ISSN: 2664-9640

Statics analysis of automatic shade system

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Abstract

In this paper, the automatic shading system is designed based on the cable-stayed structure, and the statics analysis of the structure is carried out.Sun-shade net, this paper analyses the opening and closing state, and the automatic shade system model was simplified and processing, finally, and the structure is employed to simplify the process and the structure on the basis of considering the sun-shade net opening-closing movement model, finally using stepwise loading simulation comparison of the movement way, to verify the reliability of the dynamic load movement.

Keywords

Finite element analysis;Shading network frame.

One of the core problems in the automatic shading system is the expansion and retraction of the shading network. In order to ensure the normal and stable operation of the shading network system, the structural strength of the shading network frame in various working conditions can meet the requirements of use.At the same time, the shading grid needs to bear the external loads such as the shading network and the motor gravity. From the perspective of engineering experience, the mechanism is prone to strength and safety problems.Therefore, it is important to analyze the strength of cable-stayed grid structure in work.

1. Theoretical basis of statics analysis

Static performance analysis of cable-stayed grid is an indispensable part of sunshade system. The purpose of the study is to check the stress and deformation of sunshade grid under constant load, and to ensure that the grid structure has a good bearing capacity under constant load, which is the basis of dynamic analysis[1].

Statics analysis is mainly based on the theory of elasticity, from which it can be deduced that the general differential equation of object dynamics is[2]:

$$[M]\{x\} + [C]\{x\} + [K]\{x\} = \{F(t)\} \tag{1.1}$$

The type (1.1) :

[M] -- Mass matrix

[C] -- Damping matrix

[K] -- Stiffness coefficient matrix

{x} -- displacement vector

{F (t)} - force vector

In statics analysis, the load on the grid structure under different working conditions is a constant load, and {x} is a constant value. Therefore, the velocity vector and acceleration vector in Equation (1.1) are 0, and the above equation can be simplified as:

$$Kx = F \tag{1.2}$$

From Equation (1.2), the stress and strain of the element and the whole structure can be deduced.

The fourth strength theory is widely used to check structural strength because it takes into account the effect of three principal stresses on equivalent stress and has high reliability.According to the fourth strength theory, the condition that the structure does not fail is:

$$\Sigma_e = \sqrt{\frac{1}{2}[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2]} \leq [\sigma] \tag{1.3}$$

In formula (4.3) : σ_1-- first principal stress

sigma$_2$-- second principal stress

sigma$_3$-- third principal stress

[sigma$_s$] -- allowable stress

The allowable stress can be obtained by the following formula:

$$[\sigma] = \frac{\sigma_s}{n} \tag{1.4}$$

In Formula (1.4) : σ_s is the ultimate yield strength, and n is the safety factor, which usually ranges from 1.1 to 2.0.

2. Cable-stayed grid structure model processing

2.1. 3d model simplification and processing

The establishment of 3D model is a necessary pre-step of finite element modeling, and the accuracy of 3d model is related to the accuracy of subsequent finite element analysis.The automatic shading system includes cable - pull grid, lifting system, opening and closing system, etc.The overall size is the span of the tea row is 40 m, the span of the tea column is 8 m, the height of the grid is 2.4 m, and the height of the main column is 6.0 m.The influences of different cabling modes on the automatic shading system are discussed, as shown in Table 1.1, and the model is shown in Figure 2.1

