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NEW TYPES OF CULVERTS ON THE RAILWAY TRACK

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Abstract: This article discusses new types of culverts are one of the most numerous categories of artificial structures on roads of both regional significance. These engineering structures are located in the body of the embankment of the road or railway and provide a safe drainage of water entering the roadbed. Thanks to culverts, the road drainage system provides a constant favorable humidity regime of the ground bases of road clothes and prevents the erosion of the road embankment.

In modern road construction, the most common are two types of culverts: made of corrugated metal and reinforced concrete from prefabricated elements. To increase throughput without increasing the height of the embankment, multi-point pipes are arranged from small pipes laid next to each other.

Key words: Artificial structures, waterproofing pipes, small bridges, reinforced concrete, concrete and iron pipes.

Introductions. Development of the country's economy, increase in export potential and the role of Railways in the supply of goods to consumers is incomparable. It is no accident that the railways are called the blood vessels of the country's economy it is not. Reforms carried out on the Railways of Uzbekistan sharply increase the load carrying capacity of Express Railways and passenger trains are aimed at raising the speed. Therefore, the design of rail repair in operation a great axamity is earned [1.2.3.4]. In addition, the waterproofing pipes on the railway are the most common artificial structures. Culverts located under the road are something of an alternative to bridges, so if there is no need for the latter, you can use this replacement. In addition, in some situations, it is simply not possible to build a bridge – for example, if the road is located too low [5.6.7.8.9.10].

The design of a culvert is a channel that passes through a road embankment. For the construction of a culvert, pipes of such a diameter are used that it is sufficient to transport a large volume of atmospheric precipitation. In addition, such pipes are often used in the creation of large drainage systems and underground passages. This article will focus on culverts and their application features [11.12.13.14].

In the modern market of building materials, culverts are represented in a very diverse way. The main parameter by which such pipes are classified is the material of manufacture.

According to this method of classification, the following types of culverts are distinguished:

- Reinforced concrete;
- Plastic;
- Metal corrugated.

Each material has its own characteristics. One of the main advantages of reinforced concrete structures for water drainage is the ability to create them in the place where they will be installed. The construction process in this case involves the installation of reinforced formwork, which will be filled with a concrete solution.

Figure-1. Reinforced concrete structures for water drainage.

The quality described above can be called quite useful, but it has a serious drawback – a reinforced concrete culvert under the road is installed for a very long time. Of course, there is a solution to this problem, which is to purchase ready-made reinforced concrete structures and deliver them to the installation site. The main quality of such material is its ability to withstand the influence of various external factors.

Various options of polymer products for the arrangement of culverts are a good solution. Plastic pipes withstand external loads well, but for this purpose they have to be further strengthened with the help of a concrete arch, which is filled along the outer edge of the pipe, and the weak resistance of concrete to ground movement in this case does not matter[15.16.17].

Culverts made of metal – this is a good solution to the problem of water diversion, but only if you consider it, on the one hand. Metal structures have better strength indicators compared to analogues, but this advantage is completely offset by weak resistance to corrosion. Because of this, metal pipes are only used temporarily for the construction of culverts.

Figure-2. Plastic culverts[5].

However, there is another use for metal products. They are often used for punctures of the roadbed. The fact is that it is not always possible to repair the water pipe that passes under the road, so the pipe is cleared using an external drainage system, which allows for repairs or high-quality cleaning of the system[18.19.20].

Figure-3. Culverts made of corrugated metal.

To create a reliable and high-quality culvert, it is best to use SMGK-prefabricated metal corrugated structures. According to the General classification, such structures are not ordinary pipes – the whole system becomes such only in the place where it is necessary to install culverts.

SMGK have a lot of positive qualities that are lacking in simple pipes. The main advantage of the prefabricated structure is the ability to arrange complex structures that can serve for several decades and at the same time calmly survive the impact of seismic shifts. Corrugated road pipe, among other things, is almost a third cheaper than alternative options [7].

Corrugated pipe is a natural geotechnical structure. Together with the surrounding backfill, it forms a coupled structure that accepts the loads acting on it. The corrugated pipe has elasticity, so that a uniform passive pressure is formed in the backfill. Along the pipe contour, the pressure is also uniform. At the same time, normal forces act on it, and there are no bending moments. Working together with the soil, the pipe retains its shape as a result of the stable state formed in the soil. At the same time, longitudinal displacements and deformations are possible, provided by the corrugated shape of the metal. The stabilizing effect of the soil reduces the loads acting on the pipe, compared to the calculated ones [8]. This is evidenced by the diagram of the load factor dependence on the density of the surrounding soil (Fig. 4).

