International Journal of Advanced Research in Science, Engineering and Technology

ISSN: 2350-0328

Vol. 12, Issue 12, December 2025

Mathematical Model of Natural Conditions on the Landslides to the Dam of Reservoirs

Dilmurod Tokhirovich Kodirov

Senior Researcher at the Institute of Civil Defense at the Academy of the Ministry of Emergency Situations, Tashkent, Uzbekistan

ABSTRACT. One of the reasons that the strength of all earth dams is not constant is the risk of landslides in the dams.

To ensure the safe and reliable operation of facilities when using the Akhangaran reservoir, a mathematical model of the movement of horizontal and vertical landslides has been developed on the basis of variational-statistical processing of long-term monitoring data. As a result of the analysis, based on monitoring data and tapogeodesic measurements in determining the direction and velocity of the Yukori-Turk avalanche formed on the left bank of the Ahangaron Reservoir, the avalanche displacement distance and sliding speed were determined for each rapper. As a result, a method was developed to analyze the proportion and periodic variability of external forces influencing the process of landslide movement in natural conditions. Using a mathematical model that analyzes the external natural effects of landslides, it will be possible to predict the direction, acceleration, and duration of shoreline migration in a reservoir. The results obtained are based on the development of measures to eliminate the factors influencing the avalanche action of identified external forces.

I. INTRODUCTION

The strength of 15 percent of all earth dams in the world has always been a concern. Dam accidents average 5 percent per year [4]. An initial idea of the normal operation of objects can be obtained through visual observation, therefore direct observation of objects is part of the monitoring work and is carried out at objects belonging to all classes of capital. On this basis, the composition of follow-up work is determined with the help of subsequent control and measuring instruments. It is also important to consider the condition of control and measuring instruments, pickets, signs and other control devices used in monitoring and research, drainage canals, embankments, ravines in the area where the waterworks is located [5].

According to the data, in the twentieth century, there were more than 20 accidents (hydraulic accidents) and about 30 damages related to hydraulic structures in the world [6]. Reliability of hydrotechnical constructions is a feature of the normal operation of hydraulic structures or some of their elements, during the specified service life, without negating their function.

In determining the reliability of hydraulic structures, it is necessary to use special literature, as well as to have a set of observational data for statistical analysis and to take into account the service life of structures [1, 2]. Observation of sediments in hydraulic structures consists of periodic leveling of marks, detection of sediments and analysis of results. Periodic leveling depends on the geological structure of the dam and foundation, the duration of operation, the operating conditions of the structures and other similar factors [3].

The main causes of destruction and damage of hydraulic structures are their impact on the dam as a result of improper design, misuse, construction, operational errors and coastal displacement. The probability of an accident at any reservoir increases during earthquakes, floods and other emergencies. At the same time, their constant monitoring, measurement and protection with the help of visual (inspection) or equipment (geodetic, etc.) is also one of the important factors for the stable operation of hydraulic structures [7]. Changes in hydrogeological conditions in the coastal zone lead to increased filtration and suffocation processes, landslides. In addition, water saturation of areas under the influence of precipitation and runoff can also lead to landslides.

It is advisable to monitor coastal landslides in the reservoir to identify them in a timely manner, record their rate of migration, and at the same time take the necessary measures to prevent them in a timely manner. It is known that a number of measures are being taken in the Republic of Uzbekistan to ensure the reliable and safe operation of reservoirs. In particular, the field monitoring of the current state of control and measuring instruments installed to detect landslides and subsidence is important in order to ensure the safe and reliable operation of facilities in the operation of the Akhangaran Reservoir. Therefore, the development of measures to ensure the safe and reliable operation of facilities in the operation of the Akhangaran Reservoir is one of the urgent issues.

Object of research: The object of research is the Yukori-Turk landslide formed on the left bank of the Akhangaran Reservoir, monitoring data, results of tapogeodesic measurements, landslide displacement and analysis by reference.

