Geoengineering Ltd.
Engineering Survey, Design, Construction

Geotechnical investigation of the construction sites for the towers of Ksani-Stepantsminda 500 KW transmission line

Technical Report

VOLUME 1

Textual Part

Tbilisi, Georgia
2015

Geoengineering Ltd.
Engineering Survey, Design, Construction

Geotechnical investigation of the construction sites for the towers of Ksani-Stepantsminda 500 KW transmission line

Technical Report

VOLUME 1

Textual Part

Head of Engineering Surveys Department — L. Gorgidze

Head of Sector of Engineering-geological Surveys — D. Sirbiladze

Head of Geotechnical Laboratory — R. Kavelashvili

Tbilisi, Georgia
2015

Contract No. GC-1542

Project name: **Geotechnical investigation of the construction sites for the towers of Ksani-Stepantsminda 500 KW transmission line**

CONTENTS OF THE PROJECT

VOLUME I – TEXTUAL PART

VOLUME II – ANNEXES

TEXTUAL PART

C o n t e n t s

ANNEXES

ANNEX #	ANNEX NAME	NUMBER OF SHEETS
1	Schematic Geological Map	1
2	Borehole lithologs	20
3	Laboratory testing summary table for soil composition and physical-mechanical properties	12
4	Laboratory testing results	
4.1	Moisture content	7
4.2	Particle-size distribution (sieve method)	112
4.3	Particle-size distribution (hydrometric method)	41
4.4	Atterberg limits	56
4.5	Natural density	5
4.6	Mineral particles density	5
4.7	Tensile strength in uniaxial compression (soils)	39
4.8	Tensile strength in uniaxial compression (rock)	4
4.9	Shear test of soil	12
5	Calculations for shear parameters	16
6	Soils and waters chemical composition	3
7	Soils vertical electric sounding	3
8	Photographic logs	8

1. INTRODUCTION

This technical report has been drawn up as indicated in Agreement #GC-1542 of September 14, 2015 between "SAKENERGOREMONTI" (Customer) and "Geoengineering" Ltd (Contractor). The objective of the assignment was to conduct geotechnical investigation of the construction sites for the towers of Ksani-Stepantsminda 500 KW transmission line.

As per the Customer-issued assignment, altogether 20 tower construction sites were investigated. The list and coordinates of the sites are given in Table-1.

Table 1.1 Investigated sites of Ksani-Stepantsminda 500 KW transmission line towers

Tower #	Coordinates	
	X	Y
AP-01	466908.4	4634775.8
AP-03	468218.2	4635599.1
AP-07	468401.0	4639572.4
AP-12	468362.0	4646510.0
AP-15	468549.0	4648239.0
AP-18	469040.5	4652606.8
AP-24	468668.0	4656124.4
AP-28	471164.7	4662693.3
AP-33	471916.0	4665745.0
AP-34	471061.7	4669199.3
AP-39	472768.6	4681025.7
AP-55	478535.6	4696777.3
AP-81	475603.9	4711884.3
AP-84	475183.1	4713011.7
AP-88	473835.0	4713818.0
AP-89	473490.5	4713959.9
AP-91	472564.9	4715216.3
AP-93	471900.0	4715796.0
AP-96	470486.9	4716414.9
AP-100	469174.5	4719579.4

The whole set of works was performed within the period from September 15 through October 25 2015, as per the customer-issued program and specification.

Within the field works the following was executed:

- Preliminary site investigations;
- Drilling vertical boreholes, with diameter 151-92 mm, depth 10 m, 19 boreholes in total.
- Standard penetration tests (SPT).
- Taking disturbed and undisturbed soil samples.
- Water table monitoring.

- Vertical electric sounding (VES).

Boreholes were drilled by dry core drilling method, with УРБ-2А-2 and УГБ-1-ВС self-propelled drilling rigs, with dry core drilling method, without flushing fluid. The boreholes were drilled with 152-92 mm diameter drilling equipment and soil samples were taken using appropriate diameter soil samplers.

Borehole lithologs are given in Annex-2. They include the following data:

1. Borehole number and drilling date;
2. Drilling method and type of drilling equipment;
3. Drilling diameter;
4. Geographical coordinates of borehole;
5. Depth ranges and final depth for the soil strata encountered in the boreholes;
6. Soil sampling depth range;
7. Type and depth of test executed in the borehole;
8. Description of the soil strata;
9. Ground water table in the borehole (in case of groundwater phenomena);
10. Project Name and Contract Number;
11. Name of person who prepared the description (borehole log).

Laboratory-tested were particle-size distribution, physical/mechanical properties and chemical composition for soils. Testing results are given in the textual part of the report, as well as in Annex-3 and Annex-4.

Laboratory analyses of soil samples were performed in accordance with relevant standards. Laboratory tests and standards to which they were performed are listed in Table 1.2.

Table 1.2 Types of laboratory testing works and standards to which they were performed

#	WORK NAME	TESTING STANDARD / METHOD
1	**Laboratory tests**	
1.1	Determining moisture content	BS 1377: Part-2
1.2	Atterberg limits	
1.3	Particles density	
1.4	Density	
1.5	Particle-size distribution	
1.6	Soils and waters chemical analyses	BS 1377
1.7	Uniaxial Compression Test for rock material	ASTM D 2938-95

Types and quantities of field, laboratory and office study works executed for engineering geological investigation of the survey area is given in Table 1.3.

Table-1.3 Types and quantities of works executed for investigation of the sites

N#	NAME	UNIT MEASURE	Q-TY
1 Field investigations:			
1.1	Preliminary site investigation	piece	20
1.2	Drilling vertical boreholes with sampling up to 10 m depth	piece/meter	20/192.5
1.2	Borehole logs	piece/meter	20/192.5
1.3	Standard penetration test (SPT).	1 test	103
1.4	Vertical electric sounding (VES)	1 test	60
2 Laboratory investigations:			
2.1	Moisture content	1 test	117
2.2	Atterberg limits	1 test	56
2.3	Particle-size distribution	1 analysis	56
2.4	Density	1 test	117
2.5	Particle density	1 test	108
2.6	Uniaxial compression test	1 test	17
2.7	Calculations for shear parameters	calculations	16
2.8	Chemical analysis	analysis	45
3 Office study:			
3.2	Darwing up a technical report	1 report	1

2. AVAILABLE INFORMATION ON GEOTECHNICAL CONDITIONS

There has been no material retrieved on any earlier engineering surveys on the location line of the project Ksani-Stepantsminda 500 KW transmission line. Retrieved and used in this report are archive and library materials on the natural conditions, including climate, geological structure, hydrogeological and geodynamic conditions of the area.

3. GENERAL DESCRIPTION OF ENVIRONMENT

3.1 CLIMATIC CONDITIONS

Climatic data on Ksani-Stepantsminda 500 KW transmission line location is based on the data from Mukhrani, Mtskheta, Dusheti, Pasanauri, Bursachiri, and Stepantsminda meteorological stations. The data is taken from construction climatology norm (PN 01.05-08).

According to the main characteristics given in Table-2 of the said norm, the area is attributed to sub-districts I-c and II-b.

In the tables below, the values for main meteorological elements are given according to the above data from meteorological stations.

Table 3.1.1 Main climate properties of the climate subdistrict (according to Table-2 of the norm)

Meteorological station	Above sea level elevation, m.	Climate district	Climate subdistrict	Average temperature in January, °C	3 winter months average wind velocity, m/s	Average temperature in July, °C	Relative humidity in July, %
Mukhrani	260	II	IIb	From -5 to -2	-	From +21 to +25	-
Mtskheta	464						
Dusheti	905						
Pasanauri	1064	I	Ic	From -4 to -14	-	From +12 to +21	-
Bursachiri	1760						
Stepantsminda	1747						

Table 3.1.2 Air temperature and humidity (based on Tables 11,12,13 of the Norm)

Meteorological station	Climate Characteristic	By month												Yearly
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Mukhrani	Average Monthly and Yearly Air Temperature, ^{0}C	-1.1	0.5	3.6	8.9	13.9	17.2	20.2	20.4	16.3	11.2	5.5	0.8	9.7
	Absolute Minimum Air Temperature, ^{0}C	-29.0												
	Absolute Maximum Air Temperature, ^{0}C	39.0												
	Mean Maximum of the hottest month, ^{0}C	-	-	-	-	-	-	28.7	-	-	-	-	-	-
	Mean range of air temperature, ^{0}C	6.5	7.1	7.7	8.4	8.1	7.9	7.0	7.6	8.3	8.9	7.4	6.5	-
	Relative air humidity, %	80	78	72	67	70	68	65	66	71	76	79	81	73
Mtskheta	Average Monthly and Yearly Air Temperature, ^{0}C	-0.3	2.0	5.7	11.2	16.4	20.8	23.2	23.1	18.7	13.1	7.0	2.4	11.9
	Absolute Minimum Air Temperature, ^{0}C	-24												
	Absolute Maximum Air Temperature, ^{0}C	40												
	Mean Maximum of the hottest month, ^{0}C	-	-	-	-	-	-	26.5	-	-	-	-	-	-
	Mean range of air temperature, ^{0}C	6.3	6.6	7.6	8.0	7.4	7.1	6.9	7.2	7.4	7.8	7.4	7.1	-
	Relative air humidity, %	73	70	68	65	65	61	58	56	63	70	76	75	67

Meteorological station	Climate Characteristic	By month												Yearly
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Dusheti	Average Monthly and Yearly Air Temperature, ^{0}C	-1.4	-0.5	3.6	8.9	13.9	17.2	20.2	20.4	16.3	11.2	5.5	0.8	9.7
	Absolute Minimum Air Temperature, ^{0}C	-26												
	Absolute Maximum Air Temperature, ^{0}C	35												
	Mean Maximum of the hottest month, ^{0}C	-	-	-	-	-	-	26.7	-	-	-	-	-	-
	Mean range of air temperature, ^{0}C	8.0	8.3	9.7	11.2	11.0	11.0	10.7	11.0	11.2	10.2	8.7	8.2	-
	Relative air humidity, %	72	72	70	68	72	70	69	66	72	75	75	74	71
Pasanauri	Average Monthly and Yearly Air Temperature, ^{0}C	-4.1	-2.6	1.9	7.4	12.4	15.6	18.5	18.5	14.4	9.4	3.7	-1.6	7.8
	Absolute Minimum Air Temperature, ^{0}C	-30												
	Absolute Maximum Air Temperature, ^{0}C	36												
	Mean Maximum of the hottest month, ^{0}C	-	-	-	-	-	-	25.3	-	-	-	-	-	-
	Mean range of air temperature, ^{0}C	8.6	9.5	9.6	11.3	11.8	11.9	11.2	12.1	11.3	10.8	8.8	7.9	-
	Relative air humidity, %	76	74	73	70	74	74	73	72	76	77	77	77	74
Bursachiri	Average Monthly and Yearly Air Temperature, ^{0}C	-6.1	-5.7	-2.0	2.9	8.2	14.4	14.3	14.5	10.6	6.1	0.7	-3.7	4.3
	Absolute Minimum Air Temperature, ^{0}C	-31												
	Absolute Maximum Air Temperature, ^{0}C	30												
	Mean Maximum of the hottest month, ^{0}C	-	-	-	-	-	-	19.9	-	-	-	-	-	-
	Mean range of air temperature, ^{0}C	8.5	10.0	10.9	8.8	8.7	8.6	8.9	9.3	9.2	8.7	8.0	7.9	-
	Relative air humidity, %	67	68	71	72	73	72	72	72	76	74	72	67	71
Stepantsminda	Average Monthly and Yearly Air Temperature, ^{0}C	-5.2	-4.7	-1.5	4.0	9.0	11.8	14.4	14.4	10.6	6.6	1.5	-2.6	4.9
	Absolute Minimum Air Temperature, ^{0}C	-34												
	Absolute Maximum Air Temperature, ^{0}C	32												
	Mean Maximum of the hottest month, ^{0}C	-	-	-	-	-	-	20.3	-	-	-	-	-	-
	Mean range of air temperature, ^{0}C	9.5	9.6	10.5	10.6	10.2	10.4	9.5	11.2	10.2	10.3	9.5	9.8	-
	Relative air humidity, %	62	63	66	69	70	71	74	72	72	67	64	61	68

Table-3.1.3 Amount of Precipitation and Snow Cover (based on Tables 15, 17of the Norm)

Amount of precipitation in a year, mm	Amount of precipitation in 24 hours, mm	Weight of snow cover, kPa	Number of days with snow cover	Water content of snow cover, mm	Amount of precipitation in a year, mm
Mukhrani	591	8887	0.50	29	-
Mtskheta	636	110	0.50	15	-
Dusheti	738	82	0.50	53	43
Pasanauri	999	93	0.96	95	99
Bursachiri	1400	120	2.70	150	503
Stepantsminda	786	111	0.84	104	180

Table-3.1.4 Standard Values of Wind Pressure (based on Table-18 of the Norm)

Meteorological station	Once in 5 years, kPa	Once in 15 years, kPa
Mukhrani	0.48	0.6
Mtskheta	0.73	0.85
Dusheti	0.30	0.38
Pasanauri	0.30	0.38
Bursachiri	0.38	0.38
Stepantsminda	0.23	0.30

Table-3.1.5 Greatest Wind Velocity with Probability Once in 1, 5, 10, 15, 20 Years, m/s (Based on Table-19 of the Norm)

Meteorological station	in 1 year	in 5 years	in 10 years	in 15 years	in 20 years
Mukhrani	24	28	30	31	32
Mtskheta	28	33	35	36	37
Dusheti	18	23	25	27	29
Pasanauri	17	21	23	24	25
Bursachiri	20	24	25	26	27
Stepantsminda	18	20	21	22	22

Table-3.1.6 Frequency of Wind Directions (based on Table-19 of the Norm)

Meteorological station	Wind property		Direction								Calm
			N	NE	E	SE	S	SW	W	NW	
Mukhrani	Frequency of wind directions (%)	January	4	11	32	3	1	1	31	17	-
		July	2	4	20	10	3	1	40	20	-
	Wind direction and calm frequency in a year, %		2	8	31	7	2	1	32	17	39
Mtskheta	Frequency of wind directions (%)	January	-	-	-	-	-	-	-	-	-
		July	-	-	-	-	-	-	-	-	-
	Wind direction and calm frequency in a year, %		-	-	-	-	-	-	-	-	-
Dusheti	Frequency of wind directions (%)	January	10	21	21	10	12	8	12	6	-
		July	16	18	21	12	17	7	12	7	-
	Wind direction and calm frequency in a year, %		7	17	20	12	17	9	12	6	35
Bursachiri	Frequency of wind directions (%)	January	29	8	28	18	4	1	0	2	-
		July	31	6	8	5	30	16	1	3	-

Meteorological station	Wind property		Direction								Calm
			N	NE	E	SE	S	SW	W	NW	
	Wind direction and calm frequency in a year, %		28	6	22	12	20	8	1	3	59
Stepantsminda	Frequency of wind directions (%)	January	11	1	1	4	70	13	0	0	-
		July	46	4	2	3	36	5	1	3	-
	Wind direct`ion and calm frequency in a year, %		25	2	1	4	57	9	1	1	33

Table 3.1.7 Seasonal Freezing Depth for Any Soils Depth, cm (based on Table-20 of the Norm)

Meteorological station	Clay and clayey soil	Fine and silty sand, clayey sand	Medium-grained and coarse sand; gravelly sand	Macro-fragmental soil
Mukhrani	24	29	31	36
Mtskheta	22	26	28	33
Dusheti	32	38	42	48
Pasanauri	66	79	86	99
Bursachiri	96	115	125	144
Stepantsminda	83	100	108	124

3.2 GEOMORPHOLOGICAL AND HYDROGRAPHICAL CONDITIONS

The survey area through which the project 500 KW transmission line route runs is characterized by diverse geomorphological conditions. At the start of the route, adjacent to Ksani substation, the area represents accumulation relief of alluvial/proluvial sediments developed in the r. Mtkvari inetrmountain synclinal bowl. From the area adjacent to the substation to village Old Kanda, the route lies on the monoclynal mountain range of East-West direction which is structured with Meotian-Pontian and Upper Sarmatian marine and land molasses sediments. From Old Kanda to village Eredi, the project route is located in the line of Pliocene-Quaternary plunge of the Georgian block, within the range of Mukhrani-Tirifoni low land and is represented by alluvial-proluvial deposits. Further the project route transfers into the line of Neogene structures of Kartli foot-hill, within the range of Saguramo-Ialno synclinal mountain range. The central and northern parts of the project route are located in the isoclinic-horst raise line of the main dividing ridge of the Greater Caucasus. It is located in Pshavi-Mtiuleti and Khevi regions. Mtiuleti geomorphological region includes southern slopes of the main dividing and marginal ridges. The project route follows the Ksani, Aragvi and Gudamakari valleys up to Bursachiri pass, while Khevi geomorphological region includes the valleys of the r. Terek and the r. Snostskali and is located on the northern slopes of the main and marginal ridges structured with Lower Jurassic deposits.

