Fiberglass Mobile Supports of Emergency High-Voltage Power Transmission Line

S N Popov¹, Yu Yu Fedorov¹

¹Institute of Oil and Gas Problems of the Siberian Branch of the RAS - Division of Federal Research Centre “The Yakut Scientific Centre of the Siberian Branch of the Russian Academy of Sciences”, Avtodorozhnaya str. 20, Yakutsk, 677007, Russia

E-mail: yuristan@yandex.ru

Abstract. Original designs of mobile supports have been developed to accelerate emergency recovery work on power lines. These designs are characterized by low weight of racks, possibility of rapid installation and dismantling. Supports are proposed to be made of winding or pultruded fiberglass, base of steel to be made of tubular profile or wooden beam. Verticality of racks relative to the ground is provided by spatial hinges. Fixing racks is carried out by stretch marks. It is possible to use specially developed fiberglass reinforced plastics with combined structure, in which the inner layer is made by pultruded technology with second winding layer deposited on its surface, to increase strength characteristics of racks. Combined structure of composite will improve resistance to bending deformations and increase crack resistance. The report provides detailed descriptions of developed designs.

1. Introduction
One of the main reasons of disruption of power supply to settlements and enterprises of Yakutia is numerous failures of power transmission line supports due to biocorrosion of materials and various mechanical damages. The fastest possible elimination of accidents is especially important in the winter period, since with increased duration of repair work, serious consequences due to violation of heat supply are possible.

2. Topicality
Current regulatory and technical documents [1] involve usage of special mobile supports, the design features of which are reduced in weight and do not require the use of special equipment for installation, to speed up the repair work. Power engineers demand possibility of excluding drilling operations to ensure installation work in winter period as one of the requirements for emergency reserve supports.

Meanwhile, overhead installation of power transmission line supports without fixing them in the ground is a very risky technical solution, requiring mandatory consideration of possible wind loads. Even with temporary installation of supports, the use of foundation structures is required, which makes it possible to place heavy weights on them to prevent shear or tipping of supports in strong winds. Most of the Republic of Sakha (Yakutia), except Arctic coastal territories, is related to second region by wind load [2]. Wind speed can reach up to 25 m/s and it is unacceptable to exclude this feature when carrying out repair work of temporary supports. On Arctic coast of Yakutia and islands of the Arctic Ocean, hurricane wind speeds reach 45 m/s.
The analysis of scientific, technical, and patent information shows that various designs of easily assembled power transmission line supports installed on surface foundations are currently developed and are offered in wide assortment [3-6].

Constructions with grillages in form of metal trusses connected to surface foundations and steel racks fixed on them through spatial hinges, fixed with cable ropes, are the most widespread ones. The grillage farms are made in form of separate sections, trunk is made of pipe sections with flange connections [3,4].

The design of support with X-shaped racks proposed in technical solution [5]. Racks are pivotally mounted on surface foundations and interconnected. Fixing support elements among themselves and adjusting their location is carried out by system of flexible connections (cables).

Common drawback of such designs is their sufficient complexity, which negatively affects the convenience of transportation, installation, and dismantling. Sufficiently large weight of individual metal elements increases duration of installation work and necessitates the use of special equipment (truck cranes). In addition, descriptions of structures do not provide for additional use of weights, which limits their performance at high wind loads.

3. Problem statement
It is necessary to continue research on the development of new designs of mobile power transmission line supports that provide higher technical and operational characteristics to accelerate emergency recovery work.

4. Theoretical research. Design of power transmission line supports
IOPG SB RAS also developed technical and technological solutions for creating promising mobile power transmission line supports using fiberglass [7-9] to further simplify designs, improve convenience and speed up installation work. Figure 1 schematically shows the design of fast-mounted support intended for installation on uneven soils, including slopes [7].

![Figure 1. Design scheme of fast-mounted support for lines with voltage of 0.4 – 10kV [7].](image-url)

The support includes rack 1, to the upper part of which legs 3 are pivotally connected by the axes 2. Braces 4 are attached to the bottom of the rack by axes 5. Mutual position of legs and braces is ensured by hose clamps 6. Legs 3 consist of two halves, overlapped by studs with nuts 7 of parts 8 and 9. Depending on unevenness of soil surface 10, legs 3 can change their position relative to braces 4 and...
ensure the verticality of the rack relative to the horizon and tight fit to the ground of all five reference points. Traverse 11 with insulators 12 is attached to the upper part of the rack. Additionally, rack and legs in bases can be equipped with surface foundations and be composed of two parts to reduce transport dimensions. The recommended area of application is power lines with voltage of 0.4 - 6 kV.

Tests of the support revealed drawback that is quite significant for repairmen, which consists in the need to use special car lifts for connecting insulators to electric wires for the convenience of electricians. Although this provision complies with applicable safety standards, it may slow down emergency response work.

In view of the situation described, it is possible to carry out work safely at height in new support construction [8]. Proposed construction of the support is schematically shown in Figure 2. The support by its very nature is ladder for lifting electricians mounted vertically on frame using spatial hinge, formed by pair of rectangular pipes or channels connected to each other.

