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Simulation analysis on structural stability of low wind pressure conductor passing through the pulley

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Abstract. This paper introduces the structure stability of ACSR JL/G1A-630/45-45/7 and low pressure wire DFY- 630/45(90°)-R3.2 passing through the pulley under the condition of 25%RTS and envelope angle of 30 °.The diameter of the pulley is 20 times the diameter of the wire. Simulation analysis was carried out using finite element software, It is concluded that the structural stability of low-pressure wire is weaker than that of ordinary steel core, but the overall structure is sTable and can meet the engineering requirements.

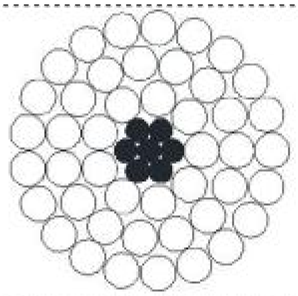
Introduction

In overhead transmission lines, the wind pressure received by the wire is 50% -70% of the wind pressure of the entire transmission line. In addition to the need for the wind wire to withstand the wind load, the tower must also withstand the wind load from the conductor.The wind pressure of the wire has a great influence on the strength design of the tower foundation and the tower itself, and it is important to reduce the wind pressure to reduce the cost of the line and improve the ability of the line to resist the strong wind. Low wind pressure wire is mainly used as a special function of the wire, used in the strong wind area, playing a role in reducing the wind load [1].

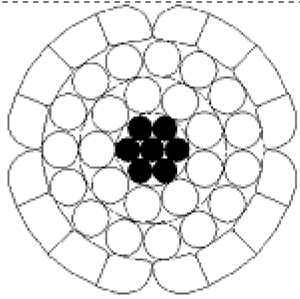
In order to minimize the resistance coefficient of the wire, it is necessary to select the best surface shape or "roughness" of the wire, and a large number of tests data provide a reliable basis for this. After considering the factors such as corona, radio disturbance characteristics, manufacturing process and wireline construction, the design of the low-pressure wire with fan-shaped cross section is designed [2].

The low-pressure ACSR DFY- 630/45 (90 °) -R3.2 is obtained by changing the structure of the outer layer of the aluminum wire by the conventional ACSR JL / G1A-630 / 45-45 / 7 ,As shown in Figure 1.The outermost layer aluminum wire of low wind pressure wire is a single aluminum wire, and the inner layer and the outer layer are round aluminum wires. And the equivalent diameter ofthe outermost layer aluminum wire is larger than the inner and the outer layer, as a new conductor, due to the lack of running experience of this type of low pressure wire passing through the pulley, we can not determine whether the structural stability of low pressure lines through the pulley can meet the requirement of engineering application, so it is necessary to study the structural stability of low pressure lines through the pulley.

By setting up finite element model of JL/G1A-630/45-45/7 and DFY- 630/45 (90 °) -R3.2, setting up a block model and performing simulation analysis, this paper analyzes the structural stability of low pressure wire.



JL/G1A-630/45-45/7



(b) DFY- 630/45 (90) -R3.2

Figure1. Conductor structure diagram

Research Program

This paper analyzes the structural stability of theconductor under the condition of 25% tension, and the conductor is wrapped by the conductor pulley with 20 times conductor diameter by the angle of 30 degree. Specific steps are as follows:

(1) Setting up finite element model of ACSR JL / G1A-630 / 45-45 / 7 and low wind pressure wire JL / G1A-630/45 (90 °) -R3.2;

(2) Setting up the pulley model;

(3) Simulation analysis was carried out to analyze the structural stability of low pressure wire of different schemes.

When the stability analysis of the wire structure is carried out, it is necessary to establish the finite element model of the single wire and establish the contact relation. Because the model is nonlinear and the prediction result is affected by friction and prestress, the stability prediction is difficult. In this paper, we first use the finite element software ANSYS to establish two kinds of steel core aluminum stranded wire model, analyze the relative deformation between the single stock under the condition of 25% tension and keeping the angle of 30 degrees with the pulley , And the stability of the wire is evaluated by using the jump criterion..

