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THE RESULTS OF THE DEFECT PLACES INVESTIGATION OF DONETSK RAILWAY ROAD BED BY GROUND PENETRATING RADAR COMPLEX

Purpose. Defective places definition of road bed at ground penetrating radar is examined. **Methodology.** For achievement of this goal the experimental research on ground penetrating radar inspection of road bed defective places of the Donetsk Railway, which are caused by a complex of various reasons of geotechnical and constructive character, were conducted. **Findings.** According to these diagnostic results of road bed on the three districts of the Donetsk Railway is revealed the main causes which lead to the defects appearance, deformities and injuries in it, there is abuse of process parameters and modify its physic mechanical soil properties of natural and technology-related factors. As it is established, the use of ground penetrating radar of series “Losa” on the railways of Ukraine allows searching ballast tank in the body of road bed, defining damp places in soil road bed and foundations, to find arrangement of foreign matter in the soil road bed and work search heterogeneity and places weakening soil. In addition, the use of ground penetrating radar provides rapid detection of defects, deformation and damage of railway track, especially in areas the most dangerous for rolling stock that creates the high level security at the main and auxiliary lines of Ukrzaliznytsia. In conducting the research was justified the high level of reliability and performance with autonomous use of ground penetrating radar. **Originality.** In modern conditions of defects determination, deformations and damages by traditional methods with application of engineering-geological investigations, it is impossible in connection with their insufficient efficiency. Therefore the using of highly effective methodology of expeditious tool identification of defective places allows reducing significantly the periods of repair of a railway track which is very important for introduction of the high-speed movement on the Ukrainian Railways. **Practical value.** On the basis of the executed investigations the main actions for defects elimination, deformations and damages which consist in the device of counter dams, the draining sections, the augercast and augured piles are offered.

Keywords: road bed; defect places; embankment; ballast stone; ballast section; counter dam; ground penetrating radar

Introduction

The practice of construction and reconstruction of a railway track introduced essential amendments in the device instrument definitions of defective places of a road bed on the different railways of Ukraine in recent years. Such places can bring to dangerous processes with accidents and smash ups and to cause the organization of special windows

for repair of the damaged railway superstructure and the road bed of the railways. As a result, it is significantly complicated the operation of the track especially for high-speed train.

In this regard, the development of scientific fundamentals and practical provisions sensing arrays soil road bed, which are the most manifest of various defects, is actual scientific and technical challenge.

Current state of the question

Due to the distribution of “sick” places in a road bed on the railways of Ukraine much attention is paid to their studying. The known scientists of Germany, France, the USA, Russia, Sweden, Canada and other states such as S. A. Lengren, I. Bergstrum, B. Erson, I. Simon, M. N. Parti, C. Coma, S. D. Bernsday, M. R. Clark, K. I. Broukhton, M. K. Ford, T. Saarenketo, A. M. Kulizhnikov, N. A. Lush Nicknames, A. A. Belozarov, G. A. Safonova, M. A. Shabashova, E. S. Ashpiz and others, were conducted many researches for the purpose of their definition and classification. Performance of inspection of the road bed by means of geophysical instruments was the main goal of the majority of works [1-9, 11-25].

The studies of the road bed defects on the running lines such as Naddvirna – Dilyatin, Khryplyn – Dilyatin, Pidvolochynsk – Ternopil and L’viv – Krasne of L’viv Railway by means of using the ground penetrating radar “Loza-V” were provided by the authors of the given work [9-10]. While probing stations of road bed were found softening of ground and waterlogged soil, resulting in subsidence of the main area of the road bed. For another thing, were found ballast bezel, subsidence of counter dam running bridge and other defective places. The ant deformation measures, which is consisting in onboard cut-out and dumping of counter dam, creation of a ditch drainage with production of water in constructions which are on sites were offered.

