PROPOSALS ON THE STABILIZATION OF THE LANDSLIDE EXISTING ON THE SEGMENTS OF THE TSKHNETI-KOJORI AND TSKHNETI-AKHALDABA MOTOR ROADS

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In order to stabilize the landslide existing at the site of its intersection with the Tskhneti-Kojori and Tskhneti-Akhaldaba motor roads, we propose to carry out construction work using the following technologies:

1. Securing lansdlide masses with earth anchors.

2. Removal of earth masses, which are in the unstable state, from the landslide slope.

3. The proposed method of actions will make it possible to consolidate the slopes.

An approximate total cost of the work on stabilization of the main landslide is 1850 thousand GEL

The grand total, overhead expenses inclusive, is 2700 thousand GEL.

Key words:

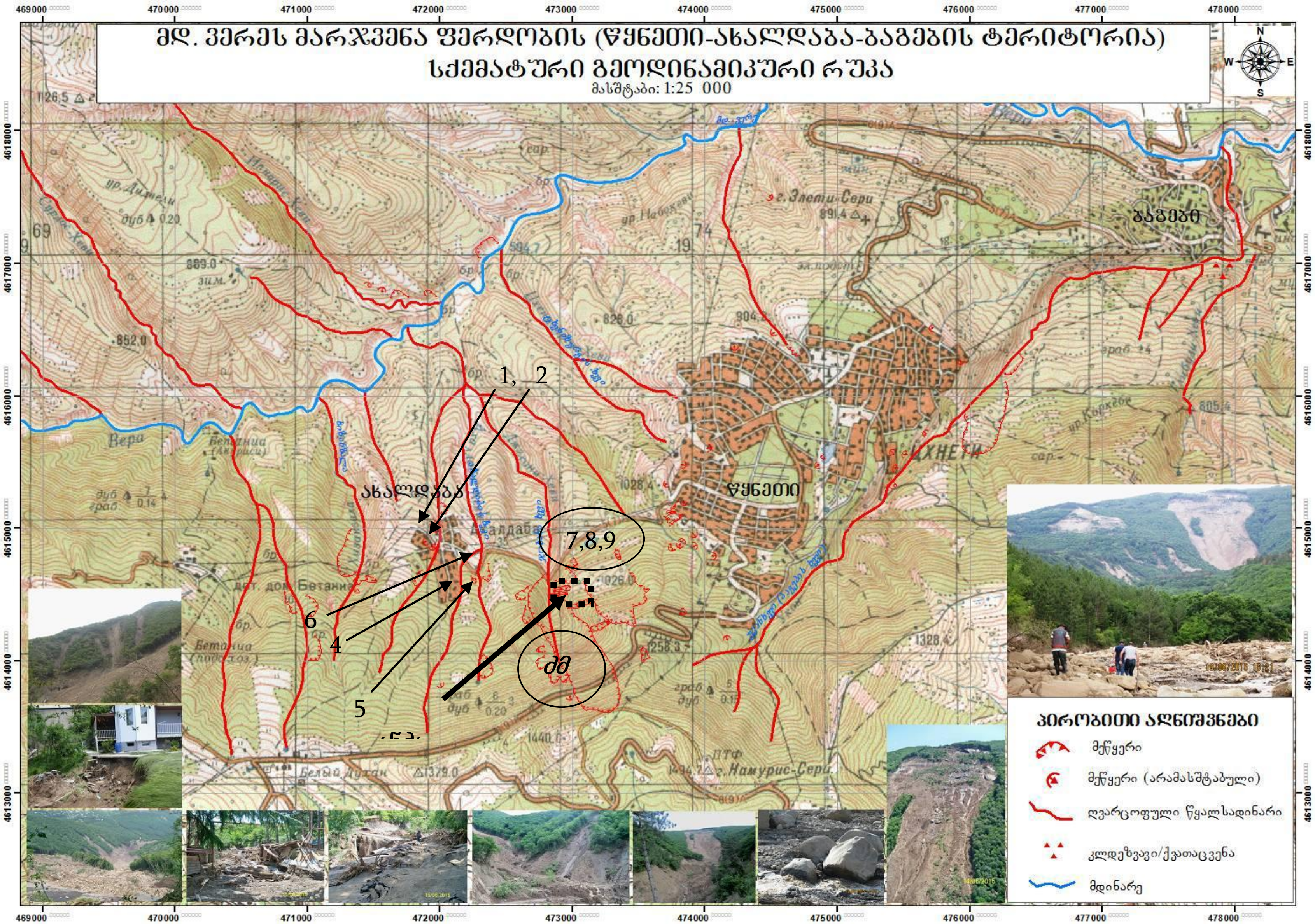
I. In order to stabilize the landslide existing at the site of its intersection with the Tskhneti-Kojori and Tskhneti-Akhaldaba motor roads, we propose to carry out construction work using the following technologies:

a) Securing lansdlide masses with earth anchors

When securing the landslide slope against a possible occurrence of land slide processes it is necessary to take into account the structure and the position of rock in the landslide slope. According to geologists' data, the rock layers are positioned in a sloping manner, in parallel to the plane along which the collapse prism of the formed landslide slope moves.

Between individual layers there are streaks of clay earth which provoke the formation of new slide planes when they get saturated with water and become swollen. In case there are no prop-ups under these layers, further landslide processes may develop. To prevent a further collapse it is necessary to secure by means of anchors the earth masses adjacent to the earth zones which are in the stable state and are located along the :contour" of the "funnel" formed after the landslide prism collapse. The earth anchors can be used in combination with supporting walls, supporting plates, prop-up belts or metal nets. Also, to speed up the drying of water-saturated parts of the landslide slope it is recommended to install in the landslide slope "drainage ground anchors" manufactured according to our patent P 5294 .

For the safety of the work on the installation of earth anchors, it is proposed to bore anchor holes using drilling mechanisms which perform vertically and horizontally oblique drilling operations and which are positioned on the stable part of the slope , i.e. at the landslide vertex or on a terrace beneath the landslide vertex. In that case, several multiple drill holes or fan-like holes can be made from a single vertically and horizontally (such drilling machines designed in the USA are employed in the oil and gas extraction industry). Holes can be drilled on the paths which repeat the direction of the collapse prism movement or crosswise the direction of the collapse prism movement, and also at some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angle to the direction of the collapse prism movement. The resulting drill hole comes out of the stable slope zone, and in passing the slide plane of the collapse prism, passes into the collapse prism and comes out onto the day surface (or in the case of drilling the hole crosswise the slope, comes out onto the opposite parallel "landslide funnel bank" on the stable rock slope), see Fig. 1. All the elements of the earth anchor are hauled by means of a rope into the formed drill hole in the same sequential order in which they will be installed on the fixed anchor. The same tensioning rope provides the tension of the anchor haulage part. After the embedment of the "anchor root", the tensioning rope can be removed from the anchor haulage part using, for example., the method proposed in our Patent P 5418.

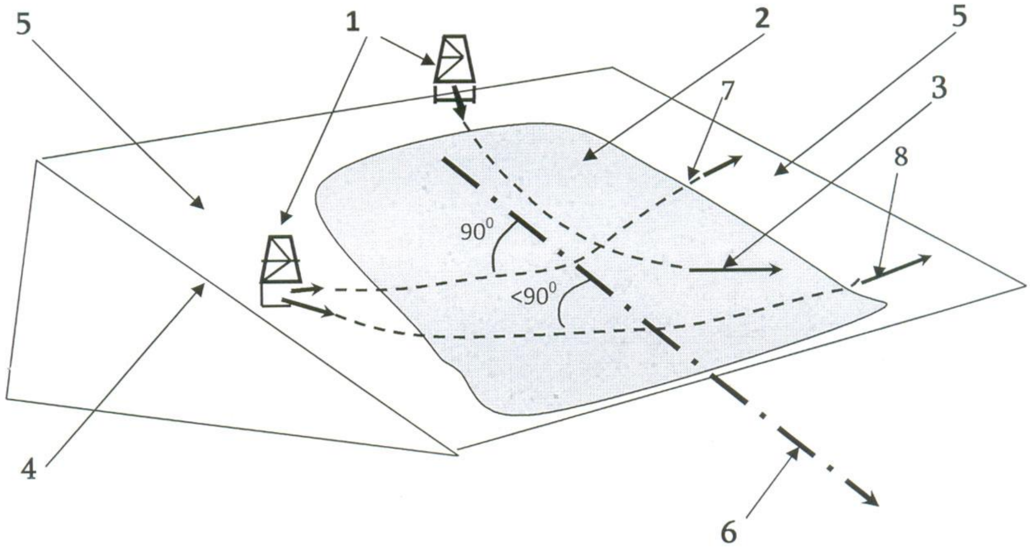

Fig. 1.