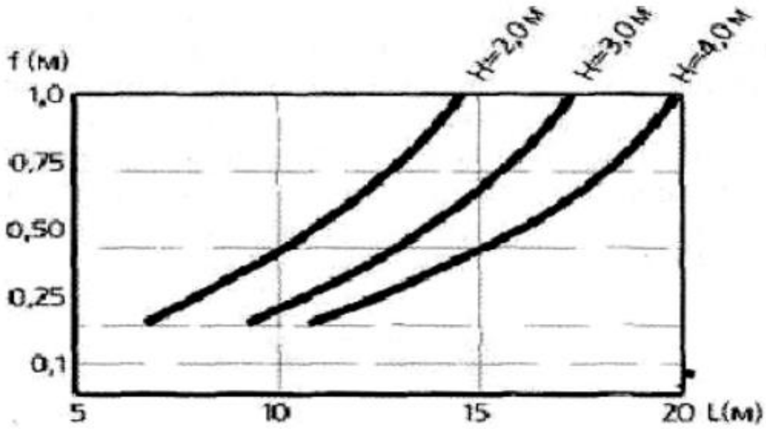

Figure-4. Diagram of the load factor dependence on the density of the surrounding soil.

Based on the analysis of the studies of culverts tubular structures made of corrugated you can do the following for the metal conclusions.

Conclusion. Using culverts allows you to move moisture under the roadbed. Of course, such systems are not relevant in all situations, but sometimes they are the only option for water diversion. A good solution is to use metal pipes as an external protective casing that protects the main pipeline. Usually for these purposes, pipes used for reinforcing the walls of drilling wells are used.

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A NEW GROUND FLOOR DIAGNOSTIC DEVICE

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Abstract: In this article, the concept of a diagnostic system using geophysical methods for specific railway track conditions, the elements of the diagnostic system are: the object of research; methods and technical means of diagnosis; classification of diagnostic signs (criteria for identifying deformations); trained technical personnel interacting with the object of research according to the rules established by the relevant regulatory and methodological documentation; expert opinion on the technical condition of the roadbed with an indication of the location, type and cause of deformations.

Keywords: Diagnostics, roadbed, soil properties, georadar, diagnostics of the main site, deformation, deep ground reference points, inclinometers, strain gauges, stresses.

Introduction. The roadbed diagnostics system is based on the use of both traditional and new geophysical methods, modern measuring equipment and computer technologies. The diagnostic system also uses specially designed mobile diagnostic laboratories. The basis of the diagnostic system of the roadbed is made up of geophysical methods, which are based on the study of anomalies of physical fields caused by changes in the lithological structure of the roadbed, the difference in physical and mechanical.

Physical fields in the roadbed arise from impacts:

• — direct or alternating electric current through electrodes driven into the ground (electrometric method and electrocontact dynamic sensing method);

• — emission of electromagnetic high-frequency signals (radar method);

• — hammer-type impact loads on the ground (seismic method);

• — moving rolling stock (vibration method).

A brief description of the geophysical methods is given below.

Electrometric method. It is based on the study of the resistance of various soils to the electric current passing through them. As a diagnostic feature, the electrical resistivity p, Ohm m is accepted. The dependence of p on the composition, properties and condition of various soils serves as the physical basis for the application of the electrometric method. The most widely used observation schemes are vertical electrical sounding (VEZ) and electrical profiling (EP)[1,2,3,4,5,6,7,8,9].

The method of electrocontact dynamic sensing (EDS). Combines two methods of simultaneous soil investigation: dynamic probing and current logging. For research, an EMF installation is used, with the help of which the depth of various layers of soil is determined by changing the magnitude of the current, and their strength characteristics are determined based on the results of dynamic probing.

Radar method. It is based on the study of the parameters of electromagnetic waves (propagation velocity and absorption coefficient) arising in soils from the pulsed action of a high-frequency generator.

The radar method does not require antenna contact with the ground surface, as in other geophysical methods, so it can be performed from mobile units (Fig.1), which provides high-speed diagnostics of extended sections of the roadbed. Georadar can diagnose the structure of the main site of the roadbed (the presence of ballast depressions), study the structure of the slope parts of the embankments (determining the size and location of ballast loops.

