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ИССЛЕДОВАНИЕ ИНЖЕНЕРНО-ГЕОЛОГИЧЕСКИХ УСЛОВИЙ УЧАСТКОВ ДЛЯ СТРОИТЕЛЬСТВА ГИДРОТЕХНИЧЕСКИХ СООРУЖЕНИЙ С ПРИМЕНЕНИЕМ ГИС-ТЕХНОЛОГИЙ

RESEARCH OF THE ENGINEERING AND GEOLOGICAL CONDITIONS OF THE AREA FOR CONSTRUCTION OF HYDRO-TECHNICAL STRUCTURES WITH APPLICATION OF GIS-TEHNOLOGIES

Гидротехникалык курулуштурды тургузуу үчүн жер аянтын тандоодо башка факторлор менен катар эле эң биринчи кезекте инженердик-геологиялык шарттарды эске алуу зарыл. Инженердик-геологиялык шарттардын биринчи кезектеги компоненттери ошол жердин рельефи, геологиялык жана тектоникалык курумунун өзгөчөлүктөрү, куруучу аянттын геологиялык- литологиялык структурасы, курулуш тургузулуучу жер кыртышынын абалы жана физикалык-механикалык касиеттери, ошондой эле табигый жана инженердик-геологиялык процесстер менен кубулуштар болуп эсептелет. Ошентип, сейсмикалык кокустугу жогору аймакта (8-9 балл) гидротехникалык курулуштарды тургузуучу райондун инженердик-геологиялык шарттарын изилдөөдө ГИСти пайдалануунун мүмкүнчүлүктөрү кеңири. ГИС сейсмикалык микрорайондоштуруу учурунда схемалык карталарды жага инженердик- геологиялык карта-схемаларды чийип, сейсмикалык натыйжаларды жакшы жагына өзгөртүү багытында пайдаланылат.

Суу сактагычтарды курууда жерди тандоо менен сейсмикалык микрорайондоштуруунун такталган схемалык карталары курулушутун бышыктыгын, узакка кызмат кылаарын, курчап турган геологиялык чөйрөнүн экологиялык коопсуздугун камсыз кылат.

Ачкыч сөздөр: *сейсмология, геологиялык изилдөөлөр, гидротехникалык курулуштардын бышыктыгын жана коопсуздугун камсыздоо, ГИС, GNSS.*

При выборе площадки для строительства гидротехнических сооружений необходимо учитывать инженерно-геологические условия в первую очередь наряду с другими факторами. Такими компонентами инженерно-геологических условий являются рельеф местности, особенности геологического и тектонического строения, геолого- литологические структуры площадки, состояние и физико-механические свойства грунтов на территории строительства, а также естественные и инженерно- геологические процессы и явления, происходящие на строительной площадке. Таким образом, возможности применения ГИС большие в исследованиях влияния инженерно- геологических условий района строительства гидротехнических сооружений, расположенных на высоко-сейсмической зоне (8 и 9 баллов) по изменению сейсмического эффекта с целью развития инженерно-геологических картосхем и схематических карт сейсмического микрорайонирования.

С учетом инженерно-геологических условий при выборе площадей для *строительства водохранилищ и его работе, а также уточненные схематические карты сейсмического микрорайонирования помогут обеспечить прочность и долговечность гидротехнических сооружений, а также экологическую безопасность окружающей геологической среды.*

Ключевые слова: *сейсмология, геологические изыскания, обеспечение сохранности и безопасности гидротехнических сооружений, ГИС, GNSS.*

While choosing a site for HTS construction along with other factors, those of engineering and geological conditions must be considered first of all. Such components of engineering- geological conditions are: land relief, features of a geological and tectonic structure, geological and lithologic structure of the area, structure, state and physical and mechanical properties of soil developed in the territory of construction, as well as the natural and engineering and geological processes and phenomena taking place on a site. Thus the possibilities of application of GIS in researches of influence of the engineering and geological conditions of the construction area of the hydro-technical structures located in the high-seismic zone (8 and 9 points) on change of the seismic effect for the purpose of development of engineering and geological schematic maps and schematic maps of seismic microzoning.

Taking into account the engineering and geological conditions while choosing the areas for construction of reservoirs and for its operation, as well as the elaborated schematic maps of the seismic microzoning will assist to provide firmness and durability of the hydro-technical structures, as well as geo-ecological safety of the surrounding geological environment.

