Analysis of the Steel Structural Reliability under the Big Data

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Abstract: In this paper, the reliability of steel roof under the big data loads is analyzed. Firstly, the roof of steel structure is shown. The relationship between roof span and stress composed of hollow steel joist beam is obtained, and the parameters of the structure of the open web steel joists that is made by the wide flange steel is given. Secondly, according to the random distribution parameters of steel roof and the big data loads, the limit state function of steel roof structural calculation is given. The function is an implicit function. Monte Carlo method is used to calculate reliability index of the steel structural roof with considering the dead loads and the big data loads. Finally, the reasonable suggestions for the reliability and safe operation of the steel structural roof are given from the reliability of the calculated of the steel structural roof.

1. Introduction

In modern manufacturing companies, big data is being captured by using lasers, sensors, wireless networks, etc. These big data include the processing of manufacturing processes, the effects of temperature, vibration, reliability data, etc. The big data is processed in the computer by using different algorithms for improving the products and to increase the competitiveness of the enterprise in the market. Big data is widely used to discover and develop new technologies, methods and decisions. Big data has been paid attention and researched in the modern society. The 5V (volume, velocity, variety, veracity, value) of big data have been defined and they are believed as important as the meaning of new technology [1].

The application principles of big data in the field of security engineering have been analyzed, the theoretical system of the secure big data application was established, the safe big data processing procedure was given, and the theoretical guidance was provided for the application of big data in the field of security science and engineering [2]. With the massive operational data of the equipment, the big data processing technology could be applied to the reliability research of the large-capacity power and electronic systems.

The reliability research has been developed by using the latest theoretical results of big data science based on the data ubiquitous relationship. The big data is done with distributed algorithms, and a feasible algorithm was given by [3].
The application of big data in traffic reliability operation has been put forward. It is believed that the new opportunities will be brought to innovation in traffic management and decision-making paradigm [4]. The data quality and data characteristics were analyzed, and the highway reliability estimation methods have been proposed [5]. The reliability of the system was predicted and analyzed using big data, and the prediction model was developed. The proposed method has been compared with the existing methods and their prediction model is better the others.

For most engineering structures, massive data would be generated during their service lifetime such as bridges, wind towers, pipelines and automobile chassis. These structures are subjected not only a large amount of imposed load, but also other loads such as wind, corrosion, vibration, etc. The data is acquired timely, and the data would be analyzed and sorted. The structural reliability can be predicted by using the data, and thus the effective maintenance and maintenance measures for the structure are proposed [6].

The existing bridge structures are normally evaluated using big data. It is suggested that the early maintenance of the bridge is very important [7]. A faster detection method which is nonlinear and more practical and feasible has been proposed by using the big data which is collected from the structural health monitoring for a large reinforced concrete structure in Italy [8]. The wind turbine failure model and the maintenance decision system is also established by using the big data which is obtained from the weather and wind power equipment [9]. In most cases, the big data has no obvious distribution rules.

The large-span steel roofs are currently used in a variety of applications in the worldwide such as railway stations, airports, warehouses, etc. The design parameters and the weight of the steel roof was studied, the minimum parameters and precautions for the steel roof design was shown. The reliability of steel structural roof under random loads was studied, the reliability of steel structural roof was changed with time response [10]. The failure mechanism of buildings under snow load was analyzed [11]. It is considered that the multiple failure factors of buildings with the snow load increasing, which increases the components of building failure. For the steel structural roof, during its service period, the steel structure roof not only bears the wind, dead load but also bears the other loads such as wind, snow, etc. The big data has been obtained timely, and the bid data would be analyzed and sorted, the reliability of the steel roof would be accurately analyzed. It is possible to provide strong data and policy support for the operation of these steel structural roof, so as to propose effective maintenance and maintenance measures. The structural reliability from time response has been studied [12], it is considering that the reliability of the structure is time-dependent due to several factors. The damage of buildings under snow load was established from the perspective of physicality and economy, it is considered that it is very important for the early maintenance and maintenance of steel roofs.

In this paper, the big data of the loads is collected from the steel roof beard the loads. The reliability of the steel roof is supported by the open web steel joists is analyzed under considering the uncertainty of load. The reliability of the steel structural roof is obtained by using the Monte Carlo method to simulate the static load and the capacity of the steel structural roof. Finally, it is shown that the method is feasibility and effectiveness by an example.

