Engineering-geological survey

Technical report

Tkibuli municipality, Gelati village, cadastral/code 39.07.31.362

Drainage channel arrangement project

adjacent to Gelati Monastery complex

Tbilisi

September

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1. Introduction

In response to the order of the LEPL Patriarchate of Georgia, geologists of the Geological Service LTD conducted engineering-geological survey in Tkibuli municipality, Gelati village, c/c 39.07.31.362, adjacent to the Gelati Monastery complex. It is planned to carry out engineering-geological survey of the area in order to determine the level and character of the ground water, for the drainage arrangement project.

The engineering-geological survey aimes to establish engineering-geological and hydrogeological conditions of the site/land plot, to study physical-mechanical properties of soils constructing the site and to assess the hazardous geodynamic events spread in the area.

The following types and scopes of work have been carried out for the arrangement of the drainage channel to be designed: Investigations conducted by the Geology Department of the National Environmental Agency in 2023 "Results of the development of natural geological processes in Georgia in 2023 and the forecast for 2024" were found and used in the conclusion, for the purpose of engineering-geological assessment of the area, the surrounding area was inspected; 3 drillholes with total depth 42 l/m were drilled in order to determine the lithological section and for sampling. Core drilling with continuous core extraction was carried out using owned by Geological Service LTD drill rig УРБ 2-А2.

Soils sampling was undertaken to study their physical-mechanical properties; testwork on soil samples was conducted at the geotechnical laboratories of Geological Service LTD and Ltd. Water and Soil. Planar and vertical connection of the drillholes was carried out according to the topographical plan provided by the customer. After the fieldwork completion, the drillholes were backfilled with the extracted material. The investigations have been carried out and the conclusion has been worked out in accordance to the requirements of the normative documents currently in force in Georgia (construction norms and rules): CNR 1.02.07-87 (Engineering surveys for construction), PN 01.05-08 (Building climatology), PN 02.01-08 (Foundations of buildings and structures), CNR IV-5-82 (Earth works), CNR 2.02.03-85 (Pile foundations), CNR 3.02.01-87 (Earthen structures, footings and foundations), PN 01.01.-09 (Earthquake / seismic resistant construction), CNR

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2.03.11-85 (Corrosion protection of building constructions), state standard 25100-82 (soils, classification). Engineering-geological survey was undertaken in August-September 2024.

2.Physical-geographic description, geological setting and hydrogeological conditions

The study area is located in western Georgia, near Kutaisi City, the general climatic conditions of the area are moderately continental. According to the construction climate zoning scheme of the territory of Georgia it belongs to the IIIბ /III b (#146, Kut., city) climatic sub-zone. Average annual air temperature is 14.5°C, absolute annual minimum - 17°C, absolute annual maximum - 40°C. Average relative humidity is 70%, average relative humidity of the coldest month - 60%, average relative humidity of the hottest month - 58%. Annual precipitation is 1394 mm, precipitation daily maximum – 166 mm. Snow cover weight is 0,50 kpa, number of days with snow cover – 26. Normative value of wind pressure is 0,73 kpa once in five/5 years, normative value of wind pressure 0,85 kpa once in 15 years. Maximum wind speed once in 1, 5, 10, 15, and 20 years is accordingly 31, 35, 37, 38, and 39 m/sec. Soils seasonal freezing normative depth any type of soils is 0 cm.

For earthquake-resistant construction, Kutaisi is rated as 8 points, and A - the dimensionless coefficient of seismicity - is 0.13.

From the geomorphological point of view, the study area is located on the accumulation plain of the of the alluvial and proluvian plains sub-zone of the intermountain lowland/depression zone with undulating terrain (National Atlas, 2012). The relief of the area is represented by the moderately inclined towards the west horizontal surface. The study area is bordered by the the Gelati Monastery gate from the west, a steep slope from the east, an asphalt road from the north, and cemeteries from the south. Absolute elevations vary between 398,8 – 406,5 m range.

According to the tectonic subdivision scheme of Georgia (Adamia, Sh., 2004) the study area is located in the precollison tectono-stratigraphic unit of the Georgian Block (Fig. 1).

