

“Monoliti” Ltd

Project for development nearby Mirza Shafi Street in Tbilisi city

Engineering-geological opinion



Tbilisi

2009

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Director

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Introduction

"Apolo G.S." Ltd, based on order, group of geologists, invited by Monoliti"Ltd, in Mtatsminda-Krtsanisi administrative district, in Abanotubani, nearby Mirza Shafi street, conducted engineering-geological research works in order to establish conditions for erection of multifunctional buildings.

Research district includes last section of Mirza Shafi street up to former administrative building of Botanic Garden, old settlement located to the south of the street and the nearby territory to the direction of Baazov street. It is completely free from building-constructions, where now there are land works in process and the original relief is completely changed.

According to the task, on the study territory there must be erected 25 story multifunctional buildings, with one underground floor. The buildings on the plans will be of straight angel shape, foundations probably will be point or tape form. Class of the buildings according to the responsibility II design stage - design.

Before commence of works, they have searched for archive materials from "Saqgeologia" for the geological studies conducted in the study district nearby territory, conducted at different times, namely at: Mirza Sahfi street N16 and Baazov street N 19.

In order to define conditions for erection of design buildings, we conducted the works of the following type and volume: for the purpose of engineering-geological assessment there was conducted recognition destinations. Because of wide spread of rock soils exposed on the territory, and of their good quality, there was defined elements of slope laying, according to the profiles, advance agreed with the project main constructor. To define lithological cut, 5 wells are drilled with total depth of 57.2 lm. Drilling was made using drilling equipment URB-2A-2 , in dry condition, using mechanical column method, in shorten routs, with drilling diameters 146-108 mm. In parallel of drilling, soils had been inspected: from exposed areas and wells they took 8 samples of soil of undamaged structure and 20 samples of rocky and semi-rocky layer. Studies of loamy and soil was conducted in water and soil laboratory of engineering geology division of "Tbilsaqproeqti". And studies for rocky layers were conducted by LEPL G. Tsulukidze Mining Institute, Division of study of layer features and current physical processes.

Field works were conducted by topographic plans with scale 1:500, made in June 2007 by company "Kirkitaдзе and Company" JSC. During the period of field works, treatment of soils was still in process on the study territory and because of this profiles built according to the topographic plans has been partially changed and the geological cuts made by us needs correction at the draft design stage.

Based on field works and laboratory studies this engineering-geological opinion was made, using the above mentioned archive materials. Studies are made and this opinion is drawn

up in Georgia according to the normative documents in force (construction rules and regulations) – ID N and year – 1.02.07-87 (engineering studies for construction), ID N and year – 2.02..01 – 83 (bases of building-constructions), ID N and year – II-7-81 (construction in seismic regions) and state standard 25100-82 (soils).

Engineering-geological studies were conducted in December 2008 and January 2009.

1. General part

1.1. Geomorphology, geological composition and hydrological conditions

Geomorphology. Studied territory in view point of orography is located on the end of Tabori (Seydabad) mountain range, its north slope. Range is of sub-longitudinal direction, it starts from the range Sakaraulo and ends on the territory of Tbilisi city in the right side of riv. Mtkvari. Its ridge portion is flat and slightly bended to the east. North slope of the range is lowered to riv. Tsavkisi-tskali, and south one to riv. Dukniskhevi.

The section for construction is located on the north slope of Tabori range, in its lower part, which first slopes, after goes down like as stairs to the direction of Abanotubani to the bed of riv. Tsavkisi Tskali. South and east parts of the section are featured with sharply separated rocky, almost vertical walls of different height, and to the north there slopes down to Mirza Shafi street. In this section total sloping of the relief varies from 20 up to 45°, if we not consider 3-4 terrace steps of tectonic relief, resulted from cut of rocky soils.

Absolute benchmark of the highest point of the section is of 463.8 meters and is located at the south border, and the lowest one is of 4330.0 m., is at the east border.

Geological composition. In view point of its tectonic feature, the territory is located on the north wing of Mamadaviti anticline, mostly in arc type part, which is erected using middle Eocene age so called “Dabakhana layer” rocks. This layer in meaning of lithology is presented of thick and of minor sickness of layer type grayish, greenish tuff genic, coarse grain sand-stones, yellowish, bluish marls and dark, mostly black mudstones. In the layers sand-stones dominate and mudstone are in submitted condition. In certain sets there are calcite lodes and zeolitized sections. In the areas where these lithology variations are presented as thin layers, they replace each other. Upper part of the cut on the south periphery of the section is presented by so called “Abikhi layer” boulder breccia, main rock of which are tuff genic sand-stones and marls, where sand-stones dominate. If there is seen some regularity in distribution in the vertical cut, on the contrary in the horizontal cut this

regularity is abolished, where these rocks are presented as thin layer sets.

Sloped angles of rocks are quite low and are near to horizontal. Elements of rock lying is as follows: tilt azimuth is of north-east 20° , and sloping angle is up to $8-12^{\circ}$. This lithology variations are covered with Quaternary Age dealluvial-proalluvial loamy layers, large insertions of shingle and tectonic grounds. Total capacity of covering rocks is of 3.0 up to 15.0m. Maximum of capacity I – I per cut, is fixed in well at: N1 Mirza Shafi street.

Hydrological conditions. According to the hydrogeological region distribution of the territory of Georgia, section is located within Tbilisi fissure and fissure-castral water pressure system, where there are developed waters of both not deep and not deep circulation. On the studied territory, neither in the wells drilled by us nor artificial and natural exposures of rocks, there is not water found in the form of springs or leakages. According to the archive materials, underground waters are in depth and in this case they are not preventing factor for construction.

2. Special part

By the recognition routs at the section and its nearby territory we have not revealed any traces of occurrence and development of dangerous geological processes, except stone falling on a small area. The section of stable and in a good condition for construction and according to the complication of engineering-geological conditions, in accordance with ID and year 1.02.07-87 Annex 10, is belongs to the complication category II (minor).

Based of field and laboratory studies, there are 5 layers on the section, meaning engineering-geologic element (SGE), which are described below.

2.1. Physical and mechanical features of the grounds

SGE-1 bulk ground tQ_{IV} – presented in 2 variety: la old bulk, which is distributed mainly along Mirza Shafi street and lb new bulk, which is formed as a result of treatment of rocky ground. ka – formed by loamy mass, solid consistency, from road metal, household and construction garbage up to 25-30%. It is opened in all the wells. Layer not contains water. Layer capacity is up to 3.0 – 5.0 m. Layer self-resistance process is completed because of its age. Layer is separated with 5 samples of not damaged structure, counting values of which are given in the Table 1.

Table 1

N	Name of physical and chemical features	Index	Measurement unit	Bulk ground
1	Density	ρ	g/cm ³	1.75
2	Dry ground density	ρ_k	g/cm ³	1.47
3	Ground particles density	ρ_s	g/cm ³	2.69
4	Natural moisture	W	%	19
5	Porosity	n	%	45
6	Porosity coefficient	e	One part	0.818
7	Humidity at liquefaction limit	W _L	One part	0.28
8	Humidity at plasticity limit	W _p	One part	0.16
9	Plasticity number	L _p	One part	0.12
10	Liquefaction limit	I _L	One part	0.17
11	Humidity quality	S _r	One part	0.59
12	Calculation impedance	R ₀	Kgp/cm ²	1.8

As there is a large number of insertions in the layer, solidity and deformation index is taken from ID and year 2.02.01.

Tested by 3 samples of ground of not damaged structure. In the Table 2 there is given index of physical and mechanical features and in aggregate table - results of laboratory studies for the layers.