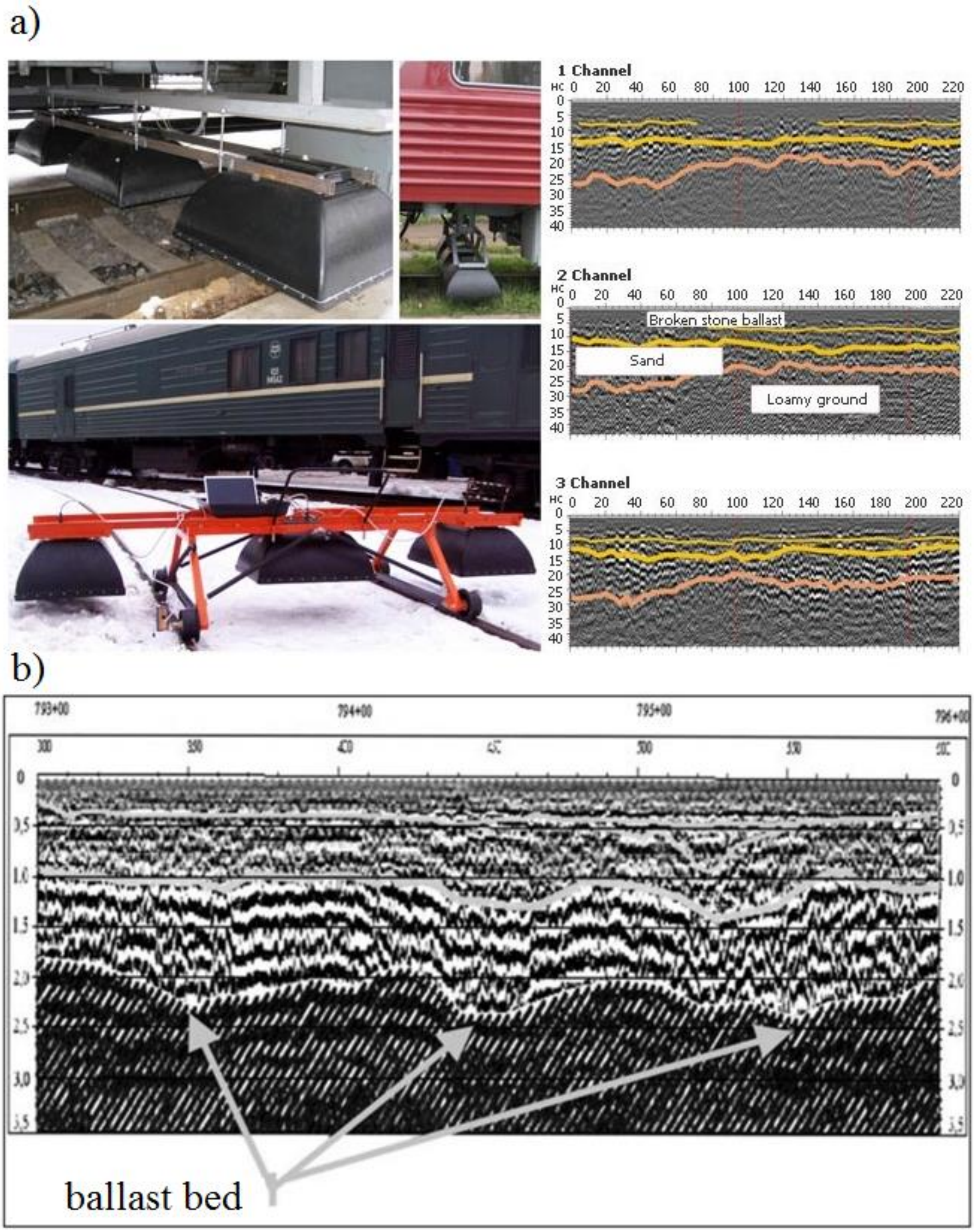

Fig. 1. Radar of the ground of the roadbed: a — the placement of the ground radar on the track trolley; b — the radar image of the fov), the determination of the boundaries of peat soils in the foundations of embankments in swamps, as well as the boundaries of the location of frozen soils. Diagnostics of the main site of the roadbed with the allocation of ballast depressions by georadar is shown in Fig. 2, b.

Seismic method. The physical prerequisite for the application of this method is the difference in the propagation velocities of longitudinal Vp and transverse Vs elastic waves associated with the presence of lithological boundaries in the earth bed and the difference in the properties and condition of the soil. Two observation methods are used: longitudinal seismic profiling and transverse seismic transmission. The seismic method is the most informative among other geophysical methods in terms of its capabilities and the range of diagnostic tasks to be solved. Vibration method. It is based on the use of soil vibrations of embankments arising from the impact of rolling stock. A group of diagnostic signs of a dynamic process corresponds to a certain condition of the operated embankments, which is a prerequisite for the use of the vibration method[10,11].

Traditional methods can be used, if necessary, at various stages of diagnosing the roadbed. Mobile diagnostic complexes (PNCs) in the form of reference load laboratories, track-measuring laboratory wagons (VP), including with radar complexes, are used for preliminary diagnostics and routine observations. Diagnostic studies of the listed complexes are carried out from the rail track and cover only the working area of the roadbed to a depth of no more than 3-4 m. Geophysical methods are usually used for detailed diagnostics, when it is necessary to obtain the most complete and specific information about the condition of the roadbed, indicating the type and size of existing deformations. Diagnostics of the main site. By the seismic method and in separate areas for a more detailed separation of soil layers by the method of electrocontact dynamic sounding, the following are determined: depressions in the main site in the form of ballast troughs, beds, bags, and also water-saturated and weakened soil zones are isolated[12.13.14.15.16.17.18.19.20].

Diagnostics of mounds of clay soils. By seismic and electrometric methods, the power of ballast plumes is established on the slopes of embankments; by the method of electrocontact dynamic sounding, separate layers of soil weakened in strength are isolated on the slopes, along which deformations of the embankment are possible. Seismic and electrometric methods and, in some cases, the method of electrocontact dynamic sounding separate the soils of the body of the embankment according to their appearance and condition, identify and outline the zones weakened in strength in the body of the embankments. The vibration method makes it possible to assess the dynamic state of embankments and predict the appearance of their sudden deformations under trains.

Diagnostics of the foundation of the roadbed. As the main methods, it is recommended to use seismic and electrometric methods; additionally, radar and the method of electrocontact dynamic sensing. When diagnosing embankments erected in swamps, using the electrometric method, the amount of immersion of the embankment into the thickness of silty sediments is determined and the sections of the path where the embankment has settled on the mineral bottom are identified.

