1. General Part

1.1. Introduction

On the basis of the request of the Transport Company on April 25, 2017, Levan Samkharauli National Forensics Bureau, Department of Kiriak Zavryev Construction Mechanics, Seismic Stability and Engineering Examination conducted an engineering-geological examination (geographical coordinates: X=482428.865; Y=4616476.924; Z=0.000) on a construction site of the III pillar tower of the ropeway in Tbilisi.

The goal of the examination was to study the engineering-geological conditions of the tower construction site and determination of the conditions of a tower foundation.

There is no information about any engineering-geological study, conducted on this construction site in the early years. Materials of geological and engineering-geological survey conducted in this district by the former "Sakgeology" and other organizations and published literature were used while developing the present report.

The following type and scope of activities were carried out to accomplish the objectives: at the initial stage, visual inspection of the survey site and its adjacent territories with the purpose to assess the engineering-geological conditions; in order to find a lithological intersection and to take samples from a rock for a laboratory examination, one 13 m depth shaft was cut within the outline of the survey site. At the time of cutting the shaft, 4 samples of rock were taken. The samples were examined at the Technical and Experimental Research Laboratory of the Bureau by the Chief Specialist T. Jajanidze.

The present technical report of engineering-geological research was concluded using the conducted field work, laboratory examinations and the above mentioned material and literature preserved in the fund. The report is concluded according to the requirements of the normative documents currently valid in Georgia, Construction Norms and Rules 1.02.07-87 (Engineering studies for construction); Construction Norms and Rules – “Foundations for buildings and constructions” (pn02.01-08); Construction Norms and Rules – “Seismic resistant construction"(pn01.01-09); state standard 25100-82 - soils. The report is enclosed by composite table of laboratory research of soils and lithological intersection of a shaft.

Engineering-geological examination was conducted in May-June 2017.

1.2. Location

Construction site of the III pillar tower is located in Tbilisi Mtatsminda District, in the vicinity of the east part of Chonkadze Street. Its geographical coordinates are following: X=482428.865; Y=4616476.924; Z=0.000.

1.3. Meteorological characteristics

Study area is included in dry, subtropical steppe climate zone of Kvemo Kartli plain, with a moderately cold winters and hot summers (III g subzone of construction – climatic zoning). Climatic elements are given according to the data indicated in climatographic references and meteorological stations “Mtatsminda” and “Observatory” located in the in the same climatic-landscape zone.

Characteristics of climatic elements

Table N1

Meteorological station	Altitude in meters	Air temperature in degrees			Relative Humidity		Average wind speed	Sediment mm			Rainfall day-night
		The coldest	For the	Average	Average	The driest		Annual total	In a cold	In a warm	
Tbilisi – “Mtatsminda”	930	-6	22.1	10.8	68	57	3.5	635	179	456	154

Tbilisi – "Observatory"	404	1.0	24.4	12.7	66	57	2.4	559	164	452	147

Average annual air temperature is 10.8 / 12.7 ◦C. The coldest month is January, with average temperature of -0.6 / 1.02 ◦C. Frosts may start in November and continue until March. An absolute minimum is -24 / -23 ◦C. The warmest month of the year is July, with an average temperature of 22.1 / 24.4 ◦C. An absolute maximum is 38/41 ° C. The annual amount of the precipitation received is 635/559 mm. Their maximum number comes in May-June, the minimum - in January, the second minimum is in August. The maximum daily precipitation is 154/147 mm. Snow may come in the period from November to April. Snow does not come every year, so a solid snow cover is too rare or can take 21/14 days. The weight of the snow in both cases is 0.50 kPa.

Average annual relative humidity of the air is 68/66%. The average relative humidity is 13% at 13 o'clock in January and 61/39% - in July. The average day-fluid amplitude of relative humidity is 11/25 and 26/35 for the same months.

