SYSTEM FOR MAINTENANCE AND RECOVERY OF CONTACT NETWORK

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ABSTRACT

The authors analyzed the possibility of using screw piles as the basis of supports of railway catenary system. The efficiency of their use is justified. A multifunctional complex for installation of catenary system's supports is offered. The element of software and hardware system for stabilization and overturn protection of the complex is presented.

Keywords: *screw piles, railway complex, catenary system, support, repair work, construction, stability.*

Background. *More than 50% of all freight traffic and about 77% of suburban passenger transportation in the country [1, 2, etc.] are carried out on electric traction. This fact, as well as a sufficiently high degree of deterioration of existing catenary system (about 27% [3]) cause the urgency of development of high-performance multi-functional railway complexes designed for construction of new electrified sections, as well as maintenance, repair, maintenance in operational condition of existing lines.*

An integral element of electrified railway is its catenary system for transmission of electric energy from traction substations on electric rolling stock. The main elements of the system are supports and support structures erected on foundations or precast piles [4].

When erecting supports on foundations a labor-intensive and lengthy preparation is required, and on precast piles – special construction equipment for piling [3]. This requires closing of a railway haul for a considerable period of time, which undoubtedly is a negative factor for electrification of existing sections or elimination of consequences of accidents and emergencies.

Objective. The objective of the authors is to consider possibility of using screw piles in the framework of catenary system supports.

Methods. *The authors use general scientific and engineering methods, simulation, comparative analysis.*

Results.

1.

In recent years, in industrial and civil construction instead of traditional concrete foundations screw piles are used more often [6]. This pile is a steel pipe, the lower part of which is equipped with cutting blades of a specific shape. The blade can convert a torque into linear force during pile penetration, due to which it as a screw is screwed into the ground to the required depth. The blade also serves to distribute the force of the support on a large ground area and prevents tearing of the pile through frost heaving forces.

Comparative characteristics of screw piles [7] and reinforced concrete piles for vibropiling type TCA [8] (three-fold, with sharpening of an underground part and anchorage of supports) are given in Table 1. A simple analysis of its data indicates that significant advantages of screw piles in comparison with precast piles are speed of installation and ability to screw into tight deep soil. In addition, indicators of their efficiency, reliability (longevity) exceed similar indicators of TCA type piles.

Therefore, the use of screw piles as supports of catenary system on the railway can be very promising. However, this will require development of special devices and machines that automate screwing process. For example, in industrial and civil construction for installation of screw piles different boring and pile-driving machines are used [9, 10], including BM-811, UBM-85 [11], and others.

In addition to direct piling automation of the entire process of current maintenance, repair and restoration of catenary system seems rational. It is known that at the same time the following types of operations are carried out [3–5]: replacement of worn-out supports of catenary system; replacement of failed supports and piles, on which the supports are mounted; replacement of worn contact wire; replacement of suspension cable, fittings, reinforcing wire in case of damage. To implement this complex of operations (installation of piles, replacement of supports, reeling out of the contact wire) it is offered to develop a multifunctional railway complex (Pic. 1)

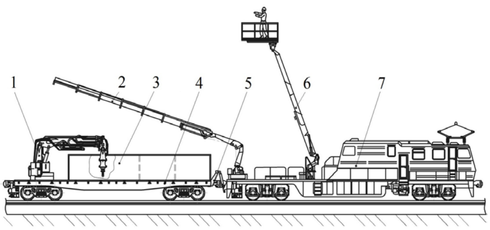
2.

The proposed complex (Pic. 1) consists of two modules: a modernized railcar AKS-01 (7) and non-self-propelled platform (4) on the basis of the cargo four-axis platform 13–401 with carrying capacity of 63 tons.

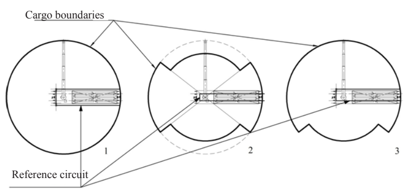
Table 1

Comparative characteristics of screw and reinforced concrete piles

Indicator	Screw piles [7]	Piles for vibropiling TCA type [8]
Depth of screwing, m	4,5	4,5
Weight of working equipment, t	1,5	2,0
Bearing capacity F_d, kN	72,6	79
Car norm, pcs.	40	16(24)
Driving force of vibratory pile-driver F_o^T,kN	–	10
Maximum torque, kN · m	50	–
Speed of vibro pile-driving, cm/min	–	15
Time of pile-driving, min	5	20
Season of works	Any time of a year	Summer season
Cost of pile, rub.	800	2000
Service life, years	100	50



Pic. 1. Multifunctional complex: 1 – universal boring machine UBM 85; 2 – manipulator TIRRE; 3 – open container; 4 – non-self-propelled platform; 5 – outriggers; 6 – lifting and rotating platform; 7 – railcar AKS-01.



Pic. 2. Options for installation of supports: 1 – supports are installed on both sides; 2 –supports are not installed; 3 – supports are installed only on the working side.

The railcar has a frame that rests on bogies. From below to the frame using power structures are suspended: traction electric motor of bogie's drive; outriggers; from two ends of the frame – track cleaners; pipe lines, electrical, pneumatic and hydraulic equipment. At one end of the frame a cargo platform is equipped, where manipulating equipment TIRRE (2) for installation of catenary system supports and lifting and rotating platform (6) are mounted. The manipulator is needed to serve the cargo platform of the complex and to supply consumables in the work zone. Under the passenger cabin in a special unit of the frame of the railcar between its carrying belts a diesel generator is installed for power supply of the traction motor ED-118AU2 and supply all AKC-01 systems with AC. On the roof of the body current collector and an antenna of safety system are placed. Under the frame there are outriggers to stabilize the railcar's frame and to unload springs while the manipulator is working.

