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Influence of Wind Power Generation on the Steel Structure Design of Green Buildings

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Abstract. Wind power generation in renewable energy is the current research focus, but the relationship between wind power generation and green buildings is the basis for ensuring the stable operation of wind power generation, so it has become the current research focus. I propose a composite method based on the heat energy limit theory to study the relationship between wind power generation and the steel structure of green buildings, find the weak points of the steel structure in time, and ensure the continuous operation of wind power generation. The simulation results show that there is a negative correlation between wind power generation and green steel structure, and there is a close relationship between the design characteristics of the steel structure, the material and the installation method of wind power generation. The composite method proposed in this paper can monitor the operation effect of power generation at noon in time, and the accuracy of heat energy monitoring of steel structure can reach 80~90%, and the whole monitoring time is less than 15 seconds, which shows that the composite method proposed by us can provide support for the design and analysis of wind power generation and green steel structure buildings, and has theoretical feasibility. Therefore, strengthening the relationship between wind power generation and green steel structure design is the technical condition for the operation and implementation of steel structure, and it is also the guarantee of wind power generation.

Key words. Wind Power Generation, Green Building, Green Building Steel Structure, Design.

1. Introduction

In recent years, with the gradual improvement of offshore and onshore wind power technology in the field of new energy, the capacity of wind turbines has been expanding, their size and weight have also increased significantly, and the standards supporting green building steel structures have also been continuously improved. However, wind power generation is affected by factors such as climate, geology and natural environment, and its own stability has great hidden dangers [1],[2]. How to effectively implement wind power generation and ensure the stable operation of wind power generation is an urgent problem to be solved. In the operating strength of wind turbines [3],[4], the steel structure has been trapped in complex factors and adverse marine conditions, and the frequency of the upper wind turbine and the resulting alternating heat energy cycles are as high as 109 times, so it poses a challenge to the steel structure of green buildings, especially those pipe joints that are susceptible to heat energy consumption. is a key factor affecting its security [5],[6]. Therefore, it is a very necessary premise to study the heat energy life of the joint position of the steel structure of the green building. Therefore, in order to ensure the safety of the wind turbine structure, it is necessary to carry out heat energy analysis on the common pipeline nodes when designing the green building steel structure of wind turbines, and the later analysis should be strengthened [7]. At present, under the combined influence of the roof load and fluctuating load of wind turbines, the heat energy consumption calculation of the conventional pipeline joint first considers the influence of individual loads, and then adopts the simple addition method, the equal width load method and the direct formula method for comprehensive calculation. The steel structure of marine green buildings is heat energy consumptiond due to the interaction of environmental loads such as wind, waves, and currents, but the detection period is long and cannot be monitored in real time. Some scholars believe that an effective treatment method should be provided to achieve continuous monitoring of steel structures. Therefore, this study defines the heat energy limit to the wind power load ratio factor as the safety factor, so as to quantify the heat energy resistance of each component of the green building steel structure [8],[9]. At the same time, this study also verifies the forging effect of load sequence on green building steel structure. It is concluded that when predicting the heat energy life of green building steel structures, the S-N curve and the Palmgren-Miner linear cumulative damage rule are used in this study, and the energy levels of these prediction methods are determined independently, without considering the load arrangement factors. The energy life of green building steel structures is affected by three wind power load modes: progressive enhancement, reverse and sine wave, and the necessary data is obtained to provide the basis for later model analysis. The study will explore how wind power affects the design of green building steel structures and provide an in-depth analysis of energy consumption and heat energy life. In view of the comprehensive effect of single-stage wind power load and multi-stage wind power load, three types of wind power generation load are considered: gradient type, reciprocating type and sine wave type [10]. In this paper, the heat energy consumption of green building steel structures under heat energy load is calculated by using the three-pile jacket wind power generation foundation, the S-N curve heat energy life estimation method and the Palmgren-Miner linear cumulative damage rule, and the overall life of the green building steel structure is evaluated. Fatigue analysis is performed in three modes under the combined action of single-stage or multi-stage wind power loads.

2. Analysis of Related Issues

The cyclic load of most marine green building steel structures is uncertain, which requires the principle of heat energy accumulation and damage. In engineering practice, the Palmgren-Miner theory is widely used and is a classic example of linear energy cumulative damage theory. According to the theory of linear t energy cumulative damage, green building steel structures will produce linear cumulative damage under cyclic loads, and when the accumulation reaches a certain level, these steel structures will suffer heat energy consumption.

