ROCK FALL AND RISK ASSISSMENT
IN URBAN AREA OF BERATI TOWN (MANGALEM)

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ROCK FALL AND RISK ASSISSMENT

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By

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January 2014

Chairman: Assistant Prof.Dr. Ylber MUCEKU

Faculty: Faculty of Architecture and Engineering

Abstract

Rock fall and risk assessment study requires extensive profession on rock and soil engineering.

Rock fall and risk assessment concepts have different point of view that the rock and soil structures are completely different. Strength properties, deformation principles etc. are all different.

Field investigations, laboratory testing and back analyses are vital instruments for determining precisely the input parameters for the analysis of the slope stability.

The main motives that made the realization of this study were the phenomena of landslide causing massive collapse of large hills of Berat city. This phenomena has caused major damage to the economic direction of the community and the preservation of values that have old buildings on these hills, to the preservation of terrain configuration, to the preserving of the landscape.

Economic development in the city of Berat in recent years has caused another risk for the instability of these hills, such as the construction sector. Too many constructions without being studied by geotechnical and absence of urban planning, has led to the acceleration of the erosion of these hills, increase the level of instability, therefore incalculable damages not only the economic aspect of the citizens, but also in the context of development of tourism in this area, that are essential for the life of a tourist city like Berat.

Abstrakti i tezës i prezantuar në Senatin e Universitetit Epoka në përmbushjen

të kërkesave për gradën Master i Nivelit të Dytë

RENIA E SHKEMBINJVE DHE LLOGARITJA E RREZIKUT

NE ZONEN URBANE TE QYTETIT TE BERATIT (MANGALEM)

Fiqiret MUHJA

Janar 2014

Kryetar : Asistent Profesor Doktor Ylber MUCEKU

Fakulteti : Fakulteti i Arkitekturës dhe Inxhinierisë

Abstrakti

Renia e shkembinjve dhe llogaritja e rrezikut kërkon shumë profesionalizëm në inxhinirinë e shkëmbinjëve dhe të dherave.

Renia e shkembinjve dhe llogaritja e rrezikut kanë pikëpamje të ndryshme, që struktura e shkëmbit dhe dherave janë krejtësisht të ndryshme.Vetitë e fortesisë, parimet e deformimit ..etj janë të gjitha të ndryshme.

Kërkimet në terren, testimet laboratorike, analizat janë instrumente jetike për përcaktimin e saktë të parametrave të dhëna për analizën e stabilitetit te shpatit.

Motivet kryesore që bënë realizimin e këtij studimi ishte fenomeni i rrëshqitjes së dherave që shkakton shembjen e masiveve të mëdha të kodrave të qytetit të Beratit.

Ky fenomen ka sjellë dëme të mëdha në drejtimin ekonomik të komunitetit dhe në drejtim të ruajtjes së vlerave që kanë ndërtimet e vjetra mbi këto kodra, të rujtjes së konfiguracionit të terrenit, të ruajtjes së peisazhit.

Zhvillimi ekonomik që ka marrë qyteti i Beratit, këto vitet e fundit, ka sjellë edhe një rrezik tjetër për qëndrueshmërine e këtyre kodrave, siç është sektori i ndërtimit .

Ndërtimet e shumta, të pa studiuara nga ana gjeoteknike dhe me mungesë te planit urbanistik, ka sjëllë shpejtimin e erodimit të ketyre kodrave, rritjen e shkallës së paqëndrueshmërisë, si rrjedhim dëmtime të pallogaritshme jo vetëm në kuadrin ekonomik të qytetarëve, por edhe në kuadrin e zhvillimit të turizmit në këtë territor, aq të nevojshëm për jetën e një qyteti turistik si Beratit.

Acknowledgements

I take this opportunity to express my gratitude to the people who have been instrumental in the successful completion of this project. I would like to show my greatest appreciation to Assistant Professor Doctor Ylber MUCEKU. I can't say thank you enough for his tremendous support and help. Without his encouragement and guidance this project would not have materialized. The guidance and support received from all the members who contributed and who are contributing to this project, was vital for the success of the project. I am grateful for their constant support and help.

I would also like to acknowledge the contributions to friends Mr. Erban Hoxha and Mr. Erald Kullau for their help, support in a number of ways during the period of completing this project.

Fiqiret MUHJA

Declaration

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at EPOKA University or other institutions.