Table 2

N	Name of physical and chemical features	Index	Measurement unit	Bulk ground
1	Density	ρ	g/cm ³	1.87
2	Dry ground density	ρ_k	g/cm ³	1.61
3	Ground particles density	ρ_s	g/cm ³	2.7
4	Natural moisture	W	%	16
5	Porosity	n	%	40
6	Porosity rate	e	One part	0.677
7	Humidity at liquefaction limit	W _L	One part	0.34
8	Humidity at plasticity limit	W _p	One part	0.22
9	Plasticity number	L _p	One part	0.12
10	Liquefaction limit	I _L	One part	<0
11	Humidity quality	S _r	One part	0.64
12	Calculation impedance	R ₀	Kgp/cm ²	2.2

Because of existence of pieced material, their laboratory testing for density and deformation features may not be done, so these features are taken from tables of ID and

year 2.02.01 – 83, which respectively are: Specific binding $C = 0.31 \text{ kgp/cm}^2$, Internal friction angle - $\Phi = 24^\circ$, deformation module $E = 170 \text{ kgp/cm}^2$. Layer not contains water. Layer capacity is from 2.5 up to 10.0 meters.

SGE – alternation of 3 thin layers of sand-stone, marls and mudstones – P_2^2 . Distributed in the north part of the territory. Presented in grayish sand-stones, yellowish, bluish marls and dark, mostly black marls. Highly weathered rocks, changed and belong to weather shingle zone, which is featured with both open and closed fissure. Weather fissures are of different sizes and directions. Mainly against stratification and perpendicularly. Width of fissures is mostly up to 1mm. In seldom cases – up to 5mm. Rocks by their fissure quality belong to rocks of minor fissured quality ($K_{\text{gap}} = 2 - 5\%$). They mostly are filled with weather products. Open fissures we meet near the surface. These SGE grounds in artificial exposures at 2-3m depth are presented in the form of shingle, density of which $\rho = 1.93 \text{ t/m}^3$ is defined in field conditions, other details are taken from Tables of ID and Y 2.02.01 – 83, which respectively are: Specific binding $C = 0.03 \text{ kgp/cm}^2$, Internal friction angle - $\Phi = 40^\circ$, deformation module $E = 300 \text{ kgp/cm}^2$, calculation impedance $R_o = 3.5 \text{ kgp/cm}^2$. Under 1-2m depth they become more reunited and massive. To study their mechanical and physical features, from exposures and wells we took 5 samples of marls, as the weakest in SGE3. Grounds were tested using spherical indicators, according to the requirements of state standard 24941-81 and 5182-84. Density, limit of solidity was studied in one axle compression in dry air and water saturated condition. Softening rate was calculated. In the Table 3 there is given results of laboratory studies. Results of rocky ground tests are given in Annexes.

Table 3

N	Place of exposure taking	Density $\rho_{\text{g/cm}^3}$	Solidity limit On one axle compression, R_c mpa		Softening coefficient K_{sof}
			Dry	Water saturated	
1	Exposure N1	1.97	7.2	3.1	0.43
2	Exposure N2	1.98	7.9	3.4	0.43
3	Exposure N22	1.96	6.8	2.7	0.4
4	Well NI 18.0-18.1	1.97	7.2	3.6	0.5
5	Well N2 9.8-10.0	1.97	6.5	2.5	0.38
	Average	1.97	7.8	3.1	<0.75

As we see from the Table, layer average density is 1.97 g/cm^3 , average value of solidity limit on one axle compression in water saturation condition equals to $R_c 3.1 \text{ mpa}$, which according to the Table 1 of state standard 25100-82 belongs to diversity of lowered solidity ground. Ground is softened, average value of layer softening coefficient is less $K_{sof} < 0.75$. To define calculation value of layer there is conducted statistic treatment of solidity limit rate (in water saturation condition), obtained as a result of laboratory tests, according to which marl solidity limit calculation value Re^1 is 2.7 mpa – meaning 27 kgp/cm^2 . Results of statistic processing is given in the annexes. Except this, marl solidity features have been defined: specific binding C , equaled to 1.5 mpa and internal friction angle $\varphi 23^\circ$. Layer's open power is 4.5 meters, layer no contains water.

SGE – 4 weathered sand-stones and mudstones – P_2^2 – are mainly presented by greenish-grayish tuff genic, average and thick layer middle layers. Rocks are weathered and belong to weathered fissure zone, which is featured by both open and closed fissures. Weathered fissures are of different sizes and directions, towards to the stratification and perpendicular. Width of the fissure in most cases is up to 2-5mm, rarely up to 10-20mm. Vertical fissures of partition is to be mentioned, width of which is sometimes more than 30mm. Rocks according to the fissure quality belong to strong fissure rocks. ($K_{fissure} = 5 - 10\%$). Mostly they are filled with weathered products. Open fissures are near the surface. As in this SGE there dominate thick and minor layer sand-stones and mudstones are presented in the form of thin middle layer and it was impossible to take samples of standard size, it contained only samples of sand-stones. 5 samples of rocky ground were tested using spherical indicators according to the requirements of state standard 24941-81 and 5182-84. Density, solidity limit for one axle compression was defined in dry air and water saturation condition. Coefficient of softening was defined. In the Table 4 there is given normal ranges of physical and mechanical features of the rocks. Test results for rocky layers are stated in the annexes.

Table 4

N	Place of sample taking	Density $\rho \text{ g/cm}^3$	Solidity limit On one axle compression, R_c mpa		Softening coefficient K_{sof}
			Dry	Water saturated	
1	Exposure N4	2.52	119.3	68.0	0.57
2	Exposure N5	2.52	127.8	83.8	0.66
3	Exposure N6	2.53	154.1	97.7	0.63
4	Exposure N7	2.5	180	143.1	0.8
5	Exposure N8	2.51	171.6	108.7	0.63
	Average	2.52	150.6	100.3	<0.75

As we see from the Tables, average density of layer is 2.52g/cm^3 , average value of solidity limit for one axle compression in water saturation condition equal to $R_c 100.3\text{ mpa}$, which according to the state standard 25100-82 Table 1 belongs to diversity of solid grounds. Ground is declined to be softened, average value of ground softening coefficient is less than $K_{sof} < 0,75$. To define the layer calculation value statistic treatment of solidity limit value obtained as a result of laboratory tests, is made (in water saturation conditions), according to which calculation value of sand-stone solidity limit R_c^1 is 70.4 mpa , same 704kgp/cm^2 . Results of statistic treatment are given in the annexes. Except the above mentioned, features of sand-stone solidity were defined: specific binding C , equal to 13.7 mpa and insides friction angle φ equals to 30° .

Layer visible power 5.0-10.0 m. Layer not contains water.

SGE – 5 weathered boulder breccias and conglomerates – P_2^2 – distributed on the south and east territory of the section. These rocks built rocky-sloping vertical walls. Base ground of boulders and large pieces of rocks are mainly tuff generic sand-stones, merls and mudstones are in subordinated condition. Rocks are weathered and belong to weathered fissure zone, which is featured both open and closed fissures. Weathered fissures are of different sizes and directions, both in perpendicular and in a chaotic manner. Width of the fissures are mostly up to 2-5 mm, in some cases up to 10-20mm. Rocks by their fissure quality belong to a rocks of a strong fissure quality. ($K_{fissure}=5 - 10\%$). Open fissures are in vertical direction and chaotic ones are filled in with weathered products and near the surface. For this SGE 5 samples were tested using the same method as SGE-3 and SGE-4 grounds. In the Table 5 is indicated normal limits of physical and chemical features. In the Annexes you find results of tests of rocky layers.