Strand jump criteria are as follows [3]:

When any aluminum line of the outermost layer protrudes from the adjacent aluminum line, it indicates that it is in the state of the strands, as shown in Figure 2.

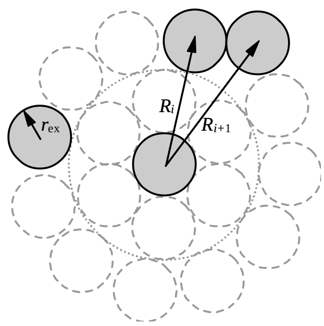


Figure2. Sketch of jump stock criterion

The formula for the calculation of the jump coefficient λ:

$$l = \max(l_i), \quad l_i = \left| \frac{R_i - R_{i+1}}{r_{ex}} \right| \quad (1)$$

Type Ri: the load deformation after the outermost I wire center to the inner steel wire after deformation center distance; Ri+1 is the outermost layer of the i+1 deformation after loading wire center to the inner steel wire after deformation center distance; Rex is the equivalent radius of the outer conductor wire; when less than k no jump in [0.5,1.0] shares, K shares jumped as the reference value of [3].

Stranded wire through the pulley, there are three kinds of load: 25% tension, the angle of 30 degrees and the conductor sliding. Which can be used to simulate 25% prestressed tension; firstly establish straight wire, gradually moving block wire bending 30 degrees to simulate the envelope through a fixed angle; one end of the wires, the gradually moving block during wire sliding relative to the pulley, the cumulative effect of cross section in order to simulate the deformation caused by the sliding guide line. The analysis scheme is shown in table 1.

Ri in the formula is the distance from the center of the outermost layer i to the center of the innermost steel wire after loading deformation; Ri + 1 is the outermost layer of the outermost layer i + 1 wire to the center of the innermost steel wire after loading deformation; rex is the equivalent radius of the outermost aluminum wire of the conductor; when λ is less than k, there is no jump, k ∈ [0.5,1.0] is the jump reference [3].

there are three loads when the strand passing through the pulley,: 25% tension, 30 ° envelope angle, and wire slip. By setting prestressing force to simulate 25% tension; through setting up a straight wire, and then gradually move the pulley so that the wire is bent to simulate the 30 degree envelope angle;By fixing one end of the wire, the conductor can slide in the process of gradually moving the slider relative to the pulley, so as to simulate the cumulative effect of the cross section deformation caused by the slide of the conductor.. The analysis scheme is shown in Table 1.

Table1 Conductor scheme

Serial number	Strand scheme	Analysis type
1	JL/G1A-630/45-45/7	static analysis
2	DFY- 630/45 (90 °) -R3.2	static analysis

Models and parameters

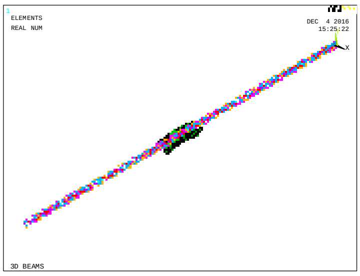
Finite element model and parameters of common steel core aluminum strand

The ordinary steel core aluminum stranded conductor JL/G1A-630/45-45/7 is made up of 7 steel conductors and 45 aluminum conductors which are twisted into 5 layers, and the outer diameter is 33.75mm. The parameters of each layer are shown in Table 2.

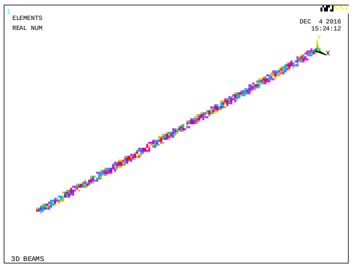
Table 2 parameters of eachconductor of common steel cored aluminum strand

Number of layers (from inside to outside)	Material	Conductor diameter (mm)	Number of conductors	Pitch ratio
1	Steel	2.81	1	--
2	Steel	2.81	6	21
3	Aluminum	4.22	9	15
4	Aluminum	4.22	15	13
5	Aluminum	4.22	21	9

