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Foundation Problems On Siltstones: A Case Study From Geotechnical Investigation In Southern Part Of Tirana Area

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ABSTRACT

This paper shows the results of the geotechnical investigation carried out in southern part of Tirana city, Albania for study a large foundation on which is planned to build the bigger supermarket. Based on duty of the designers a lot of boreholes were drilled, as well as many in situ and laboratory tests were done in construction site. The aim of this study was to make a detail description of lithology, morphology, geodynamics phenomena, hydrogeology, as well as determination of the physical and mechanical properties of soils and rocks in the study area. So, 21 boreholes in the construction site were drilled from 10.0m up to 15.0m deep. Standard Penetration Tests (SPT), soils grain size distribution, bulk density, Atterberg's limits, moisture content, specific density, shear strength, oedometer and uniaxial compressive strength tests were done for the soils and rocks in this area. PH, chloride and sulphate content were determined for soils and ground water samples. From fields and laboratories works ensue the behavior and properties of soils and rocks depend on their compositional characteristics, formation processes and environmental conditions during their geological history. The soils physical-mechanical properties have low to medium values, the underground water table varies from 4.5m to 6.0m below of earth surface. Whereas, in the central part of construction site on rocks basement-siltstones rocks is found a buried groove, which means that siltstones rocks weathering crust process is much developed than other parts of studied area. Since the engineering object has a large foundation was absolutely necessary to improve the geotechnical properties of the basement against differential settlements of engineering object. Therefore, for the improvement of the foundation was excavated a ditch 2.0m deep below of foundation level from east to west for drainage purpose. Also, to avoid the differential settlements of engineering object was used the slab foundation type. In the end of this work we have given conclusions and recommendations for the final constructions design.

Keywords: physical-mechanical properties, differential settlements, soft rock, siltstones, soils, foundation improvement, weathering crust.

INTRODUCTION

Based on the constructions design of engineering object, discussions with designers of Conisbee Civil Engineering and Landscape Company (London, England), and readily available geotechnical data in the area on May-October, 2008, 21 exploratory borings were drilled at selected locations to maximum depths of 15 m below the existing ground surface. The locations of the borings are shown on the site plan, Figure. The engineering object represents a building-big market with dimension 325.0m (length) x 120.0m (wide), forming a large foundation. The investigated area is located on the left side of Tirana-Elbasani road, in south of Tirana city including in the Farka Commune. In this work we have given the

geotechnical investigations of the construction's site. The aim of this approach is to provide information on the geology, lithology, geomorphology, hydrogeology and geotechnical characteristics of the studied area. Also, a detailed soil profile is given to use for designers, showing average or representative soil properties and values of design shear strength used for various soil strata.

METHODOLOGY

The objective of subsurface investigations or field exploration was to carry out the geotechnical investigation for project of building with 3 stores in Tirana, Albania. These explorations should identify the site in sufficient detail for the development of feasible and cost-effective construction structure designs. For success completion of geotechnical investigation is worked in field and laboratory. In connection with construction project of Conisbee Civil Engineering Company (Fig. 1) in the studied site have been executed 21 boreholes from 10.0m up to 15.0m deep (Fig. 2). Drilling has been carried out by rotary machines with the drilling rig with the possibility of continuous sampling at different depths and at each lithological change of the strata. The percentage of the samples obtained from drilling operation will be 100%. Two types of samples were collected as disturbed samples suitable for identification and index property testing purposes at various depths and undisturbed soils for physical-mechanical tests. Representative samples were placed in sealed plastic bags and Shelby (metallic tube) and transported to the laboratory for further testing. Subsurface soil and rocks properties are generally determined using one or more methods as in-situ and laboratory testing during the field exploration program. For examinations of physical-mechanical properties of soils profiles, from the drilling operation we have collected 32 samples (8 undisturbed samples and 24 disturbed samples) are analyzed in laboratory. They are taken in different level of soils profile, belong references terms and in the dependence of the lithological construction. Also from drilling operation, we have exactly determined the lithological profile of the studied area. In laboratory are examined soils and rocks for properties as grain size analysis (sieve and hydrometer tests ASTM D 422), Atterberg limits (ASTM D 4318), bulk density (ASTM D 2435), Specific density (ASTM D 854), natural water content (ASTM D 2216) deformations parameters (confined compress test, ASTM D 2435), strengths parameters (shearing box-internal friction angle, c, cohesion, ASTM D 3080) and uniaxial resistant compress in natural condition.

