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Statistical Analysis of Wind Force

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ABSTRACT: In this study, at first, the maximum wind speed has been investigated in exchange for different return periods in Ramsar, Nowshahr, Qaemshahr, and Babolsar city. For this reason, data associated with the wind maximum annual speed in these cities have been collected from 1373 to 1397. To calculate the maximum wind speed, a first-order Extreme Type I distribution has been used. It has also been attempted to examine the probability of wind speed distribution of case study cities according to different functions. For this purpose, different functions such as Normal function, Weibull function, Lognormal function, Gamble Max function, Gamma function, and Bur function have been used. Also, in this study, for the design of various functions, the EasyFit software has been used. Results show that the maximum wind speed, as well as wind-based pressure for Ramsar, Nowshahr, and Qaemshahr cities, were found to be numerically larger than the Iranian National Building Code (Part 6th). However, for Babolsar, these values are less than the values of the Iranian National Building Code. Unfortunately, the results showed that the design was not safe for Ramsar, Nowshahr, and Qaemshahr cities based on this code, because the structures should be designed to be less than the maximum wind speed and lower wind pressure than the actual values. Considering the importance of analyzing and precisely designing structures against wind and speed wind, it seems that similar research should be done for other cities to obtain validate and safe values for those cities. Paying attention to this point will lead to more accurate designs in different cities of the country. In addition, results show that for used data, the Weibull function is the best function that can be applied.

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1. Introduction

Calculating and assessment of wind-induced forces for precise analysis and design of structures is of great importance. Therefore, the probability analysis of wind speed and, subsequently, wind-induced forces is one of the most fundamental components in civil engineering. In 2011, Brano et al. [1] used seven Probability Density Functions (PDF), i.e. Weibull, Rayleigh, log-normal, gamma, Inverse Gaussian, Pearson type V and Burr, for data analysis. Their results showed that the Burr distribution was the most reliable statistical distribution. In 2018, in a study, Asghar and Liu [2] proposed an adaptive neuro-fuzzy inference system based on intelligent learning for estimation of Weibull probability density functions for available wind speed data as future research, and the suggested neuro-fuzzy mechanism can be utilized to predict wind turbine power output and estimate noise level of the wind turbine in wind farms. In a study conducted in 2018, Wang et al. [3] found that the Weibull distribution is suitable for evaluating wind speed variance of wind data in Texas. In this study, wind speed and force were evaluated for Ramsar, Babolsar, Nowshahr, and Ghaemshahr counties. Firstly, maximum wind speed, as well as basic wind pressure, are calculated for the mentioned counties. Afterward, various functions such as normal function, Weibull, function, log-normal function, Gumbel-max function, and gamma function are drawn from these data to identify the best applicable function.

2. Methodology

Maximum annual wind speed data for Ramsar, Babolsar, Nowshahr and Ghaemshahr counties were collected, in 24 years from 1994 to 2018 and a height of ten meters above ground, from the Meteorological Office Stations in Mazandaran Province and the studied counties. Extreme Distribution Type I is used to determine wind speed in Ramsar, Babolsar, Nowshahr, and Ghaemshahr.

The PDF related to this distribution is as follows [4]:

$$f_x(x) = a - e^{-e^{-a(x-\beta)}} e^{-a(x-\beta)} \quad (1)$$

Where α and β are function parameters.

Mean and standard deviation can be roughly calculated as follows: (Benjamin and Cornell, 1970) [5],

$$\mu_v = \beta + \frac{0.577}{\alpha} \quad (2)$$

$$\sigma_v = \frac{1.283}{\alpha} \quad (3)$$

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Table 1. Comparison of obtained maximum wind speed (km/h) and basic wind pressure with regulation values for the studied cities.

Ramsar	119.028	90	0.868	0.496
Nowshahr	109.910	90	0.740	0.496
Ghaemshahr	120.409	90	0.888	0.496
Babolsar	85.688	100	0.450	0.613

Where μ_v and σ_v are values for mean and standard deviation, respectively. Occasionally, β is also used in place of δ in these formulas. Therefore, to calculate α and β we have: [6]

$$\alpha = \frac{1.283}{\sigma_x} \quad (4)$$

$$\beta = \mu_x - 0.456\ \sigma_x \quad (5)$$

3. Results and Discussion

Comparison of obtained maximum wind speed and basic wind pressure with the admissible value inserted in the sixth topic of national regulations [7] are presented in Table 1.

