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Study on Nonlinear Dynamic Numerical Analysis Method of the Suspension Crossing Frame

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Abstract. At present, the calculation method based on statics does not consider the impact of the conductor on the crossing structure under the condition of disconnection or running. Therefore, the research on the element type of the suspension crossing frame and the conductor in numerical calculation and the behaviours of conductor breaking and running were carried out. Through the free swing test of the conductor, it was found that the conductor had certain flexibility under a certain length. Truss element should be selected to discretize the fiber rope of the conductor and crossing frame and this method could simulate the physical characteristics of the conductor and fiber rope objectively and truly. In the case of running line, the horizontal velocity of the conductor had almost no change along the axial direction of the conductor, while the vertical velocity presented a fluctuating distribution along the axial direction. In the case of the broken conductor, the horizontal and vertical velocity of the conductor were fluctuating along the axial direction of the conductor. The height of the conductor not only affected the horizontal velocity of the conductor, but also affected the vertical velocity of the conductor. It had important reference significance for the numerical calculation of nonlinear dynamics of the suspension crossing frame.

1. Introduction

In recent years, in order to solve the problem of energy distribution in China, large-scale construction of UHV projects has been carried out[1-6]. Construction safety should not be ignored. When crossing high-speed railway, expressway and important transmission lines in the process of stringing construction, the crossing frame is used to protect the crossed objects[7]. Because of its high specific strength, the suspension crossing frame (as shown in Figure 1) is widely used without the influence of terrain. Static method is usually used in design calculation. In fact, the high-speed impact will be produced on the crossing frame under the condition of broken line or running line accident. Therefore, the static method can not truly reflect the actual working conditions. The mechanical behavior of the conductor and the suspension crossing frame belongs to the typical dynamic problem of flexible multibody system. It is necessary to study the element type and the mechanical behavior of the conductor under accident condition, so as to facilitate the study of the solution algorithm in the future.

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Figure 1. Model drawing of the suspension crossing frame

2. Selection of Discrete Element

In order to study the discrete element of flexible body of the suspension crossing frame, the dynamic response of the JLHA1/G1A-400/50 conductor under free swing condition was analyzed, and the conductor parameters were shown in Table 1. The dynamic process of the conductor swing was recorded by high-speed camera. Simultaneously, the simulation model of truss element was established under the same conditions. The configuration changes of the conductor at different times were shown in Fig. 2 and Fig. 3.

Figure 3 showed the numerical results of the truss element. Figure 2 and figure 3 showed that there was little difference between the results of the conductor configuration at different times, which reflected the flexibility of the conductor. Therefore, truss element should be selected for discretization, so as to simulate the physical characteristics of the conductor objectively and truly. In the same way, the fiber rope used in the suspension crossing frame also had greater flexibility, so it was suitable to use truss element as the element type of modeling.

working	Type of	Cross section	Diameter	Density	E (MPa)	Rated tensile
condition	conductor	area (mm)	(mm)	(kg/km)		strength (kN)
free swing	JLHA1/G1A- 400/50	451.54	27.6	1509.3	63.0	186.91

 Table 1. Main performance parameters of test conductor

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(a)t=0.0s; (b)t=0.9s; (c)t=1.2s; (d)t=1.4s; (e)t=2.3s; (f)t=3.2s **Figure 2.** Conductor configuration at different times during free swing



(a)t=0.0s;(b)t=0.9s;(c)t=1.2s;(d)t=1.4s;(e)t=2.3s; (f)t=3.2s

Figure 3. Configuration at different time of free swing of truss element conductor

3. Behavior Analysis of the Conductor under Accident Condition

The behavior of the conductor under accident condition was line running and breaking. The implementation mode was shown in Fig. 4. The process of the conductor breaking was realized by setting failure element.

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Figure 4. Schematic diagram of dynamic behavior of the conductor running and breaking

3.1. Analysis on Running Behavior of the Conductor

The numerical calculation results of traverse running are shown in Fig. 5. The right end of the conductor was hinged and fixed, and the left end of the conductor could move freely along the tangent direction of the conductor. The accident of running from left to right occurred in the conductor. The horizontal and vertical velocities at different falling heights were shown in Fig. 6a and Fig. 6b. From the numerical results, we could see that the horizontal velocity of the conductor had little change along the axial direction of the conductor, while the vertical velocity was fluctuating along the axial direction in the case of running line. The higher the height of the conductor, the higher the speed of the traverse.





Figure 5. Stress nephogram of numerical calculation of line running



Figure 6. Variation curve of the conductor speed with spatial position under different the conductor dropping heights

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3.2. Analysis of the Conductor Breaking Behavior

The numerical model of the conductor breakage was shown in Figure 7, the horizontal and vertical velocities at different tensions and drop heights were shown in Fig. 7a and Fig. 7b. From the numerical results, we could see that the horizontal and vertical velocity of the conductor were fluctuating along the axial direction of the conductor in the case of the broken conductor. The falling height not only affected the horizontal velocity but also the vertical velocity and the higher the height, the greater the speed.



Figure 7. Numerical calculation results of the conductor breakage



Figure 8. Variation curve of the conductor speed with spatial position under different conductor

4. Conclusion

Based on the analysis of the discrete element and the behavior of the conductor under accident condition, the following conclusions are obtained.

(1) It is found that the conductor has certain flexibility under a certain length through the free swing test of the conductor.

(2) The truss element should be selected to discretize the conductor and fiber rope, so as to simulate the physical characteristics of the conductor objectively and truly.

(3) In the case of running line, the horizontal velocity of the conductor almost does not change along the axial direction of the conductor, while the vertical velocity presents a fluctuating distribution along the axial direction.

(4) In the case of the broken conductor, the horizontal and vertical velocity of the conductor are fluctuating along the axial direction of the conductor.

(5) The falling height not only affected the horizontal velocity but also the vertical velocity and the higher the height, the greater the speed.

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