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GEOLOGICAL REPORT
KURCAJ BRIDGE

ATELiER 4
ARCHITECTURE • ENGINEERING • CONSULTING

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1. INTRODUCTION

The study for the Kurcaj bridge was drafted only on the basis of a field study reconnaissance and on the basis of existing materials. The following works have been performed:
1. Geological survey of the place where the stone bridge was built in the village of Kurcaj.
2. 3 bore holes with a depth of 15.00m were drilled and the data of previous works that were carried out by the company "ALTEA & GEOSTUDIO 2000" in the valley of the Black River were used.
3. Samples were taken and analyzed in the laboratory to determine the physical-mechanical properties.
4. The engineering geological and geotechnical report for the old bridge of the Ottoman period has been prepared.

1.1 PURPOSE OF THE STUDY

The purpose of this study is to determine the physical-mechanical characteristics of soils and rocks that meet in the area where the Kurcaj bridge was built in the Ottoman Period. This is the final report that will serve the designers for the preparation of the project implementation and for the detailed program for the geological and geotechnical study.

1.2 OBJECTIVE OF WORKS

The report briefly examines the following issues, which are supported by existing geological works.
1. All previous geological works performed by the authors and other local authors have been reviewed, which have been performed for various other purposes.
2. All published and unpublished studies for the area in question have been reviewed.
3. All published maps for the geological and geomorphological construction of the area where the bridge is located have been studied.
4. Various works have been carried out according to the program designed above, but combined with existing works, which are very important to understand the geological phenomena that have occurred in the development of the geological history of this area.
5. Appropriate analyzes have been performed to determine the physical-mechanical characteristics of the underground soil layers that exist on the axis of the Kurcaj bridge, in the Kruja area.

For the performance of this study, the previous works performed by the authors of this study have been used, such as:
• Engineering geological and geotechnical studies conducted by the company Geology-Geodesy for special facilities in the district of Kruja through 1960 -1990.
• Engineering geological and geotechnical studies conducted by "ALTEA & GEOSTUDIO 2000" for the city of Kruja and the areas around this city, through 1996 - September 2020.
• Engineering geological studies by "ALTEA & GEOSTUDIO 2000" for some bridges that have been built on the Black River, through years 1996-March 2021.

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The studies were conducted in accordance with the standards presented in the tender documents such as: ASTM, AASHTO, BSI, UNI.

1.3 STRUCTURE OF THE REPORT

For the structure of the report, a mutual work with the client was performed and the main chapters have been defined as below:
1. Introduction, Purpose and Structure of the report.
2. Geomorphology divided into: location and description of the topography, physical-geological and geodynamic processes.
3. Geology and hydrogeology divided into existing documented geological studies.
4. The results of the study divided into several sub-chapters which will be treated in more detail in the relevant paragraph.
5. Conclusions and Recommendations.

2. GEOMORPHOLOGY

This chapter elaborates the description of the area where the bridge of the Ottoman period was built in the village of Kurcaj, the forms of today's topography, the geological conditions of the formation of this morphology, the description of the geological and geodynamic phenomena of the area.

2.1 LOCATION OF THE OLD OTTOMAN BRIDGE IN THE VILLAGE OF KURCAJ AND DESCRIPTION OF THE TOPOGRAPHY

The place is where the old Ottoman bridge was built in the village of Kurcaj, which represents the valley of the Black River. The bridge is made of stone and is built over the Black River.
The valley of the river Zeza represents a beautiful valley, which is wide in the first part from Fushe Kruja to Kurcaj begins to narrow. This valley was created in the Neogene-Quaternary period. The slopes of the valley are soft, on both sides of the valley are built the villages of Kruja which are very beautiful. The slopes of the valley are agricultural land and are partially covered with short vegetation (shrubs and oaks with low height. But there are also areas that are forested. The existing road, but also the new road passes in this valley. In this valley are built several villages in the district of Kruja.
The small hills from Fushe Kruja to Kurcaj are some hills with a small height of 50-250m. The villages of the area have been built on these hills. The hills are with smooth slopes with a slope of 15-20°, they are stable, they are planted with fruit trees. From the field observations, no landslide areas have been found that threaten the old bridge of Kurcaj.

2.2 PHYSICAL-GEOLOGICAL AND GEODYNAMIC PROCESSES

The study of geological phenomena of this area are based on existing studies and the new information that have been received from the current study. Based on these data, the geological phenomena that are present in the study area are described. The most obvious geological and geodynamic phenomena that are observed in this area are:

1. The phenomenon of weathering
2. The phenomenon of erosion
3. The phenomenon of consolidation of alluvial-proluvial deposits

These phenomena are explained below:

1. The phenomenon of weathering is evident in the base formations represented by the Paleogene deposits consisting of clays, sandstones that are new deposits and with poor clay cementation. These rocks under the action of atmospheric agents are transformed from soft rocks into soils. This phenomenon occurs in both parts of the Black River valley.