Table 5

N	Place of sample taking	Density $\rho\text{g/cm}^3$	Solidity limit On one axle compression, R_c mpa		Softening coefficient K_{sof}
			Dry	Water saturated	
1	Exposure N9	2.49	29.8	17.2	0.57
2	Exposure N10	2.49	30.8	19.6	0.64
3	Exposure N11	2.49	22.0	10.8	0.63
4	Exposure N12	2.49	28.2	12.2	0.49
5	Exposure N13	2.49	21.4	10.6	0.495
	Average	2.49	26.4	14.1	<0.75

As we see from the Tables average density of the layer is 2.49g/cm^3 , average value of solidity limit for one axle compression in water saturation condition equal to $R_c 14.1\text{ mpa}$, which

according to the state standard 25100-82 Table 1 belongs to diversity of solid grounds. Ground is declined to be softened, average value of ground softening coefficient is less than $K_{sof} < 0,75$. To define the layer calculation value statistic treatment of solidity limit value obtained as a result of laboratory tests, is made (in water saturation conditions), according to which calculation value of sand-stone solidity limit R_c^1 is 10.5 mpa, same 105kgp/cm². Results of statistic treatment are given in the annexes. Except the above mentioned, features of sand-stone solidity were defined: specific binding C, equal to 13.7 mpa and insider friction angle φ equals to 30°.

Layer visible power 7.0-12.0 m. Layer not contains water.

2.3 Modern geodynamic processes

On the study territory from modern geodynamic processes there is developed stone falling, the preceding process of which is physical weathering of rocky layers – disintegration is widely presented in this region.

Natural agents (insulation, freeze, wind and other) permanently impact on layer type sand-stones and mudstones. In the layers initially there first appear permanently increasing fissures in the layers and perpendicularly, which finish in fission of rock surface layer separate pieces. This process is going especially fast in thin layer sand-stones and faster in mudstones. Further they from disintegrated zones, especially along vertical fall edges, continuously, from slopes are falling down by impact of gravity forces in separate pieces or some small sized masses are falling down (up to 5.0-10. kg). Falling down material is collected at the bottom of the vertical slope, on the small areas, in the yards of residential houses located nearby or on the roofs of the houses, attached to the slope, which are time to time cleaned from fallen pieces.

3. Conclusions and recommendations

1. In Tbilisi city, in Mtatsminda-Krtsanisi Administrative district, Abanotubani, nearby Mirza Shafi street, the plot of land for the multi functional buildings is stable and is in “satisfactory” engineering-geological condition.
 2. The territory is built using tuff genic, coarse grain sand-stones, marls and mudstones of middle Eocene (P_2^2) age, so called “Dabakhana layer”, as well using “Abikhi layer” boulder breccias and conglomerates.
 3. No ground waters on the section.
- 5 engineering-geological elements are separated on the section (SGE). SGE 1 – bulk ground, SGE 2 – loamy, SGE 3 – thin layer sand-stones, marls and mudstones, SGE 4 – weathered tuff genic sand-stones and mudstones and SGE 5 – weathered boulder breccias and conglomerates,

calculation value of which is given in the Table 6.

SGE-S N	Density □/cm3	Special binding C kgp/cm2	Insider friction angle, □degree	Deformation module E, kgp/cm2	Calculation impedance Ro kgp/cm2	Solidity limit water saturation Rc kgp/cm2	Pastel coefficient	Treatment category according to difficulty ID and Y. IV-5-82
1a	1,75	0,18	19	120	1,8	-	1	II
1b	2,1	-	-	-	-	-	-	III
2	1,87	0,31	24	170	2,2	-	2	III
3	1,92	0,03	40	300	3,5	27	5	IV
	1,97	15	23	21000	-		40	V
4	2,52	137	30	53200	-	704	80	VI
5	2,49	20	27	41400	-	141	80	VI

Note: SGE-3, SGE-4 and SGE-5 deformation module is taken from archive materials.

5. Foundation of multi functional buildings is possible to be implemented on SGE -3, SGE -4 and SGE -5, as SGE – 1 and SGE -2 is of not equal distribution and capacity.

6. Any not deep foundation may be used as foundation.

7. As the sloping of relief on the section is more than 15⁰, and according to the section 1.5 of ID and Y II-7-81, we need additional measures, to strengthen the base and building constructions.

8. As the design buildings will be located closed nearby weathered rocks of vertical slope, it is necessary to protect them from stone falling and small sized failures, and due to this it will be necessary to design measures against failure (protection square or wall, tiling wall, to protect against weathering of vertical slope erection rocks and other)

8. Maximum permissible sloping of cavernous and trenches is accepted to be according to the ID and Y 3.02.01-87, p.p. 3.11, 3.12, 3.15 and ID and Y III-4-80, article 9.

9. According to the general corrected scheme of seismic region design of Georgia, Tbilisi city belongs to 8 magnitude seismic zone, so seismic degree of the area is deemed to be 8 magnitude.

Opinion is made by: Z. Chantladze

Signature

M. Babilodze

Signature

Annexes

Technical Task

to conduct engineering geologic studies

1. Name of facility – Development project in Tbilisi city, nearby Mirza Shafi street
2. Customer – “Apolo G.S.” Ltd
3. Project stage – project
4. Description of design buildings
From in the plan - straight angle
Floors – 2 – 5
Basement – basement I floor
Sizes -
7. Foundation presumable type – point type or tape type
8. Building class according to responsibility – II

Annex: District topological plan Scale 1:500

Main Constructor of the Project: Signature

Results of statistic treatment

SGE-3

N	R_c^1 (mpa)	$R_e^0 - R_e^1$ (mpa)	$R_e^0 - R_e^1$ (mpa)
1	3.1	-	-
2	3.4	-0.3	0.09
3	2.7	0.4	0.16
4	3.6	-0.5	0.25
□	15.3		0.86

Statistic value $R_c^g = 15.3 : 3.1$ mpa. Check rude mistake $(R_c^g - R_c^i) < v \times \sigma_{desc} = \sqrt{\frac{1}{n} \sum (R_c^g - R_c^i)^2} = 0.41$,
when $n=5$ $v = 2.07$, than $v \times \sigma_{desc} = 0.85$. In this case $0.6 < 0.85$. In this Table there is condition $(R_c^g - R_c^i)^1 < v \times$

σ_{desc} so all values of R_c^1 are valid for calculation. Average square decline $\sigma = \sqrt{\frac{1}{n-1} \sum (R_c^g - R_c^i)^2} = 0.46 \text{ mpa}$.

Variation coefficient $V = \frac{\sigma}{R_c^g} = 0.33$, i.e. $V=14.8\%$. Calculate R_c value for first limit condition: $a=0.95$ if $n=5$

than $ta=2.01$ precision value $P = \frac{ta \times V}{\sqrt{n}} = 0.13$ ground safety coefficient $K_g = \frac{1}{1 \pm P} = 1.15$ calculation value

will be $R_c^1 = \frac{R_c^g}{K_g} = 2.7 \text{ mPa}$ i.e. 27 kgp/cm^2 .