On the survey site, where the project transmission line is located, four sites are distinguished differing in terms of relief. The first one, from Ksani power station to Old Kanda has erosional-denudational mountainous relief. The second one, form Old Kanda to village Mchadidzhvari, includes the plain between the r. Ksani and the r. Aragvi, which (with absolute elevations up to 900 – 950 m) gradually transfers into the third, foot-hill area with undulating relief, up to borough Pasanauri – with higher absolute elevations up to 1200 m. This relief is dissected with numerous gulleys and river channels; the gulleys are mostly dry, and development of ravination is frequent, while the rivers are distinguished for small abundance of water. Land forms of the slopes are mostly gently rolling, occasionally with steep hillsides. On this site, ravination and erosion processes are frequent; mud streams, rush of water in gulleys and river channels are not rare. The fourth site goes along the narrow valley of the r.

Gudamakari Aragvi and also transfers into the river Snostskali narrow valley, with absolute elevations up to 1100-1700-1800 m, to village Achkhoti where the r. Snostskali joins the r. Terek. On this site, there are frequent erosional-denudational and gravitational processes which mainly favor formation of various land forms. Variety of landforms is also caused by the lithology of structuring rocks and tectonic structures, existence of fractured rock material, Quaternary glacial, river sediments, colluvial and denudational processes in the massive. Along the river banks, mural escarpments alternate with erosional gulleys existing between them, the bottom of which is almost everywhere covered with collapsed crushed gravel (occasionally with boulders). Therefore, often forestless and shrubby valleys of the r. Aragvi and the r. Snostskali are characterized by complicated and severe landforms having formed as a result of erosions and other active denudational processes.

In terms of hydrography, the predominant artery of the survey area is represented by the rivers: Ksani, Aragvi and Snostskali in which several small, relatively water-abundant tributaries flow in. These inflows (both left and right) are characterized by mainly small course, though during intense rains it is of mudflow character. It is also worth mentioning that snow avalanches from steep slopes are likely in the northern part of the r. Aragvi valley and most of the r. Snostskali valley.

3.3 GEOLOGICAL STRUCTURE

According to the Scheme of Tectonic Zoning of Georgia (E. Gamkrelidze, 2000) the upper northern segment of the project Ksani-Stepantsminda 500 KW transmission line is located in Kazbegi-Lagodekhi zone of the Caucasus fold system; the central segment is located in Mestia-Tianeti zone and the lower southern segment is located in Kartli molasse subzone of the Southern Caucasus intermountain area.

The survey route area is structured with both sedimented and magmatic rocks, including Lower Jurassic to Quaternary. Their description in the upward section (from old to recent) is given below, while the strata distributed on the area are graphically shown on the Schematic Geological Map of the area (see Anenx-1).

J_1t - Toarcian stage. Kazbegi-Lagodekhi zone: black clay shales, siltstones, occasionally lenses and intercalations of intraformational conglomerates. In places thick benches of thick-bedded and massive sandstones.

J_2a - Aalenian stage. Kazbegi-Lagodekhi zone: black clay shales with concretions of clayey siderite with intercalations of sandstone turbidites. In lower part of section, in places basalts and their volcanic tuffs.

J_2b-bt - Bajocian and Bathonian stages. Kazbegi-Lagodekhi zone: clay shales, quartzy and polimictic sandstones, in places sandy limestones.

J_3O_2 - Upper substage of Oxfordian stage. Mestia-Tianeti zone. Clastic-limestone flysch: clastic-limestone, and more rarely sandstone-gritstone turbidites, pelagic marls and clay shales.

J_3km-tt - Kimmeridgian and Tithonian stages. Mestia-Tianeti zone: clastic-limestone, and more rarely sandstone-gritstone turbidites, pelagic clayey limestones, marls and argillites, in places oolitic limestones.

K_1b-h_1 - Berriasian and Valanginian stages and lower substage of Hauterivian stage. Mestia-Tianeti zone: clastic-limestone and sandstone turbidites, pelagic marls, limestones, argillites and clay shales.

K_1h_2-br - Upper substage of Hauterivian stage and Baremian stage. Mestia-Tianeti zone. Sandstones-siltstone flysch: sandstone and siltstone turbidites and pelagic argillites.

K_1a-al - Aptian and Albian stages. Mestia-Tianeti zone. Sandstones-sillestone flysch: sandstone, gritstone and siltstone turbidites, pelagic clays, argillites and marls.

K_2 - Upper Cretaceous (undivided). Mestia-Tianeti zone: sandstone-sillstone (in lower part) and clastic-limestone (in upper part) flysch: siltstone, sandstone, gritstone and clastic limestone turbidites, olistostromes, pelagic marls, cherty argillites, phthanites, in places alternation of pelitomorphic limestones and marls.

E_1-E_2^2 – Paleocene, Lower and Middle Eocene. Mestia-Tianeti zone. Sandstone-silstone flysch: sandstone, siltstone turbidites, pelagic argillites and marls, limestones, cherty argillites, phthanites, in places basal conglomerates, conglomerate-breccias, sandstones and arenaceous limestones.

E_2^3 – Upper Eocene. Mestia-Tianeti zone. Sandstone-sillstone flysch: sandstone, gritstone and siltstone turbidites, pelagic marls and clays, olistostromes with intercalations of schistose clays, sandstones, gritstones and conglomerates.

E_3-N_1^1 – Oligocene and Lower Miocene (Maikop series). Mestia-Tianeti zone. Marine molasse: sandstones, gritstones, weakly carbonaceous clays with marls intercalations, sometimes gypsiferous clays and sandstones.

N_1^2 – Middle Miocene (Tarkhnian, Chokrakian, Karaganian and Konkian stages). Marine molasse: clays, sandstones, conglomerates (sometimes basal), marls, oolitic and arenaceous limestones.

N_1s_{1+2} Lower and Middle Sarmatian. Marine molasse: clays, sandstones, conglomerates, marls and limestones.

N_1s_3- Upper Sarmatian. Marine and continental molasse: sandstones, clays, conglomerates, somtimes marls.

Nm+p – Meotian and Pontian stages. Marine and continental molasse: conglomerates, sandstones, clays.

αζ **Q** - Quaternery system (undivided). αζ-subaerial calc-alkalic andesites, dacites, andesite-dacites.

ap-lb**Q** - Quaternery system (undivided). ap-alluvial-proluvial.

3.4 SEISMIC CONDITIONS

Based on Construction Rules and Regulations – Earthquake Resistant Construction (PN01.01-09) currently effective in Georgia, the survey project Ksani-Stepantsminda 500 KW transmission line route is located in the zones of different seismic activity. In Table 3.4.1 below, the data are given on the points existing near the route, magnitude (based on MSK64 scale) and nonmetric seismicity coefficient (A).

Table-3.4.1 Values of magnitude based on MSK64 scale and dimensionless seismic coefficient (A) by point

#	Point name	Magnitude (based on MSK64 scale)	Nonmetric seismicity coef-ficient (A)
1	Old Kanda	8	0.16
2	Gorovani	8	0.16
3	Tsilkani	8	0.15
4	Ereda	8	0.15
5	Tsikhevdavi	8	0.15
6	Mchadijvari	8	0.15
7	Chubiniantkari	8	0.16
8	Chilurti	8	0.16
9	Arghuni	8	0.16
10	Dudaurebi	8	0.16
11	Bantsurtkari	8	0.20
12	KadoeTi	8	0.20
13	Tsikhisdziri	8	0.16
14	Chartali	8	0.25
15	Borough Pasanauri	9	0.29
16	Zanduki	9	0.41
17	Kikhoti	9	0.41
18	Chokhi	9	0.42
19	Dzhutaro	9	0.42
20	Karkucha	9	0.43
21	Sno	9	0.43
22	Achkhoti	9	0.43

3.5 HYDROGEOLOGICAL CONDITIONS

According to hydrogeological zoning of Georgia (I. M. Buachidze), the project Ksani-Stepantsminda 500 KW transmission line crosses the following:

1. **Mestia-Tianeti fault and karstic-fault water system.**

Distribution of the groundwaters of this system is connected with the upper weathering zone of Mid- and Lower Jurassic volcanic and terrigenous deposits the depth of which is determined by the local channeling. Intense formation of cracks is observed everywhere here, while in carbonate deposits karst caverns have formed, which in its turn increases water content of this complex. In the sedimented rocks, water content of the hydrodynamic zone is low and the yield of the sources rarely exceeds 0.1-0.5 l/s, while water content of carbonate flysch deposits sometimes has 1 l/s yield. The Quaternary deposits (moraine, deluvial, proluvial and alluvial) forming a thick cover at the slope bottoms, are characterized by high water content. The yield of the sources associated with alluvial and especially with moraine deposits varies within wide range (from 1-3 l/s to 10 l/s and more). In the lower hydromechanic zone, rocks are characterized by small water content and their yield is determined by the degree of fracturing. Water circulation is relatively slowed down. Water outcrops are mainly associated with regional faults. Based on chemical composition, mainly slightly mineralized (0.02-0.2 g/l) freshwater is found containing hydrocarbonate-calcium or calcium-sodium. Occasionally are found waters containing carbonic acid and alkali salt.

2. Kartli artesian basin pore, fault and karstic-fault waters

The said artesian basin includes a wide area of Mukhrani-Tirifoni depression which is limited by the southern slopes of the Greater Caucasus Mountain Range on the north, and on the south by the northern slopes of the Trialeti mountain range of the Lesser Caucasus Mountains. The survey area includes a certain part of this artesian basin located between the r. Ksani and the r. Aragvi - left inflows of the r. Mtkvari. In this basin, Cretaceous artesian waters are distinguished, as well as phreatic waters of contemporary Quaternary and Neogene deposits. The waters of Cretaceous deposits are characterized by high mineralization, thermicity and low yield. Waters of Neogenic deposits are also characterized by small dynamic resources; their yield is not more than 0.5 l/s, while mineralization is 1 g/l. The waters are of hydrocarbonate-sulphate-calcium-containing type. Contemporary Quaternary alluvial, flood-plain and above-flood-plain terrace deposits stand out for high water content.

4. GEOTECHNICAL CONDITIONS OF CONSTRUCTION SITES

Geotechnical conditions on individual construction sites are assessed separately and their descriptions are given below.

4.1 CONSTRUCTION SITE - AP-01

The construction site of Tower AP-01 of the Project Ksani-Stepantsminda 500 KW transmission line is located on the left slope of the r. Mtkvari, adjacent to Ksani power station area, in the north-east. The aspect of the slope is south-western, with azimuth 200^0-210^0, angle of gradient of relief is 10^0-12^0. The surface of the survey site is covered with grass and brushwood. North of the site, in about 80 meters, a crosswise unlined canal with berm is observed the function of which is to remove temporary torrents of surface water.

North of the survey site, in about 170-200 meters, the slope becomes steep and in the surface outcrops observed are Lower Neogenic – Upper Sarmatian ($\mathbf{N_1s_3}$), marine molasses deposits: thick and massive-layered conglomerates, with medium and heavy-bedded clay veins. Strata dip azimuth is 15^0-20^0 and angle of gradient is 45^0-50^0. The gentle slope directly on which the survey site is located is structured with Quaternary proluvial deposits with more than 10 m thickness based on drilling data.

In geotechnical terms, the survey site is located in Kartli molasse sub-zone of the South Caucasus intermountain area.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Old Kanda), seismicity of the survey site is intensity 8 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.16.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Mtskheta meteorological station which is the nearest to the survey site.

On the survey site, a geotechnical borehole (AP-01 BH-1) was drilled with 10 m depth; standard penetration tests (SPT) were conducted in the borehole. The borehole log is given in Annex-2. Within the site, electric sounding of soils was also conducted on 3 points, and the results are given in Annex-7. For photos of the core from the borehole and of the survey site see Annex-8.

Based on the field and laboratory investigation data, within the surveyed depth (10 m) in the structure of the site there is proluvial, Quaternary soil described below as geotechnical STRATUM-1:

STRATUM-1 – Slightly moist, dense to very dense, sandy, silty/clayey GRAVEL. The gravel is subrounded and rounded. 6 borehole samples were laboratory-analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.1.1 and 4.1.2 below.

Table-4.1.1 Stratum-1 Particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %					
			Sand				
		Gravel 63.0-2.0 mm	Coarse 1.18-0.600 mm	Medium 0.425-0.212 mm	Fine 0.150-0.063 mm	Silt 0.04 – 0.002 mm	Clay < 0.002 mm
AP-01 BH-1	2.0-3.0	69.6	5.2	7.2	4.0	11.2	2.8
AP-01 BH-1	5.0-6.0	66.8	4.2	6.7	2.3	13.9	6.1
AP-01 BH-1	8.0-9.0	58.9	7.7	6.1	3.8	16.0	7.5

Table-4.1.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Moisture content of filler, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
				Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-01 BH-1	0.5-1.0	3.1	-	-	-	-	-	2.69	-	1.69
AP-01 BH-1	1.5-1.95	3.9	-	-	-	-	-	2.56	-	1.78
AP-01 BH-1	2.0-3.0	4.7	6.8	23.5	12.5	11.0	-0.52	2.65	-	1.86
AP-01 BH-1	5.0-6.0	7.8	9.8	25.6	13.3	12.3	-0.28	2.65	-	1.61
AP-01 BH-1	6.0-6.45	3.8	-	-	-	-	-	2.76	-	1.64
AP-01 BH-1	8.0-9.0	2.2	12.6	27.4	13.2	14.2	-0.04	2.69	-	1.71

Based on Standard Penetration Test (SPT) data, number of N impacts varies between 43 and 53, according to which the stratum is dense to very dense.

Values for internal friction angle and cohesion, as well as for deformation modulus of the stratum were calculated using appropriate method (method of DALNIIS GOSSTROY of the USSR). Calculations were made based on physical properties values (see Annex 5) and for consolidated soil are as follows:

- Internal friction angle $\varphi=34.1^0$;

- Cohesion C=27.2 kPa
- Deformation modulus E=41.27 MPa;

Based on the SNIP 2.02.01-83 - assumed design resistance R_0 = 0.40 MPa

Chemical composition of soils was studied on 2 borehole samples. In the chemical composition of the samples, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made with any cement. The soil is practically neutral by hydrogen ion content (pH) too. Individual results of laboratory study are given in Annex-6.

In the survey borehole, during field works, ground water did not show.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-7). Based on geophysical data, up to the sampled 15 m, specific electric resistivity of soils varies from 280 to 612 ohm m, according to which corrosive effect of soils is low.

Within the survey site and its neighbourhood, no hazardous geodynamic processes are observed.

Allowable temporary grade for STRATUM-1, according to SNIP III-B1-71 is as follows:

- up to 1.5 m. depth 1:0.5;
- from 1.5 m to 5.0 m. depth 1:1.