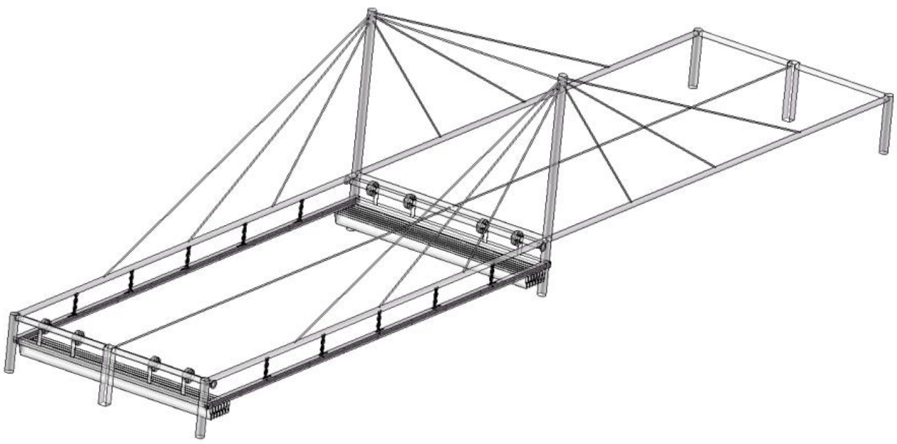

Figure 2.1 Overall mechanism

(1) Simplification of 3d model

ISSN: 2664-9640

Use the drawing software SolidWorks to conduct three-dimensional modeling of the structure. In the modeling process, some structures with no great influence on the finite element analysis results will appear in the cable-stayed grid structure, and even cause additional difficulties to the finite element structure analysis.These structures often have a great impact on the mesh quality and calculation time, so it is necessary to simplify the cable-stayed grid structure to a certain extent in the actual 3D modeling, in order to improve the mesh quality and the efficiency of finite element analysis[3].Its simplified structure is as follows:

1) Omitted parts have no obvious effect on the overall structure strength.Such as welding points, hooks, etc., these structures have little influence on the overall analysis of cable-stayed structures. The simplification of such structures is beneficial to improve the quality of grid division and reduce the workload of finite element simulation. These details can be replaced or ignored by fixed constraints.

2) Simplify the lifting part of the motion system, and replace the scissor structure with fixed constraints.The structure of this part is complicated, which makes it difficult to guarantee the quality of meshing and significantly affects the accuracy of finite element analysis results.At the same time, in the motion system of sunshade net, the lifting structure is mainly subjected to vertical load, and the load demand is mainly met by selection design. In the finite element analysis, only the overall stress distribution and displacement are discussed.

3) Simplify the internal structure of the guide rail in the motion system, and the motion of the sunshade net adopts the way of moving load.In addition to ensuring the equivalent substitution of loading mode, the computing resources can be removed to reduce the computing difficulty.

2.2. Loading and boundary conditions

In order to ensure the accuracy of finite element analysis, the correct loading of boundary conditions and the determination of load are the premise of finite element analysis.The constraint conditions imposed on the finite element model should be consistent with the actual situation in order to accurately reflect the deformation characteristics of the structure.In the model of cable-stayed grid structure, various constraints are relatively complex and difficult to calculate. In order to ensure the accuracy of finite element model analysis, reduce the calculation time and save the calculation cost, it is necessary to replace the constraints equivalently, and the simplified model should be consistent with the actual situation of the prototype as far as possible.The basic load is determined as shown in Table 1.2 below

Table 1.2 Basic load determination

The name of the	Quality (kg)	Quantity (PCS)
Sun-shade net	20kg	1
Lifting motor	10kg	2
guide	10kg	2

In this cable-pulled grid structure, the sun visor net is retracted and retracted through a guide rail.When the sunshade net is not unfolded, the sunshade net is concentrated at one end of the motor.When the motor pulls, the sunshade net runs on the guide rail until it is fully unfolded.If the motion of the sunshade net is brought into the model, it will cause difficulties in calculation and convergence, so the equivalent replacement of load should be carried out.

The main components of the cable-stayed grid structure are composed of steel pipe and steel cable. The steel pipe adopts Q235B structural steel and the steel cable adopts 304 steel. Based on the above data, the material attribute model is established in Workbench and corresponding material attribute parameters are set.Specific parameters are shown in Table 1.3:

Table 1.3 Material property setting

material	Density	Modulus of	Poisson's	Yield strength	Elastic limit
Q235	7850	2.0 e^5	0.300	235	630
304 steel	7930	1.95 e^5	0.247	205	520

The time-varying loading methods in Workbench mainly include stepwise loading, table loading and function definition.Stepwise loading method is adopted in this paper.Step by step loading method is to save the load step file every time the load is applied, and solve the load step after all the load step is applied, which is suitable for the dynamic load with changing rules[4].