It can be seen that values for maximum wind speed and basic wind pressure for Ramsar, Nowshahr, and Ghaemshahr counties are greater than the values inserted in the sixth topic. Although these values for Babolsar county are less than its Admissible value.

This shows that designs based on the sixth topic for Ramsar, Nowshahr, and Ghaemshahr will not be secure against wind speed, since according to it, structures should be designed against a maximum wind speed and basic wind pressure with values less than their actual values. Also, it appears that these studies need to be conducted for other cities to achieve valid and safe values for other cities as well.

Also, the graph of the maximum wind speed per different return periods is shown in Fig. 1. It has been observed that with the increase of return periods, maximum wind speed for all four counties increases.

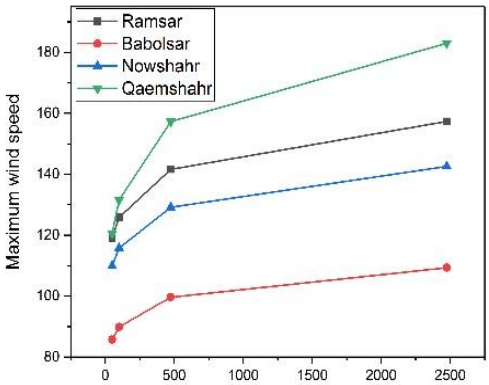

Fig. 1. Maximum wind speed per different return periods.

Furthermore, in this study, various functions were drawn using EasyFit software. Considering the different function graphs drawn, it can be concluded that for the data used in this study, the Weibull function is the best that can be utilized, since it has the most compatibility with the data.

4. Summary and Conclusions

This study has attempted to evaluate wind speed distribution probability for Ramsar, Babolsar, Nowshahr, and Ghaemshahr counties, according to various functions. To do so, maximum annual wind speed data has been collected from Meteorological Office Stations of the studied counties from 1994 to 2018 at ten meters above the ground. Initially, Extreme Distribution Type I was used to calculate maximum wind speed for four different return periods. Then, wind speed distribution probability for Ramsar County was evaluated according to the various functions.

Results showed that:

1. With the increase of return periods, maximum wind speed for all four studied counties increases. The most and least increases were those of Ghaemshahr and Babolsar counties, respectively.

2. The resulted value for maximum wind speed in this study for Ramsar, Nowshahr, and Ghaemshahr was larger than the number inserted in the sixth topic of national regulations for Iran. This value has increased by approximately 33%, 22%, and 34% for Ramsar, Nowshahr, and Ghaemshahr counties, respectively. Although, for Babolsar this value has decreased by approximately 14%, compared to the value of the sixth topic.

3. The calculated basic wind force in this study for Ramsar, Nowshahr, and Ghaemshahr counties has also exceeded the number inserted in the sixth topic of national regulations. This value has increased by approximately 75%, 49%, and 79% for Ramsar, Nowshahr, and Ghaemshahr counties, respectively. Although, for Babolsar this value has decreased by approximately 14%, compared to the value of the sixth topic. Although, for Babolsar this value has decreased by approximately 26%, compared to the value of the sixth topic.

4. The resulted increase of maximum wind speed and basic wind pressure compared to the sixth topic of national regulations indicates the fact that unfortunately the designs conducted based on the sixth topic for Ramsar, Nowshahr, and Ghaemshahr will not be secure against wind speed, since according to this topic, structures are required to be designed based on maximum wind speed and basic wind pressure values that are less than the actual values.

5. Considering the importance of precise analysis and design of structures against wind force and speed, it seems that similar research must be conducted in other cities as well, to achieve the exact and safe values. Attention to this aspect leads to safer designs in different cities across the country.

6. It has been observed that for the studied data, the Weibull function is the most appropriate since it has the most compatibility with the data.

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