FIQIRET MUHJA

Date:

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List of abbreviations

[WL] Upper limit of plasticity

[Wp] Lower limit of plasticity

[Ip] Plasticity index

[Wn] Natural water content (ASTM D 2216)

[C] Cohesion (ASTM D 2166)

[φ] Internal friction angle (ASTM D 2166)

[E] Deformations module of compressibility

[E1-3] Deformation module

[Wn] Natural humidity

[Ik] Consistency index

[Ic] Consistency

[γo] Specific weight

[γ] Natural volume weight

[γsk] Volume weight of frame

[n] Porosity

[e] Porosity coefficient

[Qh] The quaternary deposits

[N] Neogene deposits

[N13] Messinian deposits

[N12t] Tortonian deposits

[N21 h] Helmas – Pliocen formation

[N22rr] Molasses deposits

[Ms] Magnitude of earthquake

[Io] Intensity of earthquake

[Q4] Deposits of eluvial-deluvial slopes

[N12h] Molasses deposits of lower Pliocene

[N31m] Messinian molasses deposits

[Ψ] Suction

[a] Curve fitting parameter

[S_r] Degree of saturation,

[k_W] Calculated conductivity for a specified water content or negative pore water pressure (m/s)

[k_S] Measured saturated conductivity (m/s)

[Θs] Volumetric water content

[e] Natural number 2.71828

[Y] Dummy variable of integration representing the logarithm of negative

[i] Interval between the ranges of j to N

[J] Least negative pore-water pressure to be described by the final function

[N] Maximum negative pore-water pressure to be described by the final function

[Ψ] Suction corresponding to the interval

[Θ'] First derivative of the equation

[H] Total head

[U] Pore-water pressure

[γ_w] Unit weight of water

[Y] Elevation

[Δt] Time increment

[H1] Head at end of time increment

CHAPTER 1

1 INTRODUCTION

1.1 Background

Geotechnical engineering has noticed an evolution in rock fall analysis but, this evolution has been very closely followed by developments in soil mechanics and even in the rock mechanics as a whole too. The evolution of these falls seems to occur naturally but, there is a possibility that it might have occurred by humans too. When humans or even nature ruptures the balance that the natural rock falls have, the rock fall problems emerge.

These analysis get evaluated for the only reason that these may be a problem that it happen to humans even that they may be one of the ones that cause these problems, but it may take even lives if in one construction all the needed analysis are not evaluated in the right way [1]. Specialty construction techniques, used and modeled in a realistic point of view are involved in slope stabilization methods. In order that the principles of rock fall to be applied in a proper way, understanding geology, hydrology and even rock properties is a central point. Representing analyses should be based on a model of site subsurface conditions, applied loads and ground behavior.

In order to assess the results of analyses acceptable risks or safety factors must be judged (Abramson et al., 2001). Among many natural hazards, rock falls are very frequent in mountain areas. The word “rock falls” is usually used to describe small phenomena, from block falls of a few m3 up to 10 000m3 events. “Rockslides” often involve more than 100 000m3 and “rock avalanches” can reach several million cubic meters. In the following text, we will only use the word “rock falls” without any volume distinction. Rock falls are always rapid phenomena, difficult to predict without any extensive instrumentation [2]. Since more urbanization is developing in rock fall prone areas, there is a growing need for hazard assessment. As for landslides, floods, earthquakes or volcanic eruptions, evaluating rock fall hazard means estimating the location, size and probability of occurrence in a given time period of potential events, and then their propagation. The risk evaluation also includes the potential impact on vulnerable infrastructures. The propagation processes have been extensively studied and many models are available. Here we focus on the occurrence of the phenomena in the space and time domains. 1) The location and size of potential rock falls are mainly dictated by the geometrical patterns and geotechnical properties of the rock mass, with the strongest influence of existing discontinuities [3]. Detailed field work based on geotechnical and expert analysis leads to the characterization of some specific instabilities.

1.2 Scope of studying

As we know geotechnical factors are divided in positive and negative ones, and this thesis aims to analyze exactly negative ones. The main aim is to make known the rock fall risks and all the factors that affect the old houses built in the years before the cement was invented and the houses are built from stones and mud, which by studying these factors will give us parameters for the implementation of the chosen building.

Another reason why studying this project is that it aims to improve not only the recreational values of the area but also the constructional ones even to make it known to all the geological characteristics which are special of their kind in this part of Albania. Taking into consideration the importance of the area, is a very special one regarding to the standpoint of values and resources. Recently, when a regional strategy for urban development is missing, and a need is accumulated over the years, the area is a place that has one of the biggest cultural houses that are constructed in the past, and for Albania it represents a very important point for its culture.