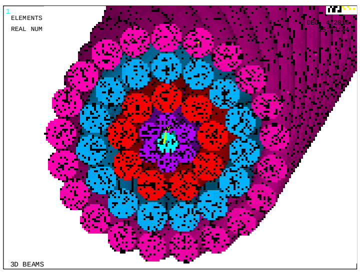
In Table 2, the elastic modulus of the aluminum alloy is 70 GPa and the Poisson's ratio is 0.3. The modulus of elasticity of steel is 200 GPa and the Poisson's ratio is 0.3.Theoretical analysis shows that the smaller the coefficient of friction between single conductors, the worse the stability of the steel, the general steel - steel, steel - aluminum, aluminum - aluminum coefficient of friction greater than 0.1, this analysis between the single conductor used as a friction Coefficient; the higher the coefficient of friction between the pulley and the conductor The worse the stability of theconductor, the actual work of the conductor and pulley is rolling friction, rolling friction coefficient is very small, far less than 0.1, this paper uses 0.1 as the friction coefficient. Using the above method, the conservative results can be obtained [4-6].When modeling, the initial state is straight conductor, the total length of the conductor is 50 times the diameter. Single conductor is used to simulate the beam element, the adjacent two conductors define the contact between. The pulley has a single R slot type, the bottom radius Rg = 36mm, and the pulley groove inclination angle β = 15 °. The model uses a circular orbit at 30 ° central angle to simulate that the pulley and the conductor are in contact at the midpoint of the conductor, and there is no contact pressure between the two. The structural finite element model is shown in Fig3.



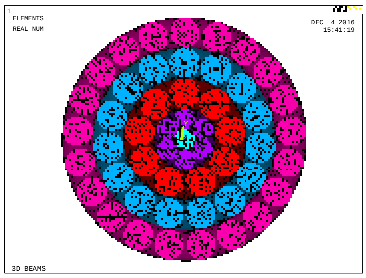
(a) Finite element model of the whole structure



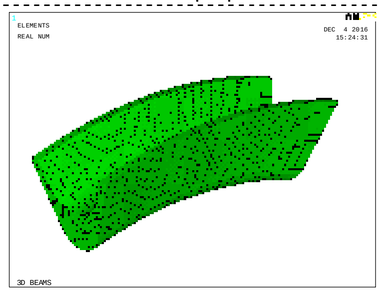
(b) Conductor



(c) Local enlargement of aconductor



(d) Cross section ofconductor

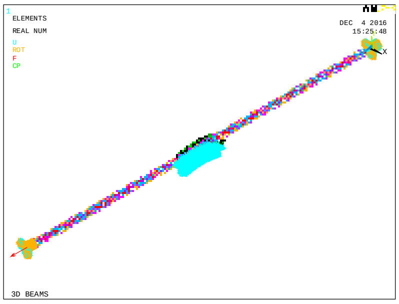


(e) Local enlargement of the pulley

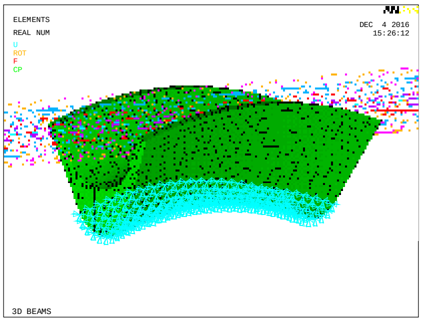
Figure3. Finite element model of structure

The simulation process is divided into two steps:

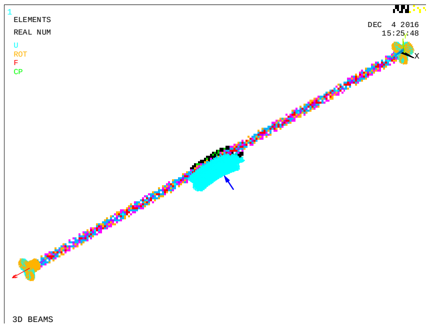
The displacement of both ends of the conducting conductor is fixed perpendicular to the conductor axis when the step (1) is simulated. Fixed pulley position. One end of the conductor is fixed along the axis of the conductor, and the other end is subjected to 37.6kN pulling force (37.6=150.45*25%). Loads and constraints are shown in Figure 4 (a) and (b).