SGE-4

N	R_c^1 (mpa)	$R_e^0 - R_e^1$ (mpa)	$R_e^0 - R_e^1$ (mpa)
1	68.0	32.3	1043.3
2	83.8	16.5	272.3
3	97.7	2.6	6.8
4	143.1	-42.8	1832
5	108.7	-8.4	70.6
□	5011.3		4547

Statistic value $R_c^g = 501.3 : 3.5$ mpa. Check rude mistake $(R_c^g - R_c^i) < v \times \sigma_{desc} = \sqrt{\frac{1}{n} \sum (R_c^g - R_c^i)^2} = 30.15$,
when $n=5$ $v = 2.07$, than $v \times \sigma_{desc} = 62.4$. In this case $42.8 < 62.4$. In this Table there is condition $(R_c^g - R_c^i)^1 < v \times$
 σ_{desc} so all values of R_c^1 are valid for calculation. Average square decline. Variation coefficient

$\sigma = \sqrt{\frac{1}{n-1} \sum (R_c^g - R_c^i)^2} = 33.7 \text{ mpa}$

Variation coefficient $V = \frac{\sigma}{R_c^g} = 0.33$ i.e. $V=33\%$. Calculate R_c value for first limit condition: $a=0.95$ if $n=5$ than

$ta=2.01$ precision value $P = \frac{ta \times V}{\sqrt{n}} = 0.3$ ground safety coefficient $K_g = \frac{1}{1 \pm P} = 1.43$ calculation value will be

$$R_c^1 = \frac{R_c^u}{K_g} = 70.14 \text{ mPa} \quad \text{i.e. } 701.4 \text{ kgp/cm}^2.$$

SGE-5

N	R_c^1 (mpa)	$R_e^0 - R_e^1$ (mpa)	$R_e^0 - R_e^1$ (mpa)
1	17.2	-3.1	9.6
2	19.6	-5.5	30.3
3	10.8	3.3	10.9
4	12.2	1.9	3.6
5	10.6	3.5	12.3
□	70.4		66.7

Statistic value $R_c^g = 75.4 : 5 = 14.1 \text{ mpa}$. Check rude mistake $(R_c^g - R_c^i) < v \times \sigma_{desc} = \sqrt{\frac{1}{n} \sum (R_c^g - R_c^i)^2} = 3.65$

, when $n=5$ $v = 2.07$, than $v \times \sigma_{desc} = 7.6$. In this case $5.5 < 7.6$. In this Table there is condition $(R_c^g - R_c^i)^1 < v \times \sigma_{desc}$ so all values of R_c^1 are valid for calculation. Average square decline. Variation coefficient

$$\sigma = \sqrt{\frac{1}{n-1} \sum (R_c^g - R_c^i)^2} = 4.1 \text{ mpa}$$

Variation coefficient $V = \frac{\sigma}{R_c^g} = 0.29$ i.e. $V=0.29\%$. Calculate R_c value for first limit condition: $a=0.95$ if $n=5$ than

$ta=2.01$ precision value $P = \frac{ta \times V}{\sqrt{n}} = 0.26$ ground safety coefficient $K_g = \frac{1}{1 \pm P} = 1.35$ calculation value will be

$$R_c^1 = \frac{R_c^g}{K_g} = 10.5 \text{ mPa} \quad \text{i.e. } 105 \text{ kgp/cm}^2.$$

Aggregate table of physical and mechanical features of ground in natural conditions/water saturation condition

NN	Waste number	Sampling depth	Laboratory number	Density	Frame density	Particles density	Natural humidity	Porosity	Coefficient of porosity	Humidity			Consistency	Humidity quality	Insider friction angle	Special binding	Compaction coefficient 1-2 kg. cm2	Deformation module 1-2 kg cm2	Site closure module	Name of round
				p	Pd	Ps	W	n	e	At the flow limit	At the limit of plasticity									
				g/cm3	g/cm3	g/cm3	%	%	unit. Part	Wu	Wp	Ip								
										unit. Part	unit. Part	unit. Part								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	Well N 1	4.5- 4.7		1,77	1,49	2,69	19	45	0,805	0,3	0,18	0,12	0,08	0,63						Loamy
2	Well N 1	7.5-7.7		1,85	1,57	2,7	18	42	0,720	0,34	0,23	0,11	<0	0,68						Loamy
3	Well N 2	4.7-4.9		1,75	1,48	2,69	18	45	0,818	0,26	0,15	0,11	0,27	0,59						Loamy
4	Well N 2	9.2-9.4		1,88	1,62	2,7	16	40	0,667	0,32	0,20	0,12	<0	0,65						Loamy
5	Well N 3	2.9-3.0		1,73	1,48	2,69	17	45	0,818	0,28	0,16	0,12	0,08	0,56						Loamy
6	Well N 4	2.5-2.7		1,74	1,47	2,69	18	45	0,830	0,29	0,15	0,14	0,21	0,58						Loamy
7	Well N 5	1.6-1.8		1,75	1,46	2,69	20	46	0,842	0,28	0,17	0,11	0,27	0,64						Loamy
8	Well N 5	2.9-3.1		1,87	1,63	2,7	15	40	0,656	0,36	0,22	0,14	<0	0,62						Loamy

Georgia, Ministry of Education and Science
LEPL G. Tsulukidze Mining Institute
Research Division for rock features and Physical processes in
massive

Approved by the Director of the Institute

Dr. N. Chikhradze

Signature

Seal

20 January, 2009

Results
of studies of physical and mechanical features of rocks of
construction site for the multi functional building under
construction
in Tbilisi city, nearby Mirza Shafi street

Head of works and division

Main Research Scientist

Dr. G. Baliashvili

Signature

Tbilisi 2009

- Work is performed based on the agreement signed with “Gengeo” Ltd
- In the first and the second tables there is stated sampling place, name of rock, its qualification by features and average values of tested features
- Tables 3-5 indicate values of studied features by samples
- Samples damaged in studies are kept in the laboratory up to 6 months.

Table 1. Average values

Sample N	Exposure N	Rock	Solidity, room temp. samples	Solidity, water saturation, samples, mpa	Coefficient of softening	Affiliation, mpa	Insider friction angle	Density, g/cm ³
1	1	Sand-stone blackish	150,6	100,3	0,67	13,7	30	2,52
2	2	Sand-stone, marl and mudstone layers alteration	7,1	3,1	0,44	1,5	23	1,97
3	3	Mudstone	62,9	34,3	0,55	3	30	2,45
4	4	Boulder breccia	26,4	14,1	0,53	2	27	2,49

Table 2. Classification

Sample N	Rock	By solidity (water saturation)	By density	By softening
1	Sand-stone blackish	Very solid	Very dense	Softing
2	Sand-stone, marl and mudstone layers alteration	Lowered solidity	Loose	Softing
3	Mudstone	Minor solidity	Dense	Softing
4	Boulder breccia	Lack of solidity	Dense	Softing

Table 3. Density

Sample N	Tested sample						
	N	Mass, g			Volume, cm3	Sample	Density, g/cm3
		In air	By paraffine		Paraffin		
			In air	In water			
1	1	81,10	85,42	48,52	4,80	32,10	2,53
	2	76,87	81,37	45,57	5,00	30,80	2,50
2	1	26,52	29,850	12,76	3,64	13,40	1,98
	2	20,74	24,25	9,82	3,90	10,53	1,97
3	1	35,97	39,62	20,94	4,06	14,62	2,46
	2	44,44	47,70	25,90	3,62	18,18	2,44
4	1	65,65	70,80		5,72	26,38	2,49
	2	73,75	77,65	43,67	4,33	29,65	2,49