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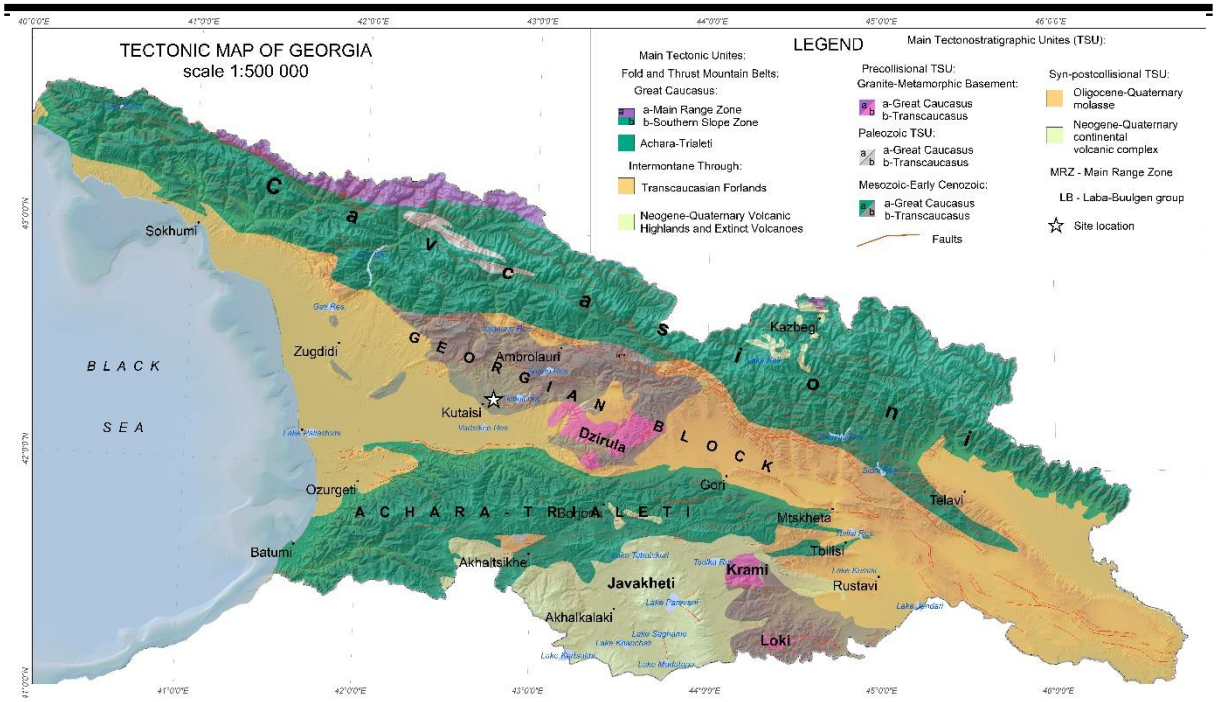

Figure 1. The location of the study area on the tectonic map of Georgia (Adamia, Sh., 2004).

The construction site is located on the Quaternary proluvial-deluvial sediments represented by brownish clay with inclusions of limstones large blocks. Quaternary sediments are underlain by the terrigenous variegated sediments of the Callovian-Tithonian Okriba suite (Fig. 2).