Despite the difference in the height of the stations, most of the characteristics of the winds are close to each other. North-west (39/28%), north (10/26%) and south-east (32/25%) winds are dominant in the districts during the year. South (7/8%), south-west (5/2%), east and west (both 3/4%) winds are much more less. While the north-east direction is the lowest - 1/3%, it is 22/23% calmer comparing with the total number of winds. The average largest and lowest average wind speeds in January - Mtatsminda - 5.6/1.7 m/s and Observatory - 4.8/0.5 m/s, in July - Mtatsminda - 6.7/2.8 and Observatory - 4.6/1.0 m/s. Normative value of a wind pressure once in 5 and 15 years is 0.30/0.38 and 0.48/0.48 kPa.

The greatest possible speed of wind at least once, in m/s

Table N2

Annually	In 5 years	In 10 years	In 15 years	In 20 years

21/19	23/24	27/27	28/28	29/30

Thunderstorms can be in maximum intensity throughout the year from May to August on the district. Hail is relatively rare, but may come from April to November; maximum amount of it comes in May. The fog is possible throughout the year in November-March. The storm is rare, more frequently - in January and February.

Special atmospheric events throughout a year, day

Table N3

Station	thunderstorm		Hail		Fog		Storm	
	Average	Maximal	Average	Maximal	Average	Maximal	Average	Maximal
Mtatsminda	34	48	1.6	5	41	82	0.3	4
Observatory	35	52	1.6	7	33	62	-	-

The depth of normative freezing of soil on Mtatsminda is as follows: for clay-creeping soils 18 cm, for fine sand and sandstone - 22 cm, for large and medium thickness of gravel - 23 cm and for coarse-grained soils - 27 cm.

1.4. Geomorphology

Construction site of the III pillar tower is located in the lower part of the north-eastern orientation slope of Mtatsminda ridge of one of the last branches of Trialeti Range and includes part of the end of a dry ravine, developed through the erosive action of periodically active water flows resulting from atmospheric sediments. Beginning of the ravine is in the upper part of the slope

and the end – at Chonkadze Str. Here, the form of a cross section of the ravine is trapezoidal with a well-defined bottom contour of about 10 meters wide, the surface of which is united and uninterrupted. The surface slope is within 2◦, sides are sloping. The bottom and sides are in a balanced condition, covered by tree-bushes and coniferous trees. Temporary flows of water generated during abundant sediments are directed to Chonkadze Street. They break and dry up in the drainage collector wells. The absolute benchmarks of site surface are within 510 meters.

1.5. Geological composition

Tectonically studied construction site of III pillar tower of the ropeway is located at the eastern border of the southern subzone of Ajara-Trialeti zone of the Small Caucasus Wrinkle System and includes the northern wing of Mtatsminda anticline wrinkle.

According to the geological map of Georgia with a scale 1: 25000, drawn in 1971 by the Geological Department of Georgia, survey site is constructed of upper Eocene age Tbilisi nummulite rows (P_2^3ts) of sandstones and argillite clay bands or middle layers. The angle of layers is 25-30^0 and the azimuth of the slope - 345^0 to the north.

Unspoiled sandstones are without slackening, gray, light gray, steel blue, on a cinnamon cement, fine and medium granular, thin, medium and thickly stratified. Argillite clays are dark, blackish, brownish, brown, and thin layered – sheeted. Both lithological varieties are slacken, crumbled and paled in different degrees in the upper part of the geological cutting. Direct exits of those soils are observed on the surface of the whole length of Mtatminda plate, from Chonkadze Street including the upper station of the ropeway. Construction site is covered with a thin cover of delusive-prolivive loamy soil.

1.6. Hydrogeological conditions

Formation, movement and distribution of soil waters on the construction side is mainly determined by geomorphologic conditions and geological structure of the north slope of

Mtatsminda ringe. The side on the whole length is well drained from surface waters and their infiltration is minimal in rocky soils. Distribution of soil waters on the side is sporadic with low quality of watering. In addition, the natural exits of soil waters are not revealed as sources or screws on any district or nearby. According to the material preserved in funds, the waters are located deeply in the ground and do not develop any hindering condition for construction on a survey site.