Figure 1. Architectonics design (after Conisbee Civil Engineering Company 2009)

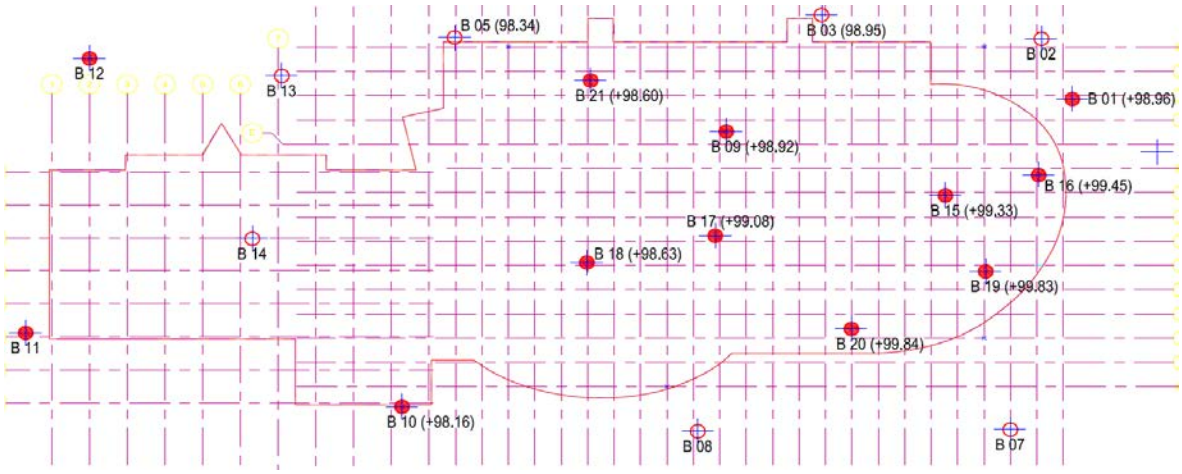


Figure 2. Boreholes locations

Also, in all boreholes each meter penetration is carried out the standard penetration test-SPT. It's very important to be emphases that during drilling operations (field works) the systematic measurements of underground water levels are made. The results of the exploration and laboratory testing are carried in studied site are presented here.

RESULTS AND DISCUSSION

Based on the duty given by Conisbee company designers (Fig. 1) detail investigations of lithology, morphology, geodynamics phenomena, hydrogeology and determination of the physical and mechanical properties of soils and rocks are carried. These results we are treated here.

Geomorphology

From the geomorphologic point of view the studied area is included in the hill's morphologic unit of the Farka-Sauku hills. It's represented by the small hill, where its top was excavated by the man works doing it a flat area. On western part of the construction site has developed its valley the Kabeli stream, which has eroded the lower part of the hill on this site. The hill is built by the combination of siltstones and claystones layers, which mostly of it is covered by diluvium deposits.

Geodynamic phenomena

From the geodynamic phenomena in the studied area is developed the erosion process.
Erosion-As results of high quantities of precipitation in the studied area along of the Kabali valley stream on both site are developed the erosion phenomena, which can cause the landslides during its valley slopes. So, from this phenomenon are threatened the studied area in the future time. Therefore, to protect the valley slopes from this phenomenon it is necessary to take the engineering measures, which represent by construction of the barriers and to plant the trees.

Geology

In the investigated area, the Quaternary deposits and Molasses rocks are found.

Quaternary deposits-It's represented by the diluvium deposits. They are 1-2m up to 4.0-5.0m thick, made up mainly silts and very fine sands, which contain the crushed sandstones rocks and are situated in lower and middle part of hills slope.