Subject of research: The subject of research is mathematical modeling that analyzes the direction of the Yukori-Turk landslide on the left bank of the Akhangaran Reservoir, monitoring data, tapogeodetic measurement results, distance of the avalanche, speed of movement, external natural forces acting on the avalanche.

The purpose of the study is to determine the direction, displacement distance and sliding speed of the Yukori-Turk landslide and to analyze the periodic variability of the external forces acting.

Research objectives: Analysis of long-term operational monitoring data of facilities in the use of the Akhangaran reservoir; Development of a mathematical model representing the direction, displacement distance and sliding speed of the Yukori-Turk avalanche; Development of a method for analyzing the proportion and periodic variability of external forces influencing the process of landslide movement under natural conditions; Determination of the magnitude of free acceleration in the directions of motion of the Yukori-Turk avalanche.

II. METHODS

Analysis and calculations in the research process Using the "Method for determining the absolute (absolute) and relative errors of measurement of physical quantities" and mathematical and statistical analysis of research data using the methods of analysis of variance in the manual . The analyzed monitoring data generalized the units of measurement and determined the time taken for the avalanche to shift on each rapper. A mathematical model was used to determine the shift times for each rapper based on mathematical processing.

III. RESULTS AND DISCUSSION

Observation of sediments in hydraulic structures consists of periodic leveling of marks, detection of sediments and analysis of results. Periodic leveling depends on the geological structure of the dam and foundation, the duration of the operation period, the operating conditions of the structures and other similar factors. Experience in the operation of ground structures recommends to measure subsidence in the first years of operation - 2 times a month, then every quarter - 1 time. After the second year of use, drowning is measured in spring and autumn, and once the drowning has subsided, once a year. Drowning in structures made of sandy soils occurs mainly during construction, while sinking in structures with clay soils is very slow [8].

The role of control and measuring instruments in ensuring the safe operation and increasing the reliability of hydraulic structures is great. We conducted field monitoring studies on the current status of control and measuring instruments installed to detect shifts and subsidence in order to ensure safe and reliable operation of facilities during the operation of the Akhangaran Reservoir [9]. The results of the observations showed that the Yukori-Turk landslide, with a volume of 20.0 million m3, a length of 370-690 m and a width of 1600 m, is located on the left bank of the Akhangaran Reservoir Dam Zone. The block landslide was formed in 1954, 18 years before the 1972 reservoir was built. Today, in 2020, is the 66th anniversary of its establishment and the 48th anniversary of its being in the zone of influence of the Akhangaran Reservoir. The block landslide occurred in 1954 on the left bank of the Akhangaran River with an area of 0.65 km2, prior to the construction of the reservoir. Reactivation in avalanches was recorded in 1958 and 1964, and new shifts were recorded in 1969, 1979, 1991, and 2009, which were wet. Geodetic monitoring of the development dynamics of landslides with a frequency of 2-4 times a year began in 1972. As of November 18, 2018, 126 periodic observations were conducted. Over the past 46 years, landslides in different zones have shifted from 15 m to 51 m horizontally and from 3.0 m to 17.7 m vertically. Block-type landslides are characterized by a constant motion of a pulsating nature, moving at maximum speed during wet years. The mechanism of development of landslides has different velocities and general horizontal

International Journal of Advanced Research in Science, Engineering and Technology

ISSN: 2350-0328

IJARSET IMPACT FACTOR 7.150

Vol. 12, Issue 12, December 2025

motion values, which occur in three different western, central, and eastern generations. The surface of the avalanche slope is damaged by numerous cracks resembling the shape of a graben formed by expansion, contraction, displacement, and subsidence. A single landslide shift is not observed across the entire region. The average speed of horizontal displacement is 1.2-4.3 mm/day, in the spring on some indicators they reach 10-12 mm/day and the maximum speed is 25.5-38.6 mm/day. During the year, the average horizontal displacements vary from 0.4 to 1.2 m and vertical displacements from 0.1 to 0.2 m. The increase in the velocity of landslides is due to the division of the avalanche array into several generations in different years, where the shear rate increases due to the decrease in volume. This law is associated with an increase in the water cross-section of the massif due to the amount of atmospheric precipitation in the spring, the flooding of the area and the duration of the constant state of the water level in the reservoir. Today, the Yukori-Turk landslide mechanism, which has been evolving for more than 60 years, remains more complex, dangerous, and unpredictable [10, 11].