The ground penetrating radars of series “Loza” of Russian production for sounding “sick” places of the road bed on the railways is widespread in recent years in Ukraine. The given ground penetrating radars belong to the class of geophysical instruments for survey of subsurface structure road bed soil at depths of 10-15 meters or more depending on the model, antennas which were used and receiving facilities and environmental parameters that sounding. The principle of ground penetrating radar’s operation is based on radiated emission to broadband electromagnetic pulses and recording their reflections from the boundaries of soil layers sections or objects elements. Exploitation of ground penetrating radar of series “Losa-B” on the railways of Ukraine is effective in solving of the following tasks:

- searching in the roadbed body of the ballast tank and gun-stocks;

- definition of damp places in soil;
- search for foreign objects in the ground and the places of its relaxation.

Purpose

To identify the defective places definition of the road bed at ground penetrating radar’s inspection.

Methodology

For achievement of the given goal, the pilot studies at ground penetrating radar’s inspection of road bed defective places of the Donetsk railway, which are caused by the complex of various reasons of geotechnical and constructive character, were conducted.

Findings

According to these survey of road bed on the three Donetsk railway stations is revealed, that the main causes that lead to the appearance of defects, deformities and injuries in it, there is a trouble of process parameters of its design and modify the physical and mechanical properties of the soil by natural and man-made factors. As it is established, the use of ground penetrating radar of series “Losa” on the railways of Ukraine allows searching in the body of the road bed ballast tanks, defining watery places in soil of road bed and foundations, to find the location of foreign matter in the soil road bed and search of irregularities and places of soil weakening.

Originality and practical value

In the modern conditions of defects determination, deformations and damages by traditional methods using engineering-geological researches it is impossible in connection with their insufficient efficiency. Therefore, the using of highly effective methodology of operational instrumental detection of the defective places allows reducing significantly the periods of the track repair that is very important for implementation of high-speed movement on the railways of Ukraine.

On the basis of the executed investigations the main actions for defects elimination, deformations and damages which consist in the device of counter dams, the draining sections, the auger cast and augured piles are offered.

Statement of the main material

The survey of the road bed and establishment of “sick” places was carried out by line service experts of the Donetsk railway on 23 km of the section Ocheretne-Gorlivka, 962 km of the section Svatove-Popasnaya and 18 km of Ocheretne-Gorlivka.

The defective place on a site 23 km Ocheretne-Gorlivka located on mounds up to 18 m, built in 1901–1903. This section concluded odd track welded on concrete sleepers with rails type R65 on crushed stone ballast and steam gauge-sectional, on wooden sleepers with rails type R65 and crushed stone ballast. On the whole area of the longitudinal profile should rise.

The defective place is divided by pipeline at 23 km (PK3 + 61) and by the bridge at 23 km (PK6 + 15). On this section of track length 254 m were anti deformation measures by means of one stage counter dam on both sides of the embankment over 150 m and 200 m from even side and 200 m – odd side. However, according to the passport PU-9 since 2002 to present time at the “sick” place observed subsidence track.

On-site inspection of the road bed status showed that on the odd side the angle of slope embankment is oversized, the outside of the track makes 2.0-2.40 m, slopes and counter dams shelves aren't created, slopes are cluttered by hard stone, on the approaches to bridges the track has a hollow, in case of cable laying integrity counter dam is broken.

From the even side such defects were marked:

- the outside of the track makes 1.5-2.0 m;
- the ballast section is oversized on 0.40-0.80 m;
- the angle of slope embankment is oversized;
- on the track the ballast is clogged with clay soils, the outside of the track isn't cut off from the polluted ballast, in the period of rains surges are carried out that also testifies to existence of ballast dimples;

– slopes blockage by work-out hard-stone.

For all measurements of ground penetrating radar soil embankment was presented by moist clay loam. At work with the ground penetrating radar was used the following modes:

- type of pass – longitudinal shooting;
- step of each frame passage 50 sm;
- measurement mode is manual;
- mode of wave forms - logarithmic;

– processing of the data – by the program “KROT”.