Table 4. Cut parameters. Rock layers

Monolith N	Sample N	Length cm.	Width sm.	Height cm.	Area cm2	Testing angles, degree	Decomposition power kgp	Voltage, mpa		Insider friction angle, degree	Binding	Stability			
								Normal	Tangent						
1	1	3,92	3,80	4,04	15,16	30	3365	11,1	19,3	30	13,7	Water saturation			
	2	3,96	3,99	3,94	15,80	30	3635	11,5	20,0						
	3	3,96	3,85	4,02	15,25	45	6015	28,0	28,0						
	4	4,00	3,86	4,04	15,44	45	6960	32,0	32,0						
2	1	3,91	3,90	3,95	15,25	30	316	1,0	1,8	23	1,5		Water saturation		
	2	3,94	3,93	3,96	15,48	45	545	2,5	2,5						
3	1	4,72	4,00	4,25	18,88	30	1250	3,3	5,7	30	3,0			Water saturation	
	2	4,20	3,95	4,00	16,59	45	1625	7,0	7,0						
4	1 2 3 4	3,92	3,90	3,98	15,29	30	428	1,4	2,4	27	2,0				Water saturation
		3,96	3,92	4,00	15,52	30	495	1,6	2,8						
		3,97	3,97	4,05	15,76	45	932	4,2	4,2						
		3,99	3,96	4,12	15,80	45	845	3,8	3,8						

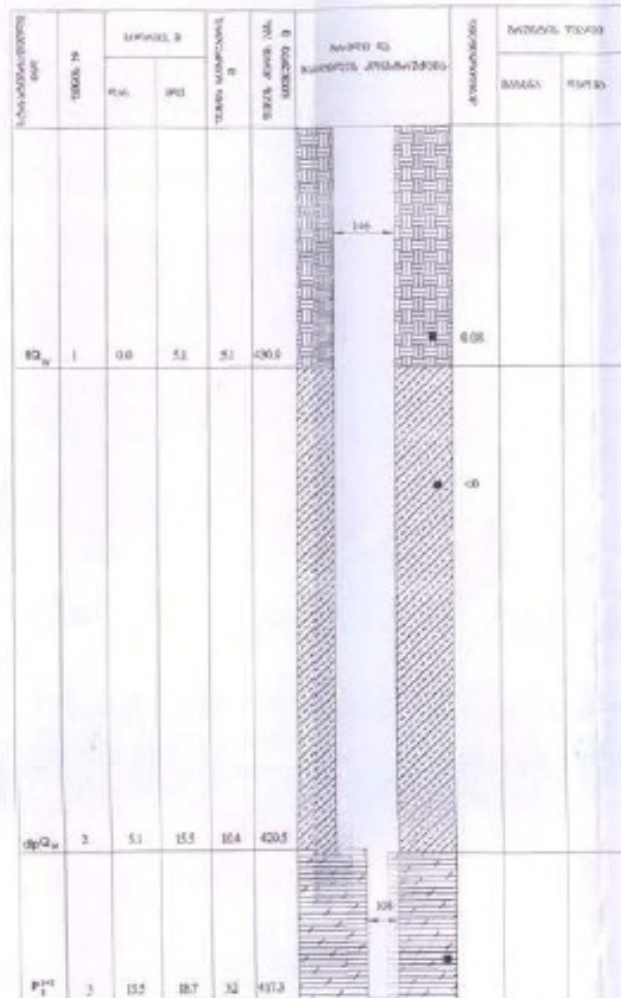
Table 5. Solidity, semi-straight shape samples

Sample N	Tested samples						
	N	Manometer number	Decomposition number	Area, sm2	Solidity, mpa		Condition at test time
					When stretching	When Compression	
1	1	85	663	6,0	6,63	119,3	Room temperature
	2	25	1250	12,5	7,10	127,8	
	3	23	1150	8,8	856	154,1	
	4	20	1000	6,0	10,0	180,0	
	5	20	1000	6,4	9,53	171,6	
	6	22	1100	9,2	7,95	143,1	Water saturation
	7	10	500	8,6	3,78	68,0	
	8	65	507	6,7	4,65	83,8	
	9	12	600	6,8	5,43	97,7	
	10	14	700	7,3	6,04	108,7	
2	1	7	35	5,0	0,40	7,2	Room temperature
	2	8	40	6,5	0,38	6,8	
	3	9,5	48	7,5	0,40	7,2	
	4	8	40	6,8	0,36	6,5	
	5	11	55	8,0	0,44	7,9	
	6	3,5	18	5,3	0,19	3,4	Water saturation \
	7	3,5	18	5,0	0,20	3,6	
	8	3	15	4,9	0,17	3,1	
	9	3	15	6,3	0,14	2,5	
	10	3	15	5,8	0,15	2,7	
3	1	4	200	4,8	2,35	42,4	Room temperature
	2	8	400	6,5	3,75	67,6	
	3	4	200	6,7	1,84	33,0	
	4	9	450	7,5	3,78	68,01	
	5	9	450	4,3	5,76	103,6	
	6	3	150	5,7	1,57	28,2	Water saturation
	7	6	300	6,0	3,00	54,0	
	8	5	250	10,5	1,73	31,1	
	9	3	150	6,5	1,41	25,3	
	10	4	200	6,7	1,84	33,0	
4	1	7	350	13,5	1,89	29,8	Room temperature
	2	7	350	12,8	1,94	30,8	
	3	3	150	6,0	1,50	22,0	
	4	4	200	6,8	1,81	28,2	
	5	4	200	9,0	1,47	21,4	
	6	3	150	6,7	1,38	19,6	Water saturation
	7	15	117	7,3	1,01	12,2	
	8	14	109	7,7	0,90	10,8	
	9	15	117	8,7	0,88	10,6	
	10	20	156	6,7	1,43	17,2	



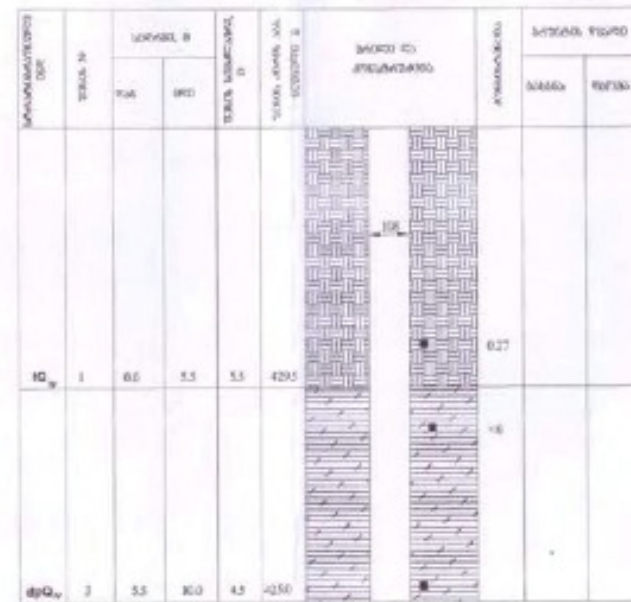
Well N1

430



Well N2

4350



Conventional signes

- | | | |
|---|---|---|
| 1 |  | Bulk ground |
| 2 |  | Loamy with boulder insertions |
| 3 |  | Thin layer sand-stones, marls and mudstones, alteration |

- Sampling place

[illegible]

Well N3

434.0

სტრატეგია	ტერმინი	სტრატეგია		სტრატეგია	სტრატეგია	სტრატეგია	სტრატეგია	სტრატეგია	
		სტრატეგია	სტრატეგია					სტრატეგია	სტრატეგია
1Q _N	1	0.0	3.0	3.0	434.0	108	0.08		
dpQ _N	2	3.0	10.0	7.0	424.0		0.33		

Well N5

439.0

სტრატეგია	ტერმინი	სტრატეგია		სტრატეგია	სტრატეგია	სტრატეგია	სტრატეგია	სტრატეგია	
		სტრატეგია	სტრატეგია					სტრატეგია	სტრატეგია