On the landslide slopes on which the roadbed is constructed, using the seismic method, the boundaries between the landslide (or prone to landslide) and stable rocks are determined; the morphology of the landslide bed is established; the geometry of the landslide blocks in the plan and sometimes the number of floors of the landslide are clarified; the nature of the fracturing of the landslide massif and the predominant direction of landslide cracks are estimated. In areas of rock recesses, the seismic method can be used: to establish the thickness of loose cover deposits of rock massifs; the thickness of the weathered zone of bedrock; identification and delineation of vertical weakened zones in rocks; determination of azimuths of vertical and steeply falling cracks or layers of vertically layered strata; determination of the coefficient of volumetric fracture voidness.

In areas where karst processes are spreading, karst cavities may be located under the roadbed or in the immediate vicinity of its bases, which, under certain conditions, pose a real threat to the safety of train traffic. The use of seismic and electrometric methods makes it possible to identify the location, depth of occurrence and thickness of the karst rocks. In areas of permafrost, where the roadbed is exploited, electrometric and seismic methods are used to determine: the depth of the upper and lower boundaries of frozen rocks; the thickness of loose deposits; thawed and talic zones in the frozen rock massif; physical and mechanical properties of frozen soils in their natural occurrence.

Thus, geophysical methods have great opportunities for detailed diagnostics of the roadbed and its base. The choice of a single geophysical method or a rational set of methods depends on the effectiveness and accuracy of the methods in specific geoseismic and geoelectric conditions of the object and their technical and economic feasibility. For the successful application of geophysical methods, a small volume (10-15% of the total amount of work) of reference drilling wells is required for a more reliable interpretation of the obtained geophysical data.

Routine observations consist in measuring the time-varying parameters of the roadbed. First of all, various deformations of the roadbed are subject to measurement at the initial stage, until they have reached large values. In addition, the parameters of the humidity and temperature regimes of the roadbed are effective for regime observations. Methods and means of regime observations should promptly provide information on changes in the main parameters of the roadbed with sufficient regularity. Methods and means of regime observations can be divided into two large groups: stationary and mobile. The first include various sensors and control and notification systems installed at the facility, the removal of information from which can be carried out on portable devices or obtained by transmitting a signal in automatic mode. These methods and means are used to measure: deformations (deep ground reference points, inclinometers, strain gauges); stresses (messdoses, strain gauges and pore pressure sensors); temperature (thermal pumps and electric thermometers, thermal imagers); humidity (strain gauges, sorption sensors); groundwater level (hydrometric wells, etc.).

Mobile vehicles include: track measuring wagons; loading devices; georadar complexes. The stability of the track gauge geometry determined by track measuring cars depends on the condition of the track elements, including the roadbed. The transition of the roadbed to an unstable state causes increased disorders of the geometry of the rail track.

Another diagnostic mobile means for identifying areas with increased deformability of the sleeper base are load complexes. These complexes perform continuous measurement along the length of the track of the elastic precipitation of the rail and sleeper under the reference load when the complex is moving at a speed of 5-10 km / h. It is desirable to carry out the passages of the complex during the unfavorable period of spring thawing of the soil of the roadbed or prolonged rains. The complex consists of a load unit mounted on a special wagon, which provides a given reference load on the track and a measuring and computing complex that fixes and processes elastic deformations (precipitation) of the track that occur during load tests.

Conclusion. With a high degree of probability of exogenous geological hazards such as landslide, karst, landslide, scree and mudslide in areas adjacent to the roadbed, alarm systems or control and notification systems should be arranged. As such alarms, separate sensors can be used (for example, such as GPS, Glonas), allowing in real time to provide information about the movements of specially installed deformation reference points, or a barrier whose sensors are triggered when the barrier is deformed or destroyed, which in their magnitude exceed the systems established by the project.

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THE USE OF UNMANNED AERIAL VEHICLES IN ENGINEERING RESEARCH

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Abstract: In this article, karsts, avalanches, landslides, flooding and mudflows are dangerous because they develop rarely, rapidly and pose a serious threat to people's lives. To prevent such situations, it is necessary to take appropriate engineering protection measures to find out what features the territory has and whether it is prone to such processes. And this requires geodetic surveys.

Keywords: Drones, karsts, avalanches, landslides, flooding, total station survey, UAV, point cloud, 3D model, terrain elevation map.

Introduction. The use of modern geodetic equipment allows us to develop the most effective measures in a short time. About what results can be achieved thanks to laser scanning and drones. Traditional methods of geodetic surveying include classical (total station survey) and satellite technologies. The methods are reliable and time-tested, but they have a number of significant drawbacks.