Keywords: *seismology, geologic engineering, safety of the hydro-technical structures, GIS, GNSS.*

Use of the competitive innovative equipment and technology meeting the international standards is the most important and key issue of today. Therefore, geo-information equipment and technology (GIS, GNSS, etc.) are used in many sectors of the national economy, as well as in all aspects of geology. Hydro-technical structures (HTS) represent a set of engineering constructions which ensures collecting and regulation of water resources for needs of power industry, melioration and other sectors.

Design and construction of new HTS is one of the complex challenges of engineering geology and engineering seismology in difference from design of a town-planning complex. HTS differs from constructions of objects industrial and civil engineering by its sizes (length>1km, height>50-100m, volume>50mln.m^3). Therefore, influence of the HTS on the geological environment is very important. The big geometrical size of the HTS, length of seismic waves, not synchronism of waves in the dam basis, on the boards and in the center of a reservoir are the reason of different fluctuations. So, it is an additional threat to stability of the dam and creates a danger to the environment.

While choosing a site for HTS construction along with other factors, those of engineering and geological conditions must be considered first of all. Such components of engineering- geological conditions are: land relief, features of a geological and tectonic structure, geological and lithologic structure of the area, structure, state and physical and mechanical properties of soil developed in the territory of construction, as well as the natural and engineering and geological processes and phenomena taking place on a site. Taking into account engineering and geological conditions while choosing the areas for construction of reservoirs it is possible to provide firmness and durability of the construction, as well as geo-ecological safety of the surrounding geological environment [1].

In practice engineering and geological justification of design of the reservoirs is carried out in several stages. At the first design stage 2 or 3 perspective areas for the reservoir construction are chosen, the seismic risk of these areas is compared and the most favorable territory is selected from the point of view of seismic risk and it is estimated economic feasibility of the HTS construction on this place. At the same stage, it is conducted an assessment of engineering and geological conditions with use of GIS. The stage of technical design begins at the chosen territory. Along with a complex of geologic and geophysical researches are conducted
engineering and geological researches for the seismic microzoning (SMZ), it is created
engineering and geological basis (EGB). Such types of works were carried out in the past, but without use of GNSS. For example, specialists of the Institute of seismology of the Academy of sciences of the RUz and NCGC have developed maps of the engineering and geological basis of SMZ for many reservoirs in the scale 1:10000. An assessment of the seismic danger is made on the basis of the modern information technologies where is provided an engineering and geological map with use of GIS [2-3].

For creation of the EGB maps the engineering and geological researches are conducted. Conditions of formation of engineering and geological factors, such as a relief of the reservoir area, geological and tectonic structure, conditions of the dam basis and boards of slopes, composition, properties of the physical and geological processes and phenomena in the pool and at the territory of reservoirs construction are studied, as well as a scale is defined. Carrying out a number of works during creation of maps with use of above-mentioned materials from the point of view of engineering and geological and engineering and seismological researches by means of GIS can be divided more precisely and quickly into "favorable", "adverse" and "middle" engineering and geological conditions of the area of researches. Along with it, in case of the expected destructive earthquakes, it is possible to allocate in advance at the territory the places of possible activation of dynamic processes, its sizes and forms in the plan. It should be noted that works on drawing up an engineering and geological basis for SMZ have to advance other complexes of works.

In the developed map of typification of the engineering and geological conditions with rather same soil conditions will be estimated earthquake force by way of engineering and geological analogy. By means of this map it is formed a plan of such engineering and geophysical field works as seismometric and seismoprospecting points of research and the line of profiles. For all carried-out field works the results of measurements by means of GNSS are plotted. In future, it will be developed an electronic map on the basis of the ArcGIS program complex. The created electronic map of the engineering and geological conditions will provide possibility of message monitoring of the engineering and geological conditions at the territory of construction of the reservoir before construction, after construction and during its operation by HTS. For this purpose are conducted periodic observations the results of which are fixed on the electronic map. Besides, the data of GIS and GNSS provide more accuracy and help to ensure a high-quality performance of work for experts of allied industries (geologists, geophysics, topographers, etc.). The developed database can be also used by specialists of other sectors that will allow them to receive more exact results by using methods of three-dimensional modeling and to save time and funds for implementation of the tasks.

For a comprehensive analysis of the HTS construction site it is advisable to establish an information industry with the powerful infrastructure meeting the specified requirements. It is necessary to create an integrated information system with the developed infrastructure. Such information infrastructure based on the modern information technologies is realized in the form of the integrated geographic information systems (GIS) [4-6].

