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Investigation of the joint operation of electric transmission lines with a new type concrete reinforced concrete foundation

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Abstract. The aim of this work was to study the joint work of structural systems "steel bearing overhead power transmission lines 10 kV – prefabricated concrete Foundation of a new type [1] – ground". For this purpose the technique of computer simulation in a PC "ANSYS" of the system. The method takes into account the spatial work of designs and physical nonlinearity of materials from which they are made. In addition, for steel was used in the theory of Mises, for concrete – Williams-Warnake, for ground – Drucker-Prager. In addition, all the necessary geometric, strength and physical characteristics of the model were obtained on the basis of the existing construction Standards for the design. The analysis of stress shows that its strength, stiffness and stability is provided, and there are reserves: for the metal supports – up to 15% to the base – 30%, ground – 1%.Therefore, further studies should consider the optimization problem for the choice of an effective constructive solution of the support and Foundation (with clarification on how to calculate them), that may be grounds to apply for a patent or utility model. Based on the obtained results it is recommended that a new type of collapsible foundations to apply in the real world.

The economic power of any state is determined by the potential of the power-to-weight ratio of the society. This potential depends on many factors, for example, on the development of energy infrastructure facilities, the material intensity of building structures used in such facilities, etc. In particular, when laying overhead power lines of various capacities and purposes, various steel supports and reinforced concrete foundations are used. From how economical it will be to constructive solutions of supports and foundations depends the cost of transportation of electric power from the source to the consumer, and, ultimately, the cost of all products produced on the basis of electricity. That is, research aimed at finding such constructive solutions has an important economic significance.

In work, the construction system "steel support of the overhead line (overhead line) of 10 kV transmission line - reinforced concrete foundation - ground of the base" is considered as an object of research.

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The HVL support has a well-known design solution for the Series 3.407.2-181.09 "Polyhedral steel supports of 6-10 kV overhead line" - anchor-angled support CM10AU, suitable for operation in climatic conditions including Kazan (II-th wind district, II area by glide). The support is intended for suspension of non-insulated steel-aluminum wires in accordance with GOST 839-80, as well as self-supporting insulated wires of type SIP-3 (SAX) according to TU 16.K71-272-98. From the wires presented in the specifications, the wire of the brand AC 185/29 has the greatest load on the pore, which we will take for calculation (the area of the aluminum part is 185 mm2, the steel core is 19 mm2, the wire diameter is 18.8 mm, the running weight is 7.28 kg / m, breaking force - 62,1 kN).

The foundation is collapsible and is performed according to the patent [1]. The general view of the basement is shown in Fig. 2. Its economic efficiency can be ensured not only due to low labor input for installation and dismantling and small transportation costs - this is stated in the patent test - but also in the calculation method when assessing the stress-strain state of the system "steel support - foundation - ground" with taking into account their joint work.

Soil conditions in the place of installation of supports can be different, take the worst option, which allows SP 22.13330.2011 "Bases of buildings and structures": type of soil - clayey soil, non-repellent, non-swelling; coefficient of porosity 0,95; modulus of deformation E = 8 MPa; yield index IL = 0.5; clutch of soil with = 15 kPa; angle of internal friction φ = 170; design resistance R0 = 150 kPa; coefficient of rigidity of the base (coefficient of the bed) k = 10 MPa / m (Designer's Handbook (Calculation and Theoretical), T.2, ed. Umanskogo AA, 1973. P. 307).

The most suitable tool for studying the system under consideration is computer simulation in the ANSYS software package (PC), which allows to take into account the spatial work of the structures and the physical nonlinear materials from which they are made.

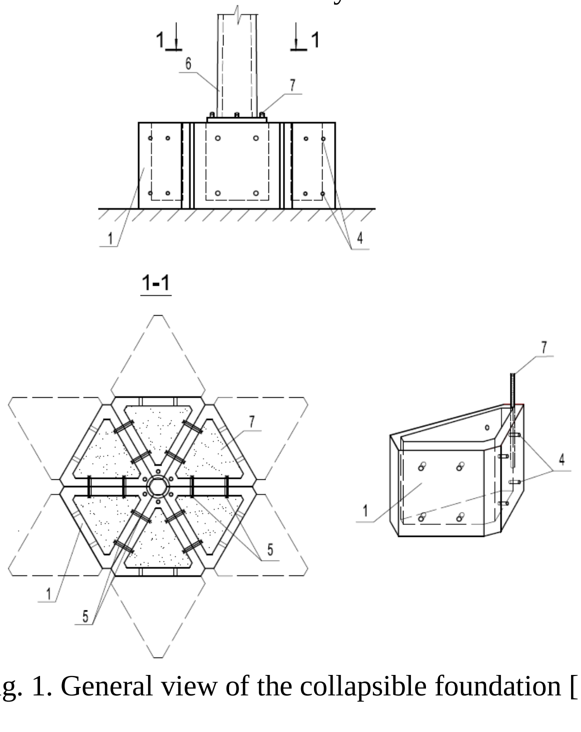


Fig. 1. General view of the collapsible foundation [1]