4.2 CONSTRUCTION SITE - AP-03

The construction site of Tower AP-03 of the Project Ksani-Stepantsminda 500 KW transmission line is located in the crestal part of the near east-west dividing ridge. The aspect of the crest slope is south-western, with azimuth 240^0-250^0, angle of gradient of relief is 10^0-25^0. The northern and southern slopes of the dividing ridge have angle of gradient 20-25^0. The surface of the survey site is covered with grass and brushwood.

In terms of geology, the survey site and its adjacent area are structured with Neogenic - Meotian and Pontian (Nm+p) marine and land molasses: conglomerates and clays.

In geotechnical terms, the survey site is located in Kartli molasse sub-zone of the South Caucasus intermountain area.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Old Kanda), seismicity of the survey site is intensity 8 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.16.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Mtskheta meteorological station which is the nearest to the survey site.

On the survey site, one geotechnical borehole (AP-03 BH-1) was drilled with 10 m depth; standard penetration tests (SPT) were conducted in the borehole. The borehole log is given in Annex-2. Within the site, electric sounding of soils was also conducted on 3 points, the results of which are given in Annex-7. For photos of the core taken from the borehole and of the survey site see Annex-8.

Based on the field and laboratory investigation data, within the surveyed depth (10 m) in the site structure there are molasse deposits, Neogenic slightly cemented gravelly conglomerates described below as geotechnical STRATUM-1:

STRATUM-1 – Slightly moist, very dense, sandy, silty/clayey GRAVEL with cobbles inclusions, occasionally with clay inclusions. The gravel is subrounded and rounded (Slightly cemented gravelly conglomerate on sand/clay cement). 6 borehole samples were laboratory-analyzed. Laboratory testing data for the samples are given in Annex-2 and Annex-3, as well as in Tables 4.2.1 and 4.2.2 below.

Table-4.2.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Sand			Silt 0,04 - 0,002 mm	Clay < 0,002 mm
				Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm		
AP-03 BH-1	0.5-1.5	8.7	61.7	4.4	4.8	3.2	12.5	4.7
AP-03 BH-1	5.0-6.0	21.0	47.9	4.8	7.0	3.6	11.8	3.9
AP-03 BH-1	8.0-9.0	8.3	64.2	3.7	5.9	2.5	10.5	4.9

Table-4.2.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Moisture content of filler, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
				Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-03 BH-1	0.5-1.5	2.5	2.7	31.9	19.6	12.3	-1.37	2.57	-	1.77
AP-03 BH-1	3.0-4.0	3.1	-	-	-	-	-	2.62	-	1.77
AP-03 BH-1	5.0-6.0	3.8	4.9	28.6	14.5	14.1	-0.68	2.58	-	1.76
AP-03 BH-1	6.3-6.6*	14.2						2.72	-	1.70
AP-03 BH-1	6.0-6.45	2.7	3.7	26.9	15.3	11.6	-1.00	2.70	-	1.65
AP-03 BH-1	8.0-9.0	3.9	-	-	-	-	-	2.66	-	1.69

6.3-6.6*- The sample is Neogenic clay vein.

Based on Standard Penetration Test (SPT) data, number of N impacts is >50, according to which the stratum is very dense.

Values for internal friction angle and cohesion, as well as for deformation modulus of the stratum were calculated using appropriate method (method of DALNIIS GOSSTROY of the USSR). Calculations were made based on physical properties values (see Annex 2) and for consolidated soil are as follows:

- Internal friction angle $\varphi=34.1^0$;

- Cohesion C=22.2 kPa
- Deformation modulus E=38.75 MPa;

Based on the SNIP 2.02.01-83, assumed design resistance R_0 = 0.40 Mpa

Chemical composition of soils was studied on 2 borehole samples. In the chemical composition of the samples, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made with any cement. The soil is practically neutral by hydrogen ion content (pH) too. Individual results of laboratory study are given in Annex-6.

In the survey borehole, during field works, ground water did not show.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-8). Based on geophysical data, up to the sampled 15 m, specific electric resistivity of soils varies from 292 to 954 ohm m, according to which corrosive effect of soils is low.

Within the survey site and its neighbourhood, no hazardous geodynamic processes are observed.

Allowable temporary grade for STRATUM-1, according to SNIP III-B1-71 is as follows:

- up to 1.5 m. depth 1:0.5;
- from 1.5 m to 5.0 m. depth 1:1.

4.3 CONSTRUCTION SITE - AP-07

The construction site of Tower AP-07 of the Project Ksani-Stepantsminda 500 KW transmission line is located north-east of village Old Kanda, in approximately 1 km, i. e. on Mukhrani-Tirifoni plain, the relief of which is slightly sloped north-eastward (dip azimuth 80^0). Adjacent to the survey site, there is a crosswise irrigation canal. The site surface is covered with grass and occasionally brushwood is found.

In terms of geology, the area adjacent to the survey site is structured with Neogenic - Meotian and Pontian (Nm+p) marine and land molasses: conglomerates, sands and clays overcovered with Quaternary clays and topsoil layer.

In geotechnical terms, the survey site is located in Kartli molasse sub-zone of the South Caucasus intermountain area.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Old Kanda), seismicity of the survey site is intensity 8 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.16.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Mukhrani meteorological station which is the nearest to the survey site.

On the survey site, one geotechnical borehole (AP-07 BH-1) was drilled with 10 m depth; standard penetration tests (SPT) were conducted in the borehole. The borehole log is given in Annex-2. Within

the site, electric sounding of soils was also conducted on 3 points, the results of which are given in Annex-7. For photos of the core taken from the borehole and of the survey site see Annex-8.

Based on the field and laboratory investigation data, within the surveyed depth (10 m), in the structure of the site there is Quaternary clayey soil (geotechnical STRATUM-1) overcovered with topsoil layer.

STRATUM-1 – Moist, brown, stiff to very stiff, slightly sandy, silty CLAY; the soil has high plasticity. 6 borehole samples were laboratory-analyzed. Laboratory testing data for the samples are given in Annex-2 and Annex-3, as well as in Tables 4.3.1 and 4.3.2 below.

Table-4.3.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Sand			Silt 0,04 - 0,002 mm	Clay < 0,002 mm
				Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm		
AP-07 BH-1	5.6-6.0	-	-	0.2	0.9	1.9	59.8	37.2
AP-07 BH-1	7.0-7.4	-	1.8	0.2	2.3	6.6	45.3	43.8
AP-07 BH-1	9.6-10.0	-	-		0.1	0.2	60.1	39.6

Table-4.3.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
			Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-07 BH-1	1.0-1.3	20.40	-	-	-	-	2.73	1.99	-
AP-07 BH-1	2.3-2.6	29.77	-	-	-	-	2.73	1.95	-
AP-07 BH-1	3.5-3.8	24.27	-	-	-	-	2.73	1.89	-
AP-07 BH-1	5.6-6.0	31.11	60.20	28.70	31.50	0.08	2.74	1.93	-
AP-07 BH-1	7.0-7.4	25.28	57.70	27.50	30.20	-0.07	2.74	2.00	-
AP-07 BH-1	9.6-10.0	26.14	55.60	21.10	34.50	0.15	2.74	1.76	-

Based on Standard Penetration Test (SPT) data, number of N impacts varies within 8-12, according to which the stratum is from stiff to very stiff.

- Average density value for the stratum is ρ=1.92 g/cm^3
- Average value for moisture content, W%=26.2
- Average value for voids ratio e=0.8
- Average value for moisture degree is Sz=0.9

Based on shear test, the values for soil strength properties are:

- Internal friction angle $\varphi=18.6^0$;
- Cohesion C=48 kPa.

Based on the performed tests, unconfined compressive strength varies within q_u - 0.23-0.33 MPa (average 0.28 MPa).

Based on the SNIP 2.02.01-83, according to the stratum composition and values of physical parameters are as follows:

- Assumed design resistance R_0 = 0.28 Mpa;
- Deformation modulus E=19.5 Mpa.

Chemical composition of soils was studied on 2 borehole samples. In the chemical composition of the samples, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made with any cement. The soil is practically neutral by hydrogen ion content (pH) too. Individual results of laboratory study are given in Annex-6.

In the survey borehole, ground water showed during field works, and standing water level is 1.5 m.

Based on the data of chemical analysis of water, 1 liter of water contains 25 ml sulphate (SO_4) and 340.42 ml chloride (Cl), according to which the water is slightly aggressive against concrete reinforcement in case of periodical wetting, and is medium aggressive against carbon steel. Water pH=6.74.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-8). Based on geophysical data, up to the sampled 15 m, specific electric resistivity of soils varies from 11 to 17 ohm m, according to which corrosive effect of soils is high.

Within the survey site and its neighbourhood, no hazardous geodynamic processes are observed.

Allowable temporary grade for STRATUM-1, according to SNIP III-B1-71 is as follows:

- up to 1.5 m. depth 1:0
- from 1.5 m to 3.0 m. depth 1:0.25
- from 3.0 to 5.0 m depth 1:0.5

4.4 CONSTRUCTION SITE - AP-12

The construction site of Tower AP-12 of the Project Ksani-Stepantsminda 500 KW transmission line is located north-east of village Dzalisi, in approximately 600-800 meters, in the lower part of the moderately steep slope with southward direction, azimuth 190^0-200^0, angle of gradient of relief is 7^0-10^0 of the survey site surface itself. The gradient of the upper part of the slope increases and gradually transfers into a steep slope (15-25^0).The surface of the survey site is covered with grass and brushwood.

In terms of geology, the area adjacent to the survey site is structured with Neogenic - Meotian and Pontian (Nm+p) marine and land molasses: conglomerates, sandstones and clays.

In geotechnical terms, the survey site is located in Kartli molasse sub-zone of the South Caucasus intermountain area.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Ereda), seismicity of the survey site is intensity 8 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.15.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Mukhrani meteorological station which is the nearest to the survey site.

On the survey site, one geotechnical borehole (AP-12 BH-1) was drilled with 10 m depth; standard penetration tests (SPT) were conducted in the borehole. The borehole log is given in Annex-2. Within the site, electric sounding of soils was also conducted on 3 points, the results of which are given in Annex-7. For photos of the core taken from the borehole and of the survey site see Annex-8.

Based on the conducted field and laboratory investigation data, within the surveyed depth (10 m), in the structure of the site there is stiff, slightly sandy clay (STRATUM-1) located on the survey site under the topsoil to 1.9 m depth and under STRATUM-1, there are molasse deposits, Neogenic slightly cemented gravelly conglomerates on the site, which are described below as geotechnical STRATUM-2:

STRATUM-1 – moist, brown, very stiff, slightly sandy, silty CLAY. - (dQ_{IV}). One sample from the borehole was laboratory analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Table 4.4.1 below.

Table-4.4.1 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
			Upper limit,WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-12 BH-1	1.0-1.2	17.8	49.3	24.1	25.2	-0.25	2.73	1.74	-

Based on Standard Penetration Test (SPT) data, number of N impacts is 30, according to which the stratum is very stiff.

- - Stratum density value is ρ=1.74 g/cm^3
- - Natural moisture content value, W%=17.8
- Average value for voids ratio e=0.84
- Moisture degree value is Sz=0.57

Based on the SNIP 2.02.01-83, according to the stratum composition and values of physical parameters are as follows:

- Assumed design resistance R_0 = 0.28 MPa

- Deformation modulus E=18 MPa;

STRATUM-2 – Slightly moist, very dense, sandy, silty/clayey GRAVEL with cobbles inclusions. Gravel is sub-rounded and rounded (slightly cemented gravelly conglomerate on sand/clay cement). 5 borehole samples were laboratory analyzed. Laboratory testing data for the samples are given in Annex-2 and Annex-3, as well as in Tables 4.4.2 and 4.4.3 below.

Table-4.4.2 Stratum-2 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Sand			Silt 0,04 - 0,002 mm	Clay < 0,002 mm
				Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm		
AP-12 BH-1	3.0-4.0	20.2	53.9	2.8	3.1	2.3	12.2	5.5
AP-12 BH-1	6.0-7.0	17.2	52.7	6.6	6.4	3	9.7	4.4
AP-12 BH-1	8.5-9.5	-	60.3	10.2	7.6	4.9	11.9	5.1

Table-4.4.3 Stratum-2 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Moisture content of filler, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
				Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-12 BH-1	3.0-4.0	6.2	-	-	-	-	-	2.37	-	1.78
AP-12 BH-1	4.5-5.0	5.6	-	-	-	-	-	2.4	-	1.71
AP-12 BH-1	6.0-7.0	7.1	12.2	27	13.2	13.8	-0.07	2.44	-	1.75
AP-12 BH-1	7.5-8.0	5.4	-	-	-	-	-	2.48	-	1.73
AP-12 BH-1	8.5-9.5	6.6	15.6	42.4	23.3	19.1	-0.40	2.53	-	1.76

Based on Standard Penetration Test (SPT) data, number of N impacts is >50, according to which the stratum is very dense.

Values for internal friction angle and cohesion, as well as for deformation modulus of the stratum were calculated using appropriate method (method of DALNIIS GOSSTROY of the USSR). Calculations were made based on physical properties values (see Annex 5) and for consolidated soil are as follows:

- Internal friction angle $\varphi=32.1^0$;
- Cohesion C=25.1 kPa
- Deformation modulus E=36.17 MPa;

Based on the SNIP 2.02.01-83 - assumed design resistance R_0 = 0.45 Mpa.

Chemical composition of soils was studied on 2 borehole samples. In the chemical composition of the samples, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made with any cement. The soil is practically neutral by hydrogen ion content (pH) too. Individual results of laboratory study are given in Annex-6.

In the survey borehole, ground water did not show.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-8). Specific electric resistivity of soils varies from 45 to 105 ohm m, according to which corrosive effect is medium and low.

Within the survey site and its neighbourhood, no hazardous geodynamic processes are observed.

Allowable temporary grade for STRATUM-1, according to SNIP III-B1-71 is as follows:

- up to 1.5 m. depth 1:0
- from 1.5 m to 3.0 m. depth 1:0.25
- from 3.0 to 5.0 m depth 1:0.5

For STRATUM-2 temporary grade is:

- up to 1.5 m. depth 1:0.5
- from 1.5 m to 5.0 m. depth 1:1

4.5 CONSTRUCTION SITE - AP-15

The construction site of Tower AP-15 of the Project Ksani-Stepantsminda 500 KW transmission line is located at village Tsikhevdavi. The survey site relief is sloped toward the village. The relief is uneven, and the surface is covered with grass and brushwood.

In terms of geology, the area adjacent to the survey site is structured with Neogenic - Meotian and Pontian (Nm+p) marine and land molasses: conglomerates, sandstones and clays which (>10m) are covered with Quaternary proluvial soils.

In geotechnical terms, the survey site is located in Kartli molasse sub-zone of the South Caucasus intermountain area.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Tsikhevdavi), seismicity of the survey site is intensity 8 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.15.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Mukhrani meteorological station which is the nearest to the survey site.

Due to absence of access road to the survey site, it was not possible to drill boreholes within the given coordinates. The survey borehole (AP-15 BH-1) was relocated south of the site, 30 meters away, adjacent to the motor road. The borehole log is given in Annex-1.

Based on the conducted field and laboratory investigations data, within the surveyed depth (10 m) in the the structure of the site there is very stiff, slightly gravelly, slightly sandy, silty CLAY. Gravel is subrounded and rounded. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.5.1 and 4.5.2 below.

Table-4.5.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
				Sand				
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm	Silt 0,04 - 0,002 mm	Clay < 0,002 mm
AP-15 BH-1		-	6.1	0.5	0.7	3.8	61.2	27.7

Table-4.5.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
			Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-15 BH-1	2.1-2.3	20.6	-	-	-	-	2.73	1.72	-
AP-15 BH-1	2.7-3.0	22.0	-	-	-	-	2.74	1.84	-
AP-15 BH-1	3.25-3.50	25.3	50.2	24.6	25.6	0.03	2.74	1.88	-

Based on Standard Penetration Test (SPT) data, number of N impacts varies within 27-31, according to which the stratum is very stiff.