სტრატეგია	ტერმინი	სტრატეგია		სტრატეგია	სტრატეგია	სტრატეგია	სტრატეგია	სტრატეგია	
		სტრატეგია	სტრატეგია					სტრატეგია	სტრატეგია
1Q _N	1	0.0	3.0	3.0	439.0				
dpQ _N	3	3.0	9.0	6.0	429.0				

Well N1

[illegible]

Well N2

[illegible]

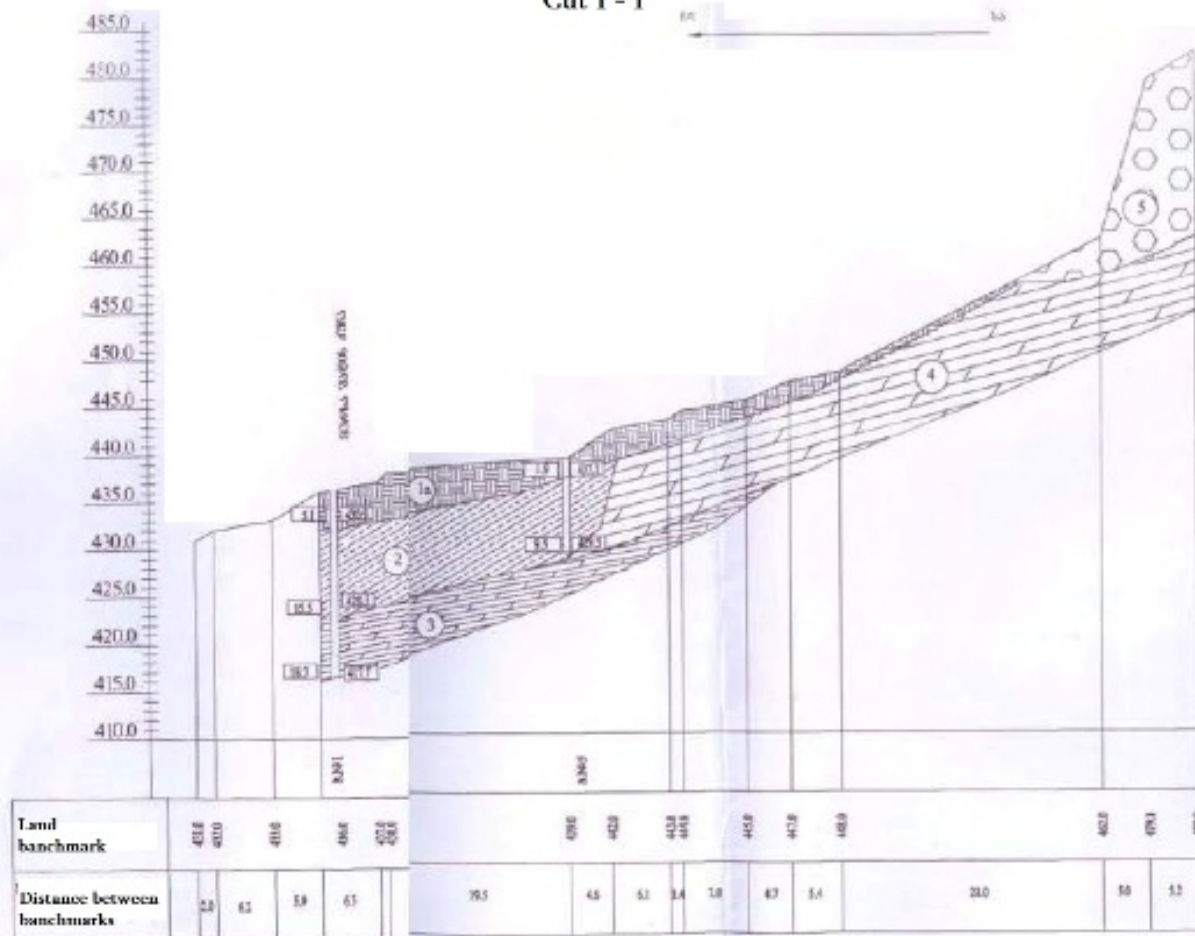
Conventional signs

- 1  Bulk ground
- 2  Loamy with boulder insertions
- 3  Thin layer sand-stones, marls and mudstones, alteration
- * Sampling place

U.S. "9/11/2001"		
ADDITIONAL WORK: 2001-2002		
ADDITIONAL WORK: 2003-2004		
ADDITIONAL WORK: 2005-2006		
ADDITIONAL WORK: 2007-2008		
ADDITIONAL WORK: 2009-2010		
ADDITIONAL WORK: 2011-2012		
ADDITIONAL WORK: 2013-2014		
ADDITIONAL WORK: 2015-2016		
ADDITIONAL WORK: 2017-2018		
ADDITIONAL WORK: 2019-2020		
ADDITIONAL WORK: 2021-2022		
ADDITIONAL WORK: 2023-2024		
ADDITIONAL WORK: 2025-2026		
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ADDITIONAL WORK: 2099-2100		
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ADDITIONAL WORK: 2165-2166		
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ADDITIONAL WORK: 2173-2174		
ADDITIONAL WORK: 2175-2176		
ADDITIONAL WORK: 2177-2178		
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ADDITIONAL WORK: 2195-2196		
ADDITIONAL WORK: 2197-2198		
ADDITIONAL WORK: 2199-2200		
ADDITIONAL WORK: 2201-2202		
ADDITIONAL WORK: 2203-2204		
ADDITIONAL WORK: 2205-2206		
ADDITIONAL WORK: 2207-2208		
ADDITIONAL WORK: 2209-2210		
ADDITIONAL WORK: 2211-2212		
ADDITIONAL WORK: 2213-2214		

Cut I - I

Cut I - I



Land benchmark	431.0 431.0	431.0	436.0	437.0 436.0
Distance between benchmarks	5.0	8.1	5.9	6.7

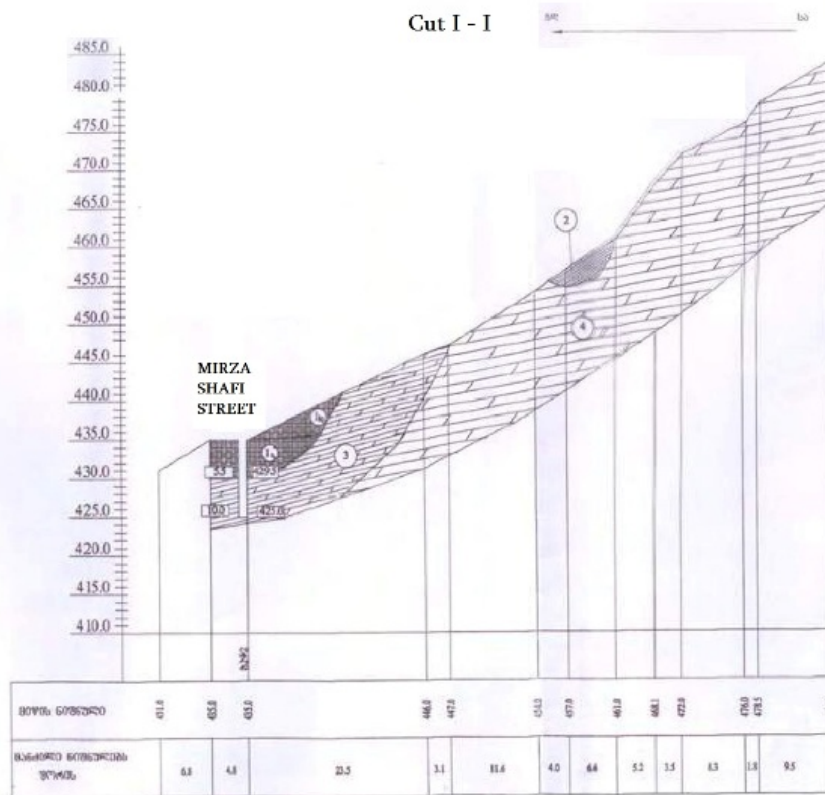
		436	422	433	443	475	489		422	431	
79.5	4.6	5.1	3.4	1.8	4.7	5.4	23.0		50	5.5	