On non- self-propelled platform (4) are located a universal drilling machine UBM-85 (1) for screwing piles for catenary system's supports and an open container to transport supports (3). On the machine a place is designed for fastening interchangeable equipment, that allows a quick change of the working body in accordance with the operation performed; for example, when replacing supports of catenary system it is possible to suspend drilling equipment, and when replacing sleepers on the rail-sleeper grid – equipment for replacement and tamping of sleepers.

The complex allows to carry out not only work on replacement of sleepers, but also delivery of sleepers and supplies to the place of technological operations, supply of sleepers and consumables in the area of the working body, producing all the necessary manipulations. To do this, instead of self-propelled platform (4) to the railcar non-propelled module to transport sleepers and supplies should be fastened, on which an articulated crane without outriggers will be installed for unloading of new sleepers and loading of old ones.

3.

When designing the complex, one of the main problems to be solved is stabilization and preservation of stability in the work of the manipulator. Installed in UBM-85 zone outriggers (5) and a rigid blocking of the platform and the railcar are required to increase the reference circuit and improve stability of the complex when mounting piles. According to [12] articulated cranes should be stable in operation, it is unacceptable to replace cargo which is in an unstable position.

Stability of articulated crane systems is checked through the calculation, in which on the basis of the reference circuit, load and mass characteristics of the elements are defined overturning and stabilizing moments. Stabilizing moment must be greater than the overturning by at least 15%. If this condition is not satisfied, then it is necessary to change the reference circuit (installation of outriggers) or limit on cargo loads. In this complex the railcar AKS-01 when the manipulator TIRRE (2) operates is affected by the overturning moment from the weight of the boom and cargo on its end, and stabilizing moment is the weight of the railcar itself.

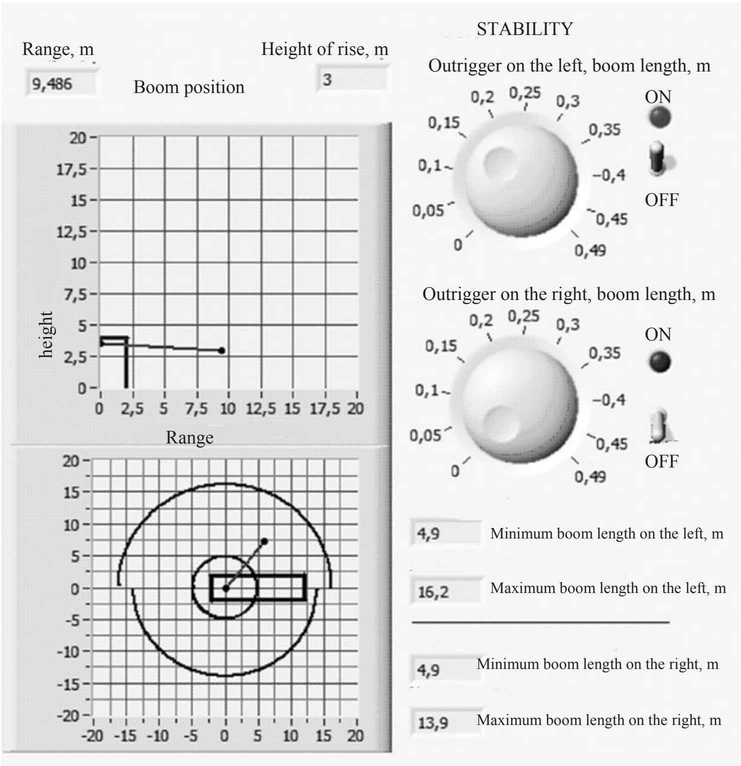
In modern automobile crane-manipulator installations electronic stabilization systems of stability and control are used [13]. With the stabilization system the control unit implements load moment limitation based on the current reference circuit (Pic. 2). After installing the crane on supports the stability control system defines cargo boundaries (case 1). As a result, the manipulator can operate with not fully forward based (case 3) or not forward based (case 2) support beams.

Maximum carrying capacity of crane-manipulator can be realized only when the vehicle is installed on fully forward based outriggers. If it is impossible, for example due to slope, trench or closely located second track, then the crane-manipulator is still functioning, but at a lower carrying capacity, even supports are absent at all. Changing the reference circuit boundaries should be carried out only in the transport position, to avoid overturn of the platform.

Similar systems can be used on manipulators mounted on railway platforms. It is proposed to analyze stability in real-time depending on indications of load sensors on the equipment using software developed in the environment LabVIEW, a part of the front panel of which is shown in Pic. 3. The input data are current values of the mass of railcars and the mass of the boom group, file with the compliance table of ultimate carrying capacity, load, boom length, angle of slope and rotation angle of the boom.

The program receives information from sensors mounted on the railcar (weight of elements, boom length, weight of load on the boom, availability of supports and their length), calculates stability, determines cargo boundaries and if they are exceeded, transmits a warning signal to the operator panel and limits the manipulator's operation. The process is in real time, information from sensors is constantly analyzed, that nullifies the chance of overturn in violation of freight limits by the operator. The program is able to reduce the time of preparation of the manipulator to work due to the possibility of carrying out operations with light loads over short distances (within the calculated freight boundaries) without installing supports.

Conclusion. The use of a multifunctional complex will reduce the time for closing of a railway haul and



Pic. 3. Part of the front panel of the device of electronic stabilization system.

reduce the amount of track equipment in carrying out the necessary work, especially related to elimination of consequences of accidents or crash of rolling stock.

Efficiency and mobility of the proposed complex, multifunctional equipment installed on the railcar, provide not only repair and construction, but also inspection and diagnostic work, current inspection of a catenary system, and if necessary repair of rail-sleeper grid.

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