A. Description of the Operating Load of Wind Power Generation

For green building steel structures used for wind power generation, their stability and heat energy resistance can have a significant impact on their overall stability and durability. It is extremely important to study the static and dynamic analysis of the steel structure of wind power generation and green buildings, as well as the evaluation of heat energy life. In this paper, the simple addition method, the average load method and the direct formula method are used to compare and analyze the heat energy consumption of wind turbines, in order to provide a scientific basis for the design of wind turbines. The cumulative damage of the green building steel structure under the same or different loads can be specifically described as:

$$D=\sum_{i=1}^{m}D_i=\sum_{i=1}^{m}\frac{n_i}{N_i} \tag{1}$$

where n is the number of cycles. N denotes the heat energy life of wind power under conventional loads. Wind power generation and load are D sum, and the rigidity strength under wind load is judged by the following criteria

$$D=\sum_{i=1}^{m}D_i=\sum_{i=1}^{m}\frac{n_i}{N_i}=1 \tag{2}$$

The intelligent algorithm monitors the heat energy consumption of the pipe junction of the renewable energy platform, which mainly shows low heat energy consumption per week. Under the load of wind power generation, the same part of the green building steel structure will undergo opposite plastic flow. After the above cycles, the total plastic strain between the power generation and the steel structure is almost zero. In the case of enhanced wind, the continuous accumulation of plastic damage, after a limited number of cycles, heat energy cracks begin to occur and gradually expand, and eventually penetrate the entire cross-section, resulting in fracture and damage to the wind turbine. In the process of wind power generation, the main heat energy life factor is the plastic zone formed under the action of alternating heat energy, and the magnitude of the plastic strain in the area is related to the load of the wind turbine. Therefore, it is necessary to understand the heat energy distribution of the wind turbine node before proceeding with a detailed heat energy life analysis. The weakness of the previous judgment based on the Miner theory was the use of load sequences for evaluation, and the independence of calculating the damage heat energy level, resulting in the load limitation of wind turbines. The heat energy life of green building steel structures is greatly affected by the load order. To put it simply, the wind power load set applied to the steel structure of the green building from high to low and from low to high is the same, and the heat energy consumption varies greatly. Therefore, this study divides the order of wind power generation loads from top to bottom and studies them in depth.

B. Example Analysis

Failure of green building steel structures is usually caused by heat energy, which is associated with repeated loads. The heat energy life of the steel structure of green buildings can be measured by the number of cycles or the duration of the load. Intercurrent load, also known as cyclic load, can be divided into constant amplitude load and variable amplitude load, which is a relatively basic type of heat energy load. Figure 1 shows the change process of alternating heat energy and time. Here, σ max with σ min refers to both the highest and lowest pressures.among:σm a x and σminMaximum and minimum heat energy, respectively; σa= （σm a x-σmin) / 2 is the heat energy amplitude, which reflects the magnitude of alternating heat energy; σa= （σm a x+σmin) / 2 is the average heat energy; △σ=σm a x-σmin=2σ。Is the heat energy range.

For the action forms of energy load, they are divided into the following three (see Figure 2): (1) gradient type, load F loading to energy load F (expressed as "MODE _ 1" below); (2) reciprocation type, the load is applied in relative direction (below as "MODE _ 2"); (3) sine wave type, load acting in a sine wave mode (below as "MODE _ 3"). For energy load type, this paper distinguishes between single stage heat energy load and multistage heat energy load.