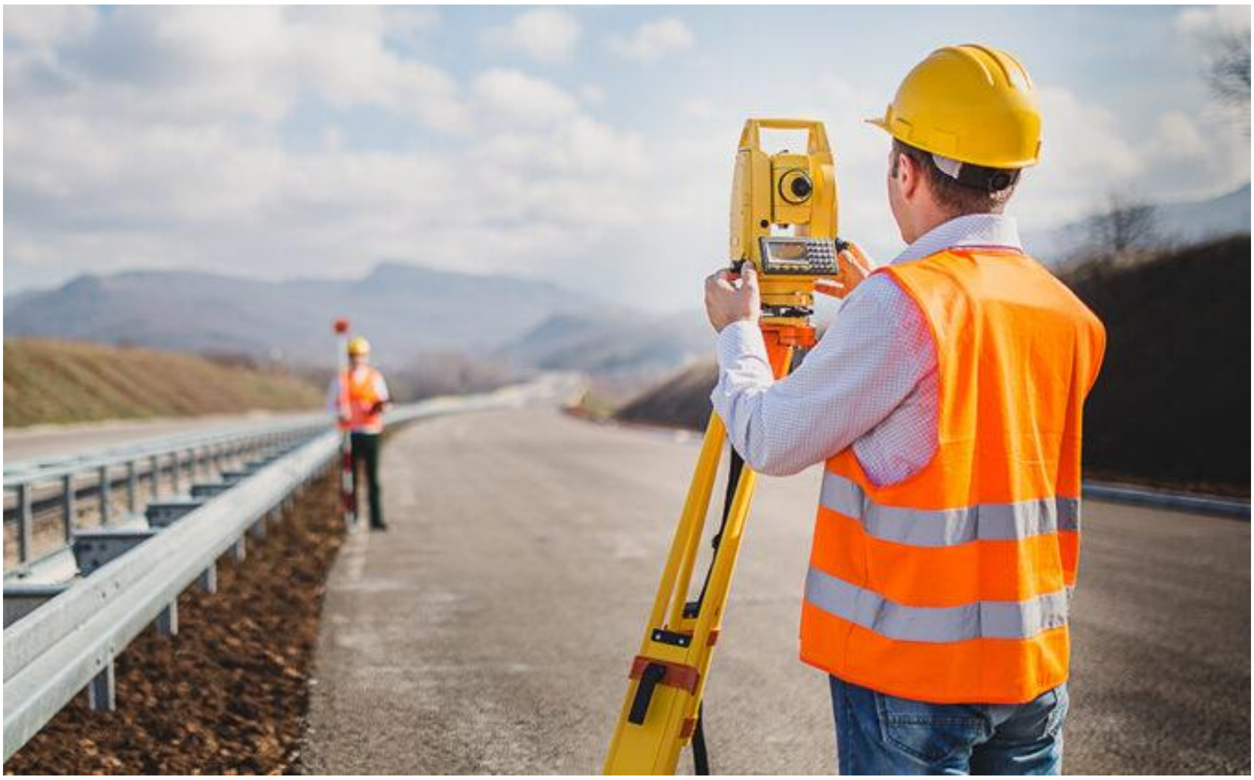

Fig. 1.Total station survey.

So, after the survey, a topographic plan is obtained that does not cover the entire territory under consideration as a whole, but only individual characteristic points, the density of which on the ground corresponds to the selected accuracy class and the scale of the survey. As a result, important terrain features may be unfixed, and this is of critical importance when designing engineering protection measures. And in the future it may lead to the development of a dangerous geological phenomenon[1,2,3,4,5,6,7].

The second disadvantage of the results of classical methods is the difficulty in interpreting the information received, since the image turns out to be flat. Another disadvantage of performing a total station survey or shooting using satellite receivers is the need to travel long distances on foot. For this reason, carrying out surveys on vast territories (several hectares) takes a lot of time, and the relevance of the information may be lost even before the survey is completed.