At the same time effective use of the integrated GIS is impossible without use of scientific elaborations and approaches to the solution of the put problems. First of all, it is an experience in development of the methods for creation of estimation and synthetic maps with using materials of remote sensing and modern computer methods of their processing, development of digital and electronic maps, database management systems, etc. Goskomzemgeodezkadastr RUz to which was entrusted creation and maintaining the automated Uniform System of the State Inventories (USSI) bought more than 100 licenses for the software ArcGIS. Licenses are bought with different extent of use of the software. This project was developed in the environment of ArcGIS and in this work the primary attention is paid to use of this software.

The hydrogeological and seismo-ecological parameters are in close relationship with the landscape. The traditional view of the relief in the form of the contour lines often complicates the development of the thematic maps and environmental analysis of the situation. In order to solve successfully the tasks set out in the project and to facilitate the analysis of maps it was developed the technology of three-dimensional representation of the digital terrain model [4-7]. The possibilities of the used software allow to specify arbitrarily both the illumination direction and its intensity. The system also allows to paint over by the pre-assigned colors depending on the selected height intervals. In this case the obtained image can be at most close to both the color space photographs and a cartographic works, painting, for example, the plains in green and the mountains in brown.

The studies conducted in the framework of this project have shown that to achieve these goals and more detailed study of the Tupolang reservoir territory and its surrounding areas it is not enough to attract medium topographic maps with a scale of 1: 500,000 and 1: 200,000. The digital topographic maps should be developed with the involvement of relief data obtained from the large-scale maps. To this end, it was developed the hybrid digital topographic maps on which the digital topographic maps with a scale of 1: 200,000 were additionally applied with the data of the reference points and contour lines from the topographic maps with a scale of 1:100,000 in strict accordance with the coordinates of the reference points and its values of heights and contours.

A three-dimensional model of the reservoir of interest was developed on the basis of the hybrid digital maps. The figure 1 shows the three-dimensional model of the Tupolang reservoir and its surroundings. The figure 2 represents a perspective view of the three-dimensional model of the Tupolang reservoir.