Repeated topogeodetic surveys of the entire landslide area were conducted in 2002 and 2017, and for a period of 44 years, compared with topographic surveys of the main landslide that occurred in 1973. According to the results of the comparison, three different areas were identified. The first is the most common red, where the relief surface of the landslides fell from 5-7 m to 10-17 m, the second is green, the landslides rose to 5-10 m, and the third is relatively uniformly marked in yellow by the relief of the landslides. . The first zone is the most common in terms of area and is more common in the upper and lower zones of the eastern and western generations. However, it is currently the most active eastern zone, where the 1969 landslide is more actively developing than the 1954 landslide; these landslide movements were not observed in the western generation. There is a third yellow central zone in the division zone of the eastern and western generations, which is currently the least mobile. In addition, in the lower part of the eastern and central zones there are areas of the second group, where the surface relief of landslides rises from 2-3 m to 7-10 m, which characterizes this zone as potentially dangerous [12, 13].

The main shift of rocks in the reservoir basin is avalanche occurs in the lower zones of the western and eastern borders. The Yukori-Turk landslide base is located in the range of 1050-1120 m, the western area is located at 1050-1090 m, the central area is located at 1050-1100 m, and the eastern area is located at 1087-1120 m. The river has a slight slope of 4-12º towards the riverbed. Hydrological conditions may be one of the main reasons for landslide displacement [14].

According to the results of topogeodesic measurements carried out for 164 days from September 6, 2018 to February 17, 2019 in the Yukori-Turk section, the following was determined (Table 1).

Table 1

№	Horizontal landslide, S_{hor}, sm	Horizontal landslide rate, V_{hor}, mm/day	Vertical landslide, h_{ver}, sm	Vertical landslide, V_{ver}, мм/day
In the Eastern generation				
Rp 35	8.6	0.5	-4.7	0.3
Rp 36	5.7	0.3	-8.0	0.5
In the central part				
Rp 3	15.1	0.9	-4.7	0.3
Rp 4	12.8	0.8	-1.9	0.1
Rp 34	11.2	0.7	-3.8	0.2
Rp 37	10.4	0.6	-5.1	0.3
In the Western generation				
Rp 8	9.5	0.6	-2.9	0.2
Rp 9	12.7	0.8	-3.6	0.2
Rp 13	16.0	1.0	-3.7	0.2
Rp 14	15.1	0.9	-3.8	0.2
Rp 21	1.1	0.1	1.2	0.1
Rp 23	3.4	0.2	0.7	0
Rp 30	5.6	0.3	-5.9	0.4
Rp 32	5.5	0.3	-2.7	0.2

International Journal of Advanced Research in Science, Engineering and Technology

ISSN: 2350-0328

IJARSET IMPACT FACTOR 7.150

Vol. 12, Issue 12, December 2025

Table 1 shows the landslide S and sinking distances and sliding velocity data of the avalanche obtained from the installed reference points over 164 days.

The units of displacement S and sinking d are given in cm, and the unit of sliding speed is given in mm/day. We summarize their units of measurement and determine the time taken for each avalanche to slide.

To do this, we first perform the following calculations.

$$\frac{1\text{ mm}}{1\text{day}} = \frac{0.001\text{ m}}{86400\text{ sec}} = \frac{1\cdot 10^{-3}\text{ m}}{86.4\cdot 10^{3}\text{ sec}} = \frac{1}{86.4}\cdot 10^{-6}\text{ m} \approx 0{,}0116\cdot 10^{-6}\frac{\text{m}}{\text{sec}} = 1.16\cdot 10^{-8}\text{ m/sec}$$

$$1\text{ cm} = 0.01\text{ m} = 1\cdot 10^{-2}\text{ m}$$

Hence, we multiply the values of the displacement S and sinking distances s given in Table 1 by $1\cdot 10^{-2}$. we multiply the sliding speed by $1.16\cdot 10^{-8}$. Then the units of measurement are generalized.