1 - down-the-hole drilling; 2 - earth mass collapse prism; 3 - trajectories of holes made by down-the-hole drilling and coming out onto the day surface; 4 - outer day surface of the landslide slope; 5 - stable part of slope; 6 - direction of the collapse prism movement during landslide downward movement; 7 - trajectory of hole drilling crosswise the direction of the collapse rock movement; 8 - trajectory of hole drilling at an angle to the direction of the collapse prism mass stream movement

When installing the so-called drainage anchor, a perforated drainage pipe is also drawn into the drill hole. This pipe is installed along the slope from the anchor root to the anchor supporting plate. Into some individual drill holes only the drainage pipe can be drawn to provide horizontal drainage for the collapse prism body or for some other underground water-saturated site of the slope, which will essentially speed up the process of landslide slope drainage .

Holes can be bored without going out onto the day surface suspending the drilling process in the collapse prism body. In that case, after reinforcing and placing concrete into the site starting from the stable rock, passing the slide surface of the collapse prism and ending in the collapse prism, "a bar" is formed that prevents the slide of the collapse prism. Holes can also be drilled without reaching the day surface and stopping the drilling operation somewhere within the collapse prism body. In that case, after the reinforcement and grouting the site adjoining the stable rock, this reinforced site gets inside the plane of the collapse prism and and thus the "bar" is formed which prevents the slide of the collapse prism.

It is desirable to install steel ropes in the drilled hole which serve as an extension of the earth anchor or reinforcement rods for slide preventing pins. For the embedment of a drill hole in concrete it is recommended to fill it up completely with fin-grained concrete or with fast hardening concrete with “penetron” admixture. This will make it possible to join the cracked rock blocks.

A more detailed description of the work operations on the proposed technique of installation of anchors is given in our submitted pending patents 13896/02 and 13921/02.

The scheme of the above-described technique of fixation of the landslide slope by earth anchors and slide preventing bars is presented in Fig. 2 which shows

1. Day surface of the landslide slope;
2. Drilling machine;
3. Earth anchor fixed in the landslide slope;
4. Slide preventing bars in the landslide slope body;
5. ”Drainage earth anchor“embedded into the landslide slope;
6. Rock layers of the landslide mass.