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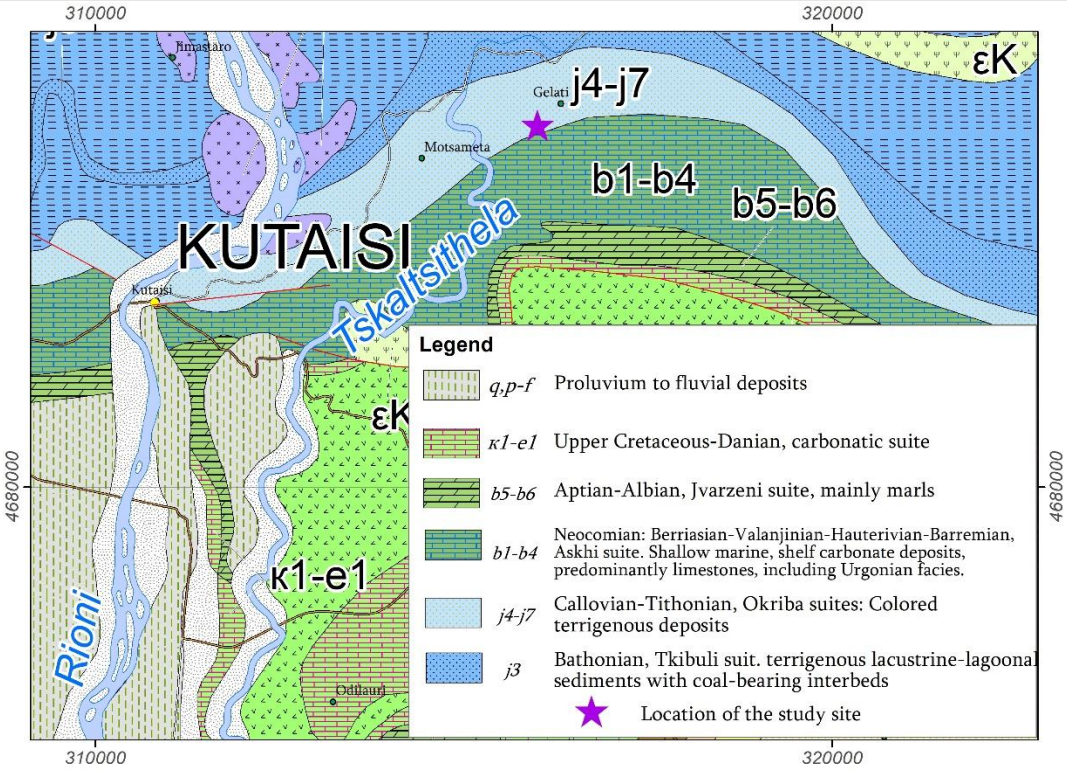

Figure 2. The location of the study area on the geological map of Georgia (Papava et. al., 1971)

The main hydrographic element of the area is the Tskaltsitela river. The Tskaltsitela headwaters are located on the mountain Nakerala slopes of the Racha range, at an altitude of 1080 m above sea level. The Tskaltitela river is the right tributary of the Kvirila river. It is 49 km long and its basin covers the 221 km^2 area. It is fed mainly by rain water and is characterized by flood events throughout the year. The Tskaltsitela river flows within the study area from the north to the south. The width of the river bed is generally 70 m. The river is 1100-1200 m away from the study site.

3.Soils physical-mechanical properties

Due to the complexity of the engineering-geological conditions, according to the Annex 10 of the CNR 1.02.07.-87 the site belongs to the II (moderate) engineering-geological category of complexity. In order to obtain an engineering-geological picture of the construction site, 3 drillholes with maximum depth of up to 15 l/m each were drilled on the

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site. Based on the analysis of conducted field work and laboratory studies, four layers were distinguished on the site. Below is a description of these layers.

Layer #1 Backfill - tQ_{IV}- Loam with inclusions of gravel and asphalt clasts, compacted. The layer thickness is 0,7-1,1 m. The layer is not considered as an engineering-geological element and therefore it was not sampled.

According to treatment complexity the soil belongs to 24-a-II category

Layer #2 Clay - pdQ_{IV} – brownish, with limestone blocks inclusions, semi-solid. Limestone blocks inclusions are observed in the layer, the blocks sizes vary within 1,1-4,5 meters range. The layer was tested by 6 soil samples with intact/undisturbed structure. The samples were tested on direct shear test by step load 0,5 kgf/cm2 to 3,0 kg. Soil physical-mechanical properties were studied: density, moisture content, plasticity limits and accotrding to their values porosity, porosity index and liquidity index were estimated. Standard values of soil physical-mechanical properties are given in Table 1. Laboratory tests results are demonstrated in the summary test-sheet.

Table 1

#	Types of physical-mechanical properties	Index	Meas. unit	Standard value
1	Density	ρ	g/cm³	1,95
2	Bulk density	ρ_δ	g/cm³	1,62
3	Mineral particles density	ρs	g/cm³	2,72
4	Natural moisture content	W	N/division	0,198
5	Porosity	n	%	40
6	Porosity index	e	N/division	0,673
7	Moisture content at liquidity limit	W_L	N/division	0,370
8	Moisture content at plastic limit	Wp	N/division	0,184
9	Plasticity index	Ip	N/division	18,7
10	Liquidity index	I_L	N/division	0,07
11	Degree of saturation	Sr	N/division	0,79
12	Poisson's ratio	μ	N/division	0,80
13	Deformation modulus	E	kgf/cm²	220
14	Internal friction angle	φ	degree	20⁰
15	Specific cohesion	C	kgf/cm²	0,58
16	Filtration coefficient	Kf	m/day	<0,005
17	Relative design resistance	R_0	kgf/cm²	3,8

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According to treatment complexity the soil belongs to 8-д-IV category.