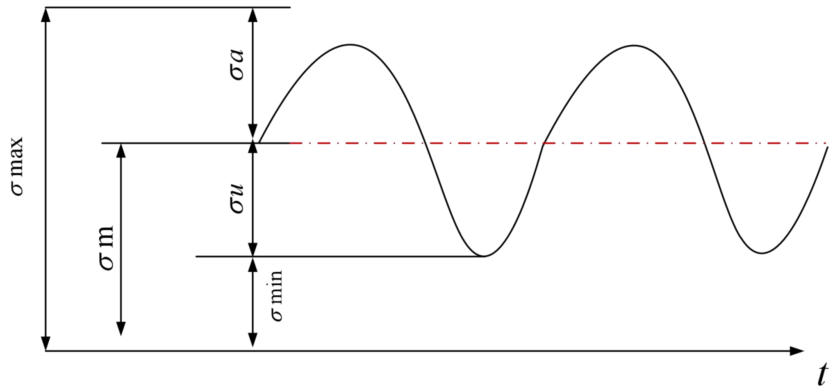


Figure 1. Time Course of Alternating Stress

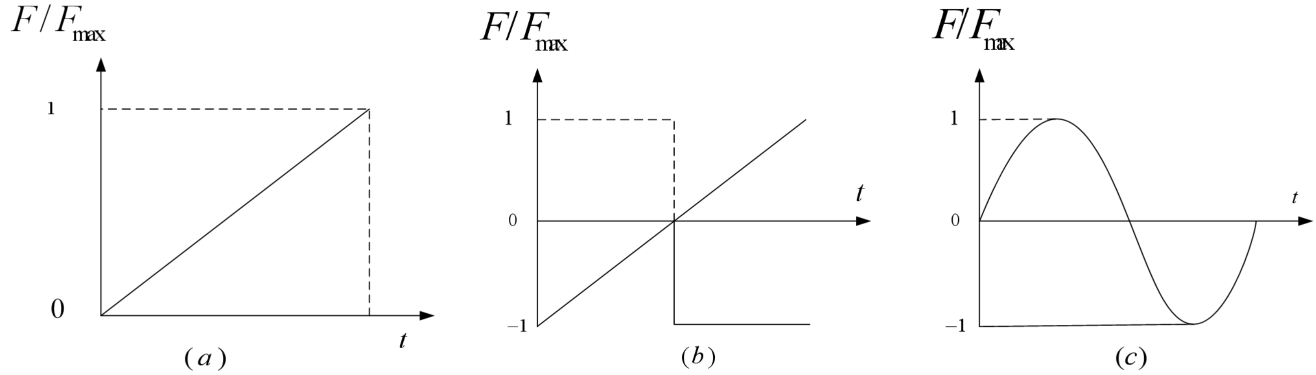


Figure 2. Loading Mode(A) Gradient (b) Reciprocal (c) Sine Wave Type

Fundamentally, the S-N curve method can only predict the initial life of a crack. However, due to the man-made "injury", the meaning of heat energy injury has become blurred, and the original extension step has been reduced to a state. Therefore, the S-N curve method is also used to estimate the entire service life of the green building steel structure.

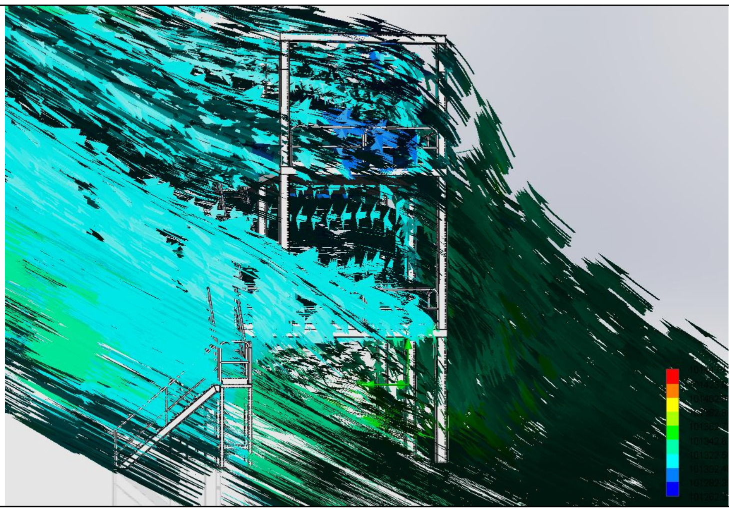
If the wind power model of the green building is set to the three-pile structure shown in Figure 3, the diameter of the tower is between 2.7~4.5m, and the diameter of the diagonal support is between 2.0~2.7m. For heat energy analysis, S-N curves with parameters ranging from 1.4 to 1.6 m were used in this study. When calculating heat energy, it needs to be carried out according to the heat energy level of the green building steel structure at each heat energy load level. The typical approach is to simulate with simplified modeling of tube elements and rod systems. At this time, the green building steel structure in Figure 3 contains 5 "nodes", which are 3 intersection points of oblique support and tower (1), 3 contact points of oblique support and pile casing, and 1 contact point of horizontal support and tower tube. In this paper, the shell cell model is chosen for the heat energy calculation, because the tube cell calculation heat energy is usually small. This approach makes heat energy calculations more rational, and each "node" is refined, allowing the study to look at the location of the damage more intuitively and in more detail. At the same time, the study can also reinforce the steel structure of the green building according to the location or location of the damage.

