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Calculation of lengths of spans of the contact network without taking into account the impact of wind

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ABSTRACT: The article presents a method for calculating the compensated contact suspension without taking into account the wind impact on its wires under certain specified initial conditions, presents several graphs of the change in the boom sag of the carrier suspension cable ПБСМ 95+БрФ-120 depending on the length of the span with different ice loads. The possibility of increasing the length of spans in the case of compensation of wind impact on the suspension wires is shown

KEYWORDS: main cable, the arrow of sag, the load, wind impact, wireless position, the tension wires

I. INTRODUCTION

From the length of the spans between the supports depends on the number of supports and supporting structures, and therefore the cost of building the contact network. Therefore, the length of the spans should be as large as possible.

However, the length of the spans depends on the greatest horizontal deviation of the wires from the axis of the current collectors under the influence of wind, this value should not exceed the permissible value.

If you exclude the impact of wind on the contact suspension, the length of the spans can be increased. At the same time, it is possible to achieve significant savings in material resources by reducing the number of used supports, supporting structures, insulators and other materials.

II. THE DETERMINATION OF THE LENGTHS OF THE SPANS

Suspension cable contact of the suspension is the most loaded element. The height of the contact wire suspension and, consequently, the quality of the current collector depends on its location.

The quality of the current collection is significantly influenced by the wind. If you remove the influence of wind on the wires of the contact suspension and the device of the contact network, you can significantly increase the length of the spans between the supports of the contact network.

To derive the equation for determining the length of the spans without wind action, we assume the following assumptions: the contact wire is in a wireless position, that is, the boom of the contact wire sagf_K=0; the minimum distance between the carrier cable under voltage and the contact wire 500 mm; the constructive height of the contact suspension - h=1,8 m; the loads from the contact and auxiliary wires, as well as from the strings and suspension parts are distributed evenly along the length of the carrier cable; the ends of the contact wires are rigidly fixed.

The carrying cable of the chain suspension has its own weight. To the load-bearing rope is suspended a contact wire with the help of strings. The combination of the masses of all wires causes a load from the weight of the wires of the contact suspension. In addition, on all wires of the contact suspension it can form ice formations that cause additional loads. The whole set of loads is perceived by the carrier cable and causes additional efforts in the carrier cable. The value of these additional loads varies depending on the change of the sag arrows and the tension of the contact wires, and only with the wireless position of the contact wires it is equal to the sum of the external loads on the individual wires of the suspension.

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To derive the equation for determining the length of the span between the supports of the contact line of the chain suspension, the following designations are accepted:
l – span length, m;
g – load from the weight of the wire chain, kN/m;
q – the resulting load of the carrier cable, kN/m;
T –the horizontal component of the tension of the carrier cable, kN;
K –Athenee contact wires, kN;
F –boom sag of the carrier cable, m;
f_K– boom of contact wire sag, m;
E – modulus of elasticity of the carrier cable, N/mm
S – cross-section of the carrier cable, mm^2;
α – temperature coefficient of linear expansion of the carrier cable material;
t – ambient temperature, °C.

The values *T*, *K*, *F*, *q* and t with index "1" refer to the initial mode, with index "*x*" – to the defined mode and with index "0" — to the mode of the wireless position of the contact wire.

Consider the equilibrium conditions of half-span chain suspension (Fig.1). Let the suspension cable has an arbitrary arrow of the sag F is not equal to the arrow of the sag of the cable at F_0wireless position of the contact wire (arrow F_0sag suspension cable has only the effect of the load self-weight of the rope). The contact wire will receive a sag arrow f_K. We denote the ratio $f_K/(F - F_0)$ by φ and call it the constructive coefficient of the chain suspension, then

$$f_K = \varphi(F - F_0) \quad (1)$$

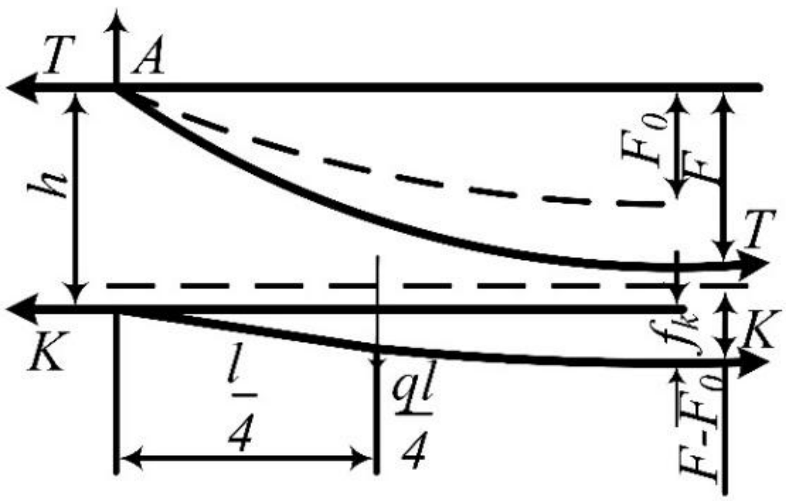

Fig. 1. Scheme of calculation of span length

Equating to zero the sum of the moments of all forces relative to point A, we obtain

$$TF - \frac{ql}{2} \cdot \frac{l}{4} + K(h + f_K) - Kh = 0$$

where, after bringing such members and replacing f_K with its expression (1), we find

$$(T + \varphi K)F = \frac{ql^2}{8} + \varphi K F_0 \,. \quad (2)$$

Since at the wireless position of the contact wire, the carrying cable can be considered as a freely suspended wire under the action of the load from the own mass of the wires of the chain suspension, the value F_0 can be determined by the formula