Conventional signes

- | | | |
|---|---|---|
| 1 |  | Bulk ground, lumpy mass, boulder, with construction and household waste |
| 2 |  | Lumpy with boulder insertions |
| 3 |  | Thin layer sand-stones, marls and mudstones, alteration |
| 4 |  | Middle sized and thick sized sand-stones and mudstones |
| 5 |  | Boulder breccias and conglomerates |

[illegible]

Cut I - I

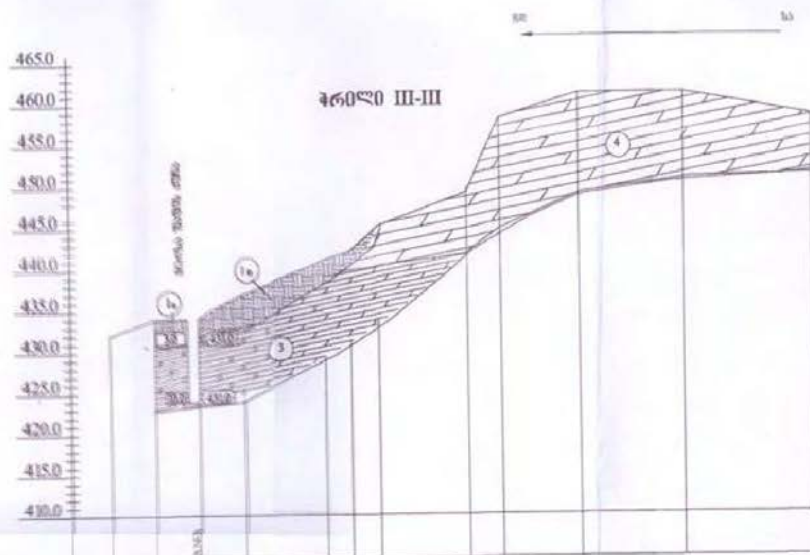


Conventional signes

- | | | |
|----|---|--|
| 1a |  | Bulk ground, loamy mass, boulder, with construction and household waste |
| 1b |  | Bulk ground, rocky ground pieces, coarse boulder, with construction and household waste insertions |
| 2 |  | Loamy with boulder insertions |
| 3 |  | Thin layer sand stone, marls and mudstones, alteration |
| 4 |  | Middle sized and thick layer sand-stones and mudstones |

[illegible]

46020 III-III



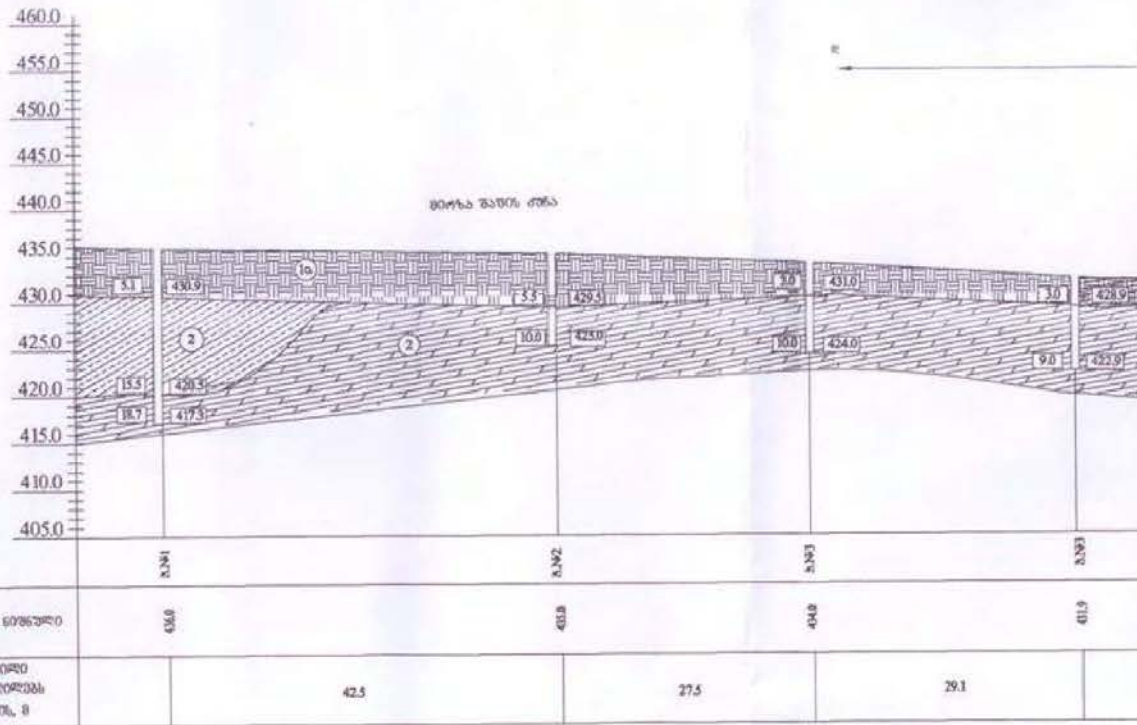
15.8	13.4	9.6	4.2	10.8	3.4	3.1	10.6	4.1	3.8	5.5	5.4	13.5-10.0% 10.0-7.5% 7.5-5.0% 5.0-2.5% 2.5-0.0%
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304(7800)0 50'85330

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[illegible]

