

Geodesy and modern technologies

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Abstract. Currently, a lot of geodetic instruments and new geodetic technologies have been created, which are fundamentally different from traditional ones. In previous years, each type of measurement had its own type of instrument: for the angular measurements, the theodolite, for high-altitude measurements - a level, for linear measurements - a tape measure and rangefinder. Each device, depending on the intended use, had its own accuracy characteristics. Over time, science is developing and technologies are moving forward, the devices used in the field of engineering and geodetic works are improving. A modern geodetic instrument is a product of new technologies that embodies the latest achievements in optics and modern satellite technologies. This article provides a classification of devices according to their purpose and describes their application.

1. Introduction

When providing the geodetic support for the construction of the airfield's main elements, the geodesist does the following types of work: updating the location of existing (previously laid) utility services, setting out and monitoring of laid underground structures and utility services' geodetic parameters, clarification of the characteristics of design (laid) utility services, surface layout, as well as reinforcement placement, marking and sawing of the expansion joints, setting out of drainage system, laying of cable ducts, checking the thickness of layers and surface slopes, cable laying and installation of lighting equipment, etc. [1].

Geodetic surveying plays an important role in constructing roads and aerodromes:

- Geodetic expertise and surveying allow monitoring the level of subsidence and deformation of roads and other traffic facilities.
- Topographic surveying is used to create topographic plans, maps, and to do the necessary calculations.

2. Survey and design

The survey and design of automobile roads and aerodromes include a range of works:

- Engineering and geodetic surveys, which are necessary for the correct assessment of the area from the viewpoint of topographic relief and of linking the object to the existing infrastructure.
- Engineering-geological surveys, the task of which is to examine the engineering-geological conditions of the site, to investigate the physical and mechanical properties of soils, and to make the engineering-geological profiles in order to design the foundations and linear or point objects.



- Engineering and hydro-meteorological surveys, which help to assess the hydro-geological conditions of the site, the presence of underground and surface water sources, as well as the meteorological and climatic components of the design area.
- Environmental - engineering surveys, which are aimed at reducing the man-made impact on the environment and at forecasting the influence of construction on environmental safety, in order to minimize its harmful effects.
- Survey of construction materials and soils, as well as of water supply sources - underground waters. This is a comprehensive laboratory analysis of materials, the identification of their composition and physical-mechanical properties.

When analyzing international experience, we may make a conclusion that the quality of surveying directly affects the service life, the quality of the work done, the consumption of materials, etc. [3, 4, 5]. All surveying activities begin with the choice of the most profitable engineering solutions for the construction or reconstruction of the object, from technical, economic and environmental points of view: interference in the economic activity of rural settlements, demolition of residential areas, occupying valuable lands and resort areas, as well as deforestation of roadside hedgerows and forests. First of all, such a survey is a collection of all the data necessary to create a design project and an assessment of the construction investments taken into account in the summary cost estimate. All the work is done in accordance with the established rules of surveying.

3. Modern geodetic equipment

Geodetic groups and cartographers, who do engineering and survey work, join in to help, with their latest geodetic equipment, instead of outdated one, and they provide high-quality and efficient performance. At present, the invention of new geodetic equipment is rapidly developing, and due to this it is possible to carry out field observations much faster and more efficiently, with the lowest standard error of the mean (SEM). SEM is minimized [6]. Among these innovations are the following surveying devices: a total station (Figure 1), a GPS antenna and a 3D scanner. This equipment, which has caused a real breakthrough in surveying, is a success, and it is continuing to develop, speeding up the work at the construction site.



Figure 1. Total station

Geodetic engineers conduct topographic surveying of the relief, in order to create new maps, if there is such a need due to absence of plan maps and archival data [1]. Further, as a rule, all collected information is passed over to the design team, in order to create project data. At the same time, the geological and laboratory survey of soils is carried out, as well as the survey of their physical and mechanical properties. Also at design stage the issue of environmental protection during construction and installation works, with the lowest possible level of hazardous substance exposure, is considered.