Considering that the “sick” place is divided by the overpass and the bridge, shooting was carried out on sections by length 56 m, 173 m and 188 m between pickets of PK2 + 75-PK7 + 60 (full length makes 485m).

In processing data of shooting by means of the program “KROT” were found ballast tanks (hollows) gun-stock, heterogeneity and instability of the embankment soil and moisture accumulation. This ballast hollows were filled with water to the depth of 1,1m from the surface within 35 m from the bridge with the largest accumulation of moisture on the approaches to it. Also was determined the presence of ballast gun-stocks at a depth of 1 m, subsidence of body of railroad over 53 m, violating the integrity of the structure of road bed within 50 m and its subsidence over a length of 80 m.

As it is set the basic reasons which lead to appearance of the road bed defects on 23 km Ocheretne-Gorlovka is the following:

- badly organized collection and lead out of a surface water;
- blockage of slopes by work-out hard stone by execution of track operations;
- width of the sub ballast is insufficient for placement of the ballast section;
- low-quality cutting of old suitable soils from the outside of the track by execution of track operations;
- increasing the thickness of ballast layer when changing the ballast for heavier types.

To eliminate the specified defects, it is necessary to execute the following:

- to provide the water drainage from the base of a road bed and the sub ballast;
- to dump slopes of the embankment;
- to lower the level of the rack head;
- in case of ballast depressions drain drainage board cuts or tenderloin cluttered ground;
- to bring slopes and counter dams shelves into the appropriate status in case of calculation of the embankment on stability.

The main recommendations about design consist in the following. Design the anti deformation actions of the road bed shall provide:

- continuity and traffic safety of trains at execution of construction works;
- the design decisions on the placement of road bed should provide the most complete of its use;

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– high stability, durability and normal operation of the road bed after its reconstruction;

– the execution of all operations with a maximum level of mechanization.

“Sick” place on 962 km of the section of Svato-Popasnaya it is located on an embankment up to 32 m high, constructed in 1895. On this section are concluded odd and even track from link segments on wooden cross ties with rails of the P 65 type on a crushed-stone ballast. On all section the longitudinal profile had rise. For elimination of defects of a track the following anti deformation actions were executed:

– the dumping one-step counter dam from the odd side is on length of 200 m;

– the dumping of two-stage counter dams on the even side on length of 170 m;

– the device of draining sections from bored piles on the even side at the bottom of counter dams.

According to PU-9 passport embankment is located out of a slope but if to consider a difference between embankment heights from both sides, an embankment the odd side less conjugate has the embankment that testifies that the embankment is on a slope. The execution the anti deformation measures in last years on this object didn't give any result in stability of the road bed and track. Therefore on-site investigation of its status showed the following. From the odd side the gradient of the embankment is oversize, the outside of the track makes 2.0 m, slopes and the shelf of the counter dams which aren't created slopes blockage by work out hard stone, on PK4 the track has a hollow, at the bottom of an embankment the vegetation that testifies about remoistening of a road bed and bad lead out of a surface water from an embankment is marked hygrophilous, the drainage system from dredging is absent.

From the even side it was marked. that the roadside makes 1.5-2.0 m, on the way the ballast is clogged with splashes of clay soil on approaches to an embankment and on an output from dredging, testifies to existence of ballast dimples, the drainage system from dredging is absent, slopes blockage by work-out hard stone.

During the work with a georadar earlier specified modes were applied. At shooting data processing by means of the “Krot” program the same defects as well as on 23 km at section Ocheretinoe-Gorlovka were found. Furthermore, it was estab-

lished irrigation areas of the soil mass of counter dam length of 40 m on the depth of 1.0 m to the ground surface, the accumulation of moisture and unstable of road bed length is 20 m, rich moist soil subsidence over a length of 140 m and the presence of foreign objects on the station distance PK 2, 3, 6 at depths 2-7 m from the ground surface.