Calculate the time that taken for horizontal landslide from "Rp 35":

$$\upsilon_{35} = 0.5\text{ mm/sec} = 0.5\cdot 1.16\cdot 10^{-8} = 5\cdot 1.16\cdot 10^{-9} = 5.8\cdot 10^{-9}\text{ m/sec}$$

$$S_{35} = 8.6\text{ cm} = 8.6\cdot 10^{-2}\text{ m}$$

$$t_{35} = \frac{S_{35}}{\upsilon_{35}} = \frac{8.6\cdot 10^{-2}}{5.8\cdot 10^{-9}} \approx 1.5\cdot 10^{7}\text{sec}$$

Using the values obtained on horizontal landslides from all the reference points given in table 1, to determine times for landslides is calculated in the same order.

Calculate the time that taken for vertical landslide from "Rp 35":

$$\upsilon_{35} = 0.3\text{ mm/day} = 0.3\cdot 1.16\cdot 10^{-8} = 3\cdot 1.16\cdot 10^{-9} = 3.48\cdot 10^{-9} \approx 3.5\cdot 10^{-9}\text{ m/sec}$$

$$S_{35} = 4.7\text{ cm} = 4.7\cdot 10^{-2}\text{ m}$$

$$t_{35} = \frac{S_{35}}{\upsilon_{35}} = \frac{4.7\cdot 10^{-2}}{3.5\cdot 10^{-9}} = 1.34\cdot 10^{7}\text{sec}$$

Using the values obtained on vertical landslides for all the rest reference points, the time for landslides is calculated in the same order.

For all the rappers, the time spent in the horizontal and vertical shifts was calculated in the above order, and the results given in Table 2 below were obtained.

We know that tapogeodesic observations were made for 164 days to determine how far and at what speed the avalanche was moving towards the reservoir under natural conditions. Using a mathematical model, we determined the shift times determined for each rapper accordingly. In Table 2, we opened an additional column and reported the results obtained on a daily basis. This is necessary for us to make it clear that while the observations were made over 164 days, the results of mathematical modeling showed that the shift times were different for each rapper. Hence, we need to determine the errors between the time taken for the displacement of the Yukori-Turk avalanche under natural conditions and the time taken for the displacement determined using a mathematical model developed.
Using mathematical calculations, we determine the absolute (absolute) and relative errors of the results of topogeodetic measurements carried out on the Yukori-Turk section for 164 days from September 6, 2018 to February 17, 2019 as follows.

The arithmetic mean of the time elapsed (t, day) is determined by the following expression.

$$\bar{t} = \frac{t_1 + t_2 + \ldots + t_n}{n};$$

$t_{real} = 164\ day$

We determine the arithmetic mean of the time taken to move horizontally.

$$\bar{t} = \frac{t_1 + t_2 + t_3 + t_4 + t_5 + t_6 + t_7 + t_8 + t_9 + t_{10} + t_{11} + t_{12} + t_{13} + t_{14}}{14} =$$

$$= \frac{172 + 190 + 168 + 160 + 160 + 163 + 158 + 159 + 160 + 168 + 110 + 170 + 187 + 183}{14} =$$

$$= \frac{2308}{14} = 164.857$$

$\bar{t} = 164.857 \approx 165\ day$

$$t_{real} \approx \bar{t}$$

$$164 \approx 164.857$$

The absolute errors of the time taken to move are determined by the following expression.

$$\Delta t = |t - \bar{t}|$$

We calculate the absolute errors of the time taken for the horizontal shift.