Molasses rocks-According to geological setting in the studied area outcrop Molasses rocks, which are part of Geological Mezezi unit (N_1^3t-m) and Geological Iba unit (N_1^3t-m).
The geological Mezezi unit (N_1^3t-m)-Clay stones and siltstone rocks predominate with to sandstone rocks. From the structural point of view the studied area take place in eastern limb of the Tirana syncline which dip to west with 5^o up to 10^o. Here the clay stones rocks are about 28.0-35.0% of the lithological profile. They have grayish and grayish-brownish color. Concerning mineralogical composition they are ilite and montmorillonite type. Whereas the sandstones rocks consist of quartz, feldspars, micas and carbonate fine up to medium grained. These are cemented by clay material. The sandstones rocks represent 20.0-25.0% of lithological profile. This rocks are covered by Quaternary deposits.
*The Geological Iba unit (N_1^3t-m)-R*represent mostly by sandstones rocks, which are interculated by the thin siltstones and claystones layers. These rocks are extended on western part of the studied area. They are included in the medium strength rocks.

Hydrogeology
The observed site related to hydrogeology is constructed by two complexes of rocks. They are Quaternary deposits and Molasses rocks. The Quaternary deposits is built by the diluvium deposits-silts and very fine sands, which contain gravels. In relation to water bearing capacity, these deposits form a poor to medium aquifer. During drilling operations, systematic measurements of underground water levels were done, from which results it is found 4.5m up to 5.0m deep.

Geotechnical condition
The geotechnical geological conditions are simply expressed in Fig. 3, 4, 5, 6 7 and 8. It shows the lithological profile in vertical and horizontal position, where are nine geotechnical units. Based on the project, which was planned for the building construction (4 stories), a lot of works are carried out. So, during on May 26-31 and October 21-26, 2008 a detailed field investigation (Fig. 2,) was carried out in studied area. Investigations was based in lithological surface observation (scale: 1: 100) of the studied area, on documentation of drilling cores obtained from 0.0-10.0m up to 15.0m (Fig. 3). On the basis of the results of the lithological, hydrogeological observations and physical-mechanical properties in the studied area, 9 geotechnical units are distinguished with different geotechnical features, which we treat as following:

Layer nr. 1-This layer represent by vegetal soils and have a thickness varies from 0.4m up to 0.8m.
Layer nr. 2-Inorganic silts and very fines sands-ML, brown color. It has a thickness varies from 0.7-0.8m up to 1.6m.
Layer nr. 3- Inorganic clays of law to medium plasticity with sand content-CL, brown and grey color. These soils types are in stiff state and are extended in southern part of studied area. It is thick 0.9-0.8m up to 2.5m.
Shtresa nr. 4-It's extend in southern part of studied area and represent by clayey sands-SC, beige color. These soils types are in medium compressed conditions. This layer is situated below layer nr.1. and have a thickness varies from 2.5m up to 5.1m.
Layer nr. 5-It's represents by the sandy clays-CL. These soils types are in stiff state. The layer is 2.1m up to 4.4m thick and it's extended on southern part of construction site.
Layer nr. 6-It's represents by the silty sands-SM. These soils types are in hard state. The layer is 0.6m up to 1.0m thick and it's extended on southern part of construction site.
Layer nr. 7- It's represents by silts and clayey fine sands-ML and CL. These soils types are in very stiff state has a thickness various from 1.1m-2.7m up to 3.2m-4.7m. It's extended on the whole of construction site. Generally this layer is found below the layer nr. 3.
Layer nr. 8-It's represents by soft rocks-combination of claystones with siltstones rocks with grey color

Layer nr. 9-It's represents by medium strength rocks-sandstones rocks with grey color.
The physical-mechanical properties of these soils are given in Table 1.1, 1.2 and 2.