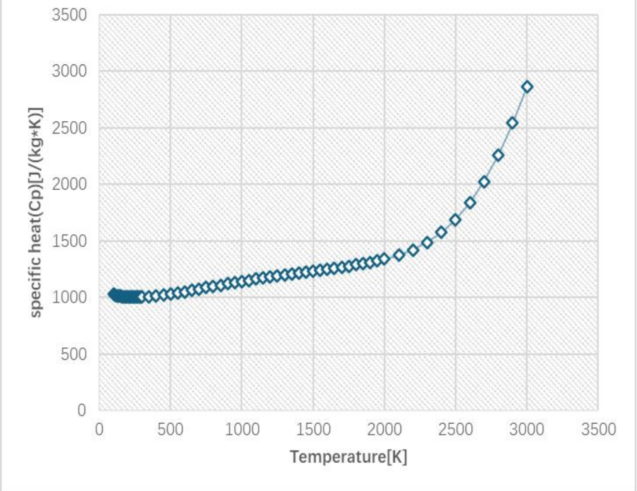
Typically, wind turbine manufacturers choose the flange position at the top of the foundation (the connection to the steel structure of the green building on the upper floor) as the criterion for bearing the load, and similarly, the same is true for heat energy loads, i.e. the load is placed on the flange position at the top of the foundation. The core research content of this paper includes:

Figure 3. Green Building Steel Structure

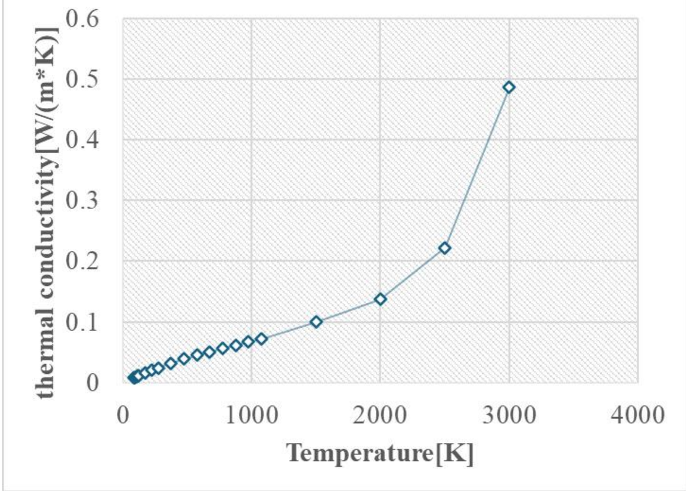
(1)The linear cumulative energy consumption of green building steel structures is generated by the aggregation of individual energy consumption. Wind application modes in different directions affect the calculation of energy consumption of steel structures, MODE_1 ~ 3. The safety factor map is used to measure the durability of each area of the green building steel structure.

(2) The single-stage wind power load research topic corresponds to the comprehensive effect of multi-stage wind power generation load, and the load type is changed to the comprehensive effect of multi-stage wind power generation load. Here, the safety factor is defined as the proportion of energy consumption of the relevant parts of the green building steel structure under the action of x, y and z, which is expressed in the form of a cloud diagram in the range of 0.5~2.0. For example, when the energy regulation factor is 1.2, this means that theenergy limit is 1.2 times theenergy level caused by the current wind load.





(a)



(b)

Figure 4. Heat energy consumption balance

(3) Transient energy consumption research. Taking into account the effects of the wind forces (x- and y-axes) shown in Figure 4, the overall instantaneous energy consumption of the green building steel structure will be studied.

3. Analysis of the Calculation Results

A. Single-Stage Fatigue Load Action

Assuming that the steel structure of the green building bears the load of single-stage wind power generation: horizontal force F=275 kN; Bending moment M = 24810 k N·m; Torque T = 3900 k N·m, cycle 110^7. The node node with the largest energy in the numerical simulation of green building steel structure 44 was analyzed. After calculation, the energy consumption of the green building steel structure caused by energy load is 3.57110^{-2}, and the life of the green building steel structure can reach about 28a.