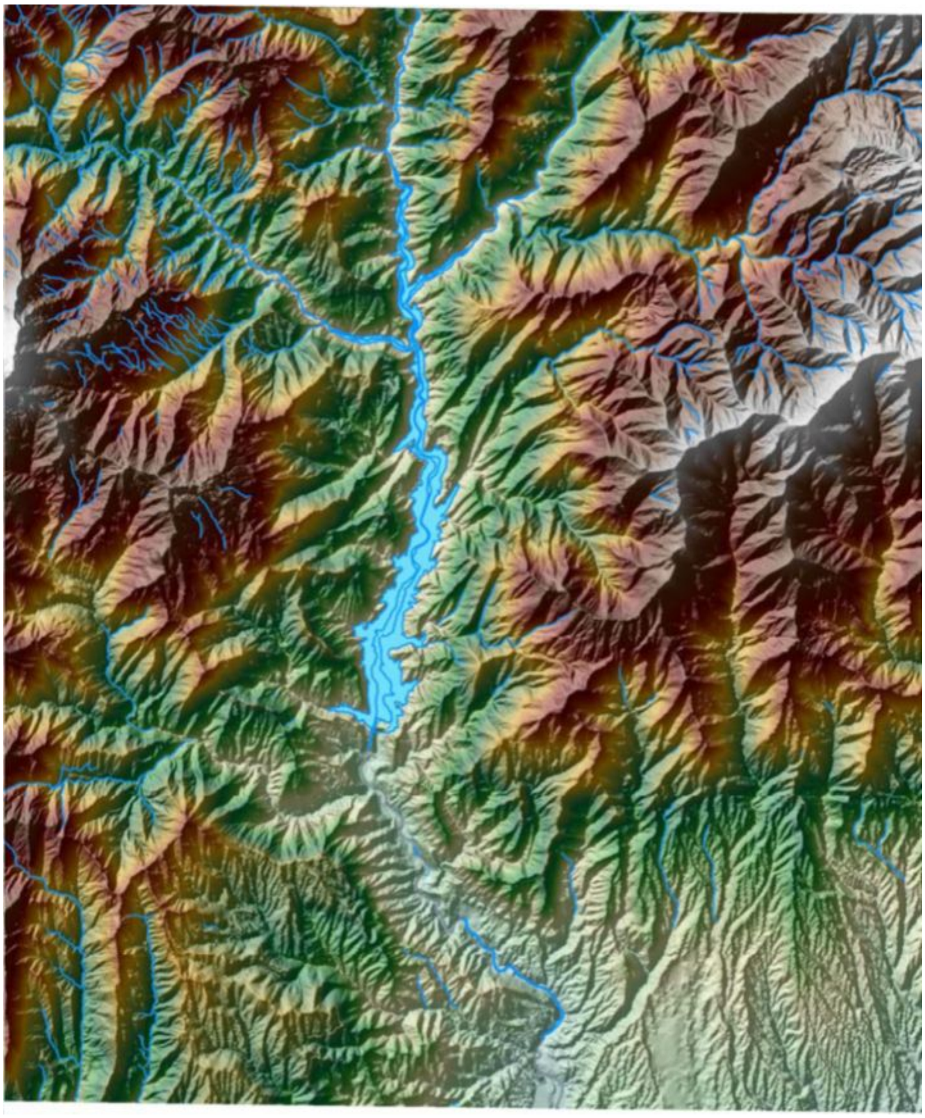

Figure 1. Digital three-dimensional model of the Tupolang reservoir and its surroundings

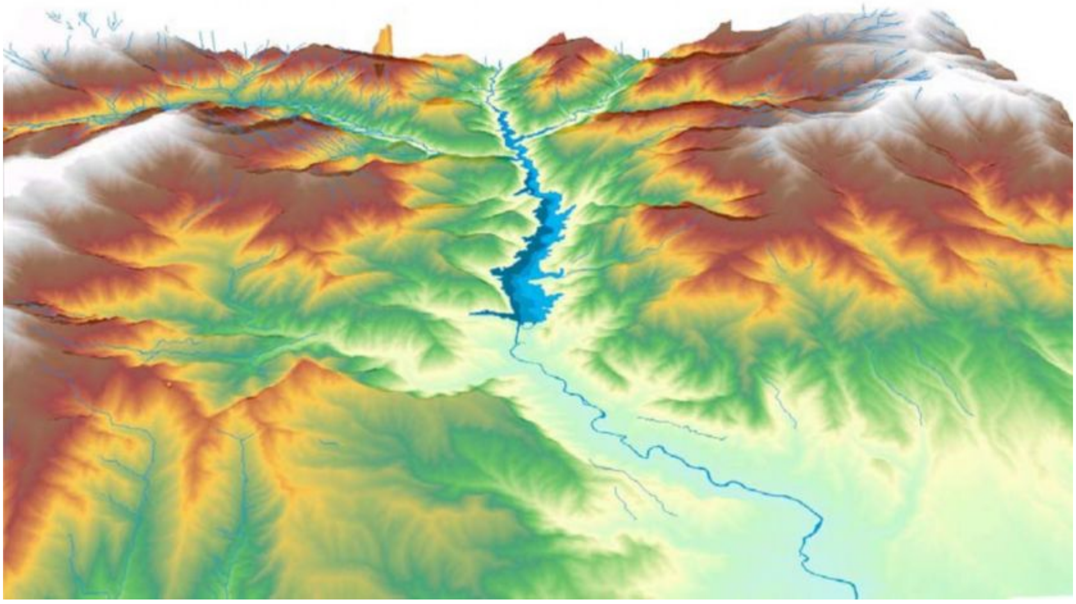

Figure 2. Perspective view of the Tupolang reservoir. View from the South

In 2015 it was carried out a field observation of the Tupolang reservoir in the Surkhandarya region located in the 9-point seismic zone. This project was developed on the basis of field engineering and seismological studies of the authors conducted in 2015. Using the remote sensing materials and engineering and geotechnical observations materials of the institute "Uzgiprovodhoz" for choosing the dam alignment in the preparation of the seismic microzoning basics. The collected materials were the basis for the geotechnical and seismo-ecological analysis of the studied reservoirs and its adjacent territories. As a result of the observations it was analyzed the engineering and seismo-geological and seismo-ecological conditions of the construction site of the Tupolang reservoir and its surrounding areas. It was developed the digital engineering-geological schematic map of the Tupolang reservoir area, within the ArcGIS environment. It was determined the areas with the class of soils containing the rigid structural connections (rocky grounds). These grounds are represented by the metamorphic and magmatic formations, as well as the areas with soils class without rigid structural bonds. The estimation of the incremental of the seismic earthquake intensity (ΔI) by the method of engineering-geological analogy. A detailed analysis of the geotechnical data allowed typifying the territory by the engineering-geological and seismo-ecological conditions. The engineering-geologcal digital map-diagram of the Tupolang reservoir site, developed in the ArcGIS environment, is stated in Figure 3.

