\frac{v}{c_j}\right)\right\}^{k_j} \quad (4)$$

c_j and k_j is a Weibull parameter for wind direction *j*. Also, return period T_j for wind direction *j* can be written by followed equation.

$$T_j = A_j T \quad (5)$$

Where *T* = return period for wind speed [yr]
T_j = return period for *j* directional wind speed [yr]
A_j = occurrence frequency of wind direction *j*

Return period for *j* directional wind speed, eq.(5), and cumulative distribution probability considering the wind direction *j*, eq.(4), have the relationships as follows:

$$p(v,j) = \frac{1}{T_j} \quad (6)$$

From the eq.(5), Eq.(6) also can be written below:

$$p(v,j) = \frac{1}{A_j T} \quad (7)$$

Eq.(7)is called a joint probabilistic distribution model which is considered the wind speed and wind direction frequency simultaneously in the equation. For the calculation of daily extreme wind speed, return period *T* has to be modified with daily scale. Then, the wind direction *j* and return period for directional wind speed can be expressed following form:

$$p(v,j) = \frac{1}{A_j \cdot 365T} \tag{8}$$

Consequently, return period *T* for directional wind speed $v(T)_j$ can be written by followed equation.

$$v(T)_j = c_j \times \ln\{A_j \cdot 365T\}^{1/k_j} \tag{9}$$

3. Calculation Results and Analysis

3.1 Statistic values analysis

Statistic values and Weibull parameters, namely, shape parameter *k* and scale parameter *c*, were calculated for Hanbit site area on daily extreme directional wind speed using the annual meteorological data on 2015. In this section, statistic values were analyzed by wind direction distribution.

Table 1. Statistic Values

Direction	Frequency	SD	avg V	K	C
N	2.1107	1.8364	5.2549	3.6886	5.8111
NNE	9.7812	1.6864	5.9279	3.5331	6.6565
NE	18.5843	1.9650	6.1662	3.9712	6.7900
ENE	5.2767	1.8787	5.1639	3.3637	5.7368
E	2.1879	1.8076	4.5553	3.1892	5.0766
ESE	1.1068	2.0055	4.5837	2.8781	5.1540
SE	1.0553	2.1383	4.4366	2.5642	5.0048
SSE	4.0154	1.3038	4.1558	4.3041	4.5606
S	8.6229	1.5024	4.4379	2.6389	5.1769
SSW	5.2767	1.3703	5.0322	2.8896	5.8454
SW	9.3179	1.7633	5.3354	3.6631	5.9030
WSW	7.8764	1.3797	5.2007	3.7612	5.8081
W	8.1853	1.3817	5.4368	4.7411	5.9338
WNW	9.8069	1.3658	5.3732	4.6445	5.8725
NW	5.9202	1.3360	5.1157	3.4427	5.7894
NNW	0.8752	1.0169	4.1500	4.7708	4.5328

Table 1 summarized the statistic values by wind direction. Including the NE and NW direction, northern direction was shown as the main wind direction in this study. There was not shown prominent difference on average extreme velocity distribution at each direction. Scale parameter was ranked in the range of 4.53 to 6.79. The highest value of scale parameter was the NE direction. Also, Shape parameter was shown in the range of 2.56 to 4.77 with highest value at NNW direction.

3.2 Estimation of directional wind speed for return period

By following the procedure explained in Section 2.2, 100 year of directional return wind speed were produced by fitting the Weibull PDF using the actual weathering data based on the daily maximum wind speeds (Fig. 1). Extreme wind speed was calculated ranging 5.60 to 12.06m/s in set of return period. Highest of all extreme directional wind speed was shown in the NNE direction and their values were 10.60 to 12.06m/s between 5 and 100 year return period. Due to the effect of *c* and *k* values, many of the wind speed would be overtaken in the many wind direction.

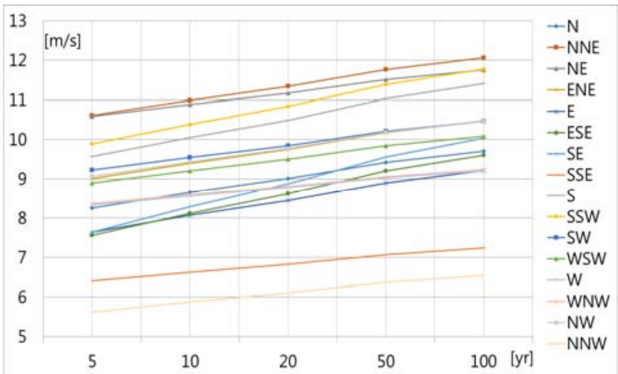

Fig. 1. Return period of wind speed on Hanbit site area

4. Conclusions

Wind characteristics was analyzed on Hanbit NPP area. It was found that the Weibull parameters k and c vary 2.56 to 4.77 and 4.53 to 6.79 for directional wind speed distribution, respectively. Maximum wind frequency was NE and minimum was NNW.

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