Under the three load modes of MODE_1-3, the minimum safety factors (Fs, min) of green building steel structures reach 2, 1.741 and 1.459, respectively. Therefore, according to the severity of these three load modes, this study can be derived: sine wave >reciprocating > progressive.

(1) The safety factor of the MODE_1 load is calculated to be greater than 2 in all cases. However, the safety factor contour is not visible in the observation range of 0.5 to 2.0. To identify weak points, this study looked at heat energy levels caused by wind power loads. The magnification here is 5 (scale = 5)

(2) In the load mode of MODE_2, the energy consumption factor of the green building steel structure, where is not enlarged, and is selected as Scale=5, which is convenient for grade comparison with MODE _1.

(3) In the load mode of MODE_3, the energy consumption factor of the green building steel structure is shown in Figure 5.

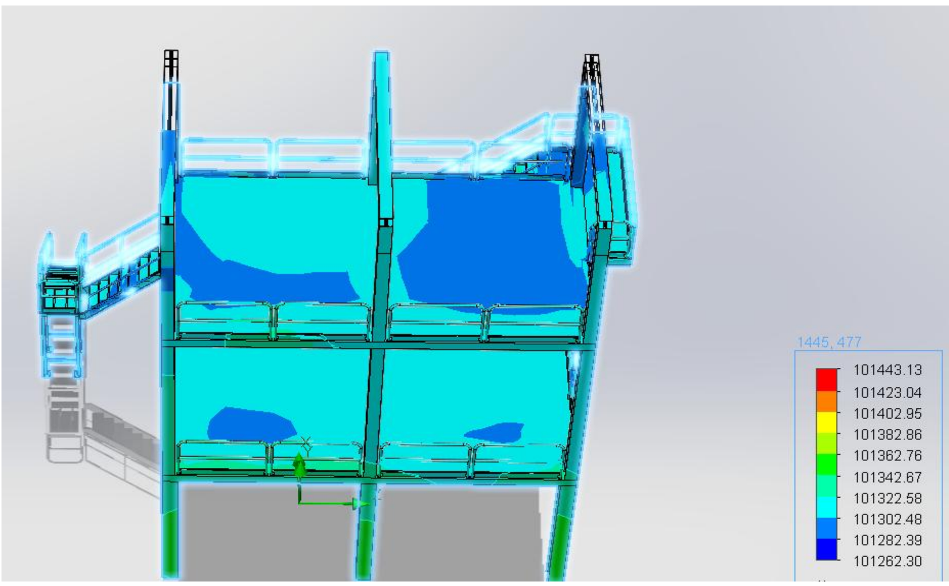


Figure. 5 Equivalent distribution of energy consumption

From Figure 5, the connecting components of the inclined bearing, tower slip and pile casing are susceptible to heat energy consumption. In addition, through the energy consumption factor contour, this study can clearly understand and evaluate the heat energy resistance of each part of the green building steel structure. In addition, it can be observed from the energy consumption factor region in the contour map that the influence of the three load modes on the damage is sine wave >reciprocating > gradient.

B. Multi-Stage Fatigue Load Effect

The energy life According to Miner's theory, the cumulative line damage of green building steel structure can be calculated to be 0.032. Considering a certain energy consumption factor, such as 3, this study concludes that the cumulative damage of green building steel structure under the specific wind power load is 0.096, and the value is less than 1, which is in line with expectations.

Table 1. Energy Consumption

Location	Energy consumption from other electricity consumption	Energy consumption from domestic electricity	Percentage of energy consumption
Corridors, doorways	0.153	6.532	25.22%
window	0.359	2.782	10.74%
walls	0.281	3.561	13.75%
floor	0.390	2.567	9.91%
interior walls	0.127	7.844	30.28%
facades	0.382	2.617	10.10%

Miner's view is that each wind power load level is completely independent, and its calculation method is to separate the energy consumption of the green building steel structure, and then accumulate all the damage data to form the overall cumulative damage of the green building steel structure. This approach does not reflect the importance of load scheduling. However, in the actual construction process, the influence of load arrangement on the energy consumption of green building steel structure is the focus of this study. After discussing the influence of the load sequence on the results, the energy levels of the finite element software were measured based on the methods of "Low and High" (WAY 1) and "High and Low" (WAY 2). Then, in this study, these energy levels were analyzed in detail according to the three display methods. The quantitative energy consumption factor of the green building steel structure is shown in Figure 6.