The essence of the modeling technique is as follows:

1 - definition of structural loads (based on the provisions of SP 20.13330.2011 "Loads and Impacts" and PEU-7);

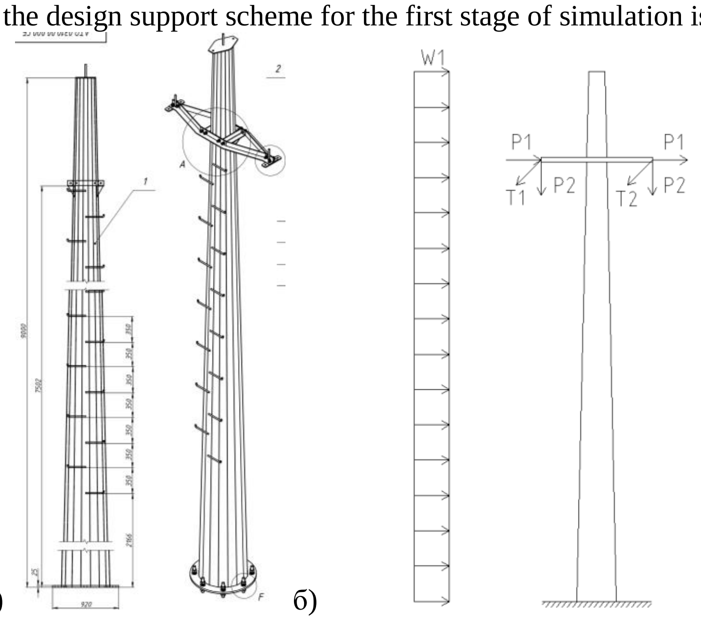
2 - static calculation of the steel support separately, as a rigidly embedded cantilever column of a hollow section (as a result, the load on the edge of the foundation is determined);

3 - determination of the dimensions of the foundation sole based on the load on it;

4 - modeling of the unified system "support-foundation-ground", determination of VAT in it;

5 - checking the elements of the system for strength, stability and deformation (respectively, in the 1st and 2nd groups of limit states).

Since we are interested in working with the foundation of only a single support, we can consider it without wires, replacing their action with the appropriate load. Otherwise, it would be necessary to consider the whole so-called "anchor span" of up to 3 km length, within which there would be several intermediate supports; All supports then would be joined by wires having a certain sag (which depends on the type of wire, the length of the intermediate spans and the ambient temperature). Thus, the design support scheme for the first stage of simulation is shown in Fig. 2,



b.a) б)

Fig. 2. Support SM-10AU: a - a general view, b - a design scheme

The calculation takes into account the following types of loads:

1 - depending on the direction of action:

- horizontal (wind on the support, wind on wires and cables, from the tension of wires and cables) and
- vertical (the weight of the support, the weight of the insulator wires (with fittings), the weight of the wires and cables, the ice load, the installation load (the weight of the fitter with the tools));

2 - depending on the duration of the action:

- Constant (own weight of the support, weight of the wires);
- temporary (wind, ice load on the wires and on the traverse).

A separate load is temperature. Since the work of the cables is not considered, therefore, this load is not taken into account in calculations.

According to PEU-7 steel supports are calculated for the following combinations of loads:

1 circuit (normal mode): The wires and the cable are not torn and free from ice. The wind is directed along the axes of the traverse.

2 circuit (normal mode): The wires and the cable are not torn and covered with ice. The wind is directed along the axes of the traverse.

3 scheme (emergency mode): One wire (on the right / left side) giving a torque to the support is broken.

4 circuit (emergency mode): Two wires are disconnected.

The "support-foundation-ground" system includes elements formed from materials with qualitatively and quantitatively differing physicomechanical properties. For their modeling, the corresponding types of finite elements and deformation laws were used.

Preliminary, the calculation of a single support was carried out, as a rigidly embedded cantilever beam, that is, without taking into account the foundation and foundation soil. As a result, the following loadings on the foundation were determined: in normal operation, N = 4078 kg, Q = 599 kg, M = 3727 kg · m; in the emergency - N = 3526 kg, Q = 1923 kg, M = 13657 kg • m. According to the formulas of SP 22.13330.2011, the required dimensions of the foundation are calculated for these loads (see table). After that, a general model of the "support-foundation-soil" system is formed, which is shown in Fig. 3.