- - Stratum density value is ρ=1.81 g/cm^3
- - Natural moisture content value, W%=22.6
- Average value for voids ratio e=0.852
- Moisture degree value is Sz=0.729

Based on shear test, the values for soil strength properties are:

- Internal friction angle $\varphi=17.4^0$;
- Cohesion C=50 kPa.

Based on the performed tests, unconfined compressive strength varies within q_u - 0.37-0.44 MPa (average 0.40 MPa;)

Based on the SNIP 2.02.01-83, according to the stratum composition and values of physical parameters are as follows:

- Assumed design resistance R_0 = 0.27 Mpa;
- Deformation modulus E=18 Mpa.

STRATUM-2 – Slightly moist, very dense, sandy, silty/clayey GRAVEL with cobbles inclusions. Gravel is sub-rounded and rounded. 3 borehole samples were laboratory analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.5.3 and 4.5.4 below.

Table-4.5.3 Stratum-2 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Sand			Silt 0,04 - 0,002 mm	Clay < 0,002 mm
				Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm		
AP-15 BH-1	4.0-5.0	-	62.7	6.2	5.2	5.0	14.0	6.9
AP-15 BH-1	8.5-10.0	-	67.8	5.4	3.7	6.9	9.9	

Table-4.5.4 Stratum-2 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Moisture content of filler, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
				Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-15 BH-1	4.0-5.0	4.9	11.5	32.7	14.2	18.5	-0.15	2.59		1.55
AP-15 BH-1	6.0-7.0	3.4						2.54		1.56
AP-15 BH-1	8.5-10.0	2.5	4.6	26.4	15.2	11.2	-0.95	2.61		1.53

Based on Standard Penetration Test (SPT) data, number of N impacts is >50, according to which the stratum is very dense.

Values for internal friction angle and cohesion, as well as for deformation modulus of the stratum were calculated using appropriate method (method of DALNIIS GOSSTROY of the USSR). Calculations were made based on physical properties values (see Annex 5) and for consolidated soil are as follows:

- Internal friction angle $\varphi=33.2^0$;
- Cohesion C=24.2 kPa
- Deformation modulus E=37.17 MPa;

Based on the SNIP 2.02.01-83 - assumed design resistance R_0 = 0.45 MPa

Chemical composition of soils was studied on 2 borehole samples. The soil shows slight chloride and sulphate aggressiveness against reinforced concreet structures during periodical wetting. The soil is practically neutral by hydrogen ion content (pH). Individual results of laboratory study are given in Annex-6.

In the survey borehole, ground water did not show during field works.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-8). Specific electric resistivity of soils varies from 180 to 600 ohm m, according to which corrosive effect of soils is low.

Within the survey site and its neighbourhood, no hazardous geodynamic processes are observed.

For STRATUM-1, allowable temporary grade according to SNIP III-B1-71 is as follows:

- up to 1.5 m. depth 1:0
- from 1.5 m to 3.0 m. depth 1:0.25
- from 3.0 to 5.0 m depth 1:0.5

For STRATUM-2 allowable temporary grade is:

- up to 1.5 m. depth 1:0.5
- from 1.5 m to 5.0 m. depth 1:1

4.6 CONSTRUCTION SITE - AP-18

The construction site of Tower AP-18 of the Project Ksani-Stepantsminda 500 KW transmission line is located 2 km east of village Mchadidzhvari, on the gentle slope of mostly western exposition with azimuth 260^0. The angle of gradient of the relief on the survey site itself is 6^0-10^0. The grade of the upper part of the slope gradually increases and transfers into a steep slope (15-25^0). The surface of the survey site is covered with grass and brushwood and in 60 m to the east the slope is forested.

In terms of geology, the area adjacent to the survey site is structured with Neogenic - Meotian and Pontian (Nm+p) marine and land molasse: conglomerates, sandstones and clays.

In geotechnical terms, the survey site is located in Kartli molasse sub-zone of the South Caucasus intermountain area.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Mchadidzhvari), seismicity of the survey site is intensity 8 by MSK64 scale. Nonmetric co-efficient of seismicity is A=0.15.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Mukhrani meteorological station which is the nearest to the survey site.

On the survey site, one geotechnical borehole (AP-18 BH-1) ws drilld with 10 m depth and a standard penetration test (SPT) was conducted in the borehole. The borehole log is given in Annex-2. Within the site, vertical electric sounding of soils was performed at 3 stations the results of which are given in Annex-7. For photos of the cores taken from the borehole and for the survey site see Annex-8.

Based on the conducted field and laboratory investigations data, within the surveyed depth (10 m) in the the structure of the site there are 3 geotechnical strata: very stiff, slightly sandy clay (STRATUM-1) which is located up to 1.0 m depth under the topsoil stratum on the site, andt is of delluvial genesis; molasse deposits located to 4.6 m under STRATUM-1, Neogenic slightly cemented gravelly conglomerates (STRATUM-2); and under them, to 10 m depth, very stiff clay was recorded which is described below as geotechnical STRATUM-3.

STRATUM-1 – moist, brown, very stiff, slightly gravely, slightly sandy silty CLAY. Gravel is angular and subangular. One sample from the borehole was laboratory analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.6.1 and 4.6.2 below.

Table-4.6.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
				Sand				
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm	Silt 0,04 - 0,002 mm	Clay < 0,002 mm
AP-18 BH-1	0.4-0.8	-	23.7	5.8	4.7	4.7	46.9	14.2

Table-4.6.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
			Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-18 BH-1	0.4-0.8	10.6	46.4	25.5	20.9	-0.71	2.73	1.75	-

Based on Standard Penetration Test (SPT) data, number of N impacts is 35, according to which the stratum is very stiff.

- Stratum density value is ρ=1.75 g/cm^3
- Natural moisture content value, W%=10.6
- Average value for voids ratio e=0.615
- Moisture degree value is Sz=0.09

Based on the SNIP 2.02.01-83, according to the stratum composition and values of physical parameters are as follows:

- Assumed design resistance R_0 = 0.3 Mpa;
- Deformation modulus E=25 Mpa.

STRATUM-2 – Slightly moist, very dense, sandy, silty/clayey GRAVEL with cobbles inclusions. Gravel is sub-rounded and rounded. (Slightly cemented gravely conglomerate on sand/clay cement). 1 borehole sample was laboratory analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.6.3 and 4.6.4 below.

Table-4.6.3 Stratum-2 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Sand			Silt 0,04 - 0,002 mm	Clay < 0,002 mm
				Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm		
AP-18 BH-1	2.2-3.0	10.9	64.0	5.7	6.1	4.8	8.5	

Table-4.6.4 Stratum-2 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Moisture content of filler, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
				Upper limit,WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-18 BH-1	2.2-3.0	3.0	4.7	23.4	14.6	8.8	-1.13	2.62	-	1.39

Based on Standard Penetration Test (SPT) data, number of N impacts is >50, according to which the stratum is very dense.

Values for internal friction angle and cohesion, as well as for deformation modulus of the stratum were calculated using appropriate method (method of DALNIIS GOSSTROY of the USSR). Calculations were made based on physical properties values (see Annex 5) and for consolidated soil are as follows:

- Internal friction angle $\varphi=34.9^0$;
- Cohesion C=18.4 kPa
- Deformation modulus E=41.65 MPa;

Based on the SNIP 2.02.01-83, Assumed design resistance R_0 = 0.45 MPa

Chemical composition of soils was studied on one borehole sample. In the chemical composition of the sample, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made with any cement. The soil is also practically neutral by hydrogen ion content (pH). Individual results of laboratory study are given in Annex-6.

STRATUM-3 – Moist, brown, very stiff, slightly sandy, silty CLAY. 4 borehole samples were laboratory analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.6.5 and 4.6.6 below.

Table-4.6.5 Stratum-3 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
				Sand				
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm	Silt 0,04 - 0,002 mm	Clay < 0,002 mm
AP-18 BH-1	9.6-10.0	-	-	-	0.2	0.4	86.5	12.9

Table-4.6.6 Stratum-3 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
			Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-18 BH-1	4.69-4.8	19.9	-	-	-	-	2.74	1.8	-
AP-18 BH-1	5.4-5.8	22.8	-	-	-	-	2.75	1.78	-
AP-18 BH-1	8.0-8.4	20.6	-	-	-	-	2.74	1.75	-
AP-18 BH-1	9.6-10.0	21.3	63.0	28.1	34.9	-0.19	2.75	1.93	-

Based on Standard Penetration Test (SPT) data, number of N impacts varies within 22-28, according to which the stratum is very stiff.

- Stratum density average value is ρ=1.81 g/cm^3
- Natural moisture content average value, W%=21.15
- Average value for voids ratio e=0.79
- Moisture degree average value is Sz=0.63

Based on shear tests, the values for soil strength properties are:

- Internal friction angle φ=18.6^0;
- Cohesion C=57 kPa

Based on the SNIP 2.02.01-83, according to the stratum composition and values of physical parameters are as follows:

- Assumed design resistance R_0 = 0.3 Mpa;

- Deformation modulus E=20.5 Mpa.

Chemical composition of soils was studied on one borehole sample. In the chemical composition of the sample, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made with any cement. The soil is also practically neutral by hydrogen ion content (pH). Individual results of laboratory study are given in Annex-6.

In the survey borehole, ground water did not show during field works.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-7). Specific electric resistivity of soils varies from 74 to 201 ohm m, according to which corrosive effect of soils is low.

Within the survey site and its neighbourhood, no hazardous geodynamic processes are observed.

For STRATUM-1, allowable temporary grade according to SNIP III-B1-71 is as follows:

- up to 1.5 m. depth 1:0
- from 1.5 m to 3.0 m. depth 1:025
- from 3.0 to 5.0 m depth 1:0.5

For STRATUM-2 allowable temporary grade is:

- up to 1.5 m. depth 1:0.5
- from 1.5 m to 5.0 m. depth 1:1

For STRATUM-3, allowable temporary grade is as follows:

- up to 1.5 m. depth 1:0
- from 1.5 m to 3.0 m. depth 1:025
- from 3.0 to 5.0 m depth 1:0.5

4.7 CONSTRUCTION SITE - AP-24

The construction site of Tower AP-24 of the Project Ksani-Stepantsminda 500 KW transmission line is located in approximately 2 km north-east of village Chilurti, in the mid-part of moderately steep slope of southern exposition with azimuth 170^0. The angle of gradient of the relief on the survey site is 10^0-15^0. The surface of the survey site is covered with grass and occasionally with brushwood; the lower part of the slope is forested.

West of the survey site, in 65-70 m, there is a southward shallow (1.5-2 m depth) erosion gulley having formed as a result of temporary torrential flows, on the sides of which observed are Neogenic - Meotian and Pontian (Nm+p) marine and land molasses deposits: slightly cemented gravely conglomerates and clays. Occasionally there are thin and medium-bedded sandstone and gritstone found. Strata dip azimuth is 100^0 and angle of gradient is 35^0.

In geotechnical terms, the survey site is located in Kartli molasse sub-zone of the South Caucasus intermountain area.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Chilurti), seismicity of the survey site is intensity 8 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.16.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Dusheti meteorological station which is the nearest to the survey site.

On the survey site, one geotechnical borehole (AP-24 BH-1) ws drilld with 10 m depth and a standard penetration test (SPT) was conducted in the borehole. The borehole log is given in Annex-2. Within the site, vertical electric sounding of soils was performed at 3 stations the results of which are given in Annex-7. For photos of the cores taken from the borehole and for the survey site see Annex-8.

Based on the conducted field and laboratory investigations data, within the surveyed depth (10 m) in the the structure of the site there are very stiff, slightly sandy clays (STRATUM-1) located on the site up to 4.5 m depth under the topsoil stratum, and under STRATUM-1 there are slightly cemented gravely conglomerates with clay veins described below as geotechnical STRATUM-2.

STRATUM-1 – moist, brown, very stiff, slightly sandy silty CLAY. 4 borehole samples were laboratory analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.7.1 and 4.7.2 below.

Table-4.7.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Sand			Silt 0,04 - 0,002 mm	Clay < 0,002 mm
				Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm		
AP-24 BH-1	4.0-4.3	-	-	-	0.1	0.6	82.1	17.2

Table-4.7.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
			Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-24 BH-1	1.0-1.2	15.9	-	-	-	-	2.74	1.84	-
AP-24 BH-1	1.2-1.5	20.0	-	-	-	-	2.73	1.87	-
AP-24 BH-1	2.7-3.0	22.4	-	-	-	-	2.73	1.82	-
AP-24 BH-1	4.0-4.3	26.6	57.0	25.6	31.4	0.03	2.74	1.85	-

Based on Standard Penetration Test (SPT) data, number of N impacts varies within 22-29, according to which the stratum is very stiff.

- Stratum density average value is ρ=1.85 g/cm^3
- Natural moisture content average value, W%=21.2
- Average value for voids ratio e=0.79
- Moisture degree average value is Sz=0.72

Based on shear tests, the values for soil strength properties are:

- Internal friction angle φ=17.4^0;
- Cohesion C=48 kPa.

Based on the performed tests, unconfined compressive strength is q_u 0.32 MPa.

Based on the SNIP 2.02.01-83, according to the stratum composition and values of physical parameters are as follows:

- Assumed design resistance R_0 = 0.3 MPa;
- Deformation modulus E=19.5 Mpa.

STRATUM-2 – Slightly moist, very dense, sandy, silty/clayey GRAVEL with cobbles inclusions and clay veins. Gravel is sub-rounded and rounded. (Slightly cemented gravely conglomerate on sand/clay cement). 2 borehole samples were laboratory analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.7.3 and 4.7.4 below.

Table-4.7.3 Stratum-2 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Sand			Silt 0,04 - 0,002 mm	Clay < 0,002 mm
				Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm		
AP-24 BH-1	5.0-7.0	6.2	50.9	5.7	8.7	8.6	4.2	15.7
AP-24 BH-1	7.0-9.0	-	67.7	6.2	5.6	4.0	2.5	14.0

Table-4.7.4 Stratum-2 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Moisture content of filler, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
				Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-24 BH-1	5.0-7.0	6.9	9.8	29.0	14.2	14.8	-0.30	2.51	-	1.74
AP-24 BH-1	7.0-9.0	8.8	14.0	35.2	14.5	20.7	-0.02	2.53	-	1.72

Based on Standard Penetration Test (SPT) data, number of N impacts is >50, according to which the stratum is very dense.

Values for internal friction angle and cohesion, as well as for deformation modulus of the stratum were calculated using appropriate method (method of DALNIIS GOSSTROY of the USSR). Calculations were made based on physical properties values (see Annex 5) and for consolidated soil are as follows:

- Internal friction angle $\varphi=32.9^0$;
- Cohesion C=27.8 kPa
- Deformation modulus E=33.93 MPa;

Based on the SNIP 2.02.01-83, Assumed design resistance R_0 = 0.4 MPa

Chemical composition of soils was studied on 2 borehole samples. In the chemical composition of the samples, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made with any cement. The soil is also practically neutral by hydrogen ion content (pH). Individual results of laboratory study are given in Annex-6.

In the survey borehole, ground water did not show during field works.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-7). Specific electric resistivity of soils varies from 12 to 30 ohm m, according to which corrosive effect of soils is medium and high.

Within the survey site and its neighbourhood, no hazardous geodynamic processes are observed.

For STRATUM-1, allowable temporary grade according to SNIP III-B1-71 is as follows:

- up to 1.5 m. depth 1:0

- from 1.5 m to 3.0 m. depth 1:025
- from 3.0 to 5.0 m depth 1:0.5

For STRATUM-2 allowable temporary grade is:

- up to 1.5 m. depth 1:0.5
- from 1.5 m to 5.0 m. depth 1:1

4.8 CONSTRUCTION SITE - AP-28

The construction site of Tower AP-28 of the Project Ksani-Stepantsminda 500 KW transmission line is located south-west of village Dadorebi and east of village Arghuni. The site represents a flank with 5^0-10^0 angle of gradient of the relief which has southward exposition (azimuth 180^0-190^0. The surface of the survey site is covered with grasses; at 60-80 meters distance, there are both coniferous and foliage trees.