$\Delta t_1 = |t_1 - \bar{t}| = |172 - 165| = 7$
$\Delta t_2 = |t_2 - \bar{t}| = |190 - 165| = 25$
$\Delta t_3 = |t_3 - \bar{t}| = |168 - 165| = 3$
$\Delta t_4 = |t_4 - \bar{t}| = |160 - 165| = 5$
$\Delta t_5 = |t_5 - \bar{t}| = |160 - 165| = 5$
$\Delta t_6 = |t_6 - \bar{t}| = |163 - 165| = 2$
$\Delta t_7 = |t_7 - \bar{t}| = |158 - 165| = 7$
$\Delta t_8 = |t_8 - \bar{t}| = |159 - 165| = 6$
$\Delta t_9 = |t_9 - \bar{t}| = |160 - 165| = 5$
$\Delta t_{10} = |t_{10} - \bar{t}| = |168 - 165| = 3$
$\Delta t_{11} = |t_{11} - \bar{t}| = |110 - 165| = 55$
$\Delta t_{12} = |t_{12} - \bar{t}| = |170 - 165| = 5$
$\Delta t_{13} = |t_{13} - \bar{t}| = |187 - 165| = 22$
$\Delta t_{14} = |t_{14} - \bar{t}| = |183 - 165| = 18$

The arithmetic mean of the absolute errors of the shift time (t, day) is determined by the following expression.

$$\Delta\bar{t} = \frac{\Delta t_1 + \Delta t_2 + \ldots + \Delta t_n}{n};$$

We determine the arithmetic mean of the absolute errors of the time taken for the horizontal shift.

$$\Delta\bar{t} = \frac{7 + 25 + 3 + 5 + 5 + 2 + 7 + 6 + 5 + 3 + 55 + 5 + 22 + 18}{14} = \frac{168}{14} = 12$$

The smaller the absolute error of the measurement, the more accurate the measurement is considered to have been performed. Rough errors that differ from the mean are omitted during the calculation of the error [15].

$$\Delta\bar{t} = \frac{7 + 3 + 5 + 5 + 2 + 7 + 6 + 5 + 3 + 5}{10} = \frac{48}{10} = 4.8 \approx 5$$

The actual value of the shift time (t, day) differs from the found average by $\pm\,\Delta\bar{t}$, ie

International Journal of Advanced Research in Science, Engineering and Technology

ISSN: 2350-0328

IJARSET IMPACT FACTOR 7.150

Vol. 12, Issue 12, December 2025

$$t_{real} = \bar{t} \neq \Delta\bar{t}$$

The actual value of the time taken for the horizontal shift is t = 164 days, the arithmetic mean value found is $\bar{t} =$ 165 days, and the arithmetic mean value of the absolute errors is $\Delta\bar{t} = 5$.

The ratio of the absolute error of the time taken to shift (t, day) to its true value is called the relative error and is determined by the following expression
.

$$N = \frac{\Delta\bar{t}}{t}$$

For horizontal shifts:

$$N = \frac{\Delta\bar{t}}{t_{real}} = \frac{5}{164} = 0.0304$$

or in percent,

$$N = \frac{\Delta\bar{t}}{t_{real}} \cdot 100 = \frac{5}{164} \cdot 100 = 3.048\ \%$$

$$t_{real} = 164\ day$$

We determine the arithmetic mean of the time taken to move vertically.

$$\bar{t} = \frac{157 + 160 + 157 + 190 + 190 + 170 + 145 + 180 + 185 + 190 + 120 + 0 + 148 + 135}{13} =$$

$$= \frac{2127}{13} = 163.615$$

$\bar{t} = 163.615 \approx 164\ day$

$$t_{real} \approx \bar{t}$$

$$164 \approx 163.615$$

We determine the absolute errors of the time taken to move vertically.

$\Delta t_1 = 7$	$\Delta t_4 = 26$	$\Delta t_7 = 19$	$\Delta t_{10} = 26$	$\Delta t_{13} = 16$
$\Delta t_2 = 4$	$\Delta t_5 = 26$	$\Delta t_8 = 16$	$\Delta t_{11} = 44$	$\Delta t_{14} = 29$
$\Delta t_3 = 7$	$\Delta t_6 = 6$	$\Delta t_9 = 21$	$\Delta t_{12} = 164$	

When calculating the arithmetic mean of the absolute (absolute) errors of the time taken for the vertical shift, we determine by subtracting the gross errors that differ from the mean.

$$\Delta\bar{t} = \frac{7 + 4 + 7 + 26 + 26 + 6 + 19 + 16 + 21 + 16}{10} = \frac{148}{10} = 14.8 \approx 15$$

The actual value of the time taken for the vertical shift is t = 164 days, the arithmetic mean value found is $\bar{t} = 164$ days, and the arithmetic mean value of the absolute errors is $\Delta\bar{t} = 15$.