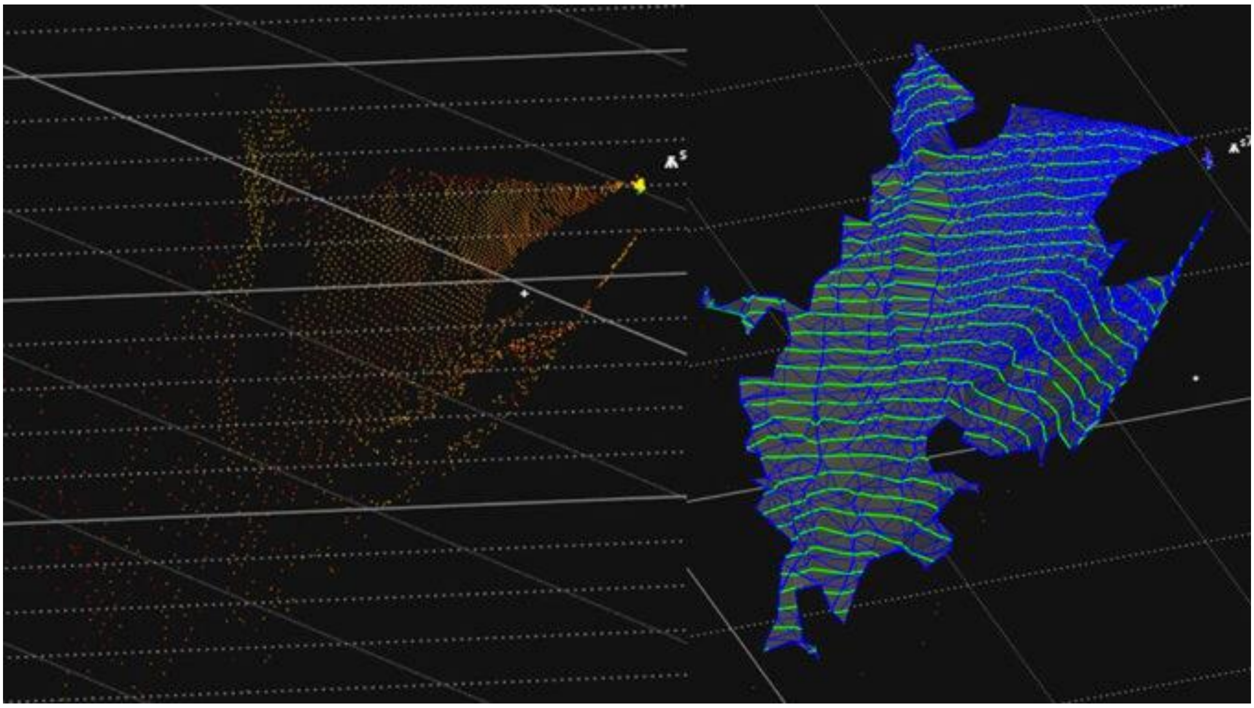

Fig. 2. Scan and surface with horizontal landslide slope near the wall ST-3.

The main advantage of laser scanning is the ability to create a three—dimensional point model of an object. The result is achieved with the help of laser scanners working on the principle of measuring the distance to the object and fixing the directions to these segments. With one scanner installation, you can form an entire point cloud of a given area of space. The array of received data is processed on a computer — surface models, elevation maps are created, horizontals are isolated. All this serves as the basis for the development of plans, sections and drawings. When aerial photography from a UAV is used, a digital camera with high resolution is used. This makes it possible to obtain a stereo image, assign the exact coordinates of the centers to the images, and also in most cases exclude the marking of ground markings. The information received is processed in a special computer program: the photos are scaled, the necessary corrections are made to them. As a result, a large-scale surface plan is formed [8,9,10,11].

The equipment set consists of several components. The first is a UAV that serves as a carrier of equipment for aerial photography and transmission of satellite signal reception. The second is a satellite receiver, which is used to determine the positions of control points or identification signs. It can also be used as a base station if there are no permanent ones available in the district. The third is a digital camera. The fourth is smartphones and PCs for performing preparatory work and desk processing of field materials. UAVs can also be equipped with multispectral, thermal imaging cameras, lidars and other devices. Aerial photography is performed according to a proven algorithm. First, the territory or object is studied, the appropriate equipment is selected. It is being prepared for operation and checked (verified, calibrated and configured). Next, flight tasks are developed: the boundaries and height, the speed of the UAV movement, the overlap of images, and so on are determined. The presence of the initial terrestrial or satellite geodetic networks is checked, solutions for connecting and linking devices to them are determined. Identification marks or control points are marked and coordinated. The UAV receiver is connected to a permanent station or to a specially installed one at points whose coordinates are known. The camera is calibrated, flight characteristics are checked[12.13.14.15.16.17.18.19.20].

Aerial photography is being performed. Then the data from the UAV is transferred to a computer, processed with the assignment of exact coordinates and heights to the centers of the images. Photogrammetric processing is carried out. A geo-linked orthophotoplane, a point cloud, a 3D model, and a horizontal elevation map are created. If additional equipment is used, thermal imaging, multispectral images and other information are prepared. In the process of work, the Institute's staff performed aerial photography from the BLPA of a section about 1.5 km long. Periodic geodetic control of the geometric parameters of the body of the embankment was carried out and geodetic control of deformations of the soil mass was carried out. The information received was analyzed, a conclusion was drawn up on the progress of construction.This made it possible to assess the condition of the embankment relative to the design solutions, as well as to analyze and control the situation with the volume of dumping and deformations of the soil massif.

The area of aerial photography was 50 hectares. An orthophotoplan, a 3D model and a height map (with horizontals) have been prepared for each measurement cycle. The analysis of materials was carried out both independently (in the current cycle) and in comparison with previous cycles. This made it possible to trace various slope and erosion processes, changes in the geometric characteristics of the embankment during construction work. It was also possible to identify some errors in the production of filling works. Then a preliminary design was developed, where solutions to the problems that arose during the construction of the embankment were proposed.

Fig. 3. Preparing drones for shooting the track.

Engineering and geological surveys as part of scientific and technical support during the construction of ski slopes and upper slopes of the cable car. The aerial photography was intended to reflect the actual situation on the site of the projected routes and supplement the archival engineering and geological materials with new data. This was necessary for the development of engineering protection measures, since, according to the design materials, most of the slopes were in an unstable state and required strengthening.

Fig. 4. Photo from the UAV.

The area of aerial photography of the territory of the future ski slopes was 224 hectares. As a result, an orthophotoplan, a 3D model and an elevation map (with horizontals) of the terrain were formed. They were used to develop topographic plans of 1:2,000 scale of hazardous geological processes and geocryological engineering zoning, and also facilitated the analysis of new and archival materials.

Conclusion. In the course of the work, the outcrops of rocky soils to the surface in areas with a slope of more than 40° were redefined. In the previous survey, performed by the classical method for a scale of 1:2,000, these areas were marked as non-rocky sandy and lumpy soil. Aerial photography from UAVs made it possible to reduce the volume of protective measures, reduce the cost of construction of trails. The relevance of new survey technologies for mining enterprises is the ability to speed up the process of obtaining extensive information about an object or territory. At the same time, in terms of accuracy of the result, such techniques are not inferior to traditional ones, and the level of safety for a person when performing laser scanning and aerial photography with BLPA is much higher.