In terms of geology, the survey site and its adjacent area are structured with Lower Neogenic – Lower and Mid-Sarmatian ($\mathbf{N_1s_{1+2}}$) marine molasses deposits: clays, sandstones, conglomerates and limestones sometimes covered with Quaternary clays and topsoil layer.

In geotechnical terms, the survey site is located in Kartli molasse sub-zone of the South Caucasus intermountain area.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Arghuni), seismicity of the survey site is intensity 8 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.16.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Dusheti meteorological station which is the nearest to the survey site.

On the survey site, one geotechnical borehole (AP-28 BH-1) was drilled with 10 m depth; standard penetration tests (SPT) were conducted in the borehole. The borehole log is given in Annex-2. Within the site, electric sounding of soils was also conducted on 3 points, the results of which are given in Annex-7. For photos of the core taken from the borehole and of the survey site see Annex-8.

Based on the conducted field and laboratory investigations data, within the surveyed depth (10 m) in the the structure of the site there is Lower Neogenic clay soil (STRATUM-1) overcovered with 0.1 meter-thick topsoil layer.

STRATUM-1 – moist, brown and grayish brown, very stiff, slightly sandy, silty CLAY. The soil has intermediate plasticity.

6 borehole samples were laboratory analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.8.1 and 4.8.2 below.

Table-4.8.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Sand			Silt 0,04 - 0,002 mm	Clay < 0,002 mm
				Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm		
AP-28 BH-1	2.8-3.0	-	-	0.1	0.6	0.7	73.3	25.3
AP-28 BH-1	5.5-5.8	-	-	-	0.5	0.3	63.0	36.2
AP-28 BH-1	7.25-7.5	-	-	-	0.4	0.8	66.9	31.9

Table-4.8.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
			Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-07 BH-1	2.8-3.0	18.8	47.3	20.8	26.5	-0.08	2.74	1.98	-
AP-07 BH-1	4.2-5.0	17.4	-	-	-	-	2.74	1.90	-
AP-07 BH-1	5.5-5.8	17.0	49.8	20.8	29.0	-0.13	2.73	2.01	-
AP-07 BH-1	7.25-7.50	16.6	45.6	22.5	23.1	-0.26	2.74	1.87	-
AP-07 BH-1	8.5-8.7	17.8	-	-	-	-	2.75	1.88	-
AP-07 BH-1	9.7-10.0	18.2	-	-	-	-	2.75	1.82	-

Based on Standard Penetration Test (SPT) data, number of N impacts varies within 21-42, according to which the stratum is very stiff.

- Stratum density average value is ρ=1.91 g/cm^3
- Natural moisture content average value, W%=17.63
- Average value for voids ratio e=0.68
- Moisture degree average value is Sz=0.7

Based on shear tests, the values for soil strength properties are:

- Internal friction angle $\varphi=23^0$;
- Cohesion C=73 kPa.

Based on the performed tests, unconfined compressive strength is q_u varies within the range of 0.37-0.44 MPa (average 0.40 MPa).

Based on the SNIP 2.02.01-83, according to the stratum composition and values of physical parameters are as follows:

- Assumed design resistance R_0 = 0.35 Mpa;
- Deformation modulus E=22.5 Mpa.

Chemical composition of soils was studied on 2 borehole samples. In the chemical composition of the samples, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made with any cement. The soil is also practically neutral by hydrogen ion content (pH). Individual results of laboratory study are given in Annex-6.

In the survey borehole, ground water did not show during field works.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-7). According to geophysical data, up to the 15 meters sampled, corrosive effect of soils varies from medium to high.

Within the survey site and its neighbourhood, no hazardous geodynamic processes are observed.

For STRATUM-1, allowable temporary grade is:

- up to 1.5 m. depth 1:0
- from 1.5 m to 3.0 m. depth 1:0.25

4.9 CONSTRUCTION SITE - AP-33

The construction site of Tower AP-33 of the Project Ksani-Stepantsminda 500 KW transmission line is located south-east of village Bantsurtkari, in the lower part of the left slope of the river Arkhalo valley, in 50-60 meters from the motor road. The exposition of the survey site is south-eastward (azimuth 120^0-130^0) angle of gradient of the site relief is 5^0-7^0. The slope has and overlapping relief.

In terms of geology, the area adjacent to the survey site is structured with E_3-N^1_1 Oligocene and Lower Miocene (Maikop series) marine molasse: sandstones, gritstones, weakly carbonaceous clays with marls intercalations, gypsiferous clays and sands. Sometimes rocks are overcovered with Quaternary overburden soil.

In geotechtonic terms, the survey site is located in Kartli molasse sub-zone of the South Caucasus intermountain area.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Bantsurtkari), seismicity of the survey site is intensity 8 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.20.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Dusheti meteorological station which is the nearest to the survey site.

On the survey site, one geotechnical borehole (AP-33 BH-1) was drilld with 10 m depth and a standard penetration test (SPT) was conducted in the borehole. The borehole log is given in Annex-2. Within the site, vertical electric sounding of soils was performed at 3 stations; the results are given in Annex-7. For photos of the cores taken from the borehole and for the survey site see Annex-8.

Based on the conducted field and laboratory investigations data, within the surveyed depth (10 m) in the structure of the site there is a Quaternary clay soil (geotechnical STRATUM-1), overcovered with 0.1 m-thick topsoil layer.

STRATUM-1 – moist, brown and grayish brown, very stiff, slightly gravely, slightly sandy silty CLAY. Gravel is subrounded and the soil has high plasticity.

6 samples from the borehole were laboratory analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.9.1 and 4.9.2 below.

Table-4.9.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
				Sand				
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm	Silt 0,04 - 0,002 mm	Clay < 0,002 mm
AP-33 BH-1	2.0-2.4	-	2.5	1.9	2.9	1.6	70.2	20.9
AP-33 BH-1	5.0-5.4	-	0.9	0.6	0.7	1.3	65.1	31.4
AP-33 BH-1	9.7-10.0	-	-	-	0.1	0.5	69.8	29.6

Table-4.9.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
			Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-33 BH-1	2.0-2.4	21.6	57.2	24.6	32.6	-0.09	2.74	1.94	-
AP-33 BH-1	2.65-3.0	22.2	-	-	-	-	2.73	1.87	-
AP-33 BH-1	3.6-4.0	23.3	-	-	-	-	2.74	1.85	-
AP-33 BH-1	5.0-5.4	22.6	60.0	26.7	33.3	-0.12	2.74	1.76	-
AP-33 BH-1	7.65-8.0	25.6	-	-	-	-	2.73	1.92	-
AP-33 BH-1	9.7-10.0	18.9	51.3	23.3	28.0	-0.16	2.75	1.96	-

Based on Standard Penetration Test (SPT) data, number of N impacts baries within 15-20, according to which the stratum is very stiff.

- Stratum density average value is ρ=1.88 g/cm^3
- Natural moisture content average value, W%=22.36

- Average value for voids ratio e=0.78
- Moisture degree average value is Sz=0.79

Internal friction angle and cohesion of the stratum were determined in laboratory:

- Internal friction angle $\varphi=19.5^0$;
- Cohesion C=65 kPa

Based on the performed tests, unconfined compressive strength varies within q_u - 0.31-0.42 MPa (average 0.36 MPa;)

Based on SNIP 2.02.01-83, according to the stratum composition and values of physical parameters are as follows:

- Assumed design resistance R_0 = 0.3 Mpa;
- Deformation modulus E=19.5 Mpa.

Chemical composition of soils was studied on 2 borehole samples. In the chemical composition of the sample, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made with any cement. The soil is also practically neutral by hydrogen ion content (pH). Individual results of laboratory study are given in Annex-6.

In the survey borehole, ground water did not show during drilling.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-7). Specific electric resistivity of soils varies from 6 to 10 ohm m, according to which corrosive effect of soils is high.

In terms of geodynamics, adjacent to the survey site, surface erosion processes are observed, and there are 3-4 meters long cross fractures. In 50 meters west of the site, an approximately 100 meters long, southward, shallow (0.5-0.7 m depth), narrow channeling is observed, which has formed as a result of torrential flows of surface waters. The survey site is covered with grasses and brushwood. Morphologically, the slope has landslide relief. It is rugged and on the surface overlapping landforms are found. Currently the landslide is stabilized, though it is not excluded that during abundant precipitation periods, affected by surface and upper ground waters, in case of soil saturation it may activate.

Proceeding from the above, we consider it expedient that the support tower be located beyond the landslide body, on a stable site.

4.10 CONSTRUCTION SITE - AP-34

The construction site of Tower AP-34 of the Project Ksani-Stepantsminda 500 KW transmission line is located on the southern slope of a roughly EW trending mountain range between villages Tsikh-isdziri and Kadoeti, in the upper part, at 50-69 meters distance from the crest. Exposition of the slope is south-eastward (azimuth 150^0-165^0); the angle of gradient of the slope relief is 20^0-30^0. The survey site and the slope are covered with grasses and sometimes with thin forest.

In terms of geology, the survey site and its adjacent area are structured with Upper Cretaceous (K_1) deposits: aleurolitic, sandstone, gritstone and clastic limestone turbidites, pelagic marls, cherty argil-lites, sometimes with alternation of pelitomorphic limestones and marls.

In geotechnical terms, the survey site is located in Mestia-Tianeti zone of the South Caucasus intermountain area.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Kadoeti), seismicity of the survey site is intensity 8 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.2.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Pasanauri meteorological station which is the nearest to the survey site.

On the survey site, one geotechnical borehole (AP-34 BH-1) was drilled with 10 m depth; standard penetration tests (SPT) were conducted in the borehole. The borehole log is given in Annex-2. Within the site, electric sounding of soils was also conducted on 3 points, the results of which are given in Annex-8. Schematic layout of boreholes and VESs is given in Annex-7. For photos of the core taken from the borehole and of the survey site see Annex-9.

Based on the conducted field and laboratory investigations data, within the surveyed depth (10 m), coarse soil was recorded – up to 2.0 m (geotechnical STRATUM-1) and rock material 2.0-10.0 (geotechnical STRATUM-2).

STRATUM-1 – moist, sandy, silty/clayey GRAVEL. Gravel is subangular.

1 borehole sample was laboratory analyzed. Laboratory testing data for the sample are given in Annex-3 and Annex-4, as well as in Tables 4.10.1 and 4.10.2 below.

Table-4.10.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
				Sand				
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm	Silt 0,04 - 0,002 mm	Clay < 0,002 mm
AP-39 BH-1	0.5-1.0	-	60.3	9.3	5.0	4.7	15.5	5.2

Table-4.1-.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
			Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-39 BH-1	0.5-1.0	22.3	39.9	18.1	21.8	0.19	2.19		1.49

Values for internal friction angle and cohesion, as well as for deformation modulus of the stratum were calculated using appropriate method (method of DALNIIS GOSSTROY of the USSR). Calculations were made based on physical properties values (see Annex 5) and for consolidated soil are as follows:

- Internal friction angle $\varphi=32.2^0$;
- Cohesion C=17.2 kPa
- Deformation modulus E=26.85 MPa;

Based on the SNIP 2.02.01-83, Assumed design resistance R_0 = 0.4 MPa

Chemical composition of soils was studied on one borehole sample. In the chemical composition of the sample, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made with any cement. The soil is also practically neutral by hydrogen ion content (pH). Individual results of laboratory study are given in Annex-6.

STRATUM-2 – moderately and slightly weathered, moderately weak, brownish gray, highly fractured, lamellar and thinly bedded ARGILLITES AND SILTSTONE – (K_2) Upper Creataceous deposits. Stratum dip azimuth is 350^0 and dip angle is 25^0-20^0.

1 borehole sample was laboratory analyzed. Laboratory testing data for the sample are given in Annex-3 and Annex-4, as well as in Tables 4.10.1 and 4.10.2 below.

STRATUM-2 unconfined compressive strength in natural state is from 5.8 MPa to 8.2 MPa, according to which the rock is moderately weak. Average value for strength is ρ=2.57 g/cm^3.

In the survey borehole, ground water did not show during field works.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-7). According to geophysical data, up to the 15 meters sampled, specific electric resistivity of soils varies from 43 to 146 ohm m, according to which corrosive effect of soils is medium and low.

For STRATUM-1, allowable temporary grade according to SNIP III-B1-71 is as follows:

- up to 1.5 m. depth 1:0
- from 1.5 m to 3.0 m. depth 1:025
- from 3.0 to 5.0 m depth 1:0.5

Within the survey site and its neighbourhood, no hazardous geodynamic processes are observed.

Allowable temporary grade for STRATUM-1 is:

- up to 1.5 m. depth 1:0.5;
- from 1.5 m to 5.0 m. depth 1:1.

4.11 CONSTRUCTION SITE - AP-39

The construction site of Tower AP-39 of the Project Ksani-Stepantsminda 500 KW transmission line is located in the upper part of the left steep slope of the r. Chartlis Khevi valley, north of village Chartli. Exposition of the slope is southward (azimuth 180^0), the angle of gradient of the slope relief is 35^0-45^0. The survey site and the slope are covered with grasses and sometimes with thin forest. adjacent to the survey site there is a place of former estate and remains of old buildings.

In terms of geology, the survey site and its adjacent area are structured with Aptian and Albian (**K_1a+al**) deposits: clastic limestone turbidites, pelagic marls, cherty argillites, sometimes with alternation of pelitomorphic limestones and marls.

In geotechnical terms, the survey site is located in Mestia-Tianeti zone of the South Caucasus intermountain area.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Chartali), seismicity of the survey site is intensity 8 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.25.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Pasanauri meteorological station which is the nearest to the survey site.

As long as there was no access road to the survey site, one borehole (AP-39 BH-1) was drilled with 10 m depth as nearly as possible to the site. Standard penetration tests (SPT) were conducted in the borehole. The borehole log is given in Annex-2. Within the site, electric sounding of soils was also conducted on 3 points, the results of which are given in Annex-7. For photos of the core taken from the borehole and of the survey site see Annex-8.

Based on the conducted field and laboratory investigations data, within the surveyed depth (10 m), coarse soil was recorded – up to 1.2 m (geotechnical STRATUM-1) and rock material 1.2-10.0 (geotechnical STRATUM-2).

STRATUM-1 – moist, sandy, silty/clayey GRAVEL. Gravel is subangular.

1 borehole sample was laboratory analyzed. Laboratory testing data for the sample are given in Annex-3 and Annex-4, as well as in Tables 4.11.1 and 4.11.2 below.

Table-4.11.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Sand			Silt 0,04 - 0,002 mm	Clay < 0,002 mm
				Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm		
AP-39 BH-1	0.5-1.0	-	76.4	5.4	3.7	4.4	10.1	

Table-4.11.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
			Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-39 BH-1	0.5-1.0	10.4	35.8	21.6	14.2	-0.79	2.48	-	1.55

Values for internal friction angle and cohesion, as well as for deformation modulus of the stratum were calculated using appropriate method (method of DALNIIS GOSSTROY of the USSR). Calculations were made based on physical properties values (see Annex 5) and for consolidated soil are as follows:

- Internal friction angle $\varphi=35.4^0$;
- Cohesion C=28.8 kPa
- Deformation modulus E=55.21 MPa;

Based on the SNIP 2.02.01-83 - assumed design resistance R_0 = 0.4 MPa

Chemical composition of soils was studied on one borehole sample. In the chemical composition of the sample, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made with any cement. The soil is also practically neutral by hydrogen ion content (pH). Individual results of laboratory study are given in Annex-6.