Before carrying out the action load analysis, it should be considered that the motion mode of the sunshade net should be consistent with the reality.The sunshade net deployable mode is bilateral deployable. Simulation comparison is conducted to verify the reliability of dynamic load movement.In view of the length of unilateral guide rail in this paper is 20m, starting from both ends, a discrete position of moving load is set every 1m. There are 20 discrete positions of moving load in total, and a total of 40 discrete positions of moving load are set.A separate calculation condition was established for each discrete position of the moving load, and the unit concentrated load was applied to the discrete position of the corresponding moving load to obtain the equivalent structural stress of all nodes.Figure 2.1 is a schematic diagram of the stepwise loading method.FIG. 2.2 is the loading step application diagram.

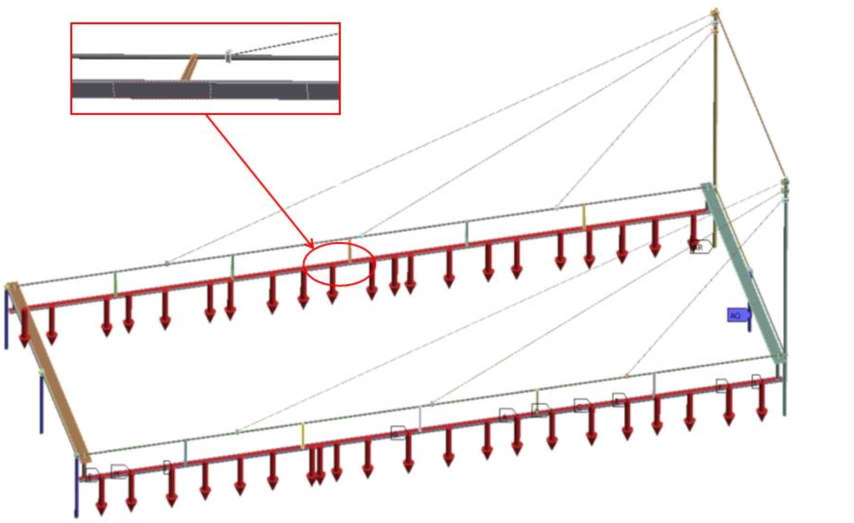

Figure 2.2 Stepwise loading method

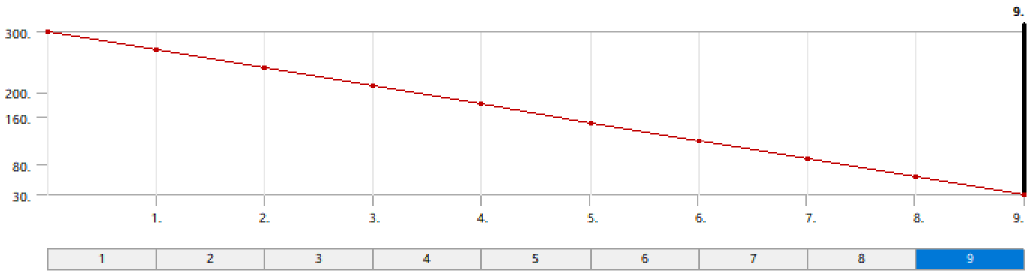

Figure 2.3 Load step application

3. Structural motion analysis of cable - stayed grid

(1) Dynamic load analysis of cable-stayed grid

FIG. 3.1 is the stress cloud diagram of the shading network under dynamic load. It can be seen from the diagram that the stress distribution of the shading network is uniform in the process of movement, and the maximum stress appears at the beam and cable, which is 40.52mpa, meeting the design requirements.