The main reasons which are resulted in defects of a road bed on 962 km, except specified for 23 km, the following is:

– the lack of drainage systems at the exit from dredging;

– the low-quality off take superficial riding party of a slope;

– the blocking up and insufficient depth of mountain ditches;

– the dumping of an embankment from low-quality soils developed near the located dredging.

To eliminate the specified defects, it is necessary to implement the same recommendations about technology of works as well as on 23 km of site Ocheretne-Gorlovka, and on design of their implementation. “Sick” place on 18 km of the section Ocheretne-Gorlovka it is located on an embankment height to 17,3 m, constructed in 1903 and it is reconstructed in 1966. On this site it is concluded a joint less track on ferroconcrete cross ties with rails of the P65 type and a crushed-stone ballast. On all site the longitudinal cross-section has descent. In 1991-1992 from both parties of an embankment on length of 150 m of one-stage counter dams were poured out. According to PU-9 passport since 1998 to the present time on “sick” place track sagging is watched. On-site investigation of a status of a road bed showed that on the odd side the steepness of the slope of the embankment is oversize, the roadside makes 1.2-2.40 m, slopes and shelves of the counter dams not created, on slopes of the counter dams the vegetation that testifies to availability of moisture in a body of a counter banquet is hygrophilous, water conducting pipes on an input is shielded, the rainwater catchment isn't created on a bottom. From the even side it was marked that the outside of the track makes 0.6-1.0 m, and in curve part of track a roadside of a road bed is absent, the ballast section is oversized on 0.4-0.6 m, the steepness of a slope of an embankment is also oversized, on the shelf counter dams of a crack have disclosures 0.2-0.7 cm, on an output from a pipe the course and the appropriate ditch silted between the left wall of a day off the

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crown of tube and a body of a road bed is pockets with a source output.

By operation with a georadar the modes specified earlier were applied to determination of defects. In case of shooting data handling the “Krot” program revealed the same mains defect as well as on 23 km and 962 km.

The basic reasons leading to appearance of defects of the road bed and the recommendation about elimination of shortcomings and the main recommendations about design against deformation actions on 18 km similar which are found and offered for 23 km the section Ocheretne-Gorlovka.

Thus, georadar application in case of survey of sections of a “sick” road bed of a track allows refusing the device of labor-consuming prospecting apertures first of all.

Conclusions

According to these survey and research road bed on three areas of Donetsk railway to the following conclusions:

– the basic reasons of defects origin and “sick” places of the road bed on the railways of Ukraine including Donetsk railway, violation of technological parameters of its construction and change of physic and mechanical properties of soil under the influence of natural and technogenic factors is;

– the application of the georadar of the “Loza” series on the railways of Ukraine allows to solve a number of tasks:

1) to carry out the search in a body of a road bed of ballast tanks and gun-stocks;

2) to define the wet places in soils of a road bed and the bases;

3) to find locations of outside objects in soil of a road bed;

4) to run for search of non-uniformity and places of weakening of the soil.

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РЕЗУЛЬТАТИ ОБСТЕЖЕННЯ ГЕОРАДАРНИМ КОМПЛЕКСОМ ДЕФЕКТНИХ МІСЦЬ ЗЕМЛЯНОГО ПОЛОТНА ДОНЕЦЬКОЇ ЗАЛІЗНИЦІ

Мета. Основною метою роботи є встановлення дефектних місць земляного полотна при геодарному обстеженні. **Методика.** Для досягнення поставленої мети були проведені експериментальні дослідження по геодарному обстеженню дефектних місць земляного полотна Донецької залізниці, які обумовлені комплексом різноманітних причин геотехнічного і конструктивного характеру. **Результати.** Згідно з наведеними результатами обстеження земляного полотна на трьох дільницях Донецької залізниці виявлено, що основними причинами, що призводять до появи дефектів, деформацій та пошкоджень у ньому, є порушення технологічних параметрів його конструкції та змінення фізико-механічних властивостей ґрунту під впливом природних та техногенних факторів. Як встановлено, застосування георадарів серії «Лоза» на залізницях України дозволяє провести пошук в тілі земляного полотна баластових корит, визначити вологі місця в ґрунтах земляного полотна та основ, знаходити місця розташування сторонніх об'єктів в ґрунті земляного полотна і робити пошук неоднорідності та місць ослаблення ґрунту. Крім того, використання георадарів забезпечує оперативне виявлення дефектів, деформацій та пошкоджень залізничної колії,