STRATUM-2 – moderately and slightly weathered, moderately weak to moderately strong, brownish gray, highly fractured, thin- and medium-bedded CHERTY ARGILLITES AND SILTSTONES – (K1a+al) Aptian and Albian deposits. Stratum dip azimuth is 340^0 and dip angle is 50^0.

STRATUM-2 unconfined compressive strength in natural state varies from 11.7 MPa to 22.2 MPa, according to which the rock is moderately weak to moderately strong. Average value for strength is ρ=2.58 g/cm^3.

In the survey borehole, ground water did not show during drilling.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-8). According to geophysical data, up to the 15 meters sampled, specific electric resistivity of soils varies from 75 to 200 ohm m, according to which corrosive effect of soils is low.

For STRATUM-1, allowable temporary grade is:

- up to 1.5 m. depth 1:0.5
- from 1.5 m to 5.0 m. depth 1:1

4.12 CONSTRUCTION SITE - AP-55

The construction site of Tower AP-55 of the Project Ksani-Stepantsminda 500 KW transmission line is located south of village Kikhoti, in the relatively gentle mid part of the right high slope of the r. Shavi (Gudamakari) Aragvi valley. Exposition of the survey site itself is northward (azimuth 350^0-360^0); the relief slope on the site 7^0-10^0. Adjacent to the site, to the east, there is an erosion gulley. In 35 m north of the survey site, the slope becomes steep (30^0-40^0) and retains the inclination up to the r. Shavi Aragvi floodplain. This part of the slope is forested. South-west of the survey site, on the upper steep slope several shallow erosion gulleys originate. The surface of the survey site is covered with grass.

In terms of geology, the survey site is structured with glacial and deluvial deposits and its adjacent area is represented by J_3km+tt – Kimmeridgian and Tithonian stages: clastic-limestone, and more rarely sandstone-gritstone turbidites, pelagic clayey limestones, marls and argillites, sometimes oolitic limestones.

In geotechtonic terms, the survey site is located in Mestia-Tianeti sub-zone of the Caucasus fold system.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Kikhoti), seismicity of the survey site is intensity by MSK64 scale. Nonmetric coefficient of seismicity is A=0.41.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Bursachiri meteorological station which is the nearest to the survey site.

On the survey site, one geotechnical borehole (AP-55 BH-1) was drilld with 2.5 m depth. The borehole log is given in Annex-2. Within the site, vertical electric sounding of soils was also performed at 3 stations; the results are given in Annex-7. For photos of the cores taken from the borehole and for the survey site see Annex-8.

Based on the conducted field and laboratory investigations data, within the surveyed depth, in the structure of the site, up to 2.3 m depth, there is a Quaternary clay soil (geotechnical STRATUM-1), overcovered with 0.2 m-thick topsoil layer. From 2.3 m to 2.5 m, a gravelly soil stratum (STRATUM-2) has been recorded. Based on vertical electric sounding data, from 2.5 m the stratum extends to the sampled 10 m depth.

STRATUM-1 – moist, brown, stiff, slightly gravely, slightly sandy silty CLAY.

3 samples from the borehole were laboratory analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.12.1 and 4.12.2 below.

Table-4.12.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
				Sand				
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm	Silt 0,04 - 0,002 mm	Clay < 0,002 mm
AP-55 BH-1	0.5-0.7	-	-	0.3	1.6	2.7	61.8	33.6
AP-55 BH-1	1.3-1.5	-	-	0.6	1.9	3.9	61.5	32.1
AP-55 BH-1	2.1-2.3	-	-	0.8	1.3	4.1	64.1	29.7

Table-4.12.6 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
			Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-55 BH-1	0.5-0.7	27.1	38.9	21.3	17.6	0.33	2.74	1.93	-
AP-55 BH-1	1.3-1.5	27.8	41.2	22.2	19.0	0.29	2.73	1.92	-
AP-55 BH-1	2.1-2.3	26.1	42.3	20.4	21.9	0.26	2.74	1.89	-

- Stratum density average value is ρ=1.91 g/cm^3
- Natural moisture content average value, W%=27.0
- Average value for voids ratio e=0.82
- Moisture degree average value is Sz=0.90

Internal friction angle and cohesion of the stratum were determined by testing:

- Internal friction angle φ=18.0^0;
- Cohesion C=53.3 kPa.

Based on SNIP 2.02.01-83, according to the stratum composition and values of physical parameters are as follows:

- Assumed design resistance R_0 = 0.25 Mpa;

- Deformation modulus E=15.0 Mpa.

Chemical composition of soils was studied on 2 borehole samples. In the chemical composition of the sample, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made with any cement. The soil is also practically neutral by hydrogen ion content (pH). Individual results of laboratory study are given in Annex-6.

STRATUM-2 – Moist, sandy, silty/clayey GRAVEL with cobbles inclusions. Gravel is sub-angular and sub-rounded. Based on vertical electric sounding data, the stratum extends to 10 m depth sampled from 2.5 m.

In the survey borehole, ground water did not show during drilling, though in case of abundant precipitation, show of surface waters is not excluded.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-7). Based on geophysical data, up to 5.5 m depth, specific electric resistivity of soils varies from 32 to 45 ohm m, according to which corrosive effect of soils is medium. From 5.5 m to 15 m, specific electric resistivity of soils varies from 51 to 114 ohm m, according to which corrosive effect of soils is low.

Based on the accounts from the local population, south-west of the survey site, at the upper steep slope, snow avalanches occure. They are directed form south-east to north-west, therefore they do not threat the project tower. In 35 m north of the survey site, from the crest of the plained slope to the valley bottom, the clayey slope has steep garde and erosion processes are undergoing on it which are currently slowed down, though their activation is not excluded. In order to increase reliability, it is expedient to move the tower 20 m in south-eastern direction.

For STRATUM-1, allowable temporary grade according to SNIP III-B1-71 is as follows:

- up to 1.5 m. depth 1:0
- from 1.5 m to 3.0 m. depth 1:025
- from 3.0 to 5.0 m depth 1:0.5

For STRATUM-2 allowable temporary grade is:

- up to 1.5 m. depth 1:0.5
- from 1.5 m to 5.0 m. depth 1:1

4.13 CONSTRUCTION SITE - AP-81

The construction site of Tower AP-81 of the Project Ksani-Stepantsminda 500 KW transmission line is located in the floodplain of the river Snostskali left inflow – r. Kvenamtistskali, on the left bank, at 90 m distance from the river bed. The relief of the survey site is slightly tilted northward (dip azimuth 2^0-3^0); angle of gradient of the relief is 3^0-8^0. On the east and on the west, the survey site is confined with steep slopes structured with laminated Jurassic slates (strata dip azimuth 310^0, dip angle 75-80^0. The surface of the survey site is covered with grass.

In geotechnical terms, the survey site is located in Kazbegi-Lagodekhi zone of the Caucasus fold system.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Karkucha), seismicity of the survey site is intensity 9 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.43.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Stepantsminda meteorological station which is the nearest to the survey site.

On the survey site, one borehole (AP-81 BH-1) was drilled with 10 m depth and standard penetration tests (SPT) were conducted in the borehole. The borehole log is given in Annex-2. Within the site, electric sounding of soils was also conducted on 3 points, the results of which are given in Annex-7. For photos of the core taken from the borehole and of the survey site see Annex-8.

Based on the field and laboratory investigation data, within the surveyed depth (10 m) in the site structure there are alluvial, Quaternary soil described below as geotechnical STRATUM-1:

STRATUM-1 – Slightly moist (from 4.9 m saturated), dense to very dense, sandy, silty GRAVEL with cobbles inclusions. The gravel is subrounded and subangular. 6 borehole samples were laboratory-analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.13.1 and 4.13.2 below.

Table-4.13.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
				Sand				
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm	Silt 0,04 - 0,002 mm	Clay < 0,002 mm
AP-81 BH-1	1.0-2.0	12.3	65.0	9.3	4.3	2.0	7.1	
AP-81 BH-1	3.0-4.0	-	57.1	14.9	7.8	3.8	12.8	3.6
AP-81 BH-1	8.0-9.0	7.9	57.6	12.5	7.2	5.1	9.7	

Table-4.13.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Moisture content of filler, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
				Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-81 BH-1	1.0-2.0	3.8	5.0	30.0	20.4	9.6	-1.60	2.56	-	1.74
AP-81 BH-1	2.0-3.0	4.0	-	-	-	-	-	2.51	-	1.70
AP-81 BH-1	3.0-4.0	5.2	6.8	34.6	21.2	13.4	-1.07	2.63	-	1.69
AP-81 BH-1	4.0-5.0	5.6	-	-	-	-	-	2.58	-	1.64

Borehole #	Sampling depth range, m	Natural moisture content, W%	Moisture content of filler, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
				Upper limit,WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-81 BH-1	6.0-7.0	4.6	-	-	-	-	-	2.55	-	1.69
AP-81 BH-1	8.0-9.0	4.9	6.3	31.7	21.4	10.3	-1.47	2.60	-	1.66

Based on Standard Penetration Test (SPT) data, number of N impacts varies from 32 to >50, according to which the stratum is dense to very dense.

Values for internal friction angle and cohesion, as well as for deformation modulus of the stratum were calculated using appropriate method (method of DALNIIS GOSSTROY of the USSR). Calculations were made based on physical properties values (see Annex 5) and for consolidated soil are as follows:

- Internal friction angle $\varphi=34.1^0$;
- Cohesion C=25.4 kPa
- Deformation modulus E=42.95 MPa;

Based on the SNIP 2.02.01-83 - assumed design resistance R_0 = 0.40 MPa

Chemical composition of soils was studied on two borehole samples. In the chemical composition of the samples, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made with any cement. The soil is also practically neutral by hydrogen ion content (pH). Individual results of laboratory study are given in Annex-6.

In the survey borehole, standing level of ground water is 4.9 m.

Based on the data of chemical analysis of water, 1 liter of water contains 155.02 ml chloride (Cl); sulphate (SO_4) did not reveal, according to which the water is slightly aggressive against concrete reinforcement in case of periodical wetting, and is medium aggressive against carbon steel. Water pH=6.96.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-8). Based on geophysical data, up to the sampled 15 m, specific electric resistivity of soils varies from 285 to 919 ohm m, according to which corrosive effect of soils is low.

Within the survey site and its neighbourhood, no hazardous geodynamic processes are observed, though in case of flood, inundation of the area is not excluded.

Allowable temporary grade for STRATUM-1, according to SNIP III-B1-71 is as follows:

- up to 1.5 m. depth 1:0.5

- from 1.5 m to 3.0 m. depth 1:1

4.14 CONSTRUCTION SITE - AP-84

The construction site of Tower AP-84 of the Project Ksani-Stepantsminda 500 KW transmission line is located on the floodplain of the river Snostskali, on the right bank, at about 70 m distance from the river bed. The relief of the survey site is plained, slightly tilted north-westward (dip azimuth 300^0-310^0); angle of gradient of relief is 2^0-3^0. On the east and on the west, the survey site is confined with steep slopes structured with laminated Jurassic slates (strata dip azimuth 320^0 and 330^0, dip angle 70-80^0). At the survey site, the right bank of the river Snostskali is stabilized with anti-erosion concrete blocks and along the river there is an earth berm of 2.5-3 m height on which a motor road is arranged. The surface of the survey site is covered with grasses.

In geotechnical terms, the survey site is located in Kazbegi-Lagodekhi zone of the Caucasus fold system.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Karkucha), seismicity of the survey site is intensity 9 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.43.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Stepantsminda meteorological station which is the nearest to the survey site.

On the survey site, one borehole (AP-81 BH-1) was drilled with 10 m depth and standard penetration tests (SPT) were conducted in the borehole. The borehole log is given in Annex-2. Within the site, electric sounding of soils was also conducted on 3 points, the results of which are given in Annex-7. For photos of the core taken from the borehole and of the survey site see Annex-8.

Based on the field and laboratory investigations data, within the surveyed depth (10 m) in the site structure there is alluvial, Quaternary soil described below as geotechnical STRATUM-1:

STRATUM-1 – Slightly moist (from 1.8 m saturated), medium dense to dense, sandy, silty/clayey GRAVEL with cobbles inclusions. The gravel is subrounded and subangular. 6 borehole samples were laboratory-analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.14.1 and 4.14.2 below.

Table-4.14.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Sand			Silt 0,04 - 0,002 mm	Clay < 0,002 mm
				Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm		
AP-81 BH-1	1.0-2.0	-	65.0	18.0	7.4	2.6	7.0	
AP-81 BH-1	3.0-4.0	-	58.1	13.7	8.5	4.4	10.9	4.4
AP-81 BH-1	8.0-9.0	-	59.9	12.7	6.8	3.2	12.4	5.0

Table-4.14.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Moisture content of filler, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
				Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-81 BH-1	1.5-2.0	3.3	6.3	30.2	18.2	12.0	-0.99	2.79	-	1.65
AP-81 BH-1	3.5-5.0	4.4	-	-	-	-	-	2.65	-	1.67
AP-81 BH-1	6.0-7.0	3.5	-	-	-	-	-	2.68	-	1.64
AP-81 BH-1	7.5-8.3	5.0	8.8	31.6	22.2	9.4	-1.43	2.71	-	1.66
AP-81 BH-1	8.3-9.45	5.8	-	-	-	-	-	2.73	-	1.69
AP-81 BH-1	9.8-9.95	5.3	8.3	27.8	18.5	9.3	-1.10	2.42	-	1.65

Based on Standard Penetration Test (SPT) data, number of N impacts varies from 17 to 37, according to which the stratum is dense to very dense.

Values for internal friction angle and cohesion, as well as for deformation modulus of the stratum were calculated using appropriate method (method of DALNIIS GOSSTROY of the USSR). Calculations were made based on physical properties values (see Annex 5) and for consolidated soil are as follows:

- Internal friction angle $\varphi=33.4^0$;
- Cohesion C=26.4 kPa;
- Deformation modulus E=36.8 Mpa.

Based on the SNIP 2.02.01-83 - assumed design resistance R_0 = 0.40 Mpa.

Chemical composition of soils was studied on two borehole samples. In the chemical composition of the samples, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete or steel structure. The soil is also practically neutral by hydrogen ion content (pH). Individual results of laboratory study are given in Annex-6.

In the survey borehole, standing level of ground water is 1.8 m.

Based on the data of chemical analysis of water, chloride (Cl); sulphate (SO_4) did not reveal in water; according to which the water is not aggressive against any type of concrete made on any cement and against any steel structures. Water pH=6.96.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-7). Based on geophysical data, up to the sampled 15 m, specific electric resistivity of soils varies from 313 to 950 ohm m, according to which corrosive effect of soils is low.

Within the survey site and its neighbourhood, currently no hazardous geodynamic processes are observed. In case of flood, the area may become inundated.

Allowable temporary grade for STRATUM-1, according to SNIP III-B1-71 is as follows:

- up to 1.5 m. depth 1:0.5
- from 1.5 m to 3.0 m. depth 1:1

4.15 CONSTRUCTION SITE - AP-88

The construction site of Tower AP-88 of the Project Ksani-Stepantsminda 500 KW transmission line is located east of village Karkucha, on the right bank of the river Snostskali, at 50 m distance from the river bed, on the above-flood-plain elevated area, on the debris cone. The relief of the survey site is sloped south-westward (dip azimuth 200^0-210^0); angle of gradient of relief is 10^0-15^0. On the north and south, the survey site is confined with steep, dissected slopes of the river Snostskali valley. The relief on the survey site is rough, waved, and its surface is covered with grass. At the base of the debris cone where the survey site is located, between the motor road and the r. Snostskali, a shallow pond is observed. Near the survey site, a gulley with 40-50 m-wide debris cone joins the river Snostskali on left bank.

In geotechnical terms, the survey site is located in Kazbegi-Lagodekhi zone of the Caucasus fold system.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Karkucha), seismicity of the survey site is intensity 9 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.43.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Stepantsminda meteorological station which is the nearest to the survey site.