2. The phenomenon of erosion is visible at the bottom and on both sides of the Black River valley. Surface water currents that accumulate during the period of massive rainfall erode the permeable part of the base formation and transport the material to the lowest points of the topography. The Black River in this segment has a steep slope and has great power to erode the slope and its two banks. From the field observations it has been concluded that the main causes that have brought the damage to the bridge is the phenomenon of erosion.

3. Consolidation of alluvial-proluvial deposits. These deposits consist of layers of sands, silts and clays. In these parts of the deposits of the terraces of the Black River, alluvial deposits are present that intertwine with the deposits of the streams of the area. Under these conditions, fine grained materials are deposited. From the observations conducted in the area it is clear that the presence of these deposits, which have negatively affected the facilities that are built on these deposits, such as deformations of the pavements of existing roads and deformation of existing bridges.

3. GEOLOGICAL AND HYDROGEOLOGICAL CONSTRUCTION

This chapter deals with the geological composition of the area using existing works and field works performed by "ALTEA & GEOSTUDIO 2000" Sh.p.k. Geological drillings has been carried out in the field. Based on the work done it is elaborated on the geological conditions divided into existing studies and new studies conducted by the study group.

3.1 EXISTING STUDIES

In the Kruja area, geological studies have been carried out for the rural roads of Kruja, for the study of useful minerals that are present in this area and many constructions that have been carried out in the Black River valley. Regional studies have been conducted for the construction of the geological map of Albania. The Black River area is part of the geological-structural area of

Kruja in Albania. Cretaceous to Quaternary deposits are present in this area. The following deposits are present in the area where the road passes:

- Upper Cretaceous carbonate deposits and Eocene deposits (Pg_2; Cr_2)
- Oligocene Flysch Deposits (Pg_3^1; Pg_3^2; Pg_3^3)
- Quaternary deposits Qh_1 - Qh_2
- Upper Eocene Cretaceous deposits (Pg_2; Cr_2) are represented by a combination of white to gray limestones with strong cracks. Some of the cracks are filled with silvery material and some are empty. Limestone layers have good qualities to be used as materials for the construction of this road. Several laboratory tests were performed to evaluate their qualities.
- Oligocene flysch deposits (Pg_3^1) are represented by a combination of sandy clays and rarely conglomerates. They are gray to beige, they have poor to good cementation, they have joints. The top of these deposits is quite weathered. These rocks meet in the hills that are present in the southeast of the axis of this road. They are covered with deluvial-eluvial layers of considerable thickness (3.50-4.00 m). Flysch layers have poor quality and they lost their condition. Therefore, they are not recommended to be used as a material for the construction of this road. Several laboratory tests were performed to evaluate their qualities and therefore this recommendation could be made.
- Quaternary deposits including Holocene and Pleistocene deposits in the study area meet only the following deposits:

Alluvial deposits are represented by deposits of the Black River and some other streams. They consist of light to medium plasticity silts and clays, sands and gravels.
Pleistocene-Holocene deposits represent old and new deluvial-eluvial deposits consisting of gravely silts and clays of slightly to moderately consolidated nature. They meet in the hilly part of the area from Fushe Kruja to Kurcaj.

3.2 HYDROGEOLOGICAL CONDITIONS

From the studies carried out in the area of Kurcaj village of Kruja district (from the measurements carried out in the drilling) it results that the level of groundwater in winter and summer is different. According to the hydrogeological composition two hydrogeological complexes were observed which are described in more detail below:

3.2.1 Water-bearing complex of weathered rocks

The aquifer complex of shale deposits represents the alluvial-proluvial deposits of the plain in the Black River valley. Quaternary deposits are widespread from previous works. A package thickness of up to 15-30 m from the ground surface is identified. The properties of gravels for irrigation are evaluated as good with Q> 800m^3 / day. The main hydrogeological properties of gravel deposits are: high porosity and the relationship between permeability and hydraulic conductivity.

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3.2.2 Compact rock aquaifer complex

According to the characteristics there exists several rock types that have different hydrogeological characteristics, which are described in more detail below:
Pelogenic deposits consist of layers of clays, sandstones and conglomerates. Sandstone and conglomerate layers have good permeability and groundwater can be found in these rocks. Clay and siltstone layers have poor permeability, they have low water content. The authors of the study have used all existing works and new works. Measurements have been performed at several times throughout the study period and it results that in most of the area the groundwater level is 0.50-1.00m in the plain area and 3.00-4.00m in the hilly area. From the performed analyzes it results that they are neutral waters, they are not aggressive towards iron and concrete.

4. ENGINEERING-GEOLOGICAL CONDITIONS OF THE AREA WHERE THE OTTOMAN BRIDGE ON THE BLACK RIVER IS LOCATED

The assessment of the geological strata was made based on the data performed by the geological survey of the bridge site from the drilling performed as well as the data obtained from the laboratory analyzes. The results of these studies will be discussed in more detail below. At the site of the old bridge over the Black River we have identified several different geological-lithological layers with physical-mechanical characteristics as follows:

LAYER No.1

It is represented by vegetative soil that consists of medium-sized, brown, moist medium plasticity silty sands. Containing plant roots are slightly compacted exists on both sides of the banks of the Black River (see geological sections).