This allows you to design engineering protection measures for an object in the shortest possible time or optimize ready-made solutions.

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TOPOGRAPHIC SURVEY USING A QUADCOPTER

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Abstract: The article considers the justification of the possibility of using aerial photography by geodetic quadcopter in order to obtain a topographic basis for the design of highways. The topographic basis is obtained in the form of an orthophotoplan of the terrain with accuracy corresponding to regulatory requirements.

Keywords: railway design, digital terrain model, quadcopter, unmannedaerial vehicle (UAV), point cloud, identification mark, orthophotoplane.

Introduction. Drones are used to build images, create maps and spatial analysis in areas such as topographic aerial photography of the area. Today, it is no exaggeration to say that quadrocopters are the fastest and most effective method of aerial photography. In addition, unlike shooting from manned aircraft, the use of drones is much cheaper, and also makes it possible to get better results. The main advantages quadrocopters for geodesy: reduction of time costs, simplification of work, the ability to shoot in hard-to-reach places.The survey of the terrain by a quadcopter for the purpose of further designing a highway can be attributed to such a type of survey as topographic and geodetic surveys (TGI). According to the results of the TGI, topographic and geodetic data and materials should be obtained to compare options for highway routes and prepare documentation for territory planning under the placement of the selected railway option. The design documentation should substantiate the design needs for the chosen route direction, provide materials for choosing the location of sections of crossings over natural and artificial obstacles, comparison and evaluation of route options, recommendations for choosing the optimal railway route option for subsequent stages of design and survey work (PIR) [1,2,3,4].

Aerial photography is one from methods of drawing up topographic maps and plans large scale. The results of the work are orthophotoplans, topographic maps and plans, digital models of terrain and relief (CMR and CMR), which can be used to solve the problems of design, construction and reconstruction of railways. The use of aerial photography from UAVs is due to economic feasibility or lack of other technical and practical possibilities for obtaining reliable topographic materials, however, the use of UAVs in construction is currently not legally fixed, there are no methods and recommendations for the use of geodetic quadrocopters in obtaining a topographic basis for design. The kit for aerial photography should include a UAV with an on-board and / or ground-based GNSS receiver of geodetic accuracy, an on-board complex control, avionics, payload and ground control station. According to I. 5.1.1.16 SP 47.13330.2012, the average errors in determining the planned position of objects and terrain contours with clear, easily recognizable outlines (boundaries) relative to the nearest points (points) of the geodetic basis should not exceed 0.5 mm for open areas and 0.7 mm for mountainous and forested areas on the scale of the plan in undeveloped territories. Following these requirements, the error in determining the planned coordinates is presented in Table 1 [5,6,7,8,9,10].

Table 1. Errors in determining the contours of objects

The scale of the plan	Errors, m	
	open country	mountainous and forested areas
1:500	0,25	0,35
1:1000	0,5	0,7
1:2000	1,0	1,4
1:5000	2,5	3,5

When aerial photography with UAVs, it is necessary to take into account factors that hinder the work (the presence of vegetation, terrain fractures, the inability to decipher individual elements of the survey, seasonality, the presence of shadows, clouds, industrial smoke and atmospheric haze, complicating or excluding the process of decoding, the presence of objects with high reflectivity, the presence and height of buildings). The technical equipment of the UAV should ensure the safe performance of flights, taking into account the geographical features of the territory of the Republic of Uzbekistan. The purpose of this work is to substantiate the possibility of conducting topographic surveys using a quadrocopter during engineering and geodetic surveys of railways. The assessment was carried out on the basis of aerial photography data from a quadrocopter DJI Mavic 2 Pro and their subsequent processing.

Source data: aerial photography results (527 photos from the camera of the DJI Mavic 2 quadcopter Pro), the first part of the images has a nadir view, the other part is perspective; the coordinates of the terrain, 5 pieces. The data was loaded into photogrammetric processing software, in our case — AgisoZ Metashape. After uploading the images, the program aligns the photos and builds a sparse point cloud. The entire assessment of the accuracy of the reconstructed scene and the output results is evaluated on it. After its construction, the coordinates of the ground identification signs are loaded to control the accuracy on them[11,12.13.14.15.16.17.18.19.20].

If necessary, they can be used to fit the model as a support. The tasks that we will solve with the helpof the Metashape program are carried out in four stages:

1. Determination of the parameters of the external and internal orientation of the cameras. At the first stage, Metashape finds common points of photos and uses them to determine all camera parameters: position, orientation, internal geometry (focal length, distortion parameters, etc.). The results are a sparse cloud of common points in the 3D model space and data on the position and orientation of cameras. The data on the position and orientation of the cameras is used in further processing stages.

2. Building a dense point cloud. Before proceeding to the next stage of creating a 3D model or beforeby exporting the model, a dense point cloud can be edited and classified.

3. Construction of a three-dimensional surface: a polygonal model and/or CMM. A three-dimensional polygonal model describes the shape of an object based on a dense point cloud.