On the survey site, one borehole (AP-88 BH-1) was drilled with 10 m depth and standard penetration tests (SPT) were conducted in the borehole. The borehole log is given in Annex-2. Within the site, electric sounding of soils was also conducted on 3 points, the results of which are given in Annex-7. For photos of the core taken from the borehole and of the survey site see Annex-8.

Based on the field and laboratory investigations data, within the surveyed depth (10 m) in the site structure there is alluvial, Quaternary soil described below as geotechnical STRATUM-1:

STRATUM-1 – Slightly moist (from 7.7 m saturated), dense to very dense, sandy, silty GRAVEL with cobbles inclusions. The gravel is subrounded and subangular. 6 borehole samples were laboratory-analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.15.1 and 4.15.2 below.

Table-4.15.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
				Sand				
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm	Silt 0,04 - 0,002 mm	Clay < 0,002 mm
AP-88 BH-1	1.0-2.0	-	63.3	9.6	5.1	3.1	12.9	6.0
AP-88 BH-1	3.0-4.0	-	68.4	9.0	4.9	2.7	10.5	4.5
AP-88 BH-1	9.0-10.0	7.7	59.7	13.5	6.0	3.4	9.7	7.7

Table-4.15.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Moisture content of filler, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
				Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-88 BH-1	1.0-2.0	5.7	6.2	34.8	22.5	12.3	-1.33	2.49	-	1.56
AP-88 BH-1	3.0-4.0	8.8	11.2	34.6	21.5	13.1	-0.79	2.55	-	1.42
AP-88 BH-1	4.5-6.0	6.2	-	-	-	-	-	2.58	-	1.44
AP-88 BH-1	6.0-7.0	6.8	-	-	-	-	-	2.63	-	1.59
AP-88 BH-1	8.0-9.0	7.6	-	-	-	-	-	2.60	-	1.61
AP-88 BH-1	9.0-10.0	9.2	12.7	32-.1	22.1	10.0	-0.94	2.69	-	1.65

Based on Standard Penetration Test (SPT) data, number of N impacts varies from 48 to >50, according to which the stratum is dense to very dense.

Values for internal friction angle and cohesion, as well as for deformation modulus of the stratum were calculated using appropriate method (method of DALNIIS GOSSTROY of the USSR). Calculations were made based on physical properties values (see Annex 5) and for consolidated soil are as follows:

- Internal friction angle $\varphi=33.5^0$;
- Cohesion C=28.9 kPa
- Deformation modulus E=42.46 MPa;

Based on the SNIP 2.02.01-83 - assumed design resistance R_0 = 0.40 MPa

Chemical composition of soils was studied on two borehole samples. In the chemical composition of the samples, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made on any cement. The soil is also practically neutral by hydrogen ion content (pH). Individual results of laboratory study are given in Annex-6.

In the survey borehole, standing level of ground water is 7.7 m.

Based on the data of chemical analysis of water, 1 liter of water contains 177.3 ml chloride (Cl); sulphate (SO_4) did not reveal in water; according to which the water is slightly aggressive against concrete reinforcement in case of periodical wetting and medium aggressive against carbon steel. Water pH=6.96.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-7). Based on geophysical data, up to the sampled 15 m, specific electric resistivity of soils varies from 290 to 418 ohm m, according to which corrosive effect of soils is low.

In geodynamic terms, it is noteworthy that the survey site is located on the debris cone, in the lower part of the deep erosion gulley existing on the right slope of the river Snostskali valley, and according to the local population's experience, snow avalanch on the slope periodically reaches the motor road, as a result of which there is a hazard of snow avalanch on the project site.

Allowable temporary grade for STRATUM-1, according to SNIP III-B1-71 is as follows:

- up to 1.5 m. depth 1:0.5
- from 1.5 m to 5.0 m. depth 1:1

4.16 CONSTRUCTION SITE - AP-89

The construction site of Tower AP-89 of the Project Ksani-Stepantsminda 500 KW transmission line is located south of village Karkucha, on the right bank of the river Snostskali, in approximately 20 meters from the river bed, in the flood-plain. The relief of the survey site is slightly tilted north-westward (dip azimuth 280^0-290^0); angle of gradient of relief is 2^0-3^0. On the north and on the south, the survey site is confined with steep slopes of the river Snostskali valley. The right bank of the river Snostskali bed is reinforced with anti-erosion concrete blocks and along the river there goes an earth berm on which the motor road is arranged.

In geotechnical terms, the survey site is located in Kazbegi-Lagodekhi zone of the Caucasus fold system.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Karkucha), seismicity of the survey site is intensity 9 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.43.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Stepantsminda meteorological station which is the nearest to the survey site.

On the survey site, one borehole (AP-89 BH-1) was drilled with 10 m depth and standard penetration tests (SPT) were conducted in the borehole. The borehole log is given in Annex-2. Within the site, electric sounding of soils was also conducted on 3 points, the results of which are given in Annex-7. For photos of the core taken from the borehole and of the survey site see Annex-8.

Based on the field and laboratory investigations data, within the surveyed depth (10 m) in the site structure there is alluvial, Quaternary soil described below as geotechnical STRATUM-1:

STRATUM-1 – Slightly moist (from 4.5 m saturated), medium dense to dense, very sandy, silty GRAVEL with cobbles inclusions. The gravel is subrounded and subangular. 6 borehole samples were laboratory-analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.16.1 and 4.16.2 below.

Table-4.16.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Sand			Silt 0,04 - 0,002 mm	Clay < 0,002 mm
				Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm		
AP-89 BH-1	1.0-2.5	-	61.4	16.1	9.3	4.4	8.8	
AP-89 BH-1	3.0-4.0	-	65.1	15.1	6.5	3.6	9.7	
AP-89 BH-1	4.0-5.5	-	52.4	15.4	8.4	4.5	13.5	5.8

Table-4.16.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Moisture content of filler, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
				Upper limit, WL %	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-89 BH-1	1.0-2.5	2.7	3.4	27.9	18.2	9.7	-1.53	2.79	-	1.79
AP-89 BH-1	3.0-4.0	3.0	-	-	-	-	-	2.75	-	1.72
AP-89 BH-1	4.0-5.5	2.9	4.0	33.0	20.3	12.7	-1.28	2.67	-	1.69
AP-89 BH-1	6.5-8.0	6.7	9.2	31.4	19.7	11.7	-0.90	2.65	-	1.74
AP-89 BH-1	8.0-9.0	6.0	-	-	-	-	-	2.68	-	1.69
AP-89 BH-1	9.0-10.0	7.7	-	-	-	-	-	2.59	-	1.59

Based on Standard Penetration Test (SPT) data, number of N impacts varies from 27 to 38, according to which the stratum is medium dense to dense.

Values for internal friction angle and cohesion, as well as for deformation modulus of the stratum were calculated using appropriate method (method of DALNIIS GOSSTROY of the USSR). Calculations were made based on physical properties values (see Annex 5) and for consolidated soil are as follows:

- Internal friction angle $\varphi=33.5^0$;
- Cohesion C=24.9 kPa
- Deformation modulus E=35.71 MPa;

Based on the SNIP 2.02.01-83 - assumed design resistance R_0 = 0.40 Mpa.

Chemical composition of soils was studied on two borehole samples. In the chemical composition of the samples, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made on any cement. The soil is also practically neutral by hydrogen ion content (pH). Individual results of laboratory study are given in Annex-6.

In the survey borehole, standing level of ground water is 4.5 m.

Based on the data of chemical analysis of water, 1 liter of water contains 177.3 ml chloride (Cl); sulphate (SO_4) did not reveal in water; according to which the water is slightly aggressive against concrete reinforcement in case of periodical wetting and medium aggressive against carbon steel. Water pH=6.96.

Based on the data of chemical analysis of water, 1 liter of water contains 163.12 m.l chloride (Cl); sulphate (SO_4) did not reveal in water; according to which the water is slightly aggressive against concrete reinforcement in case of periodical wetting and medium aggressive against carbon steel. Water pH=6.96.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-7). Based on geophysical data, up to the sampled 15 m, specific electric resistivity of soils varies from 300 to 500 ohm m, according to which corrosive effect of soils is low.

In geodynamic terms, within the survey site and its neighbourhood, no hazardous geodynamic processes are observed, though, in case of flood, the area may become inundated.

Allowable temporary grade for STRATUM-1, according to SNIP III-B1-71 is as follows:

- up to 1.5 m. depth 1:0.5
- from 1.5 m to 5.0 m. depth 1:1

4.17 CONSTRUCTION SITE - AP-91

The construction site of Tower AP-91 of the Project Ksani-Stepantsminda 500 KW transmission line is located in the flood-plain of the river Snostskali, on the right bank, in approximately 30 meters from the river bed. The relief of the survey site is plain, slightly tilted north-westward (dip azimuth 280^0-290^0); angle of gradient of relief is 2^0-3^0. In 35 meters from the survey site, there is the right steep slope structured with laminated Jurassic slates (strata dip azimuth 310^0 and 320^0, dip angle 75-80^0). At the survey site, the banks of the river Snostskali bed are stabilized with anti-erosion concrete blocks and along the river there is an earth berm of 2.5-3 m height on which the motor road is arranged. The surface of the survey site is covered with grasses. Near the site, shallow ponds of 0.2-0.3 m depth are found, due to which a drainage pipe is arranged on the area.

In geotechnical terms, the survey site is located in Kazbegi-Lagodekhi zone of the Caucasus fold system.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Karkucha), seismicity of the survey site is intensity 9 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.43.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Stepantsminda meteorological station which is the nearest to the survey site.

On the survey site, one borehole (AP-91 BH-1) was drilled with 10 m depth and standard penetration tests (SPT) were conducted in the borehole. The borehole log is given in Annex-2. Within the site, electric sounding of soils was also conducted on 3 points, the results of which are given in Annex-7. For photos of the core taken from the borehole and of the survey site see Annex-8.

Based on the field and laboratory investigations data, within the surveyed depth (10 m) in the site structure there is alluvial, Quaternary soil described below as geotechnical STRATUM-1:

STRATUM-1 – Saturated, medium dense to dense, very sandy, silty GRAVEL with cobbles inclusions. The gravel is subrounded and subangular. 6 borehole samples were laboratory-analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.17.1 and 4.17.2 below.

Table-4.17.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Sand			Silt 0,04 - 0,002 mm	Clay < 0,002 mm
				Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm		
AP-91 BH-1	6.0-7.0	-	55.2	14.0	8.8	4.6	11.1	6.3
AP-91 BH-1	7.0-8.0	-	51.7	14.1	6.5	4.7	15.9	7.1
AP-91 BH-1	9.0-10.0	-	51.7	14.0	8.7	4.5	14.5	6.6

Table-4.17.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Moisture content of filler, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
				Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-91 BH-1	1.0-2.0	4.4	-	-	-	-	-	2.45	-	1.63
AP-91 BH-1	2.5-3.5	3.0	-	-	-	-	-	2.47	-	1.57
AP-91 BH-1	4.0-5.0	4.7	-	-	-	-	-	2.51	-	1.59
AP-91 BH-1	6.0-7.0	5.8	7.2	30.8	20.4	10.4	-1.27	2.50	-	1.62
AP-91 BH-1	7.0-8.0	4.9	6.7	31.6	21.4	10.2	-1.44	2.44	-	1.55
AP-91 BH-1	9.0-10.0	5.4	6.9	30.9	19.0	11.9	-1.02	2.48	-	1.55

Based on Standard Penetration Test (SPT) data, number of N impacts varies from 24 to 34, according to which the stratum is dense to very dense.

Values for internal friction angle and cohesion, as well as for deformation modulus of the stratum were calculated using appropriate method (method of DALNIIS GOSSTROY of the USSR). Calculations were made based on physical properties values (see Annex 5) and for consolidated soil are as follows:

- Internal friction angle $\varphi=32.4^0$;
- Cohesion C=26.9 kPa;
- Deformation modulus E=33.47 Mpa.

Based on the reference normative literature (SNIP 2.02.01-83), according to the stratum composition and values of physical parameters:

Assumed design resistance R_0 = 0.40 MPa

Chemical composition of soils was studied on two borehole samples. In the chemical composition of the samples, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made on any cement. The soil is also practically neutral by hydrogen ion content (pH). Individual results of laboratory study are given in Annex-6.

In the survey borehole, standing level of ground water is 0.8 m.

Based on the data of chemical analysis of water, chloride (Cl) and sulphate (SO_4) did not reveal in water; according to which water is not aggressive against any type of concrete and steel structure. Water pH=6. 65.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-7). Based on geophysical data, up to the sampled 15 m, specific electric resistivity of soils varies from 313 to 950 ohm m, according to which corrosive effect of soils is low.

Within the survey site and its neighbourhood, currently no hazardous geodynamic processes are observed. In case of flood, the area may become inundated.

Allowable temporary grade for STRATUM-1, according to SNIP III-B1-71 is as follows:

- up to 1.5 m. depth 1:0.5
- from 1.5 m to 3.0 m. depth 1:1

4.18 CONSTRUCTION SITE - AP-93

The construction site of Tower AP-93 of the Project Ksani-Stepantsminda 500 KW transmission line is located in the flood-plain of the river Snostskali, on the left bank, in approximately 200 meters from the river bed. The relief of the survey site is plain, slightly tilted north-westward (dip azimuth 310^0-320^0); angle of gradient of relief is 2^0-3^0. In 50 meters west of the survey site, there is the left steep slope of the river Snostskali valley, which is structured with laminated Jurassic slates (strata dip azimuth 310^0 and 320^0, dip angle 70-75^0). The banks of the river Snostskali bed are stabilized with anti-

erosion concrete blocks and along the river there is an earth berm of 2.5-3 m height. The surface of the survey site is covered with grasses.

In geotechnical terms, the survey site is located in Kazbegi-Lagodekhi zone of the Caucasus fold system.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Karkucha), seismicity of the survey site is intensity 9 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.43.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Stepantsminda meteorological station which is the nearest to the survey site.

On the survey site, one borehole (AP-93 BH-1) was drilled with 10 m depth and standard penetration tests (SPT) were conducted in the borehole. The borehole log is given in Annex-2. Within the site, electric sounding of soils was also conducted on 3 points, the results of which are given in Annex-7. For photos of the core taken from the borehole and of the survey site see Annex-8.

Based on the field and laboratory investigations data, within the surveyed depth (10 m) in the site structure there is alluvial, Quaternary soil described below as geotechnical STRATUM-1:

STRATUM-1 – (Saturated from 4.1 m), medium dense to dense, very sandy, silty GRAVEL with cobbles inclusions. The gravel is subrounded and subangular. 6 borehole samples were laboratory-analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.18.1 and 4.18.2 below.

Table-4.18.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Sand			Silt 0,04 - 0,002 mm	Clay < 0,002 mm
				Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm		
AP-93 BH-1	6.0-7.0	7.6	63.4	12.6	5.5	2.8	8.1	
AP-93 BH-1	7.0-8.0	-	67.0	14.2	6.3	3.2	9.3	
AP-93 BH-1	9.0-10.0	2.3	65.3	13.4	7.3	3.9	7.8	

Table-4.18.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Moisture content of filler, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
				Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-93 BH-1	2.0-3.0	2.0	2.1	28.2	17.8	10.4	-1.51	2.69	-	1.85
AP-93 BH-1	3.5-4.5	3.1	-	-	-	-	-	2.55	-	1.74

Borehole #	Sampling depth range, m	Natural moisture content, W%	Moisture content of filler, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
				Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-93 BH-1	4.5-5.5	4.0	-	-	-	-	-	2.53	-	1.67
AP-93 BH-1	5.5-6.0	6.8	10.5	28.7	19.0	9.7	-0.88	2.58	-	1.59
AP-93 BH-1	6.5-8.0	4.7	8.6	26.8	19.7	7.1	-1.56	2.56	-	1.55
AP-93 BH-1	9.0-10.0	4.4	-	-	-	-	-	2.51	-	1.64

Based on Standard Penetration Test (SPT) data, number of N impacts varies from 21 to 32, according to which the stratum is dense to very dense.