LAYER No.2

It consists of light to medium plasticity moist brown silty sands, that contain fine and medium gravel and cobbles. Gravels are of sandstone and limestone origin. They have a semi-angular, angular, rounded and semi-rounded and granular shape. They are moderately compacted (see geological sections).

Physico-mechanical characteristics for this layer are:

Granulometric composition

Clay (<0.002 mm) 15.60%
Silt (0.002-0.075 mm) 31.80%
Sand (<4.75 mm) 17.30%
Gravel (> 4.75 mm) 35.30%

Plasticity

Liquid limit ..... W_L = 34.90%

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Plasticity limit ..... W_p = 23.20%
Plasticity index ..... Ip = 11.70
Natural water content ..... Wn = 25.70%
Specific weight ..... Gs= 2.67
Bulk unit weight ..... g_n = 1.96 T/ m^3
Void's ratio ..... e = 0.70
Deformation modulus ..... E = 86.00 kg / cm^2
Internal friction angle ..... f = 20°
Cohesion ..... c = 0.18 kg / cm^2
Allowable bearing capacity ..... σ = 1.80 kg / cm^2
Number of SPT drops ..... SPT N= 12-16

LAYER No.3

It is represented by the beige-gray silty sand with gravel. They are moist to saturated state. It contains silty sand and sand bands. Gravel rocks are slightly rounded to angular, are of carbonate and sandstone origin. They contain limestone blocks with dimensions 0.50-1.00m^3. They are moderately compacted (see geological sections).

Physico-mechanical characteristics for this layer are:

Granulometric composition

Clay (<0.002 mm) 10.90%
Silt (0.002-0.075 mm) 15.80%
Sand (<4.75 mm) 21.60%
Gravel (> 4.75 mm) 51.70%

Plasticity

Liquid limit ..... W_L = 21.70%
Plasticity limit ..... W_p = 16.30%
Plasticity index ..... Ip = 5.40
Natural water content ..... Wn = 12.60%
Specific weight ..... Gs= 2.68
Bulk unit weight ..... g_n = 2.12 T/ m^3
Void's ratio ..... e = 0.64
Deformation modulus ..... E = 86.00 kg / cm^2
Internal friction angle ..... f = 32.70°
Cohesion ..... c = 8.74 kPa
Allowable bearing capacity ..... σ = 2.40 kg / cm^2
Number of SPT drops ..... SPT N= 26-32

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LAYER No.4

It is represented by claystones, sandstones and siltstones, with beige-gray color, they are less moist, they are with weak to medium cementation, with cracks. They are highly compressed (see geological sections).

Physico-mechanical characteristics for this layer to be obtained:

Natural water content ..... Wn = 9.74%
Specific weight ..... Gs= 2.64
Bulk unit weight ..... g_n = 2.26 T/ m^3
Internal friction angle ..... f = 29.50°
Cohesion ..... c = 0.52 kg/cm^2
Unconfined compressive strength..... UCS= 19.80 MPa
Allowable bearing capacity ..... σ = 3.20 kg/cm^2
Number of SPT drops..... SPT N>50

LAYER No.5

It is represented by claystones, sandstones and siltstones, they are gray in color, they are less moist, with medium to good cementation, they are less cracked. They are highly compacted (see geological sections).

Physico-mechanical characteristics for this layer to be obtained:

Natural water content ..... Wn = 6.80 %
Specific weight ..... Gs= 2.65
Bulk unit weight ..... g_n = 2.38 T/ m^3
Internal friction angle ..... f = 30°
Cohesion ..... c = 0.64 kg/cm^2
Unconfined compressive strength..... UCS= 4.80 MPa
Allowable bearing capacity ..... σ = 3.60 kg/cm^2
Number of SPT drops..... SPT N>50

5. CONCLUSIONS AND RECOMMENDATIONS

1. The area where the Stone Bridge was built in Kurcaj is with hilly topography, the slopes of the valley are with gentle to very steep slopes.

2. During the geological survey and geological-field works which have been carried out for the geological and geotechnical study, no phenomena of mass movements of terrestrial or rock masses have been ascertained, which may threaten the stability of the old bridge.

3. In the study area, Paleogene deposits are found up to Quaternary deposits consisting of claystones, siltstones, sandstones, conglomerates and rarely limestone. Quaternary deposits are represented by silts, clays, sands and gravels.

4. The foundations of the old bridge are mainly damaged by the erosion of the river at the moment when it is filled by rain.

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5. It is recommended that the foundations of the existing bridge be protected from the erosion of the Black River.

6. It is recommended that in the axis of the bridge to ensure a rushing current, the large rock blocks should not stay in their position because they are the main cause that change the direction of flow of the Black River.