Table 1.1. The mean physical-mechanical properties of representative's soils

Geotechnical unit	SPT-N	Physical mechanical properties					
		Sand	Silt	Clay	W_L	W_p	Soils type
		%	%	%	%	%	
Layer 2	11-13	28.4	57.4	14.2	40.1	24.8	ML
Layer 3	18-25	47.2	42.4	10.4	35.2	23.8	ML-CL
Layer 4	9-11	28.1	58.7	13.2	40.3	23.6	CL
Layer 5	14-18	50.9	41.4	7.7	33.6	20.7	SC
Layer 6	10-12	46.6	45.6	7.8	34.9	22.3	CL
Layer 7	35-48	59.6	33.6	6.8	27.5	20.9	SM

Table 1.2. The mean physical-mechanical properties of representative's soils

Geotechnical unit	Physical mechanical properties					
	W_n	γ	γ_o	φ	c	E
	%	kN/m^3	kN/m^3	(o)	kPa	kPa $x10^4$
Layer 2	29.10	19.0	26.9	16	20	0.6-0.8
Layer 3	25.30	19.5	26.6	24	25	1.15
Layer 4	29.90	18.8	26.8	15	15-20	0.52
Layer 5	24.8	19.0	26.5	26	5	0. 86
Layer 6	26.71	18.9	26.6	20	10	0.57
Layer 7	23.60	19.8	26.4	32	5	1.45

W_n - Natural water content, (W_L, W_p)-Atteberg limits, I_c-Consistency Index, I_p-Plastic Index, γ-Bulk density, γ_o-Specific density, φ - Internal friction angle, c -Cohesion, E- eodometric test, USCS - Unified soils classification system,

Table 2. The mean physical-mechanical properties of representative's rocks

Geotechnical unit	Physical mechanical properties							
	n	W_n	γ	γ_o	τ_c	E	E_{el}	Rock type
	%	%	kN/m^3	kN/m^3	kPa $x10^4$	kPa $x10^4$	KPa $x10^4$	
Layer 8	17.2	18.3	24.63	25.22	1.74	387	258	Sandstones
Layer 9	49.1	4.7	25.49	25.85	0.21 –0.34	63.2	44	Siltst.-clayst.

W_n - Natural water content, γ-Bulk density, γ_o-Specific density, n-porosity, τ_c-unaxial resistant compress in natural condition, E- Deformations module, Eel-Elasticity module