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 12, Issue 12, December 2025

Table 2

№	Horizontal shift, S_{hor}, (m)	Horizontal shift rate, V_{hor}, 10^{-9} (m/sec)	Time spent for horizontal shift, t_{hor}, 10^{7} (sec)	Time spent for horizontal shift, t_{hor}, (day)	Acceleration, a_{hor}, 10^{-16} (m/sec^2)	Vertical shift, h_{ver}, (m)	Vertical shift rate, V_{ver}, 10^{-9} (m/sec)	Time spent for vertical shift, t_{ver}, 10^{7} (sec)	Time spent for vertical shift, t_{ver}, (day)	Acceleration, a_{ver}, 10^{-16} (m/sec^2)
In the Eastern generation										
Rp 35	0.086	5.8	1.5	172	3.9	-0.047	3.5	1.3	157	2.6
Rp 36	0.057	3.5	1.6	190	2.1	-0.08	5.8	1.4	160	4.2
In the central part										
Rp 3	0.151	10.4	1.4	168	7.2	-0.047	3.5	1.3	157	2.6
Rp 4	0.128	9.3	1.4	160	6.7	-0.019	1.2	1.6	190	0.7
Rp 34	0.112	8.1	1.4	160	5.9	-0.038	2.3	1.6	190	1.4
Rp 37	0.104	7.0	1.5	173	4.7	-0.051	3.5	1.5	170	2.4
In the Western generation										
Rp 8	0.095	7.0	1.4	158	5.1	-0.029	2.3	1.2	145	1.9
Rp 9	0.127	9.3	1.4	159	6.8	-0.036	2.3	1.5	180	1.5
Rp 13	0.16	11.6	1.4	160	8.4	-0.037	2.3	1.6	185	1.5
Rp 14	0.151	10.4	1.4	168	7.2	-0.038	2.3	1.6	190	1.4
Rp 21	0.011	1.2	0.9	110	1.2	0.012	1.2	1.0	120	1.1
Rp 23	0.034	2.3	1.5	170	1.6	0.007	-	-	-	-
Rp 30	0.056	3.5	1.6	187	2.2	-0.059	4.6	1.3	148	3.6
Rp 32	0.055	3.5	1.6	183	2.2	-0.027	2.3	1.2	135	2.0

We determine the relative error for vertical displacement by the following expression.

$$N = \frac{15}{164} = 0.0914$$

or in percent,

$$N = \frac{\Delta \bar{t}}{t} \cdot 100 = \frac{15}{164} \cdot 100 = 9.146\ \%$$

The relative error between the actual value of the displacement time and the value of the time determined by mathematical calculations was 3% for the horizontal displacement and 9% for the vertical displacement, respectively.

International Journal of Advanced Research in Science, Engineering and Technology

ISSN: 2350-0328

IJARSET IMPACT FACTOR 7.150

Vol. 12, Issue 12, December 2025

IV. CONCLUSIONS

The development of a monitoring regime by linking landslides generated at reservoir dams with climate and changes in water flow will increase the accuracy of predictive analysis. A mathematical model was developed based on the monitoring data of natural displacements of the Yukori-Turk landslide detected on the left bank of the Akhangaran Reservoir. Using this mathematical model, the horizontal and vertical displacement of the avalanche was calculated. The difference between the practical and calculated results was 3 ÷ 9%.

The disproportion of horizontal and vertical displacements of the Yukori-Turk landslide under natural conditions detected on the left bank of the Akhangaran Reservoir is to some extent affected by changes in soil layers as a result of climate change.