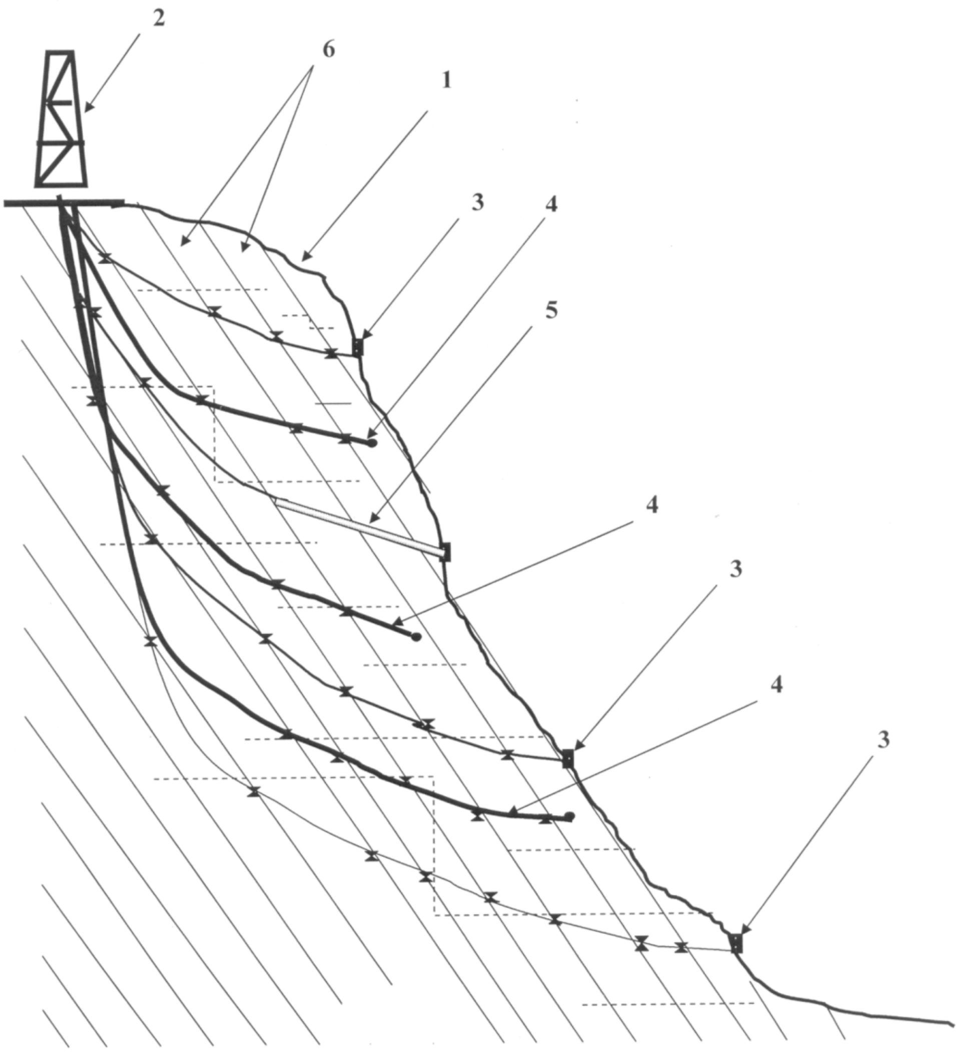

Fig. 2.

II. Removal of earth masses, which are in the unstable state, from the landslide slope.

To ensure the safety of work operations, earth masses which are in the unstable state and should be removed from the slope and transported to the preliminarily selected sites can be excavated, transported and dumped at the pre-planned side by the hydraulic excavation technology.

Using this cheapest type of excavation and employing hydraulic monitors, including those with remote control, earth masses can be mined by pressurized water. The formed hydro mass (pulp) can be flushed down from the upper points of the landslide to the lower points and collected in specially selected banked-up sites. The water flushes down the preliminarily installed chutes or mud stream beds which are preliminarily washed out by hydraulic monitors. The settled hydro mass forms a terrace, while the clarified water is removed through the specially built drainage wells. A required quantity of water is supplied to the hydraulic monitors by means of pumps from the water reservoir which is created on the Vere river by the dam with a sluice. Clarified water is discharged into the Vere river via the pipes from the drainage wells.

If necessary, several terrace levels can be arranged. On the topmost terrace, a site can be reserved for accumulating and keeping earth masses that potentially might move down from the landslide risk zone.

A schematic plan of the installation of hydraulic mechanisms in the landslide zone is shown in Fig. 3, while the section of the landslide slope with hydro mechanic elements is shown schematically in Fig. 4.

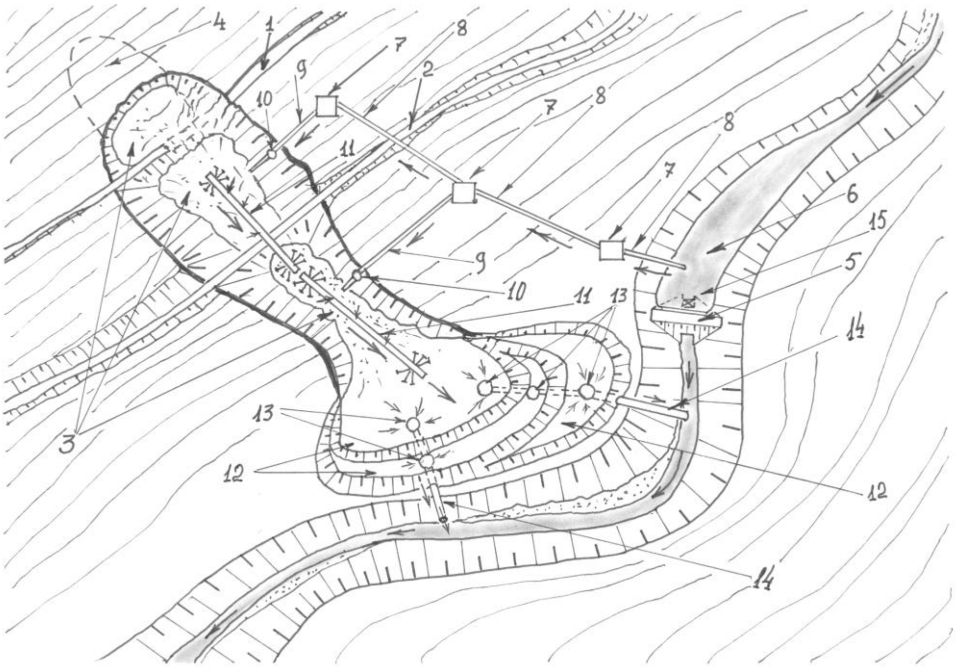

Fig. 3. Hydro mechanization of the work on excavation and removal of earth masses after the landslide collapse *(plan)*