2. Special part

2.1. **Engineering-geological conditions**

Detailed examination of the construction site of the III pillar tower of the ropeway and nearby areas was conducted. No trace of dangerous geological phenomena has been observed. The construction site is sustainable and locates within the satisfactory engineering-geological conditions. It belongs to the Construction Norms and Rules 1.02.07-87 according to the complexity of engineering-geological conditions and II (medium) category of complexity according to the Table 10.

According to the data of the field and laboratory examinations 3 types and conditions of soils are observed in the geological environment of the survey site:

Layer N1 – layer of clay with solid gravy supplements up to 30%, with plant roots (dpQ_{IV}); layer N2 – slacken sandstones and argillites (p_2^3); layer N3 – weakly slacken sandstones and argillites (p_2^3).

The layers are graphically expressed on a shaft cutting.

Below is the engineering-geological characterization of the above-mentioned layers. Classification of the soils is made according to the state standard 25100-82.

2.2. Physical-mechanical characteristics of the soils

Layer N2 – layer of clay with solid gravy supplements up to 30%, with plant roots (dpQ_{IV}). It is spread out from the ground surface as the first layer. According to the material preserved in the fund, the layer density is p=1.8 g/cm^3. The layer is waterless. Capacity of the layer is 0.5 m.

Layer N3 - Slacken sandstones and argillites rows (p_2^3). It is open from 0.5 m depth under the layer N1. It is presented with brownish-grayish scattered thin and medium granular layered sandstones and thin layered argillite rows. The mentioned lithological ratio is within 90:10% in a lithological context. Sandstones are resistant to aging agents, characterized by a dense structure. Argillites are a weak soil. It easily reacts to the slackening agents. The sandstone color is changed from 0.8 m. It is changed and becomes gray. Density and strength increases in the same direction. The layer is described and evaluated visually. The capacity of the layer is 0.3 meters.

Layer N3 – weakly slacken sandstones and argillite rows (P_2^3) slightly fragrant, opened from 0.8 m depth. It is represented by the gray medium and narrow grained thin and medium layered sandstones on clay cement. With thin layer-like dark blackish sheeted structure argillite middle layers. Sandstones are dominant in a lithological intersection 90%. Samples could not be taken from the argillites due to their structure and fracturing nature. 4 samples were taken from the sandstones. Laboratory examination results of sandstone samples are shown in table N4 below.

Table N4

Shaft ##	Sample taking interval, m	Density p g/cm^3	Endurance margin on one-axis shrinking R_c mPa (cm^2-kgf)		Softening coefficient Ksof	The angle of the inner friction φ°	Specific traction C Mpa
			Natural	Saturated with water			
1	0.8 – 0.9	2.64	596	569	0.95	-	-
1	0.9 – 1.0	2.65	644	590	0.92	-	-

1	1.1 – 1.2	2.65	605	589	0.97	-	-
1	1.2 – 1.3	2.65	-	-	-	40	22.9
Average values		2.65	615	583	0.95	40	22.9

As it can be seen from the table, endurance margin in the conditions of natural moisture changes in the range of 596-644 cm^2-kgf for the sandstones. 615cm^2-kgf is taken as an average value. The value of it is in the range of 569-590 cm^2-kgf when saturated with water. The average value R_c average=583 cm^2-kgf. Softening coefficient Ksof is in the range of 0.92-0.97. The average value equals to 0.95.