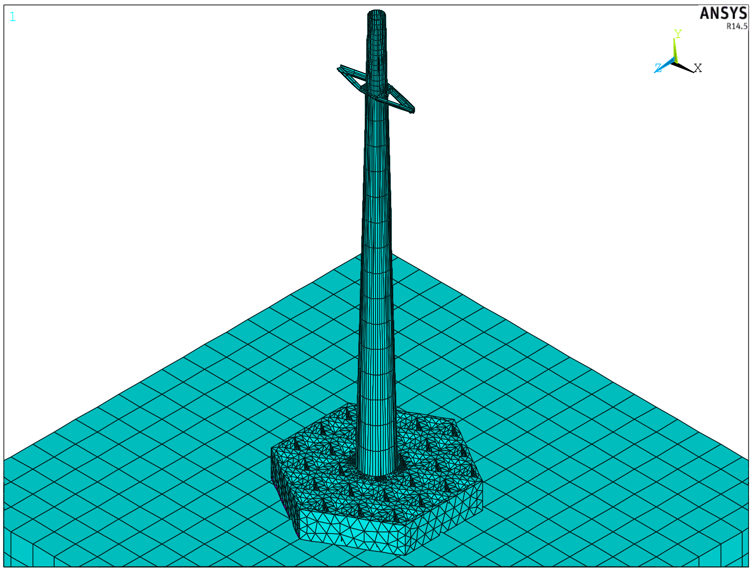


Fig. 3. Finite-element model of the "support-foundation-ground" system

The results of determining the VAT in the model are shown in Fig. 4.

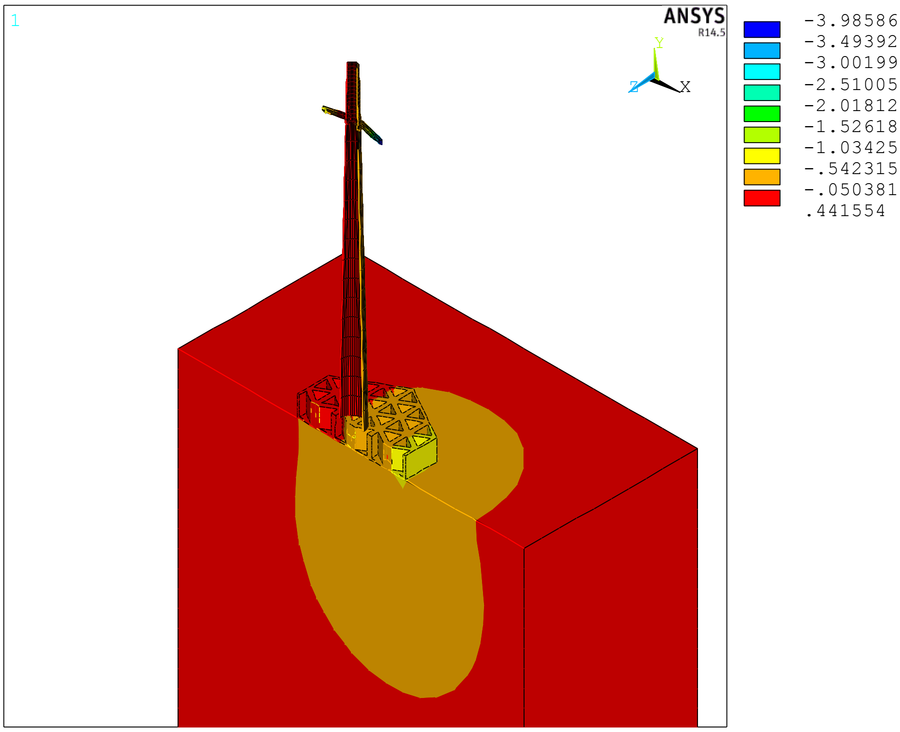


Fig. 4. Assessment of the VAT of the "support-foundation-ground" system

Conclusions.

1. The technique of computer modeling in PC "Ansys" of the constructive system "steel support VLEP - collapsible foundation of a new type [1] - foundation soil" was developed. The technique takes into account the spatial operation of the structures and the physical nonlinearity of the materials from which they are made. In this case, for the steel was used the theory of Mises, for concrete - Williams-Varnak, for ground base - Drucker-Prager. In addition, all the necessary geometric, power and physical characteristics of the model are obtained on the basis of the current building standards for design.
2. The analysis of the VAT system showed that its strength, rigidity and stability are ensured, and there are reserves: for the metal support - up to 15%, for the foundation - 30%, for the foundation soil - 1%. Therefore, in future studies, it is necessary to consider the optimization problem of choosing an effective constructive support and foundation solution (with the specification of the methodology for their calculation), which may be the basis for filing a patent application or utility model.
3. It is established that the joint work of the rack with the foundation is ensured. The suppleness of conjugation of prisms, of which the foundation is made, did not have a significant effect on the VAT of the system as a whole. Proceeding from the above, it is recommended that a new type of collapsible foundations be used in real conditions.

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