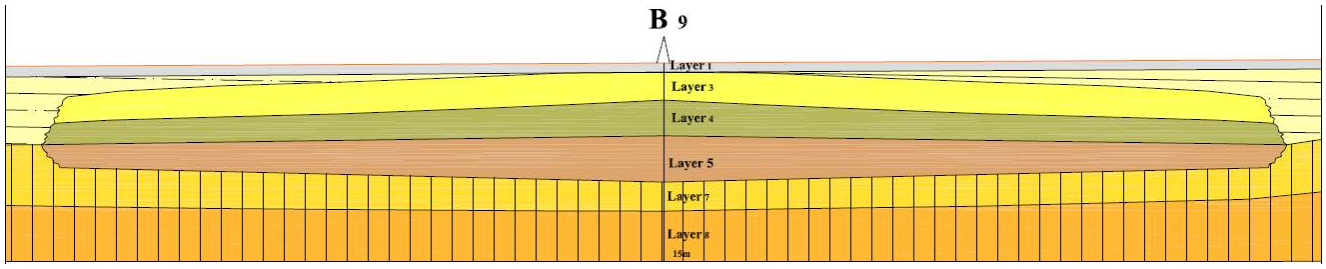
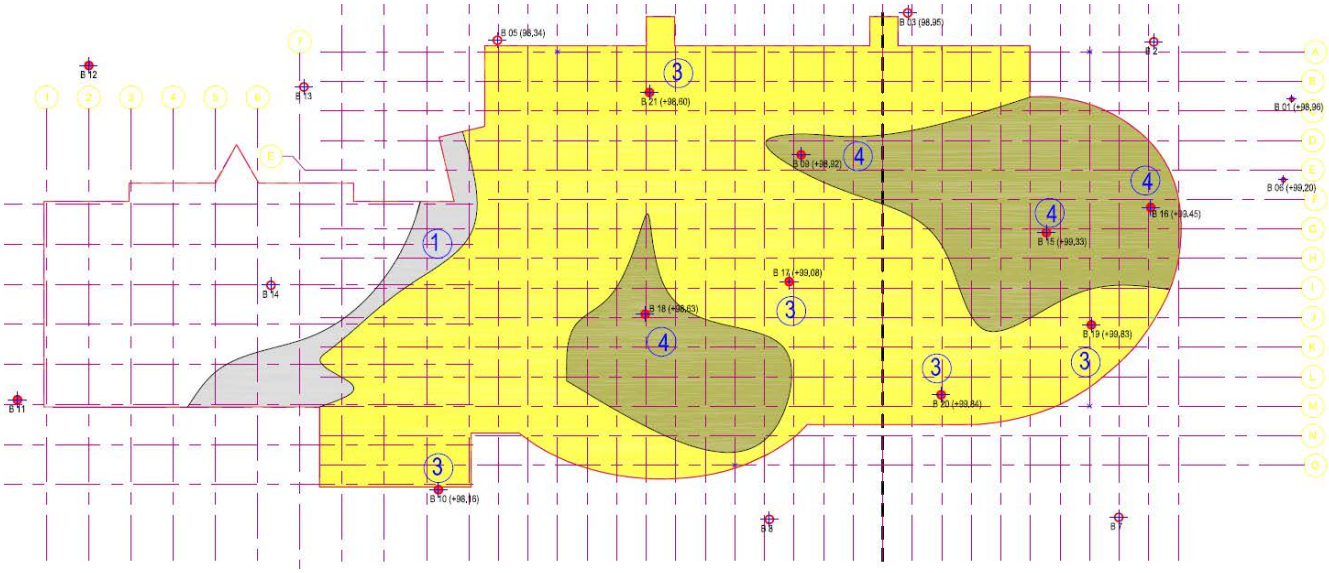
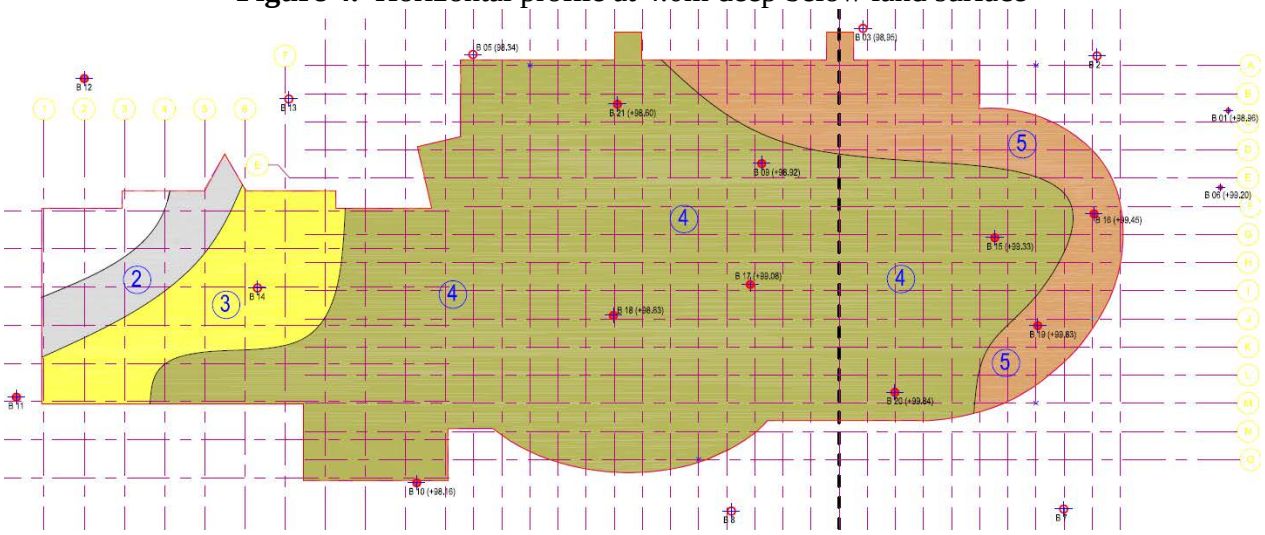