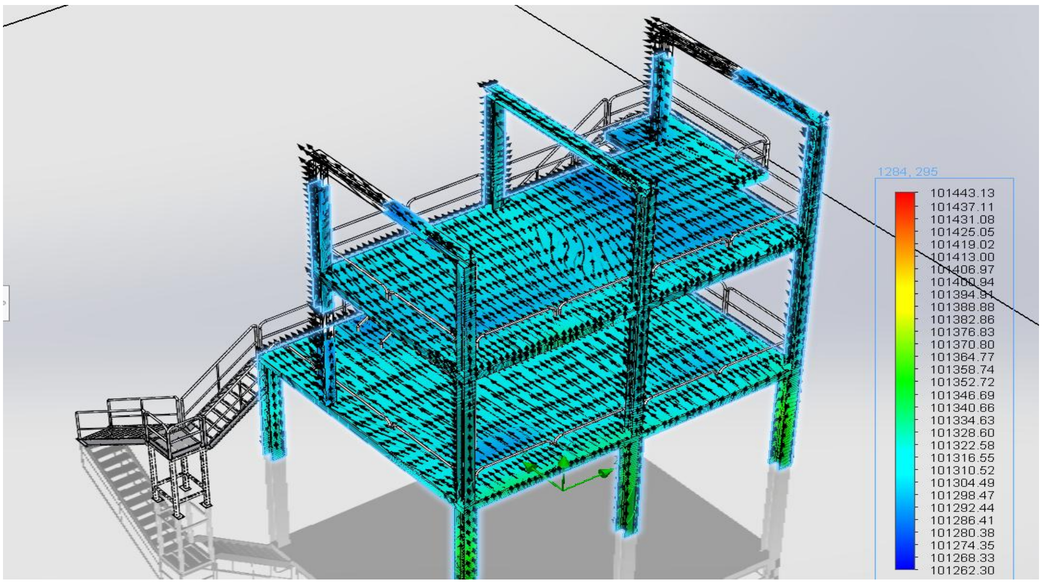


Figure 6. Energy Consumption Rheology of Steel Structure Buildings with Different Coefficients

Obviously, the energy consumption ability of green building steel structures is still manifested in three modes> sine wave, reciprocating motion > gradient. Under the same multi-level energy load and the same load method, the load sequence from high to low is not conducive to the energy resistance of the green building steel structure, that is, the load sequence from low to high will cause a "forging effect" to the green building steel structure.

C. Transient Dynamics Analysis

Figure 4(a) shows that under the influence of shock load, the elevation gradually increases from node 1 to tower 4, and four points on the tower are extracted, where node 4 is located at the top of the tower and the displacement response of the x-axis is shown in Figure 7.

Obviously, when the shock load begins, the peak of the nodal displacement response approaches the t=2s moment, while the peak of the displacement response at the height of the tower gradually lags behind the t=2s moment. In the direction of the tower, with the increase of height, the peak value of the displacement response of the x-axis gradually increases, and the swing range of the reaction curve becomes clearer and clearer. That is, when approaching the impact point, the hysteresis of the reaction peak will gradually stabilize as the impact load gradually decreases. However, at tower heights far from the point of impact, it takes longer to flatten, although it tends to decay after the peak of the displacement response.

Under the influence of impact loads, the energy consumption identification results of green building steel structures can be represented by the energy consumption factor contour and contour diagram and the contour diagram can be converted into probability and statistical results. Here, probability statistics indicate the percentage of probability of failure is shown in Figure 7.

