

Diagnostics of the Roadbed

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Abstract— The article deals with the scientific direction related to determining the actual state of the roadbed. Also with periodic monitoring of the roadbed during the operation of the railway track. And diagnostics of the roadbed is a system consisting of a set of interrelated elements. The economic effect of using a geophysical diagnostic system is due to the faster removal of the speed limit for trains.

Keywords— Railway Track, Roadbed, Diagnostics, Train Traffic, Geophysical System.

I. INTRODUCTION

Scientific direction related to determining the actual state of the roadbed, qualitative and quantitative assessment of changes occurring in it under the influence of dynamic train loads and the influence of natural and climatic factors, as well as periodic monitoring of the roadbed during the operation of the railway track, diagnostics of the roadbed is a system consisting of a set of interrelated elements. It includes: objects of research; methods and technical means of diagnostics; classification of diagnostic features (criteria for recognizing deformations); specially trained personnel who interact with the object of diagnosis according to the rules established by the relevant regulatory and methodological documentation; conclusion about the technical condition of the object with justification for its further operation or suggestions for taking urgent measures to strengthen it [1].

From the diagnostic point of view, the operated roadbed is divided into the following categories: category I – emergency roadbed, i.e. there are areas where major deformations have occurred and the movement of trains has been stopped (for example, alloys of slopes, destruction of embankments, karst sinkholes). In this case, there is an urgent

restoration of the roadbed and at the same time, a survey is performed not only of the destroyed section, but also of the adjacent sections of the roadbed; Category II-operated sections with detected deformations of the roadbed, which are subject to warnings about limiting train speeds; category III-sections of the roadbed, located in difficult engineering and geological conditions, therefore requiring increased attention due to the possibility of manifestation of deformations on them (areas of karst, swamps, landslides, permafrost); category IV-high mounds of clay soils, which are usually potentially unreliable; Category V is a stable roadbed, but its condition must be evaluated when setting the timing of track repairs.

II. MATERIAL AND METHODS

Depending on the category of the condition of the roadbed and operational conditions, diagnostic studies of the roadbed (the study of signs that characterize its technical condition) are divided into detailed, reconnaissance (preliminary) and regime studies. Detailed diagnostics is carried out on the objects of the roadbed with already detected or obvious signs of deformation (I, II, III categories) and aims to obtain initial data for the development of measures to strengthen the

roadbed. Reconnaissance diagnostics is performed for the purpose of preliminary assessment of the object's condition and determining the need for further detailed examination (category III, IV and V). Routine diagnostics of the object (monitoring of its technical condition) is carried out periodically during the operation of the path to identify abnormal and doubtful sections (in the future they are examined in detail) and determine the timing and order of repair work. They apply to all categories of roadbed, but above all to categories IV and V. The diagnostic system contains traditional and new methods based on various physical principles (geophysical methods), and specially designed mobile diagnostic systems[2].

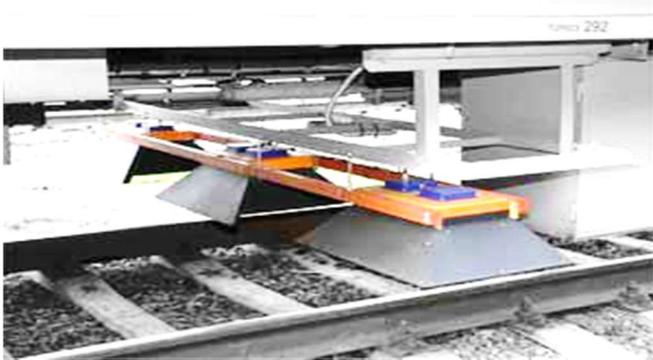


Fig.1. Application of GPR In Railways.

Traditional methods include operational observations (visual inspection, track alignment, measurements of ground mass displacements by beacons and marks, checking the position and growth of cracks); geodetic methods (levelling at the points of gates and rail heads, checking the track shift, shooting transverse and longitudinal profiles of the roadbed); engineering and geological methods (drilling wells, construction of pits, slots, clearing, soil sampling and laboratory tests to determine the physical and mechanical properties). In some cases, special mechanical methods of testing soils in the array are used.

Methods of operational observations and geodetic methods characterize the external signs of deformation; engineering and geological methods determine the internal structure and condition of the soil of the roadbed; mechanical methods allow us to assess the strength characteristics of soils in the massif without sampling. Using only traditional methods and the existing rates of their use, the problem of timely detection of dangerous sections of the roadbed for train traffic cannot be solved in the next decade.

Geophysical methods are the basis of the modern system of diagnostics of the earth bed, based on the study of patterns of changes in various physical fields in the soil of the earth bed, depending on their composition, properties and condition. Physical fields in the roadbed can arise from the direct effects of direct or alternating electric current through electrodes hammered into the ground (electrometric method); from the impact of shock loads (for example, a hammer) on

the ground (seismic method); from a moving train (vibration method); from the radiation of electromagnetic high-frequency probing signals (radar method). The basic scheme of application of geophysical methods is as follows: excitation of physical fields in the groundbed reception and conversion of response signals (system response) registration of signals by measuring equipment automated system for processing the received information interpretation and engineering-geological interpretation of diagnostic results. Geophysical methods are usually used in conjunction with a small amount of control drilling (usually 10-15% of the total amount of drilling performed in a traditional survey), which is necessary for a more reliable interpretation and engineering-geological interpretation of the data obtained. Below is a brief description of the geophysical methods that are used in the diagnosis of the roadbed.