According to its seismic properties the soil belongs to the II category of soils

Layer #3 Loam - pdQ_{IV}- Yellowish-brownish, gravel inclusions up to 20%, slightly calcareous/carbonate bearing, semi-solid. The layer is observed as a lense in Drillholes #1 and #3 in the central and southern parts of the study area. The ground water strike and the rest water level were observed in this layer. The layer was tested by 3 soil samples with intact/undisturbed structure. Soil physical-mechanical properties were studied: density, moisture content, plasticity limits and accotrding to their values porosity, porosity index and liquidity index were estimated. According to their standard values, on the basis of Table 3 of the Annex 3 of PN 02.01-08 the value of soil relative design resistance was obtained. Standard values of soil physical-mechanical properties are given in Table 2. Laboratory tests results are demonstrated in the summary test-sheet.

Table 2

#	Types of physical-mechanical properties	Index	Meas. unit	Standard value
1	Density	ρ	g/cm³	1,88
2	Bulk density	ρ_δ	g/cm³	1,53
3	Mineral particles density	ρs	g/cm³	2,72
4	Natural moisture content	W	N/division	0,229
5	Porosity	n	%	44
6	Porosity index	e	N/division	0,781
7	Moisture content at liquidity limit	W_L	N/division	0,356
8	Moisture content at plastic limit	Wp	N/division	0,212
9	Plasticity index	Ip	N/division	14,3
10	Liquidity index	I_L	N/division	0,12
11	Degree of saturation	Sr	N/division	0,80
12	Poisson's ratio	μ	N/division	0,35
13	Deformation modulus	E	kgf/cm²	150
14	Internal friction angle	φ	degree	22⁰
15	Specific cohesion	C	kgf/cm²	0,22
16	Filtration coefficient	Kf	m/day	0,005-0,4
17	Relative design resistance	R_0	kgf/cm²	2,2

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According to treatment complexity the soil belongs to 33-г-III category.

According to its seismic properties the soil belongs to the II category of soils

Layer #4 Clay -j4-j7 – Greyish-greenish (variegated), layered, solid. The layer was tested by 4 soil samples with intact/undisturbed structure. Soil physical properties were studied: density, moisture content, plasticity limits and accotrding to their values porosity, porosity index and liquidity index were estimated. According to their standard values, on the basis of Table 2 and Table 3 of the Annex 3 of PN 02.01-08 and Table 3 of Annex 3 the values of soil strength and deformation characteristics were obtained. Standard values of soil physical-mechanical properties are given in Table 3.

Table 3

#	Types of physical-mechanical properties	Index	Meas. unit	Standard value
1	Density	ρ	g/cm³	2,00
2	Bulk density	ρ_δ	g/cm³	1,66
3	Mineral particles density	ρs	g/cm³	2,74
4	Natural moisture content	W	N/division	0,204
5	Porosity	n	%	39
6	Porosity index	e	N/division	0,651
7	Moisture content at liquidity limit	W_L	N/division	0,566
8	Moisture content at plastic limit	Wp	N/division	0,298
9	Plasticity index	Ip	N/division	26,8
10	Liquidity index	I_L	N/division	0,00
11	Degree of saturation	Sr	N/division	0,86
12	Poisson's ratio	μ	N/division	0,42
13	Deformation modulus	E	kgf/cm²	240
14	Internal friction angle	φ	degree	20^0
15	Specific cohesion	C	kgf/cm²	0,68
16	Filtration coefficient	Kf	m/day	<0,005
17	Relative design resistance	R_0	kgf/cm²	4,5

According to treatment complexity the soil belongs to 8-д-IV category.

According to its seismic properties the soil belongs to the II category of soils

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4.Hydrogeological conditions of the study area

According to hydrogeological map of Georgia the study area is located in the hydrogeological district of the Georgian Block artesian basins, in the distribution area of fractured and fractured-karst waters of the Tskaltubo artesian basin, which is characterized by weak water abundance (D<0.1 l/sec) and low mineralization rate (less than 1g/l; Buachidze & Zedgenidze, 1970; Zedgenidze, 1971).

