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# Study on Transmission Line Structure under Ice Storm

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**Abstract.** In this paper, according to the ice storm weather, through the numerical analysis of meteorological records, the movement rule of ice storm weather and the mechanism of action on overhead transmission lines are studied, and the ice storm weather model suitable for overhead transmission lines is established. Then the ice storm weather model is connected with the failure probability of the overhead transmission lines, and the structural reliability of the overhead transmission lines under the ice storm weather is analyzed. Finally, based on the evaluation of the reliability of the lines, the restoration model of the damaged overhead transmission lines is established. So as to provide a theoretical basis for the safe operation of the power grid.

## 1. Introduction

In the overhead transmission lines, the tower is high, the conductor span is large, the structure system is flexible, sensitive to the wind action, and prone to collapse under the ice overload and the combined action of ice and wind [1-3]. By analyzing the data of climate, aerodynamics and structural mechanics in the past overhead transmission line accidents, it can be found that about 70% of the line faults are caused by overload caused by extreme wind or ice storm.

Ice storm can seriously endanger the safety of the power system, which will lead to a wide range of power accidents, and need to concentrate a lot of manpower and material resources for maintenance, resulting in extremely serious consequences for the power system. The safety of overhead transmission lines is directly related to the economic construction and people's life of a country. In modern society, the security of infrastructure is very important, especially the security of power facilities. With the development of high-tech such as high-speed railway, communication and information technology, new energy vehicles and so on, the whole society is more dependent on electric energy [4-6]. The stable supply of electric power is the basic condition of economic development and national security. It is of great practical significance to study the structural reliability of overhead transmission lines under ice storm weather. It can give early warning to the influence degree of different lines under ice storm weather in advance, provide basis for the structural safety assessment of overhead transmission lines after ice storm weather, and provide support for the repair and recovery of overhead transmission lines after ice storm weather.

In its life cycle, ice storm moves with time, and its impact on the line also changes. In this paper, based on the temporal and spatial changes of weather conditions, an ice storm weather model for overhead transmission lines is established. Then, based on the Monte Carlo simulation, the ice storm weather model and the vulnerability model of overhead transmission lines are linked to analyze the

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structural reliability of the transmission line system. Finally, based on the reliability analysis of overhead transmission lines, considering the correlation of various factors during maintenance, the recovery time model after the ice storm disaster is established.

## 2. Ice storm model of overhead transmission lines

In this section, the synoptic principle and the synoptic dynamics method are used to analyze the origin, movement path, circulation situation and multi-scale characteristics of the ice storm weather, analyze and summarize the ice storm weather process, study the action law of the ice storm weather on the overhead power transmission line in the movement process, and establish the ice storm weather model suitable for the overhead power transmission line.The two-variable function below has suitable properties to serve as a basic model for describing wind and ice load.

$$f\left(x,y\right)=A\exp\left[-\frac{1}{2}\left((x-x_{center})/\sigma_x\right)^2+\left((y-y_{center})/\sigma_y\right)^2\right] \tag{1}$$

A load function corresponding to point can be calculated from

$$L\left(x_j,y_j,t\right)=A\exp\left[-\frac{1}{2}\left((x_j-x_{center})/\sigma_x\right)^2+\left((y_j-y_{center})/\sigma_y\right)^2\right] \tag{2}$$

The wind load function for a line segment represented by a point is obtained from Eq. (2)

$$\begin{aligned}L_W\left(x_j,y_j,t\right)=A_1\exp&\left[-\frac{1}{2}\left((x_j-x_{center})/\sigma_{x_1}\right)^2+\left((y_j-y_{center})/\sigma_{y_1}\right)^2\right]\\&-A_2\exp\left[-\frac{1}{2}\left((x_j-x_{center})/\sigma_{x_2}\right)^2+\left((y_j-y_{center})/\sigma_{y_2}\right)^2\right]\end{aligned} \tag{3}$$

The ice load function is achieved by the following integration of the ice build up function for this segment

$$L_I\left(x_j,y_j,t\right)=\int_0^t A_3\exp\left[-\frac{1}{2}\left((x_j-x_{center})/\sigma_x\right)^2+\left((y_j-y_{center})/\sigma_y\right)^2\right]du \tag{4}$$

Based on the probability of occurrence of ice storm, a random method for selecting weather parameters is established. The load of overhead transmission line in ice storm mainly includes wind load and ice load, which is determined by the ice storm weather model passing through the line area. The load model of wind load and ice load related to time and location is established.The derivation according to the variational method is as follows

$$w_\alpha(t)=\sin\alpha t \tag{5}$$

The particular line segment is shown in Fig. 1.This figure with distance on the x-axis can represent the wind part of the weather. Fig.2 exhibits the ice build up function for a particular segment.