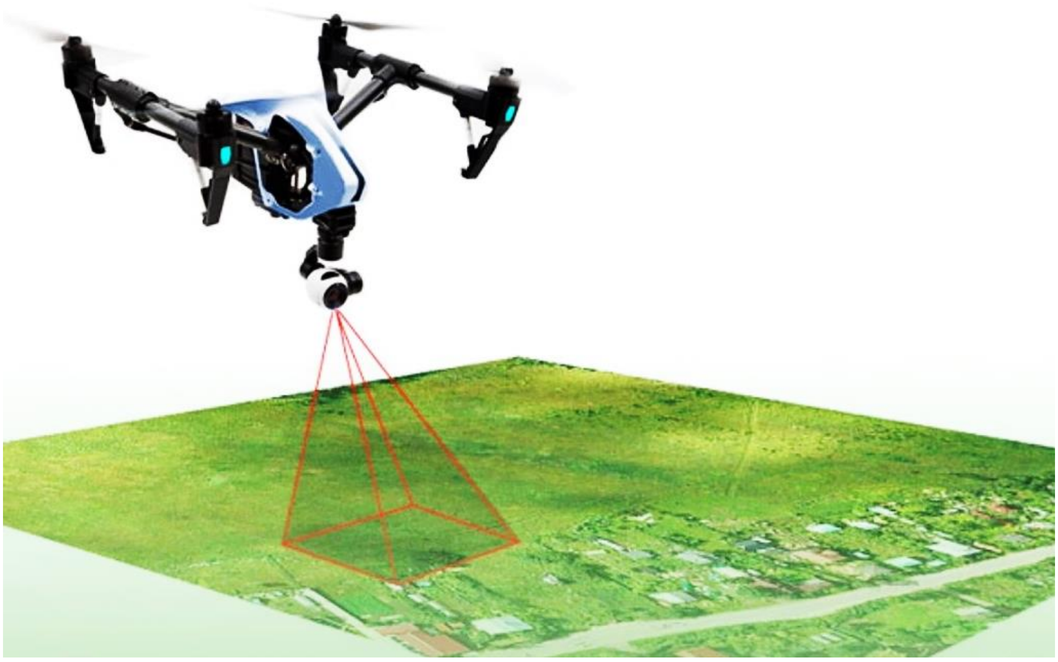

Fig. 1. Digital terrain model (the size of the CMM is 10590x10140, at 6.73 cm / pixels)

4. Building a texture for a polygonal model (if it was built), as well as building an orthophotoplane. The finished orthophotoplane is shown in Figure 2.

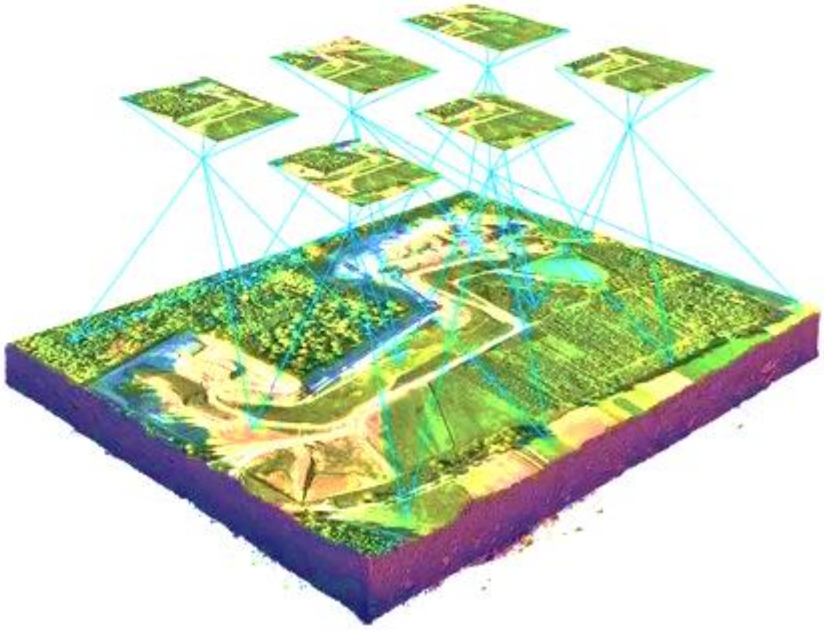

Fig. 2. Orthophotoplane.

The orthophotoplane we have obtained has the size 36006x34329 pixels, at 1.76 cm/ pixels. The standard error does not exceed 3.7 cm, which, according to Table 1, may correspond to a 1:500 scale plan. According to the results of the work, it becomes obvious that the use of quadrocopters in conducting engineering and geodetic surveys is no longer the technology of the future, but the technology of the present. Accordingly, the problem of the lack of regulatory documentation on this topic was a significant gap in the organization of work.

Conclusion. In addition to everything, it is worth adding that, using quadrocopter, it is not necessary to dwell only on engineering and geodetic surveys, since the darkening of the quadrocopter opens up wide opportunities in such areas as:

— monitoring of the condition of the roadway;

— control over construction and repair works;

— obtaining information about the condition of the roadway (detection of defects of the roadway and their parameters);

— determination of transport flow parameters.

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