We may make a conclusion from the above-said that all surveying activities are inextricably linked with geodetic measurements. The latest innovative equipment is actively used in geodesy, and that allows making measurements with millimeter and even fractions of millimeter accuracy.

When solving many problems of engineering geodesy, electronic devices, optical precision zenith plummets (ZP) are used. As a rule, they are used at objects associated with increasing the number of stores in large scale development. Precise levels are used for creating unique nuclear energy facilities and other corporate and secret facilities, special technological lines, etc. Also on construction sites total stations, robotized total stations, laser range finders that have substituted light range finders, GLONASS and GPS systems are widely used.

Let Us take a closer look at the total station, and at the use of satellite technologies and 3D scanning in engineering geodesy and aero geodesy.

The total station is a high-precision and high-quality modern geodetic device that has greatly simplified making geodetic measurements. In fact, the total station consists of the goniometric part, the light range finder and the built-in computer.

Thus, using the goniometric part, the horizontal and vertical angles are determined, the light range finder determines the distances, and the built-in computer solves various geodetic tasks, provides device control, management and storage of measurement results. The measurement results can be downloaded into a PC and processed using special programs.

Total stations can operate both in reflector mode (the observer takes measurements using special devices-reflectors, prisms, reflecting marks) and in reflectorless mode (the observations are carried out directly on the observed object). There are also robotized total stations, allowing one person to make observations; according to a given program, these devices themselves find the position of the reflector and take measurements.

In order to obtain a three-dimensional image of the district space, necessary for creating digital maps, laser scanners are used (Figure 2).



Figure 2. Laser scanner

Laser scanners are more complex apparatuses compared to total stations, although they have got similar operation principles.

A laser scanner scans the space within a fraction of a second, digitizes the set of characteristics of the real surface, and then presents the result in the three-dimensional coordinate system.

Considering the technical side, it can be said that the laser scanner is a device equipped with a reflectorless laser range finder and a system for changing the direction of the laser beam - a special folding mirror.

The development of modern technologies for performing field engineering and geodetic works is inextricably linked with global positioning systems (such as the American GPS (NAVSTAR) and the Soviet GLONASS), which are actively used in space geodesy, and this helps to increase labor productivity and improve measurement accuracy.

GPS is a global positioning system based on satellites orbiting the earth. Anywhere on the Earth (excluding the Polar Regions) GPS provides, in almost any weather, the data about the speed and location of objects.

GLONASS is a world-wide global positioning system that began in the USSR and is based on satellites moving around the Earth along three orbital planes, with an inclination of orbital planes of 64.8° and a height of 19,400 km.

GLONASS has got a more stable connection than GPS, but the lifetime of a GLONASS satellite is shorter. The disadvantage common for both global positioning systems is that, under certain conditions, the signal may not reach the receiver, also signal distortion and/or delay may occur. For example, it is practically impossible to pin down one's exact location in underground conditions (basement, tunnel) inside a reinforced concrete building, even using professional geodetic receivers.

One of the important advantages of GPS over usual survey methods is that we obtain 3D coordinate points. The three-dimensional point position is determined using intersections from artificial satellites of the Earth.

GPS receivers are available for any accuracy requirements and for many special kinds of measurements.

At present, satellite technologies have made significant progress, and are rapidly replacing traditional geodetic methods for determining coordinate points, line lengths, angles and azimuths.

An unmanned aerial vehicle (UAV) - is aircraft controlled remotely, without any crew on board.

More and more often, unmanned aerial vehicles are used in construction to fulfill tasks related to geodesy (or cartography), for which aerial photography is required. To determine coordinate points and flight-path speed, modern UAVs, as a rule, use satellite navigation receivers (GPS or GLONASS). The orientation of the apparatus in space is determined by gyroscopes and accelerometers.

4. Conclusion

Due to modern geodetic devices, hardware and software, the process of doing engineering and geodetic works is becoming more and more perfect and easy year after year, which makes it possible to fulfill complex geodetic tasks within shorter periods of time. The new technologies introduced into geodetic devices facilitate accurate measurements and, in some cases, eliminate errors made due to human factor.

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