The electrometric method using profiling and vertical sensing allows detecting deformations of the main site in the form of ballast depressions and moistened soil zones; determining karst cavities; estimating the amount of embankment precipitation in swamps; identifying the boundaries of frozen soils in the body of embankments and their base, as well as solving a number of other tasks. Along with electrical measurements using profiling and probing techniques, when measurements are made on the surface of the roadbed, a modification of the electrometric method - electrodynamic probing (EDS) - has been developed. The essence of the EDZ is that a metal probe consisting of several interconnected pipes is hammered into the soil array at the depth being studied by the blows of the reference load. As the probe dives into the ground at certain intervals, the depth of the current passed into the ground through the electrodes at the end of the probe is measured. The EDS method allows you to obtain not only a lithological section of the roadbed, but also data on the strength characteristics of sand and clay soils to a depth of about 5-7 m.

The seismic method in modification of profiling, longitudinal (along the path) and circular (on the slopes of embankments) sounding, x-ray (seismotomography) of the body of the embankment from opposite slopes allows solving the vast majority of problems that occur in all types of diagnostic studies of the earth bed. Among them, detailed studies of the internal structure of the roadbed, determination of water saturated zones in the embankments and the level of ground water at their base, assessment of soil properties and determination of weakened strength zones in the embankments and their base; survey of the roadbed operated in difficult engineering and geological conditions.

The vibration method is developed for the diagnosis of embankments, which are considered as a system that converts the input dynamic effect in the form of a train load into an output response (system response), for example, in time-varying oscillatory processes. A certain state of the operated embankment corresponds to a group of features that appear as different parameters of oscillations. As a result of research

on reference objects of the roadbed, a classification of diagnostic features for various types of deformations was developed. A significant advantage of this method is the ability to assess the dynamic state of the embankment during its operation, i.e. during the impact of the rolling stock. The vibration method is used for reconnaissance diagnostics of embankments with the identification of anomalous objects; for monitoring the condition of embankments during the operation of railway tracks in the year-round cycle in order to predict their condition, including the organization of high-speed passenger trains; to detect embankments that are prone to sudden emergency deformations during the movement of the rolling stock.

The radar method is based on the use of short electromagnetic signals emitted by the radio transmitter that penetrate the ground through the transmitting antenna. Reflecting from layers of soil that have different electromagnetic properties, signals with information about the state of the environment are picked up by the receiving antenna. The echo depth of the reflecting contact is determined by the delay time between the probing and reflected signals (t) and the propagation speed of radio waves (v): $h=v*t/2$. The rate of propagation of radio waves depends on the dielectric permittivity of the soil (ϵ). The difference in ϵ values for different soils allows you to determine the boundaries between the layers of soil in the roadbed and detect various inhomogeneities. The radar method is characterized by high resolution, technology and high technical and economic indicators. This is due to the possibility of continuous non-contact measurements using the vehicle. To survey a relatively small extent of the plots is used for moving track radar complex "Geodirectory", created on the basis of the GPR (vehicle type defectoscopic bogie) and other accessories. The Geodefektoscope measuring system is designed to assess the state of the upper part of the roadbed at depths of 1.5-2 m with reference to specific pickets. Objectives: the identification of ballast recesses in the main site, the definition of the boundaries of the freezing and thawing of the soil, the allocation of plots with the ballast splashes etc. Measurements are performed continuously along the length of the path with the speed of movement of the operator 3-4 km/h is possible in principle, the location of the GPR system in the car potismedicine and receive comprehensive information on the diagnosed parameters of track structure and subgrade.

Methods of engineering analysis and computer processing of data are used in the diagnosis of the roadbed at the stage of reconnaissance surveys or monitoring the technical condition of the path for processing track measuring tapes. The technology of testing by special mobile complexes with reference loads is also used (for example, LIGO structures of NPF "Spetsmash"), which allow to assess the quality of the sub-rail base and identify potentially dangerous areas where detailed diagnostic studies need to be organized [three].

III. RESULTS

The modern system of diagnosis of the subgrade allows for the basis of assessment of its actual technical condition to substantiate the order and to set the dates of repair and reinforcement fabrics; to provide increased security of trains, which is achieved timely identification of damaged areas; to create safe working conditions on the paths personnel, as in the application of geophysical methods using a portable handheld apparatus, and a measurement is performed outside of the envelope approximation buildings.

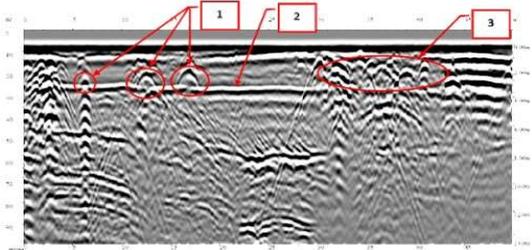


Fig-2. Detection of a fault in the roadbed.

During the production of works, the train schedule is not violated and the provision of technological "Windows" is not required.

IV. CONCLUSION

The economic effect of using a geophysical diagnostic system is due to the faster removal of the speed limit for trains when passing deformed sections (restrictions are removed after work on strengthening the roadbed); the exception of interruptions in train traffic due to timely prevention of sudden destruction of high embankments and the occurrence of karst failures near the track; significant reduction of expensive and time-consuming exploration work.

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