According to the state standard 25100-82, sandstone belongs to a strong rock variety. It is not subject to softness. The value of a softening coefficient is Ksof average>0.75. Due to the fact that the samples of argillites could not be taken, the value of argillites endurance margin is taken from the technical report of engineering-geologic research conducted in relation with the multifunctional complex construction at Barnovi and Brothers Kakabadze Streets in 2003 by "Sainjgeo" Ltd – Engineering-Geological Research Center and equals to 12.8cm^2-kgf. While calculating the normative average balanced value of layer endurance margin due to the coherence of sandstones and argillites in the geological context we take experimentally obtained lowest point of sandstone endurance margin when saturated with water. The average balanced value of layer endurance margin will be 569x0.9+12.8x0.1=513 cm^2-kgf. The layer is waterless. The open capacity of the layer is 0.5 meters.

Conclusions and recommendations

1. Construction site of the III pillar tower of the ropeway is located in the lower part of Mtatsminda slope, at the end of the dry ravine, on the territory in the vicinity of the east part of Chonkadze Street (geographical coordinates are following: X=482428.865; Y=4616476.924; Z=0.000). The absolute marks in the study area are in the range off 510 meters according to GPS.
2. The study site can be reached from Chonkadze Street.
3. Survey site is constructed of upper Eocene (P_2^3) age sedimentary rocks, of the so called Tbilisi nummulite rows of sandstones and argillite middle layers, which are covered by a thin clay bands from above.
4. The area surveyed is in good condition from the hydrogeological point of view, which is due to the absence of groundwater.
5. On the basis of the field and laboratory examination data, 1 engineering-geological element (E.G.E) is allocated in the lithological intersectionting of the study site excluding the layer N1 clays and layer N2 slacken sandstones with argillite middle layers, which will be removed for foundation due to its small capacity.

I E.G.E – weakly slacken sandstones with argillite middle layers (P_2^3) layer N3; below, in the table N5, there are normative values of physical-mechanical properties characteristics of the mentioned E.G.E, used for project calculation, which is obtained through the laboratory examinations, as well as using the reference literature.

Table N5

# #	Characteristics of soils	Normative values
		I E.G.E Layer N3
1.	Density p g/cm^3	2.65
2.	Endurance margin on one-axis shrinking in water saturated condition R_c^w cm^2-kgf	513

3.	Underlay coefficient cm^2-kgf	100
4.	Poisson ratio μ	0.20

6. Laying and preparation of the pillar tower foundation should take place in maximally possible tightened deadlines.
7. Maximum permissible slope of artificial slopes of the foundation prepared for the foundation of the pillar tower may be adopted considering the requirements 3, 11 of Construction Norms and Rules 3.02.01-87 and requirements of Construction Norms and Rules III-4-80.
8. According to the seismic hazard map of Construction Norms and Rules – "Seismic resistant construction"(pn01.01-09), Tbilisi belongs to the 8-point seismic zone.

According to the table N1 of the same normative document and according to the seismic characteristics, the study site soils belong to: layers NN1 and 2 – II category, layer N3 – I category.

Reporting seismicity shall be determined as 8 points.

9. According to their difficulties, the soil groups spread on a surveyed area is given according to the Table 1.1 of Construction Norms and Rules IV-2-82 and belong to:

Layer N1 – 33c;