(a) Simulation step (1) constraints and loading



(b) The constraint conditions of the simulation step (1) pulley



(c) Simulation step (2) constraints and loading conditions

Figure4. constraints and loading conditions of the simulation step

When the step (2) is simulated, the pulley is extruded along the direction of the verticalconductor in the circular orbit plane of the pulley. When the angle between the conductor and the pulley reaches 30 degrees. Load and constraint conditions are shown in Figure 4 (c). According to the geometric analysis of Figure 5, theconductor will slide relative to the pulley and the sliding distance is about 27.6mm, which can be used to simulate the cumulative effect of the cross section deformation.

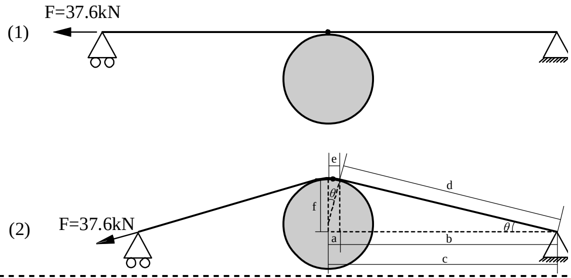


Figure 5 Analysis of the relative sliding of the cable in the simulation process

In Figure 5, the length of the strand axis is calculated, and the values of the parameters are shown in Table 3 (unit: mm):

Table 3 The numerical value of the angle of the envelope with the degree of 30 degrees relative to the pulley

parameter	a	b	c	d	e	f	g	θ
Numericalvalue(mm)	91.7	752	843.8	778.6	92.8	202.1	27.6	15

Among them, f is the distance of the pulley, and the G is the sliding distance of theconductorrelative to the pulley.

Finite element model and parameters of low pressure steel cored aluminum strand

The finite element modeling method of low wind pressure steel core aluminum strand is the same as the 2.1 section, and the ratio of the outer pitch diameter is the same as that of the 9 section. The cross section of the finite element model of low pressure steel core aluminum strand is shown in figure 6.

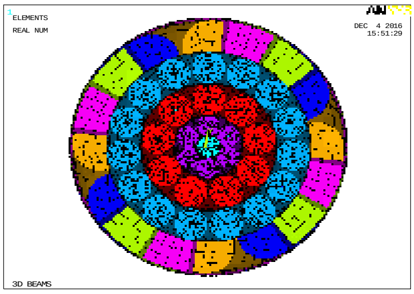
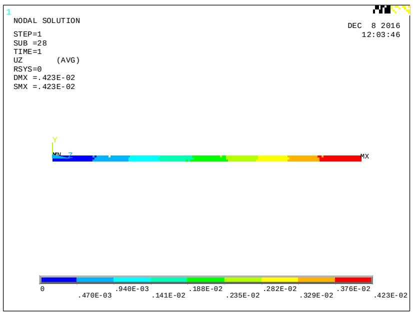


Figure6. cross section of finite element model of low wind pressure conductor

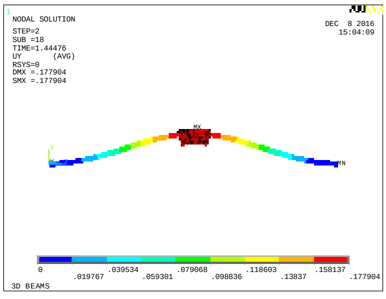
Analysis results

Analysis results of steel core aluminum strand JL/G1A-630/45-45/7

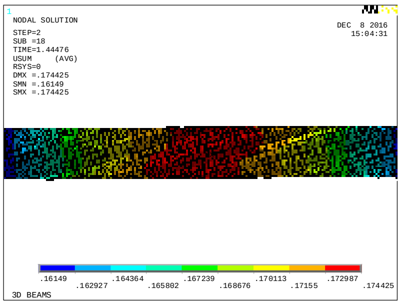
The 2.1 section finite element model is used to analyze the stability of the cable in two steps. At the end of the simulation step (1), the displacement nephogram of the strand is shown in Figure 7 (a). At the end of the simulation step (2), the displacement pattern of the model is shown in Figure 7 (b). At the end of the simulation step (2), the local displacement nephogram of the contact part between the strand and the pulley is shown in Figure 7 (c).