Using a mathematical model that analyzes the natural external forces acting on an avalanche, it will be possible to predict the direction, acceleration, and duration of the coastal migration in the reservoir. The obtained results allow to develop measures to eliminate the factors influencing the avalanche action of the identified external forces.

Through the developed mathematical model, other reservoirs can be widely introduced in order to analyze the reliability of ground dams and avalanche movement movement and to assess the probability of landslide hazards.

Based on the analysis of natural displacements of the Yukori-Turk landslide detected on the left bank of the Akhangaran Reservoir, it is recommended to identify the most active influences of external natural forces and develop measures to eliminate these effects.

REFERENCES

[1]. Babuskin, L., 1982. Climatic Atlas of UzbekSSR. 65.
[2]. Bakiev, M., Kaveshnikov, N., Tursunov, T. 2008 Use of hydrotechnical construction. Tashkent, 460 p.
[3]. Kodirov, D. T., Kodirov, S. B., Sherbaev, M. R., Turdiboev, Y. Y., Rustamov, S. T., Muzaffarova, G. V. 2021. Results of field observations at the Talimarjan Reservoir. "ACADEMIC RESEARCH IN EDUCATIONAL SCIENCES (ARES)" 2-TOM 4-edition. 1213-1220 (https://doi.org/10.24411/2181-1385-2021-00721).
[4]. Xojiev, A., Murtazaeva, G., Xaydarov, T. Issues of enhancing safety of hydrotechnical constructions. 2019. "AGRO ILM" , 3(59) (May-June). Tashkent. B. 77.
[5]. Belolipov, I., Zaurov, D., Eisenman, W. 2013, The Geography, Climate and Vegetation of Uzbekistan. Medicinal Plants of Central Asia: Uzbekistan and Kyrgyzstan, 340.
[6]. Kodirova, A. To use river waterworks. 2008, TIIAME. Tashkent. 354 p.
[7]. Canuti, P., Casagli, N., Ermini, L., Fanti, R., and Farina, P. 2004, Landslide activity as a geoindicator in Italy: significance and new perspectives from remote sensing, Environ. Geol., 45, 907–919.
[8]. Bakiev, M., Yangiev, A. A., Raxmatov, N. "Hydrotechnical construction", Tashkent. 2018. 233 p.
[9]. Kodirov, D. T., Urunov, N. N., Kodirov, S. B. Results of field studies of the static stability of the Akhangaran waterworks. Collection of materials of the seminar of young scientists of the XXII International Scientific Conference, "Construction - formation of the living environment". Tashkent, 18–21 April. 2019. 408-413 pp. (https://www.elibrary.ru/item.asp?id=38178810).
[10]. Casagli, N., Fanti, R., Nocentini, M., and Righini, G. 2005, Assessing the
[11]. capabilities of VHR satellite data for debris flow mapping in the Machu Picchu area, in: Landslides, risk analysis and sustainable disaster management, edited by: Sassa, K., Fukuoka, H., Wang, F., and Wang, G., Proceeding of the First General Assembly of the International Consortium on Landslides.
[12]. Kodirov, D. T., Makhmudov, E. J. 2020. Development of measures for reliable and safe operation of the Ahangaron Reservoir. SCIENCE, RESEARCH, DEVELOPMENT, 3230. 2020. Berlin. p 86. (http://xn--e1aajfpcds8ay4h.com.ua/files/104_06_ix_2020.pdf).
[13]. Kodirov, D. T., Kodirov, S. B. Sherbaev, M. R., Ermanov, R. A. 2021. Analysis of the impact of landslide processes on the Ahangaron Reservoir Dam. "ACADEMIC RESEARCH IN EDUCATIONAL SCIENCES (ARES)", 2 том, 5 edition. 606-615, (https://doi.org/10.24411/2181-1385-2021-00933).
[14]. Bimurzaev, G. A. The mechanism of formation and development of modern landslides due to man-made impact on the upper reaches of the Ahangaron River, 2020. Tashkent.
[15]. Central Asia and Caucasus Disaster Risk Management Initiative (CAC DRMI), 2009, Risk Assessment for Central Asia and Caucasus Desk Study Review.