![Design scheme of fast-mounted support for lines with voltage of 0.4 - 10 kV](image)

**Figure 2.** Design scheme of fast-mounted support for lines with voltage of 0.4 - 10 kV [8].

In the figure shown, support rack contains two channels 1, connected by braces 2 and cross members 3. a traverse 4 with electrical insulators 5 is attached to the upper part of the wall of one of channels. Cross members are attached to channel shelves on one side, and braces are fixed to shelves of the opposite side. Lower parts of channel walls with spatial hinge 6 are connected to longitudinal beams 7 mounted above transverse beams 8. Upper parts of channels are connected to ends of transverse beams of the base by bracing cables 9. The length of bracing cables is regulated by lanyards 10.

It is most rational to make support base of wooden beams to reduce the cost of supports, increase the ease of installation, and simplify manufacturing. It is advisable to use fiberglass for parts of the rack to minimize weight. In this case, the mass of the base will significantly exceed the mass of the rack, which can be installed even without the use of lifting mechanisms by three to four installers manually. In addition, reducing the weight of the rack will help to increase the stability of the support during wind loads, and weights can be placed on base beams.

If necessary, in areas with increased wind load, weights with the required mass are placed on base beams.

The developed support structure is recommended for temporary installation during emergency recovery work on power lines with voltage of 0.4-10 kV.
For power lines with higher level of electrical voltage (35-110 kV), portal intermediate support design is proposed [9], which is shown schematically in Figure 3.

**Figure 3.** The design scheme of mobile support for power transmission line with voltage of 35-110 kV.

The support consists of rectangular base of two pairs of pipes 1. One pair is located along the longitudinal axis of power lines, the second pair is perpendicular. Two pairs of braces 2, interconnected pivotally by axes 3 with upper ends through spacers 4 and lower ends with longitudinal pipes of the base from different sides, form support racks. Racks braces are interconnected by couplers 5 to increase the rigidity. Spacers 4 are made of the same size in width with diameters of longitudinal pipes of the base, which makes it possible to drill holes for hinge axis 3 perpendicular to pipes and simplifies technology for their manufacture. It is advisable for manufacture of supports to use pipes of the same diameter. In this case, spacers 4 can be fixed with their lower ends on parallel braces, and traverse can be attached to upper ends. The location of longitudinal pipes of the base above transverse ones helps to create more convenient conditions for raising racks and provides opportunity to increase distances from ends of braces to axes and, therefore, strength of lower ends of braces. It is possible to install additional supports 6 between pipes and the ground, made in the form of segments of pipes used in the base to exclude possibility of deflection of longitudinal pipes.

It should be noted that in considered structures of power transmission towers for manufacturing of racks, it is planned to use fiberglass profiles obtained by winding or pultrusion technologies [10-13]. Comparison of mechanical properties of fiberglass made using various technologies shows that winding composites are much less resistant to cyclic bending deformations than pultruded ones. The disadvantage of pultruded composites is significant difference between longitudinal and lateral strengths due to the structure of material and unidirectional arrangement of fibers [14-16].

Patent [17] proposed manufacturing technology and construction of fiberglass rack of power transmission line support with combined structure of composite material to reduce these shortcomings. It is proposed that tubular rectangular or round stand be made in the form of two-layer part, in which the inner layer is made using pultrusion technology with axial arrangement of fibers, and the outer one is wound onto the surface of the inner with cross reinforcement.

The inner pultruded layer is characterized by greater resistance to repeated cyclic bending deformations. External winding layer largely eliminates the difference between longitudinal and
transverse strength and provides increased resistance to occurrence of longitudinal cracks. When using the same type of binder in processes of pultrusion and winding, high level of interlayer adhesion is ensured [18]. The ratio of layers thicknesses must be determined by calculation, depending on operating conditions. It is possible to adjust thickness of outer winding layer with its decrease in the upper part to reduce weight of rack and save materials during manufacturing process [19].

Reducing the negative impact of the anisotropic characteristics of pultruded fiberglass, especially at joints of support with base or spatial hinge, can also be achieved by local reinforcement with unidirectional laminate sticker on surface of rack. Laminate is glued so that reinforcing fibers of rack and laminate are mutually perpendicular. Simple method can significantly reduce the risk of cracks in pultruded composite at joints [20].

5. Practical significance
Distinctive feature of developed designs, in addition to traditional ones (minimizing the total weight, compactness during storage and transportation, as well as convenience of installation) is maximum reduction in weight of rack, installation of which is the most time-consuming. At the same time, it is considered that weight of base mounted on soil surface can be relatively large, but the mass of its elements should not exceed allowable load lifting standards established for installers. Steel profiles or wooden beams, pretreated with corrosion and decay agents, providing increased fire resistance, can be used for base parts manufacturing.

6. Conclusions
Original designs of mobile supports for high-voltage power lines designed for usage during emergency recovery operations have been developed. Proposed designs are characterized by reduced weight of racks, which will contribute to acceleration and simplification of installation work. Composites of combined structure, that combine pultruded and winding technologies, have been developed to improve technical characteristics of fiberglass racks used for racks manufacturing.

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