1. Tskhneti-Kojori road; 2. Tskhneti-Akhaldaba road; 3. Remaining earth mass of the collapse prism after the landslide fall; 4.Collapse prism of the landslide mass that remained stable; 5. Temporary earth dam with a sluice; 6. Temporary water reservoir for water collection for hydraulic monitors;; 7. Pumps for water supply to hydraulic monitors 8. Pipeline supplying water to pumps; 9. Pipeline supplying water to hydraulic monitors; 10. Hydraulic monitors; 11. Hydraulic mass (pulp) discharge chutes; 12. Terraces formed by hydraulic deposition; 13. Drainage wells; 14. By-pass drainage pipe for water discharge into the river; 15.Sluice

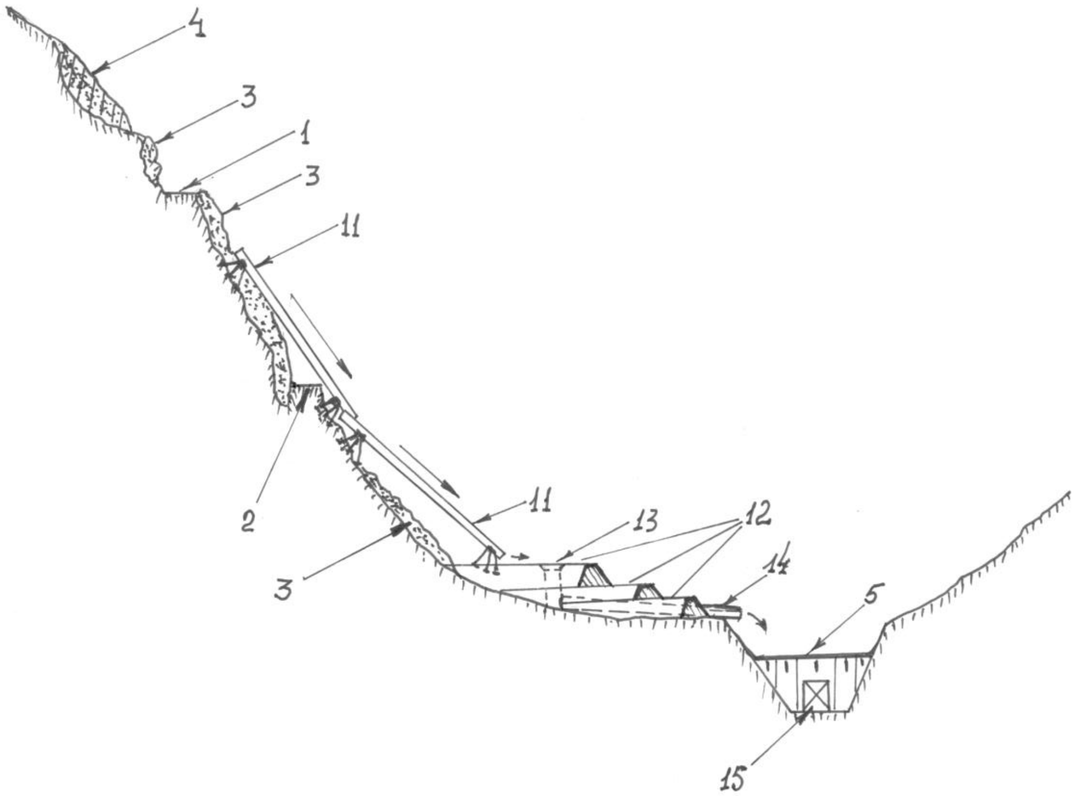

Fig. 4. Hydro mechanization of the work on excavation and removal of earth masses after the landslide collapse *(section)*
1. Tskhneti-Kojori road; 2. Tskhneti-Akhaldaba road; 3. Remaining earth mass of the collapse prism after the landslide fall; 4.Collapse prism of the landslide mass that remained stable; 5. Temporary earth dam with a sluice; 6. Temporary water reservoir for water collection for hydraulic monitors;; 7. Pumps for water supply to hydraulic monitors 8. Pipeline supplying water to pumps; 9. Pipeline supplying water to hydraulic monitors; 10. Hydraulic monitors; 11. Hydraulic mass (pulp) discharge chutes; 12. Terraces formed by hydraulic deposition; 13. Drainage wells; 14. By-pass drainage pipe for water discharge into the river; 15. Sluice

The proposed method of actions will make it possible to consolidate the slopes; it provides maximal safety and offers minimal economic expenses. Moreover, work operations realized according to the proposed method minimize the violation of ecological stability of the territory where they are carried out and, in their turn, restore through the deposition of terraces the earth mantle in the zone damaged by the past landslide.