Values for internal friction angle and cohesion, as well as for deformation modulus of the stratum were calculated using appropriate method (method of DALNIIS GOSSTROY of the USSR). Calculations were made based on physical properties values (see Annex 5) and for consolidated soil are as follows:

- Internal friction angle $\varphi=35.5^0$;
- Cohesion C=20.6 kPa
- Deformation modulus E=39.8 MPa;

Based on the SNIP 2.02.01-83 - assumed design resistance R_0 = 0.40 Mpa.

Chemical composition of soils was studied on two borehole samples. In the chemical composition of the samples, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made on any cement. The soil is also practically neutral by hydrogen ion content (pH). Individual results of laboratory study are given in Annex-6.

In the survey borehole, standing level of ground water is 4.1 m.

Based on the data of chemical analysis of water, 1 liter of water contains 212.76 m.l chloride (Cl); and sulphate (SO_4) did not reveal in water; according to which water is slightly aggressive against concrete reinforcement in case of periodical wetting and it is medium aggressive against carbon steel. Water pH=6. 88.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-7). Based on geophysical data, up to the sampled 15 m, specific electric resistivity of soils varies from 270 to 804 ohm m, according to which corrosive effect of soils is low.

Within the survey site and its neighbourhood, currently no hazardous geodynamic processes are observed. In case of flood, the area may become inundated.

Allowable temporary grade for STRATUM-1, according to SNIP III-B1-71 is as follows:

- up to 1.5 m. depth 1:0.5
- from 1.5 m to 3.0 m. depth 1:1

4.19 CONSTRUCTION SITE - AP-96

The construction site of Tower AP-96 of the Project Ksani-Stepantsminda 500 KW transmission line is located south-east of village Sno, on the left bank of the river Snostskali, at approximately 150 m distance from the river bed, on the above-flood-plain elevated area, on the debris cone of the erosion gulley. The relief of the survey site is slightly tilted north-eastward (dip azimuth 30^0-40^0); angle of gradient of relief is 15^0-20^0. In 15 meters west of the survey site, there is a small rivulet the outlet of which are the springs flowing into the midstream of the gulley. Due to the sloped relief, the water stream is fast. The surface of the survey site is covered with grass. At the base of the debris cone, where the survey site is located, between the motor road and the r. Snostskali, shallow ponds are observed.

In geotechnical terms, the survey site is located in Kazbegi-Lagodekhi zone of the Caucasus fold system.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Karkucha), seismicity of the survey site is intensity 9 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.43.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Stepantsminda meteorological station which is the nearest to the survey site.

On the survey site, one borehole (AP-96 BH-1) was drilled with 10 m depth and standard penetration tests (SPT) were conducted in the borehole. The borehole log is given in Annex-2. Within the site, electric sounding of soils was also conducted on 3 points, the results of which are given in Annex-7. For photos of the core taken from the borehole and of the survey site see Annex-8.

Based on the field and laboratory investigations data, within the surveyed depth (10 m) in the site structure there is alluvial, Quaternary soil described below as geotechnical STRATUM-1:

STRATUM-1 – Slightly moist, medium dense to very dense, very sandy, silty GRAVEL. The gravel is subrounded and subangular. 6 borehole samples were laboratory-analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.19.1 and 4.19.2 below.

Table-4.19.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Sand			Silt 0,04 - 0,002 mm	Clay < 0,002 mm
				Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm		
AP-88 BH-1	5.8-6.0	-	56.3	11.1	5.9	3.9	16.9	5.9

Borehole #	Sampling depth range, m	Fraction content in mass, %						
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Sand			Silt 0,04 - 0,002 mm	Clay < 0,002 mm
				Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm		
AP-88 BH-1	8.0-8.3	-	56.7	11.1	7.6	4.9	13.3	6.4
AP-88 BH-1	9.7-10.0	-	59.0	12.8	6.7	3.1	13.5	4.9

Table-4.19.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Moisture content of filler, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
				Upper limit,WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-96 BH-1	1.0-2.0	6.4	-	-	-	-	-	2.46	-	1.48
AP-96 BH-1	2.0-3.5	8.9	-	-	-	-	-	2.40	-	1.53
AP-96 BH-1	4.0-5.5	7.5	-	-	-	-	-	2.46	-	1.48
AP-96 BH-1	5.8-6.0	10.6	11.2	32.5	21.1	11.4	-0.87	2.36	-	1.38
AP-96 BH-1	8.0-8.3	11.4	12.3	37.0	20.5	16.5	-0.50	2.43	-	1.41
AP-96 BH-1	9.7-10.0	7.9	9.6	33.8	20.5	13.3	-0.82	2.56	-	1.52

Based on Standard Penetration Test (SPT) data, number of N impacts varies from 23 to >50, according to which the stratum is dense to very dense.

Values for internal friction angle and cohesion, as well as for deformation modulus of the stratum were calculated using appropriate method (method of DALNIIS GOSSTROY of the USSR). Calculations were made based on physical properties values (see Annex 5) and for consolidated soil are as follows:

- Internal friction angle $\varphi=32.6^0$;
- Cohesion C=30.5 kPa
- Deformation modulus E=33.49 MPa;

Based on the SNIP 2.02.01-83 - assumed design resistance R_0 = 0.40 Mpa.

Chemical composition of soils was studied on two borehole samples. In the chemical composition of the samples, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made on any cement. The soil is also practically neutral by hydrogen ion content (pH). Individual results of laboratory study are given in Annex-6.

In the survey borehole, ground water did not show during field works.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-7). Based on geophysical data, up to the sampled 15 m, specific electric resistivity of soils varies from 443 to 804 ohm m, according to which corrosive effect of soils is low.

In geodynamic terms, it is noteworthy that the survey site is located on the debris cone, in the lower part of the deep erosion gulley existing on the left slope of the river Snostskali valley, and according to the local population's observations, there have been snow avalanches on the slope, therefore, there is a hazard of snow avalanch on the project site.

Allowable temporary grade for STRATUM-1, according to SNIP III-B1-71 is as follows:

- up to 1.5 m. depth 1:0.5.
- from 1.5 m to 3.0 m. depth 1:1.

4.20 CONSTRUCTION SITE - AP-100

The construction site of Tower AP-100 of the Project Ksani-Stepantsminda 500 KW transmission line is located in the flood-plain of the river Snostskali, on the left bank, at approximately 100-120 m distance from the river bed. The relief of the survey site is plain, slightly tilted north-westward (dip azimuth 320^0-330^0); angle of gradient of relief is 2^0-3^0. The banks of the r. Snostskali bed are reinforced with anti-erosion concrete blocks and a berm of 2.5-3 m height goes along the river. The surface of the survey site is covered with grasses.

In geotechnical terms, the survey site is located in Kazbegi-Lagodekhi zone of the Caucasus fold system.

Based on the construction norm currently effective in Georgia - Antiseismic Construction (PN 01.01-09, point Achkhoti), seismicity of the survey site is intensity 9 by MSK64 scale. Nonmetric coefficient of seismicity is A=0.43.

Climatic conditions of the site are described in Section 3.1 of Geotechnical Report, based on the data from Stepantsminda meteorological station which is the nearest to the survey site.

On the survey site, one borehole (AP-100 BH-1) was drilled with 10 m depth and standard penetration tests (SPT) were conducted in the borehole. The borehole log is given in Annex-2. Within the site, electric sounding of soils was also conducted on 3 points, the results of which are given in Annex-7. For photos of the core taken from the borehole and of the survey site see Annex-8.

Based on the field and laboratory investigations data, within the surveyed depth (10 m) in the site structure there is alluvial, Quaternary soil described below as geotechnical STRATUM-1:

STRATUM-1 – (Saturated from 2.5 m), very dense, sandy, silty GRAVEL with cobbles inclusions. The gravel is subrounded. 6 borehole samples were laboratory-analyzed. Laboratory testing data for the samples are given in Annex-3 and Annex-4, as well as in Tables 4.20.1 and 4.20.2 below.

Table-4.20.1 Stratum-1 particle-size distribution

Borehole #	Sampling depth range, m	Fraction content in mass, %						
		Cobbles 200-63,0 mm	Gravel 63,0-2,0 mm	Sand			Silt 0,04 - 0,002 mm	Clay < 0,002 mm
				Coarse 1,18-0,600 mm	Medium-grained 0,425-0,212 mm	Fine 0,150-0,063 mm		
AP-100 BH-1	0.5-1.5	12.1	58.7	6.2	4.6	1.9	6.4	
AP-100 BH-1	4.0-5.0	6.2	56.4	9.1	4.5	1.4	5.8	
AP-100 BH-1	8.0-9.0	16.8	58.2	11.9	6.7	1.2	5.2	

Table-4.20.2 Stratum-1 physical properties parameter values

Borehole #	Sampling depth range, m	Natural moisture content, W%	Moisture content of filler, W%	Plasticity			Consistency index, I_L	Density, g/cm^3		
				Upper limit, WL%	Lower limit, Wp%	Plasticity number, Ip		Mineral parts, ρ_s	Natural, ρ	Bulk density, ρ
AP-100 BH-1	0.5-1.5	3.2	4.0	24.8	17.9	6.9	-2.01	2.70	-	1.64
AP-100 BH-1	2.0-3.5	4.5	-	-	-	-	-	2.68	-	1.63
AP-100 BH-1	4.0-5.0	3.6	4.3	24.2	17.5	6.7	-1.97	2.65	-	1.66
AP-100 BH-1	5.2-6.0	4.6	-	-	-	-	-	2.63	-	1.60
AP-100 BH-1	7.0-8.0	4.4	-	-	-	-	-	2.61	-	1.58
AP-100 BH-1	8.0-9.0	4.1	8.7	23.2	19.6	3.6	-3.03	2.60	-	1.68

Based on Standard Penetration Test (SPT) data, number of N impacts is >50, according to which the stratum is very dense.

Values for internal friction angle and cohesion, as well as for deformation modulus of the stratum were calculated using appropriate method (method of DALNIIS GOSSTROY of the USSR). Calculations were made based on physical properties values (see Annex 5) and for consolidated soil are as follows:

- Internal friction angle $\varphi=36.4^0$;
- Cohesion C=16.9 kPa;
- Deformation modulus E=49.32 Mpa.

Based on the SNIP 2.02.01-83 - assumed design resistance R_0 = 0.45 Mpa.

Chemical composition of soils was studied on two borehole samples. In the chemical composition of the samples, there were no sulphate and chloride components found in terms of aggressiveness against reinforced concretes, therefore, the soil is not aggressive against any type of concrete made on any cement. The soil is also practically neutral by hydrogen ion content (pH). Individual results of laboratory study are given in Annex-6.

In the survey borehole, standing level of ground water is 2.5 m.

Based on the data of chemical analysis of water, 1 liter of water contains 148.93 m.l chloride (Cl); sulphate (SO_4) did not reveal in water; according to which water is slightly aggressive against concrete reinforcement in case of periodical wetting and it is medium aggressive against carbon steel. Water pH=6. 88.

On the survey site, as per Customer-issued assignment, three vertical electric sounding tests were conducted (see Annex-7). Based on geophysical data, up to the sampled 15 m, specific electric resistivity of soils varies from 291 to 747 ohm m, according to which corrosive effect of soils is low.

Within the survey site and its neighbourhood, currently no hazardous geodynamic processes are observed. In case of flood, the area may become inundated.

Allowable temporary grade for STRATUM-1, according to SNIP III-B1-71 is as follows:

- up to 1.5 m. depth 1:0.5
- from 1.5 m to 3.0 m. depth 1:1

4.21 Characteristic data of soils physica-mechanical properties and Explanation of Essence of Design Resistivity (R_0)

Characteristic data of soils physica-mechanical properties

Tower #	Layer #	Depth,m	Density kN/m^3	Designed Resistance kN/m2	Strength in uniaxial compression kN/m2	Angle of Internal friction, ^{0}
AP-01	1	0.0-10.0	19.5	400	–	34.1
AP-03	1	0.0-10.0	20	400	–	34.1
AP-07	1	0.0-10.0	19.2	280	280	18.6
AP-12	1	0.0-1.9	17.4	280	–	19
	2	1.9-10.0	20	450	–	32.1
AP-15	1	0.0-3.8	18.1	270	400	17.4
	2	3.8-10.0	20	450	–	33.2
AP-18	1	0.0-1.0	20	450	–	19
	2	1.0-4.6	17.5	300	–	34.9
	3	4.6-10.0	20	450	–	18.6
AP-24	1	0.0-4.5	18.5	300	300	17.4
	2	4.5-10.0	20	300	320	32.9
AP-28	1	0.0-10.0	19.1	400	–	23
AP-33	1	0.0-10.0	18.8	300	360	19.5
AP-34	1	0.0-2.0	19.5	400	–	32.2
	2	2.0-10.0	25.7	–	7000	28
AP-39	1	0.0-1.2	20	400	–	35.4
	2	1.2-10.0	25.8	–	17000	28
AP-55	1	0.0-2.3	19.1	250	–	18
AP-81	1	0.0-10.0	20	400	–	34.1
AP-84	1	0.0-10.0	19.5	400	–	33.4
AP-88	1	0.0-10.0	20	400	–	33.5
AP-89	1	0.0-10.0	19.5	400	–	33.5
AP-91	1	0.0-10.0	19.5	400	–	32.4
AP-93	1	0.0-10.0	20	400	–	35.5
AP-96	1	0.0-10.0	19.5	400	–	32.6
AP-100	1	0.0-10.0	20	400	–	36.4

Explanation of Essence of Design Resistivity (R_0)

Normative Base for Calculation of Safe Bearing Capacities

Safe bearing capacities for foundations are determined from design soil resistivity values provided in Construction norms and regulations (SNiP – 2.02.01-83). Below is given the extract from SNiP - 2.02.01-83.

Design Soil Resistivity Values

1. Design soil resistivity values of base R_o provided in Tables 1-5 are intended for preliminary determination of foundation sizes. The range of application of R_0 and R'_0 values for the final determination of foundation sizes is indicated in Section 2.42 for Table 4, Section 8.4 for Table 5 and Section 11.5 for Table 6.
2. For soils with intermediate values e and I_L (Tables 1-3), p_d and S_r (Table 4), S_r (Table 5), as well as for foundations with intermediate values λ (Table 6), R_0 and R'_0 values are determined based on interpolation.
3. R_0 values (Table 1-5) refer to foundations with width $b_0 = 1$ m and foundation depth $d_0 = 2$ m.

When using R_o values for the final determination of foundation sizes (Items 2.42, 3.10 and 8.4), design soil resistivity for base R, kPa (kgf/cm^2) is determined by the following equation:

When d=2 m (200 cm)

$$R = R_0[1 + k_1(b - b_0)/b_0] \times (d + d_0)/2d_0 ; \qquad (1)$$

When d > 2 m (200 cm)

$$R = R_0[1 + k_1(b - b_0)/b_0] + k_2 \gamma'_{II} (d - d_0), \qquad (2)$$

Where, b and d=width and depth of design foundation, m (cm),

γ'_{II} = design value of specific gravity of soil lying over the base foundation, kH/m^3 (kgf/cm^3)

k_1 = co-efficient of k1=0,125 is taken for bases arranged of coarse and sandy grounds, except sandy silt, and k1=0,05 for bases constructed of sandy silt, clay sands, clay loams and clays

k_2 = co-efficient of k_2=0,25 is taken for bases arranged of coarse and sandy grounds, and k_2=0,15 for clay sands and clay loams k_2=0,2 and clays.

Note: For structures with a basement 20m in width, B=20 m and depth $d_b > 2$ м, the depth of external and internal foundations is calculated as: d=d_1 + 2m (where, d_1 is effective depth of foundation computed from the expression (8) of the Standards).

When B>20m, d=d_1 is taken.