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особливо в місцях найбільш небезпечних для рухомого складу залізниць, що призводить до створення високого рівня безпеки на головних та допоміжних лініях Укрзалізниці. При проведенні досліджень був обґрунтований високий рівень надійності та ефективності роботи георадарів з автономним застосуванням.

Наукова новизна. В сучасних умовах визначення дефектів, деформацій та пошкоджень традиційними методами із застосуванням інженерно-геологічних досліджень неможливе в зв'язку з їх недостатньою оперативністю. Тому використання високоефективної методології оперативного інструментального виявлення дефектних місць дозволяє суттєво скорочувати періоди ремонту залізничної колії, що дуже важливо для впровадження швидкісного руху на залізницях України. **Практична значимість.** На основі виконаних досліджень запропоновані головні заходи по усуненню дефектів, деформацій та пошкоджень, які полягають у влаштуванні контрбанкетів, дренажних перерізів, буроін'єкційних або буронабивних паль.

Ключові слова: земляне полотно; дефектні місця; насип; баласт щебеневий; баластна призма; контрбанкети; георадар

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РЕЗУЛЬТАТЫ ОБСЛЕДОВАНИЯ ГЕОРАДАРНЫМ КОМПЛЕКСОМ ДЕФЕКТНЫХ МЕСТ ЗЕМЛЯНОГО ПОЛОТНА ДОНЕЦКОЙ ЖЕЛЕЗНОЙ ДОРОГИ

Цель. Основная цель работы – определение дефектных мест земляного полотна при георадарном обследовании. **Методика.** Для достижения поставленной цели были проведены экспериментальные исследования по георадарному обследованию дефектных мест земляного полотна Донецкой железной дороги, которые обусловлены комплексом разнообразных причин геотехнического и конструктивного характера. **Результаты.** Согласно с приведёнными результатами обследования земляного полотна на трёх участках Донецкой железной дороги обнаружено, что основными причинами, которые приводят к появлению дефектов, деформаций и повреждений в нём, являются нарушения технологических параметров его конструкции и изменения физико-механических свойств грунта под влиянием естественных и техногенных факторов. Как установлено, применение георадаров серии «Лоза» на железных дорогах Украины позволяет провести поиск в теле земляного полотна балластовых корыт, определить влажные места в грунтах земляного полотна и оснований, находить места размещения посторонних объектов в грунте земляного полотна и производить поиск неоднородностей и мест ослабления грунта. Кроме того, использование георадаров обеспечивает оперативное выявление дефектов, деформаций и повреждений железнодорожного пути, особенно в местах наиболее опасных для подвижного состава железных дорог, что приводит к созданию высокого уровня безопасности на главных и вспомогательных линиях Укрзалізниці. При проведении исследований был обоснован высокий уровень надёжности и эффективности работы георадаров с автономным применением. **Научная новизна.** В современных условиях определение дефектов, деформаций и повреждений традиционными методами с использованием инженерно-геологических изысканий невозможно в связи с их недостаточной оперативностью. Поэтому использование высокоэффективной методологии оперативного инструментального определения дефектных мест разрешает существенно сокращать периоды ремонта железнодорожной колеи, что является важным для внедрения скоростного движения на железных дорогах Украины. **Практическая значимость.** На основании проведенных исследований предложены главные мероприятия по устранению дефектов, деформаций и повреждений, которые состоят в устройстве контрбанкетов, дренажных сечений, буроин'єкционных или буронабивных свай.

Ключевые слова: земляное полотно; дефектные места; насыпь; балласт щебеночный; балластная призма; контрбанкеты; георадар

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