36090 V - V

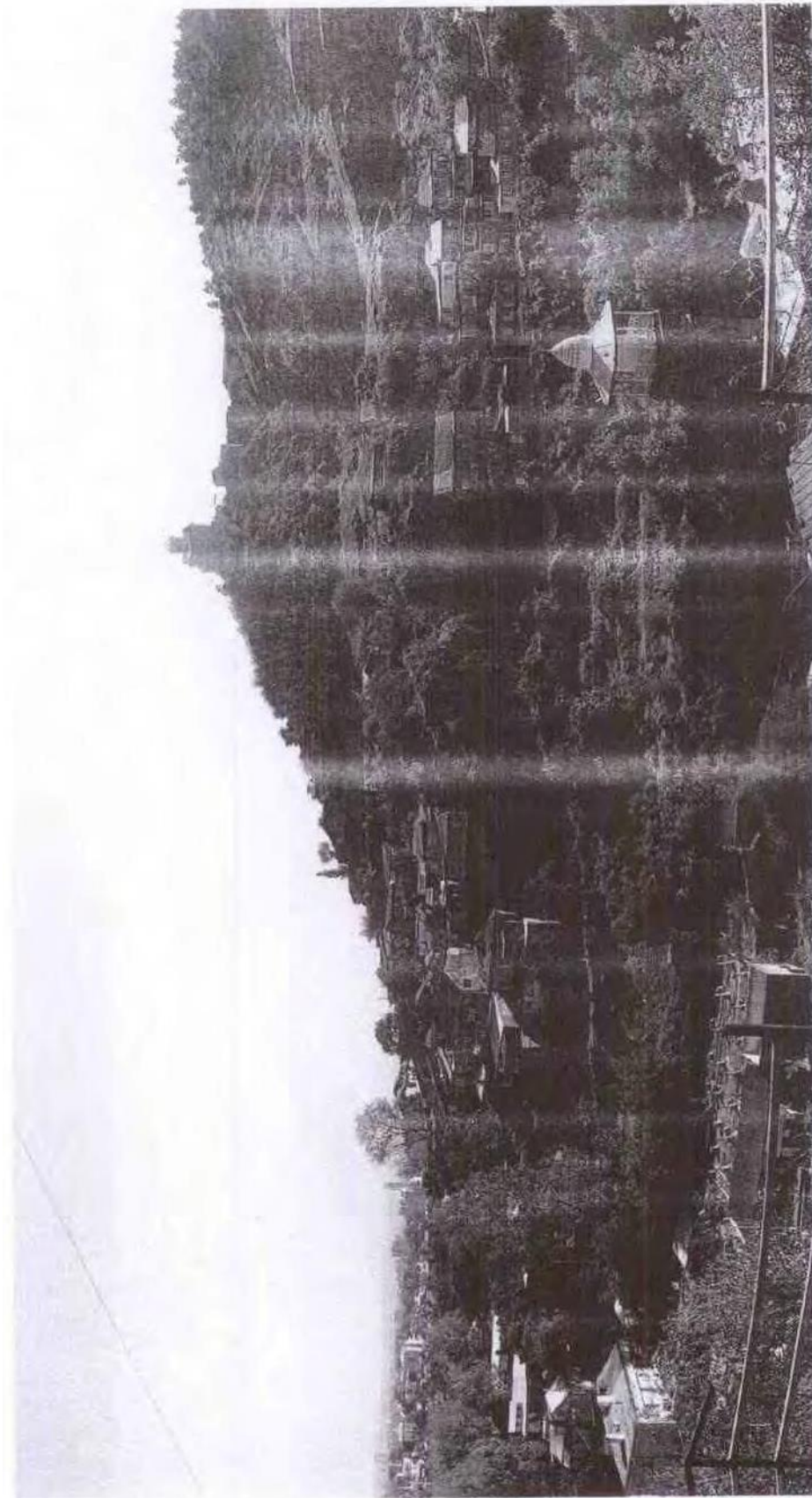


304780000 607860000

- [illegible]

[illegible]

General view of the area in 2006



General view of the area in 2006





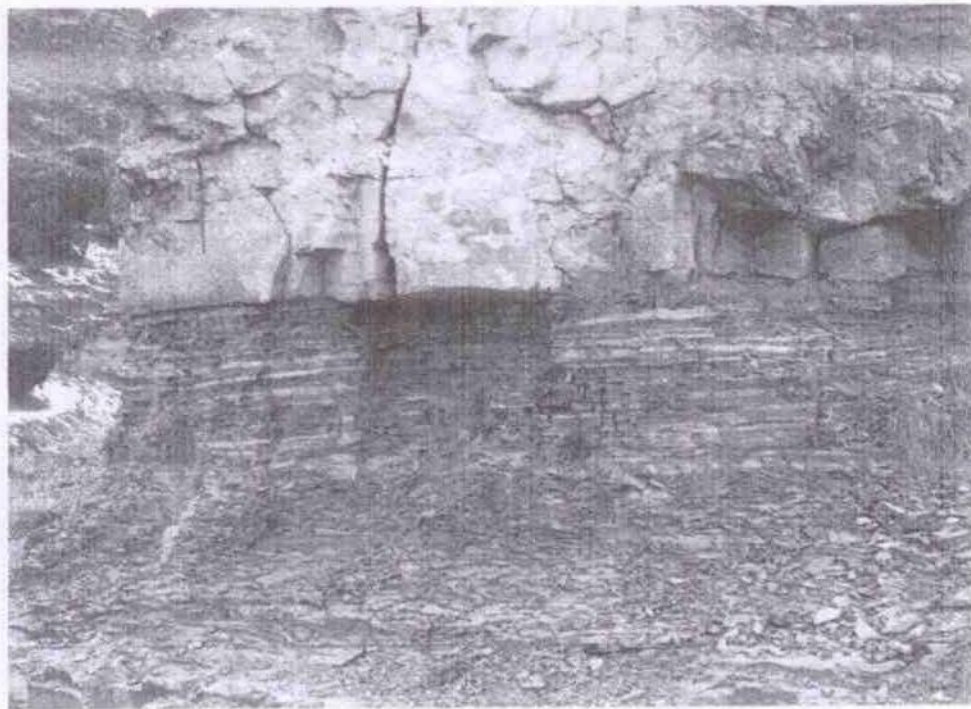
Intensively fissured sand-stones and mudstones,
in the front we see construction and household waste



Intensive chaotic fissure of rocky layers



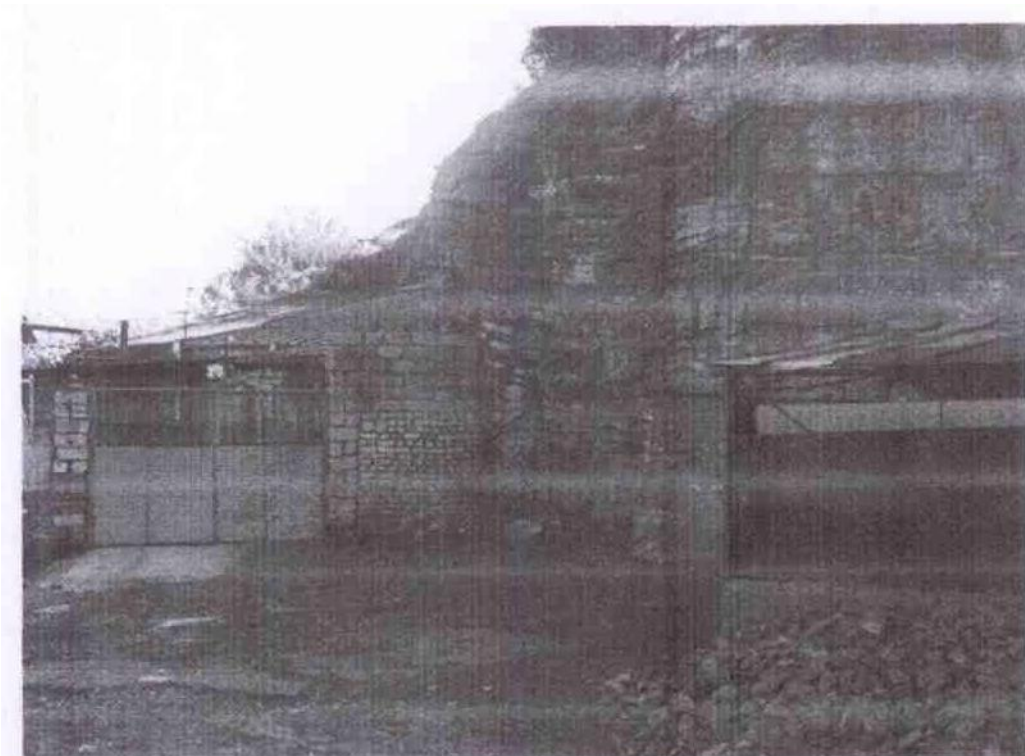
Boulder breccias, three grown up in a fissure



Open vertical fissure in boulder breccias,
thin layer filled up fissures
in thin layer sand-stones and mudstones



Tuff genic sand-stones. In the front view
bulk generated from sand-stone treatment



Minor and thick layer sand-stones,
in the front view thin mudstones
collected as a result of stone falling