Figure 3. Cross section from northeast to southwest



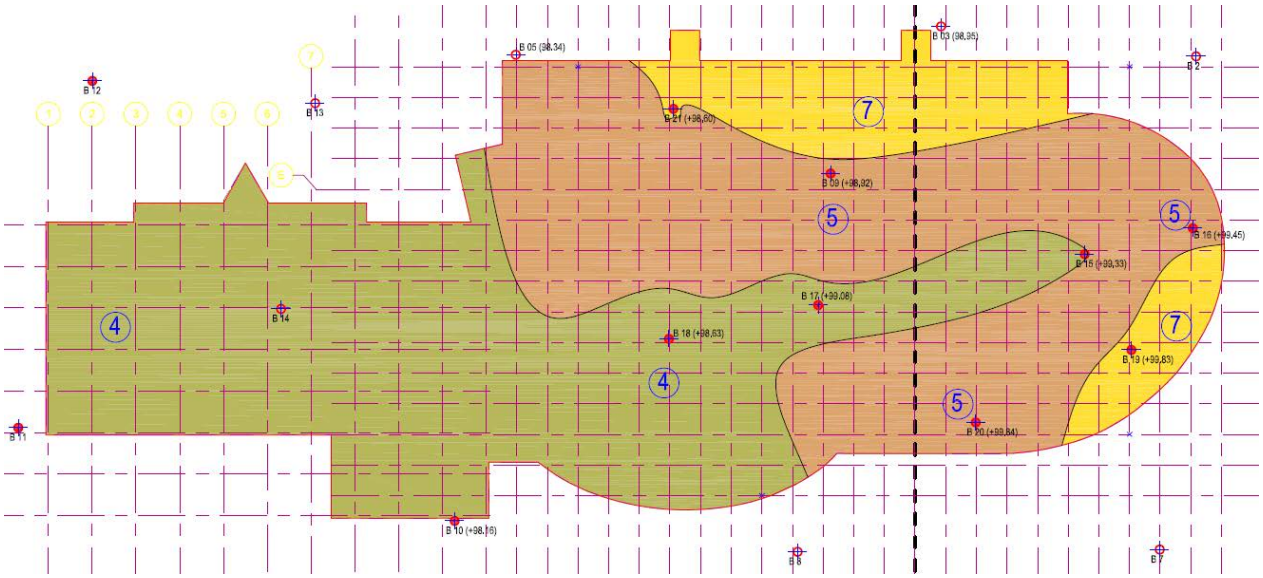
1, 3 and 4 are geotechnical units

Figure 4. Horizontal profile at 4.0m deep below land surface



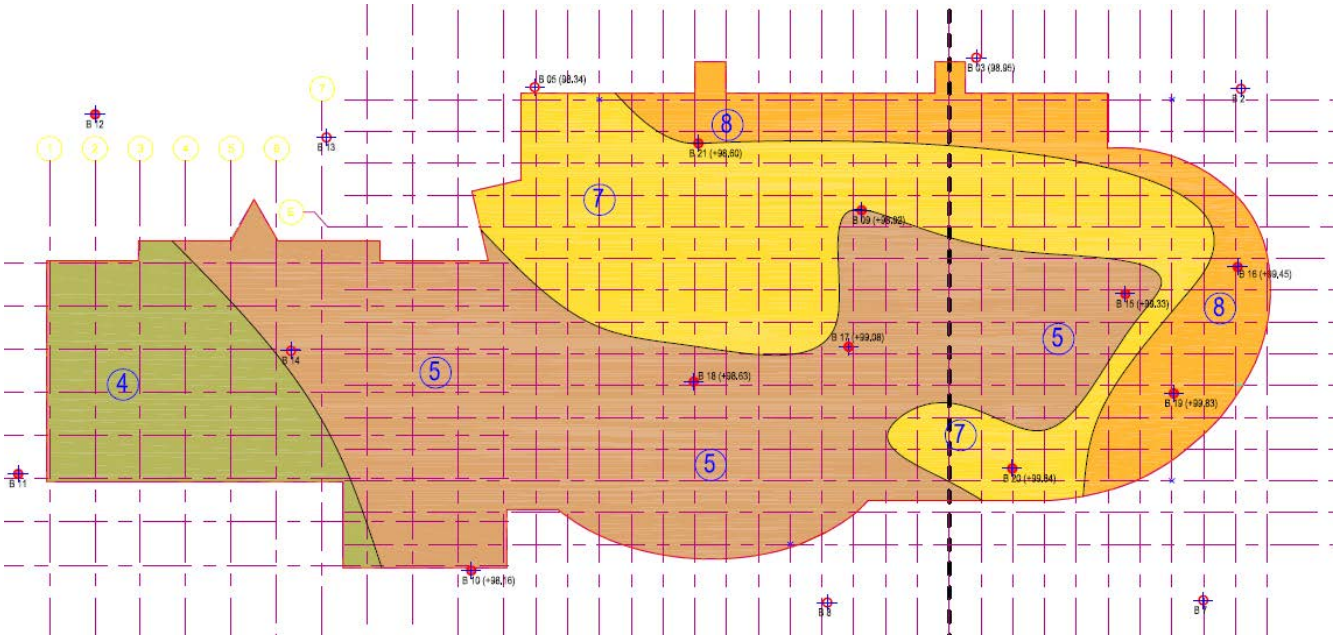
2, 3, 4 and 5 are geotechnical units

Figure 5. Horizontal profile at 6.0m deep below land surface



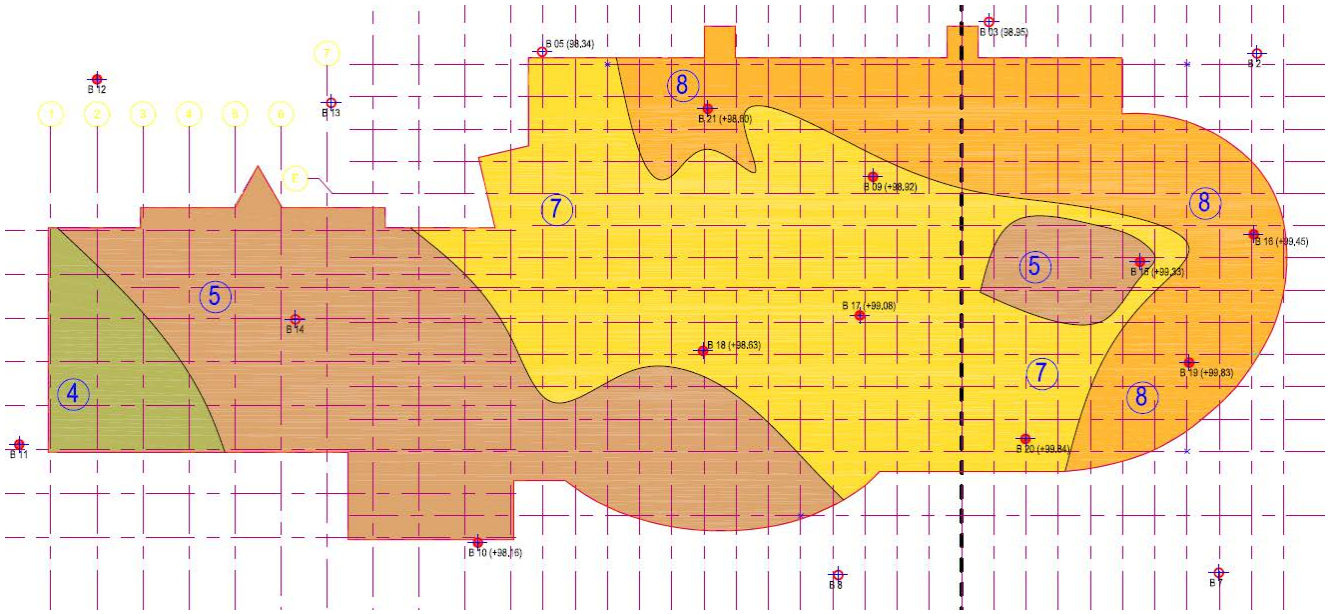
4, 5, 7 and 8 are geotechnical units

Figure 6. Horizontal profile at 8.0m deep below land surface



4, 5, 7 and 8 are geotechnical units

Figure 7. Horizontal profile at 10.0m deep below land surface



4, 5, 7 and 8 are geotechnical units

Figure 8. Horizontal profile at 11.0m deep below land surface

The siltstones-soft rocks built the lower part of lithological profile of the studied area, which in contact with water during excavation works decompose as results of waters absorption, therefore this rocks transforms primary structures from rocks to the soils, that means change the physical-mechanical properties, as well. Thus, in these rocks in upper part (1.5-2.0m deep) we have a reduction of geotechnical properties (it is verified the geotechnical properties decrease more than half of their values). As is seen it, gradually, mainly due to the influence of stress and water (climate, precipitation), the siltstones rocks transforms back into more homogeneous soil. Even underground water and low overburden pressure the upper part of siltstones rocks became relatively heterogeneous due to weathering crust development. The properties of this layer