### 2. The Steel Structural Roof

The open web steel joists that is pre-made is the main component of the steel roof. It is consisted by two truss beam who are placed horizontally up and down, the up is named the winding, the down is named lower chord, the middle of the winding and the lower chord are place vertical the trusses and the middle trusses named the steel mesh. It is shown as Fig. 1.
The upper and lower chords of the open web steel joists are composed by the wide flange steel, the wide flange steel is H beam steel. The shape of the steel is that the width of the flange is greater than or equal to the web height. The beam of the general steel structural roof would be made by using the wide flange. The merit of the structure is the section modulus, moment of inertia and strength of the section steel are significantly better than the same heavy others.

The weight of the steel structural roof is made by using the open web steel joists 10 to 40 percent is lighter than other steel structural roof, and its bearing capacity is more than other steel structural roof. Moreover, the wide flange steel has the advantages of wide flange edge, thin web and many specifications, so that it has the advantages of flexible splicing and beautiful appearance when manufacturing steel structural roof. In addition, it is easy to assemble into various components because its outer sides of the flange are parallel, the edge ends are right angles. It is saving the work about 25% when the welding and riveting would be done, which can greatly speed up the construction speed of the project and shorten the construction period.

When designing the steel structural roof, the self-weight and big data load would be fully considered. The steel structural roof is composed by the open web steel joists that has the large span and the greater stress. The relationship between the span of the roof and the average stress of the roof is shown in Table 1.

| Span (mm) | 6000  | 12000 | 18000 | 24000 |
|-----------|-------|-------|-------|-------|
| Stress (MPa) | 0.00311 | 0.00528 | 0.0072 | 0.0077 |

It is shown by Table 1, the span is larger, and the dead load are larger too. It is shown that the big data loads would be studied while the dead load of the steel structural roof must be considered.

The steel structural roof made of the open web steel joists is a square or rectangular grid made up of several horizontal and vertical beams. The steel structural roof is covered with some skins to form a roof that is sheltered from wind, snow and rain. The parameters of the steel structural roof are shown as Table 2.
3. The Reliability of the Steel Structural Roof under the Big Data Loads

The dead load is noted as \( D \), its stress is noted as \( d \), the big data loads is noted as \( B \), its stress is noted as \( b \), the limit loads of the steel structural roof is noted \( R \), its strength is noted as \( r \). The reliability index of the steel structural roof is noted as \( \beta \), above various are all random, the limit state function is shown as follow.

\[
L = R - D - B
\]

If \( L > 0 \), the roof is reliability, or else, the roof failure.

Eq. 1 is an implicit function; it would be computed by using the Mont Carlo method.

The probabilistic distribution of the dead load of the roof and the big data load is shown as Table 3.

| Loads            | Distribution type | Mean (MPa) | Coefficient of correlation |
|------------------|-------------------|------------|---------------------------|
| Dead             | Normal            | 0.00869    | 0.10                      |
| Big data loads   | Lognormal         | 0.00445    | 0.44                      |

The random parameters of the open web steel joist are shown as Table 4.

| Distribution type | Mean       | Coefficient of correlation |
|-------------------|------------|---------------------------|
| Elastic modulus   | 1.7×10^5MPa| 0.076                     |
| Yield strength    | 240MPa     | 0.11                      |
| Section modulus   | 8.0cm      | 0.05                      |

The Eq. 1 can be computed by using the Mont Carlo method according to the Table 1 to 4. Its reliability index is 1.45, the reliability of the steel structural roof is 0.9265.

It is shown by the result, the reliability of the steel structural roof is high in the service period. Although,
the roof must be cleaned the snow and checked out and reinforced the thick part in the extreme weather.

4. Conclusion

The reliability of steel structural roof is computed under big data loads. According to the safety rules of the building and serviceability objectives, the Monte Carlo method is used to consider the uncertainty of roof load and the big data loads on the roof. The reliability of the steel structural roof under the big data loads was obtained. However, it should be noted that this reliability assessment is usually less than 25-45%. Although the reliability is similar, even if the roof design has the same load exceeding 50 years of the load, the substantial difference in probability shape will result in the distribution of the maximum snow load per year. Producing different reliability results, these are important for roof snow loads.

In additional, the application of this analysis method should be fully consider the difference climate and geological distribution. The annual maximum snow load has a great impact on the reliability analysis. At the same time, changing the physical characteristics of the roof has little effect on the reliability index. Secondly, there is a strong correlation between the reliability and maintainability of steel roofs. Finally, for the steel structural roof, the design of the deflection limit results in a larger cross-sectional dimension, resulting in considerable improvement in safety, maintainability and reliability.

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