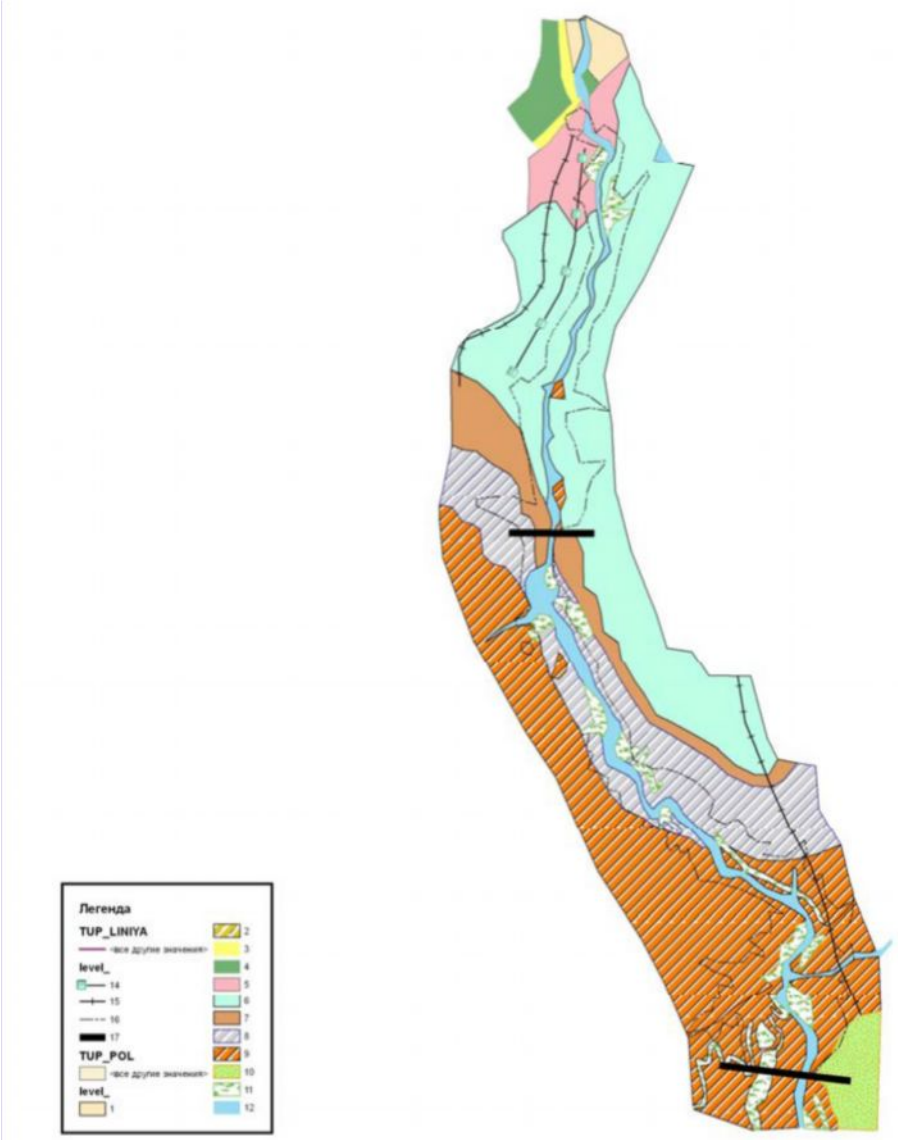

Figure 3. Digital engineering and geological schematic map of the Tupolang reservoir site
Legend:

I) **Class of the soil with rigid structural bonds (group of rocky soils).**

1) Magmatic intrusive rocks (granites-Pz); 2) Metamorphic, regionally metamorphosed rocks (schists, gneisses -Pt); 3) Cemented sedimentary fragmental rocks (sandstones, grits, carbonaceous siltstone -J1+2); 4) Sedimentary carbonate rocks (various crystal bituminous limestones -J3); 5) Cemented sedimentary fragmental rocks (conglomerates, grits, sandstones, siltstones, mudstones - K1); 6) Cemented sedimentary fragmental and carbonate rocks (sandstone, siltstone, mudstone, limestone - k2); 7) Sedimentary carbonate rocks (limestones Pg1); 8) Cemented sedimentary fragmental and carbonate rocks (siltstones, clay, mudstone, sandstone - Pg2+3); 9) Cemented sedimentary fragmental rocks (sandstone, siltstone, clay - Pg3 - N1, N2).

II. **Class of the soils without rigid structural bonds**: 10) Diluvial-proluvial loess loams with interlayers of gravel and pebbles (dpQII); 11) Alluvial-proluvial loess with rare inclusion of debris and gravel lenses (apQIII); 12) Modern alluvial boulder-gravel with sand filling, the top covered by the loess loam and sandy loam with a width up to 3.0 m (aQIV); 13) Tectonic fractures; 14) Axes of anticlinal and 15) synclinal structures.

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