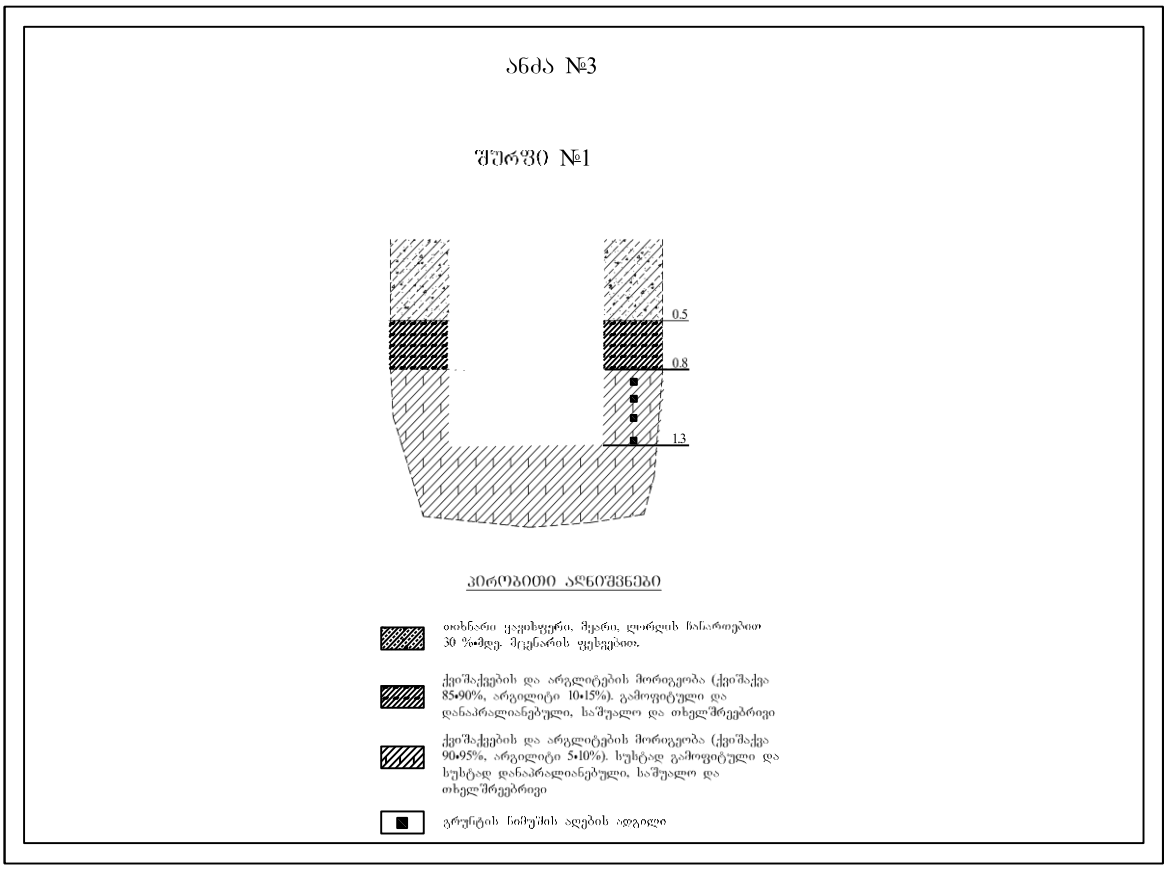
Layers NN2 and 3 – 28f.

Engineer-geologist /signed/ Gabriel Chicharauli

Field and Laboratory Examination Results

TOWER №3

Shaft №1



Conventional Signs

Layer of clay with brown solid gravy supplements up to 30%, with plant roots

Sandstones and argillites rows (sandstone 85-90%, argillite – 10-15%) Slacken and crushed, medium and thin layer-liked

Sandstones and argillites rows (sandstone 90-95%, argillite – 5-10%) weakly slacken and weakly crushed, medium and thin layer-liked

Place of soil sampling

Compilation table of soils laboratory examination

№	Bore №	Interval of sample-taking, m	Natural density, p	Endurance on one-axis shrinking R_c cm^2-kgf		Softening coefficient Kcof	The angle of the inner friction φ°	Specific traction C Mpa	Soil description
				Natural	Saturated with water				
1	Sh-1	0.8 – 0.9	2.64	596	569	0.95			Solid sandstone
2	Sh-1	0.9 – 1.0	2.,65	644	590	0.92			Solid sandstone
3	Sh-1	1.1 – 1.2	2.,65	605	589	0.97			Solid sandstone
4	Sh-1	1.2 – 1.3	2.,65				40	22.9	Solid sandstone
Average				615	583	0.95	40	22.9	

Chief Specialist /signed/ Tatia Jajanidze