An approximate total cost of the work on stabilization of the main landslide is 1850 thousand GEL, inluding:

700 thousand GEL for the installation of earth anchors,
720 thousand GEL on the removal of earth masses from the landslide slope by the hydraulic mechanization method;
430 thousand GEL for unforseen additional expenses.

The grand total, overhead expenses inclusive, is 2700 thousand GEL.

At the dangerous sites it is proposed to carry out the following kinds of work according to the respective site numbers:

Site no. 1 with coordinates X-471988, У-4614829. Straightening of mudflow bed and reinforcement of the bed slopes by bearing walls, reinforcement (concrete grouting) of the bed bottom at the sites of different height. These measures are needed because the mud stream bed is located within the boundaries of Akhaldaba.

In these conditions, the straightening of the bed is the simplest measure from the engineering point of view and cost-effective because of the use of hydraulic mechanization, more exactly, the wash-out of earth masses by a hydraulic monitor. The washed-out mass (pulp) can be discharged from the terraces made at low levels.

Site no. 2 with coordinate X-472110, У-4614839. Restoration of the bearing wall and stabilization of the wall foundation. When restoring the roadway, it is necessary to provide the stability of the adjacent areas. In restoring the bearing wall, it is necessary to provide the stability of the wall foundation. In restoring the roads, it is necessary to provide the stability of the road beds.

Site no. 3 with coordinates X-472199, У-4614745. Straightening of the mudstream bed and consolidation of the bed slopes by supporting walls. The buildings that are situated near the bed must be provided with stable foundations and stable access roads.

Site no. 4 with coordinates X-472250, У-4614642. Straightening and fortification of the bed banks in the vicinity of the Akhaldaba populated area, and in the vicinity of the Akhaldaba motor road.

Site no. 5 with coordinates X-472820, У-4614507 should be considered together with site no. 6 with coordinates X-472874, У-4614617; - X-472915, У-4614669; X-472934, У-4614677; - X-472955, У-4614716, and also with site no. №7 with coordinates X-473332, У-4615005; - X-473366, У-4615022. Straightening of the river bed and fortification of the river banks with supporting walls by meand of stabilizing earth anchors. When restoring the roads, it is necessary to provide the stability and safety of the road bed by means of supporting walls and fixed "drainage earth anchors".

Site no. 8 with coordinates X-473520, У-4615042 and also

Site no. 9 with coordinates X-473748, У-4615271 must be fortified with supporting walls and fixed "drainage earth anchors".

The site (hill) with a power transmission line tower must be fortified by walls with earth and "drainage" anchors and, if necessary, the inner horizontal drainage system should be created.

I would like to suggest different approach to solve the problem, the idea belongs to Mr. SHALVA GAGOSHIDZE – Doctor of Technical Science.

Schematic solution for rehabilitation of Tskneti-Kiketi and Tskneti-Akhaldaba motorway (see the attachment prepared in Google Earth map where the roads with the benchmarks and approximate lengths are shown in yellow and they, of course, need to be revised based on the accurate topographic and geological data).

In addition, I believe, that:

1. we should refuse to run any landslide supporting and landslide flushing activities since such activities are associated with large scale, quite dangerous, expensive and, at the same time, in terms of the road rehabilitation aimless works;
2. it is desirable to arrange just automatic relaying system registering dangerous deformations on the existing landslide and adjacent landslide dangerous zones. In addition, it is required to explode (or use any other method, in particular using expansion concrete) large size cobblestones remaining on just the landslide so that in case they roll down they do not create any danger during rehabilitation works on Tskneti-Akhaldaba motorway;
3. stability of high voltage power transmission towers on top of the landslide and the adjacent landslide dangerous zones need to be checked and, if necessary, urgent rehabilitation activities need to be worked out.