transform from soft rocks to soils [1]. Also, it is observed from the rocks samples, which are taken for laboratories analysis. When submerged in the laboratory, the rocks specimens from the present sites decompose quickly into fine grained particles. No cementation of the undisturbed overburden was detected. Further the behavior of the upper part of the siltstones rocks is influenced by the partial saturation and by continuous air phase. The soils mostly consisted of inorganic silts and very fines sands (ML), clays of law to medium plasticity with sand content (CL), clayey sands (SC), sandy clays (CL), silts and clayey fine sands (ML and CL). From field works (boreholes) results that rocks basement (siltstones) in the central part of construction site on rocks basement-siltstones rocks is found a buried groove, which means that siltstones rocks weathering crust process is much developed than other parts of studied area. Furthermore, the soils physical-mechanical properties have low to medium values, the underground water table varies from 4.5m to 6.0m below of earth surface. For all above mentioned it, is absolute necessity to improve the construction foundation via excavation a ditch 2.0m deep below of foundation level from east to west for drainage purpose. Also, to avoid the differential settlements of engineering object was recommended used the slab foundation type.

CONCLUSION AND RECOMMENDATIONS

- The soils, which built the upper part of lithological profile of the studied area, have low to

medium geotechnical properties.

- The siltstones-soft rocks built the lower part of lithological profile of the studied area, which in contact with water during excavation works decompose as results of waters absorption, therefore this rocks transforms the primary structures from rocks to the soils, that means change the physical-mechanicals properties, as well.
- The siltstones-soft rocks in upper part (1.5-2.0m deep) have a reduction of geotechnical properties in contact with water and air.
- From field works (boreholes) results that rocks basement (siltstones) in the central part of construction site on rocks basement-siltstones rocks is found a buried groove, which means that siltstones rocks weathering crust process is much developed than other parts of studied area.
- Due to, the foundation forms a large plain it was absolutely necessary to improve the Geotechnical properties of the basement to save the engineering object to differential settlements.
- The underground water in the studied area is found in two complexes are soils (silts and clays) and rocks (siltstones and claystones).
- The underground water table in the soils aquifer is 4.5m up to 6.0m below of earth surface.
- For all above mentioned it, is absolute necessity to improve the construction foundation via excavation a ditch 2.0m deep below of foundation level from east to west for drainage purpose.
- For avoiding of the differential settlements of engineering object was recommended to use the slab foundation type.

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