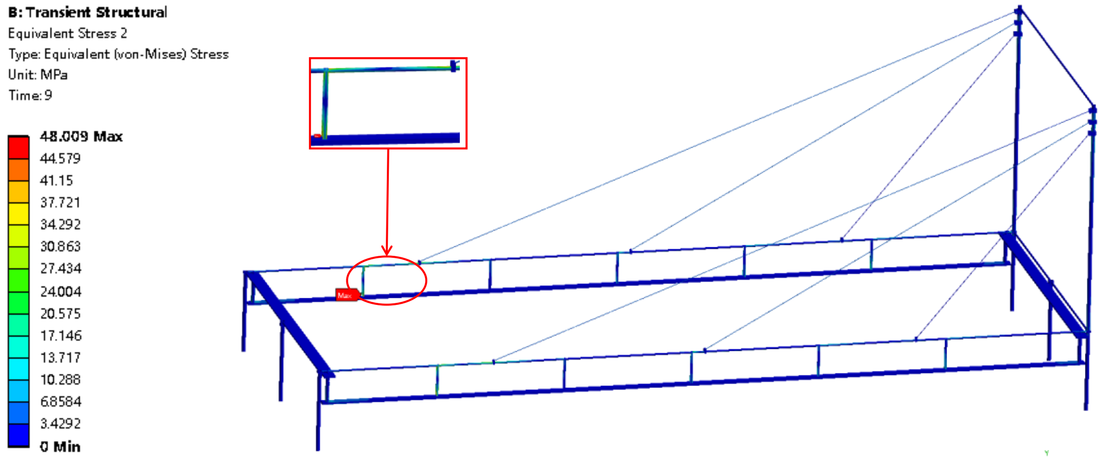

FIG. 3.1 Stress cloud diagram under dynamic load

FIG. 3.2 is the shading grid displacement cloud diagram under dynamic load. It can be seen from the diagram that the maximum deformation position is at the first cable, which is 10.427mm.Secondly, the main deformation region appeared between the first cable and the second cable, and the deformation degree ranged from 6.703mm to 8.934mm.The guide rail and beam are kept in a safe range during the movement of the sunshade net.

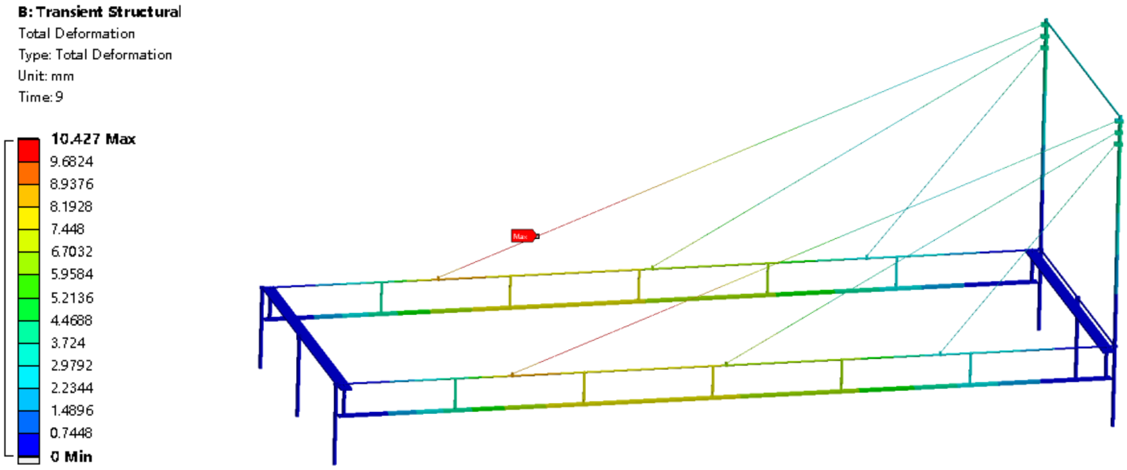

FIG. 3.2 Dynamic load displacement cloud diagram

4. Conclusion

The deformation of guide rail and beam is the largest at the center and the smallest at both sides. The deformation of cable is the largest at the middle and the smallest at the two sides.At the same time, it can be seen that the maximum deformation point at the guide rail is located in the middle of the guide rail, and the deformation at the two ends of the guide is relatively small. Therefore, setting a connection point between the middle of the guide rail and the beam can

ISSN: 2664-9640

effectively reduce the deformation caused by insufficient weight and stiffness of the guide rail.The deformation on the beam is small at the cable contact point and becomes large between cables, so the installation of the cable can effectively prevent the large deformation of the beam caused by load and dead weight.At the same time, when setting the connection between beam and guide rail, high strength materials should be considered, or more connections should be set here to reduce stress concentration.

The maximum stress is 40.53 Mpa and the maximum deformation is 10.427 mm under dynamic load, which meet the structural design requirements.

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