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$$F_0 - \frac{gl^2}{8T}. \qquad (3)$$

Substituting this value F_0 in equation (2), we obtain:

$$(T+\varphi K)F = \frac{ql^2}{8} + \frac{gl^2}{8}\cdot\frac{\varphi K}{T_0},$$

where

$$F = \frac{(q + g\frac{\varphi K}{T_0})l^2}{8(T+\varphi K)}. \qquad (4)$$

Designate

$$W = q + g\frac{\varphi K}{T_0} \text{ и } Z = T + \varphi K \qquad (5)$$

then the expression of the boom sag of the carrier cable will take the form

$$F = \frac{Wl^2}{8Z}. \qquad (6)$$

According to the derived formulas, we determine the length of the span of the real contact suspension ПБСМ95+БрФ120 without taking into account the wind impact. This contact suspension has the following parameters:

- the tension of the suspension cable of T=15 kN;
- the tension of the contact wire of K=20 kN;
- specific load from one meter of the carrier cable g=0,77 kN/m;
- specific load from one meter of contact wire q=1.07 kN/m;
- the arrow of the sag of the contact wire f_0=0,03 m.

To determine the length of the span is necessary to know the values that depend on the length of the span. Let's use consecutive substitutions, given the values of the lengths of spans in the range from 1 to 100 meters and build a graph of changes in the arrows of sag in the MATHCAD software shell

Based on the initial conditions of the boom sag of the carrier cable in the middle of the span

F =1800-500=1300 мм.

In the method of calculation of chain suspensions used until recently, the value of the constructive coefficient of the chain suspension φ was assumed to be constant and equal

$$\varphi = \frac{(l-2c)^2}{l^2} \qquad (7)$$

where C is the distance from the supports to the nearest simple (not spring) strings.

Graphs of dependence $F=f(l)$ are constructed by formulas (5), (6) and (7). The graphs are shown in Fig. 2. The figure shows three graphs with a change in the parameter of the resulting load on the load-bearing cable without ice (figure 1) and in ice mode with wind at q=33.8 N/m and q=50.7 N/m.

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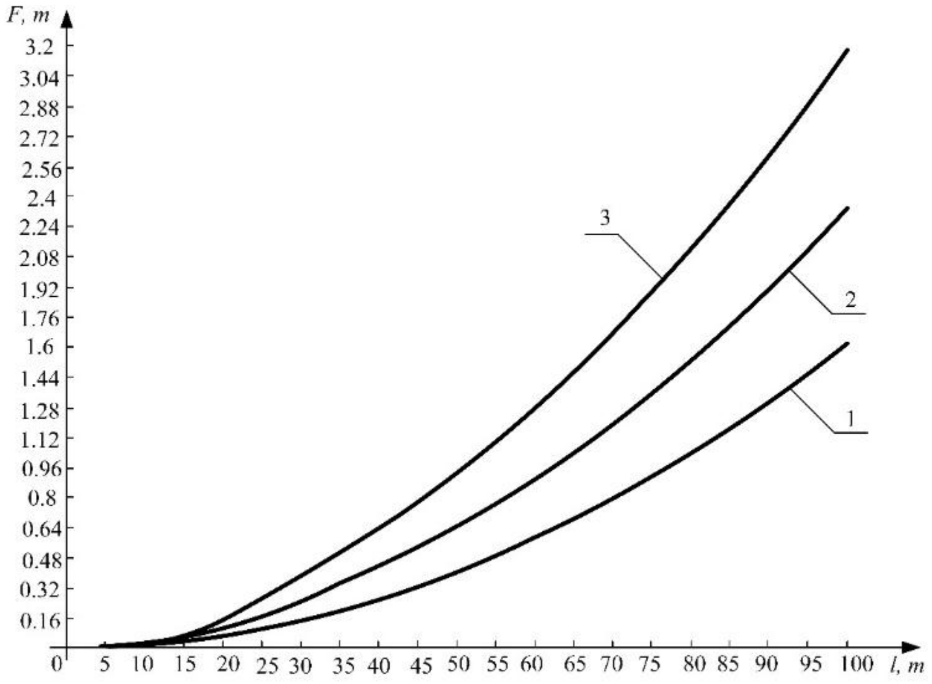

Fig. 2. Graph of dependence of the boom sag of the carrier cable on the length of the span

III. CONCLUSION

Analyzing the obtained graphs, it can be concluded that in the absence of ice and wind, the length of spans on the contact network can be increased to 90 meters with a minimum distance from the carrier cable to the contact wire of 500 mm. With an increase in the load from the ice mass, the span length must be reduced:
with a wall thickness of ice 15 mm – up to 74 meters;
with a wall thickness of 25 mm ice – up to 61 meters.

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