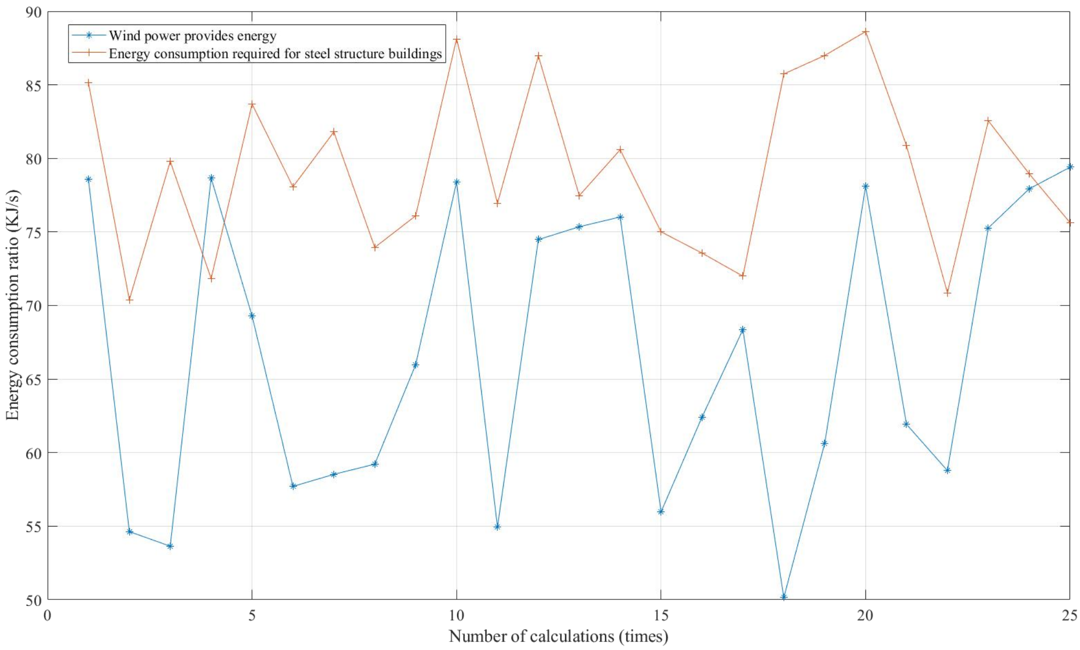


Figure 7. Building energy consumption and energy consumption provided by wind power

Obviously, under the influence of this impact load, the steel structure of the green building is most prone to energy consumption is the connection between the diagonal support and the pile casing. Figure 4(b) shows the energy consumption identification results of the green building steel structure. Obviously, the joint position between the oblique support and the tower and the joint position between the oblique support and the pile sleeve are prone to energy.

4. Conclusion

To sum up, this paper mainly studies the energy performance and service life of green building steel structure, selects three piles of green building steel structure as an example, uses the linear cumulative damage rule of miners to evaluate the energy life, and calculates the linear cumulative damage and service life. In this study, wind power generation loads are divided into two types: single wind power load and double wind power load. In this study, when studying three different load modes of wind power generation (gradient type, reciprocating type, and sine wave type), the energy characteristics and service life of green building steel structures can be understood through the signal-to-noise curve. In this study, the ratio of the energy limit to the energy level of each part of the green building steel structure is used as the energy consumption factor, and then the contour map is used to directly measure the resistance of each part of the green building steel structure under the influence of energy load.

In order to quantify the heat energy resistance of each part of the green building steel structure, this study first needs to obtain the heat energy data of each position of the green building steel structure under the influence of load, that is, the energy data of the elements or nodes obtained through meshing in the numerical simulation process. These energy data are obtained based on the application of wind power loads. In this study, this study will compare the results of wind power loads applied in two directions in the case of multi-level wind power loads, i.e., "low-high" and "high-low". The "motion effect" of wind power load on green building steel structure was studied. Therefore, the energy analysis method of green building steel structure for wind power generation has been studied in depth, which is divided into single-stage energy load and multi-stage heat energy load. Based on the linear cumulative damage theory, the energy consumption and heat energy life of the green building steel structure are calculated. Through the study of three energy load modes of gradient, reciprocating and sinusoidal on the energy consumption of green building steel structure, the importance of energy load mode to the energy consumption of green building steel structure is confirmed, and the heat energy consumption ability of green building steel structure in different fields is quantified by the energy consumption factor. According to the types of green building steel structures and the setting of energy loads involved in this study, the severity of energy consumption of green building steel structures by the three influencing modes is a gradually increasing < anti-< sine waveform. After comparing the relationship between energy consumption and load arrangement of green building steel structures, it can be seen that the linear cumulative damage theory does not fully consider the role of load arrangement.

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