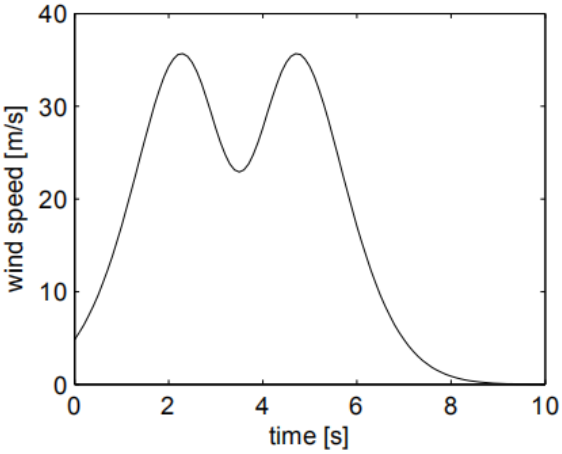


Figure 1. A wind load function for a particular segment.

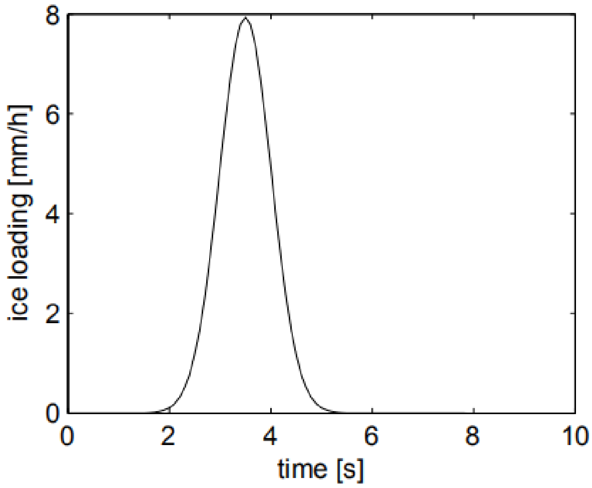


Figure 2. Ice build up function for a particular segment.

## 3. The improved weather model

Because the failure probability of the line is determined by the wind load and ice load function determined by the ice storm weather in this area and the vulnerability model of the line components, it is necessary to establish the relationship between the wind load, ice load function and the failure probability of the line under different ice storm weather conditions. The wind function in polar coordinates

$$W\left(r,\theta,t\right)=A\exp\left[-\frac{1}{k}\left(b(r-300)^2+c\min(\theta-4\pi/3+2\pi,2\pi-(\theta-4\pi/3+2\pi))^2\right]\quad(6)$$

The whole line is divided into appropriate line sections. Each line section includes several towers and several sections of wires. When the ice storm passes through the area where the overhead transmission line is located, the impact on different line sections of the overhead transmission line over time must be analyzed.According to Eq. (6), the load function for wind is achieved as

$$L_w\left(x,y,t\right)=w_\beta(t)V\left(x,y,t\right),\quad w_\beta(t)\in[0,1]\quad(7)$$

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In this paper, we use the simulation method of non Gaussian cross-correlation random number to simulate the correlation of maintenance personnel status, maintenance spare parts location, road condition, damage point location of each line during the recovery process of overhead transmission line after ice storm.The ice accretion on the phase line according to the Simple model is shown in Fig.3.

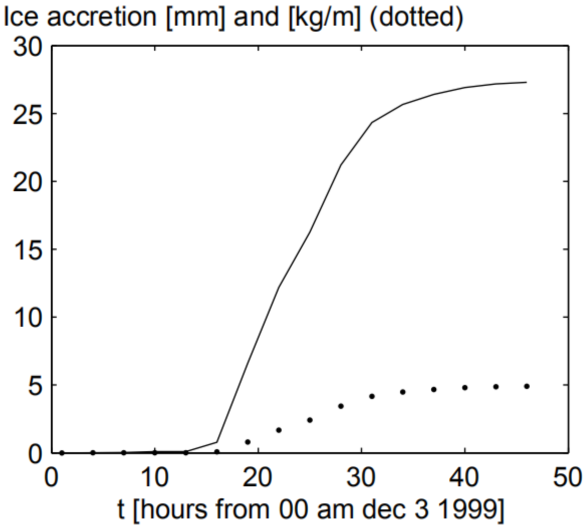


Figure 3. Ice accretion on the phase line

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