(a) Displacement nephogram of the conductor at the end of the simulation step (1)



(b) Displacement pattern of the model at the end of the simulation step (2)



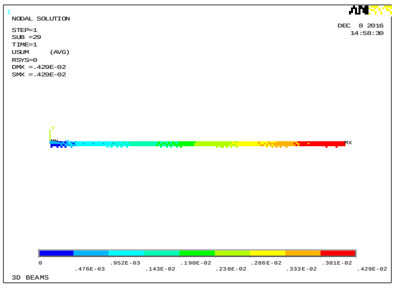
(c) Transfer of the local position of the contact part between the strand and the pulley at the end of the simulation step (2)

Figure 7 JL/G1A-630/45-45/7 displacement results of steel core aluminum strand

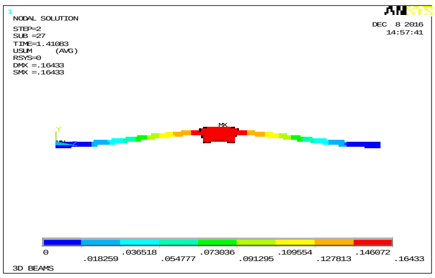
The formula (1) is used to calculate the jump coefficient I of all the single conductors in the outermost layer. It is found that the jump stock coefficient is 0.088, which is far less than k. Skip stock.

Analysis results of low wind pressure conductor JL/G1A-630/45 (90) -R3.2

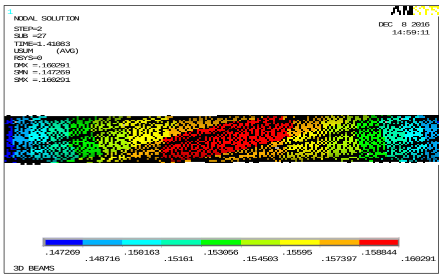
The 2.1 section finite element model is used to analyze the stability of the cable in two steps. At the end of the simulation step (1), the displacement nephogram of the strand is shown in Figure 8 (a). At the end of the simulation step (2), the displacement pattern of the model is shown in Figure 8 (b). At the end of the simulation step (2), the local displacement nephogram of the contact part between the strand and the pulley is shown in Figure 8 (c).



(a) Displacement nephogram of the conductor at the end of the simulation step (1)



(b) Displacement pattern of the model at the end of the simulation step (2)



(c) Transfer of the local position of the contact part between the strand and the pulley at the end of the simulation step (2)

Figure 8 Displacement results of low wind pressure JL/G1A-630/45 (90) -R3.2

It is found that the jump stock coefficient is 0.349 and the reference interval is less than k. Skip stock.

Conclusion

For ordinary steel core aluminum stranded JL/G1A-630/45-45/7 and low pressure of ACSR JL/G1A-630/45 by ANSYS software (90 degrees) at 30 DEG -R3.2 envelope angle, through the analysis of 20 times the diameter of the conductor line tackle when each single strand of conductor strand tension deformation of 25% conditions, the jumping stock criterion of structure stability evaluation of twisted pair. The results of the analysis of jump stock coefficient are shown in Table 4.

Table 4 Analysis results of the jumping coefficient of two kinds of conductors

Workingcondition	conductorscheme	Stock jumpcoefficient	The number of conductors in the outermost ring
1	JL/G1A-630/45-45/7	0.088	21
2	JL/G1A-630/45(90°)-R3.2	0.349	16

Analysis results show:

(1) The jump coefficient of JL/G1A-630/45-45/7 is0.088, which is far less than the requirement of engineering project.

(2) The coefficient of the low pressure steel core aluminum strand JL/G1A-630/45 (90 DEG) -R3.2 is less than that of [0.5,1] in the project.

(3) The jump coefficient of low wind pressure steel coredaluminum strand is smaller than that of the conventional conductor, and the structural stability of the conductor is weaker than that of the conventional conductor.

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