Within the study area the water was detected in two drillholes (DH #1 and DH #3). In the DH #1 water strike was established at 12 meters depth and the rest water level was established at 11,6 m, at absolute elevation 394,9 m. In the DH #1 water strike was established at 9,8 m depth and the rest water level was established at 9,6 m depth, at absolute elevation 396,0 m. The water is hosted by loam lenses which are represented as intercalations/interlayers at the construction site. The water belongs to the fresh water category. The chemical composition of the sample taken from the DH #1 belongs to chloride-hydrocarbonate-sulfate sodium-calcium-magnesium type, while the sample taken from the DH #3 is of bicarbonate-sulfate sodium-magnesium-calcium composition. The reaction is neutral according to the concentration of hydrogen ions (pH=7.61÷7.78)

From the point of view of aggressiveness, the mentioned water samples do not show aggressiveness towards any brand of concrete. However, the aggressive effect of the analyzed water sample on the reinforcement of the steel-concrete construction under the conditions of permanent moistening in water is evaluated as "no", and with periodic moistening - "weak". The degree of aggressive impact of the same environment on carbon steel, below the ground water level, according to the instructions of the building norms and rules, is rated as "moderate".

5.Conclusions and recommendations

1. The land plot allocated for the arrangement of a drainage channel in the vicinity of the Gelati Monastery complex (Tkibuli Municipality, Gelati village, c/c 39.07.31.362) is located

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on the moderately inclined to the west terrain. To the west of the area the slope becomes steep. So-called "drunken trees", indicative of an unstable geodynamic area are observed as well, however, no other diagnostic indicators of landslide processes are observed in the study area surroundings. In other respects, the area is stable and hazardous geological events (karst, suffosion, etc.) are not developed.

2. Three engineering-geological elements were identified on the construction site (the backfill layer is not taken into account): the normative/standard and reference values of these elements are given in Table 4.

Table 4

EGE	Standard and reference values	Density g/cm³	Specific cohesion X kgf/cm²	Internal friction angle, φ degree	Filtration coefficient kf m/day	Relative design resistance R_0, kgf/cm²	Deformation modulus E MPa	Poisson's ratio μ	Soil type
I	A_n	1.95	0.58	20°	<0,005	3.8	22	0.42	Clay semi-solid
	α =0,85	1.94	0.56	20°					
	α =0,95	1.93	0.55	20°					
II	A_n	1.88	0.22	22°	0,005-0,4	2.5	15	0.35	loam semi-solid
III	A_n	2.00	0.68	20°	<0,005	4.5	24	0.42	Clay solid
Note: the reliability of the probability when determining the reference characteristics of the soil is considered - α=0.95 when calculating the bearing capacity of the base, α=0.85 when calculating the deformation									

3. Represented on the construction site EGE I is represented by semi-solid clay with limestone blocks inclusions. The soil has good strength and deformation properties.

4. EGE II is a semi-solid loam. The soil has satisfactory strength and deformation properties.

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5. EGE III is represented by solid/hard clay. The soil has high strength and deformation properties.

6. The groundwater strike in the study area was established at 9,6-11,6 m depth, the standing water level elevation is 396,1 m. Water is not aggressive towards any brand of concrete, it is not aggressive towards reinforcement in the conditions of constant sinking of reinforced concrete structures, it is weakly aggressive during periodic moistening.

7. In the study area, ground water is discharged from the high points of the slope in the direction of the Gelati Monastery. To avoid this process, it is recommended to arrange drainage channels, with water discharge to the west of the Gelati Monastery. For conducting drainage and water discharge works requirements CNR 3.02.01-87, Chapter 2 should be taken into account and 0.01 l/s water inflow/influx rate for 1m^2 of the pit should be accepted.

8. The cut slope inclination of the foundation pit is defined in accordance with requirements of CNR III-4-80, Chapter 9, Table 4. In case of vertical cut slope inclination, with pits depth more than 5 meters the cut slopes should be reinforced using sheet piling, piles/deadman, load-bearing walls or other techniques.

9. Kutaisi City according to Annex of Seismic risks map PN 01.01.-09 (Earthquake / seismic resistant construction) is attributed to the 8 points sismic hazard zone, with dimensionless coefficient of seismicity A - 0.13; Constructing the site soils due to their seismic properties are attributed to the II category according to the Table # 1 of the same collection.

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