CHAPTER 2

2 METHODOLOGY

2.1 Literature review

“A rock fall is a detached fragment of rock (a block) that falls along a vertical or sub-vertical cliff, proceeds down slope by bouncing and flying along ballistic trajectories or by rolling on talus or debris slopes” [4]. So the rock fall is nothing else but a detached fragment of rock that falls from mother rock, the problem doesn’t stay at the moment that the rocks fall, because this is something that we can’t predict, but the problem stays at the moment after this fragment is detached and where it will go, and what will happen at the place where it has stopped. Among many natural hazards, rock falls are very frequent in mountain areas. The word “rock falls” is usually used to describe small phenomena, from block falls of a few m^3 up to 10 000m^3 events [5]. “Rockslides” often involve more than 100 000m^3 and “rock avalanches” can reach several million cubic meters. In the following text, we will only use the word “rock falls” without any volume distinction. Rock falls are always rapid phenomena, difficult to predict without any extensive instrumentation [6]. Since more urbanization is developing in rock fall prone areas, there is a growing need for hazard assessment. As for landslides, floods, earthquakes or volcanic eruptions, evaluating rock fall hazard means estimating the location, size and probability of occurrence in a given time period of potential events, and then their propagation. The risk evaluation also includes the potential impact on vulnerable infrastructures [7]. The propagation processes have been extensively studied and many models are available. Here we focus on the occurrence of the phenomena in the space and time domains. 1) The location and size of potential rock falls are mainly dictated by the geometrical patterns and geotechnical properties of the rock mass, with the strongest influence of existing discontinuities. Detailed field work based on geotechnical and expert analysis leads to the characterization of some specific instabilities.

At the place that these part of rock has stopped it might catch a lot of problems in the buildings of the town, but also in the human lives activity, because it might leave them out by causing to them a lot of material damages, but also it might take their lives if they aren't aware at the moment when the rock falls (Figure 1).

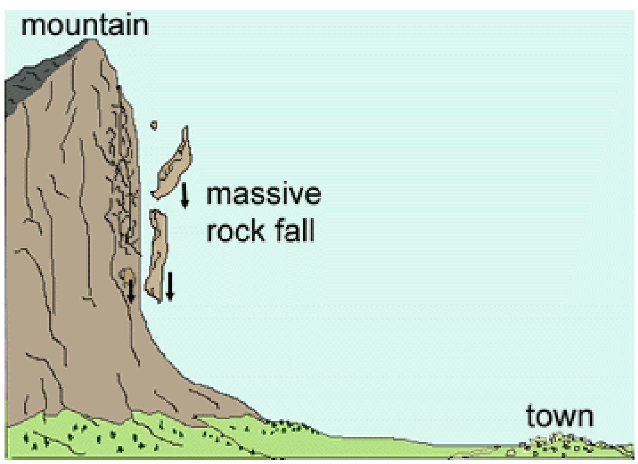

Figure 1.Rockfall inteisty of Berat Magalen, [8]

Rock falls are generally initiated by some climatic or biological events that causes a change in the forces acting on a rock. These events may include pore pressure increases due to rainfall infiltration, erosion of surrounding material during heavy rain storms, freeze-thaw processes in cold climates, chemical degradation or weathering of the rock, root growth or leverage by roots moving in high winds, poor drainage system, unstable hills, unconsolidated hilly slopes, no protection from the falling rocks, soft composition of rocks[9]. One of the causes was the pore pressure due to rainfall infiltration, if we see the table of the rainfalls of the city of Berat (Magalen) in the period 1990 to 2009 (Figure 3).

2.2 Mechanics of rockfalls

Rockfalls are generally initiated by some climatic or biological event that causes a change in the forces acting on a rock[10]. These events may include pore pressure increases due to rainfall infiltration, erosion of surrounding material during heavy rain storms, freeze-thaw processes in cold climates, chemical degradation or weathering of the rock, root growth or leverage by roots moving in high winds. In an active construction environment, the potential for mechanical initiation of a rock fall will probably be one or two orders of magnitude higher than the climatic and biological initiating events described above.

Once movement of a rock perched on the top of a slope has been initiated, the most important factor controlling its fall trajectory is the geometry of the slope. In particular, dip slope faces, such as those created by the sheet joints in granites, are important because they impart a horizontal component to the path taken by a rock after it bounces on the slope or rolls off the slope [11]. The most dangerous of these surfaces act as ‘skijumps’ and impart a high horizontal velocity to the falling rock, causing it to bounce a long way out from the toe of the slope.

2.3 Possible measures which could be taken to reduce rock fall hazards

2.3.1 Identification of potential rock fall problems

It is neither possible nor practical to detect all potential rock fall hazards by any techniques currently in use in rock engineering. In some cases, for example, when dealing with boulders on the top of slopes, the rock fall hazards are obvious [12]. However, the most dangerous types of rock failure occur when a block is suddenly released from an apparently sound face by relatively small deformations in the surrounding rock mass. This can occur when the forces acting across discontinuity planes, which isolate a block from its neighbors, change as a result of water pressures in the discontinuities or a reduction of the shear strength of these planes because of long term deterioration due to weathering [13]. This release of 'key blocks' can sometimes precipitate rock falls of significant size or, in extreme cases, large scale slope failures (Figure 2).

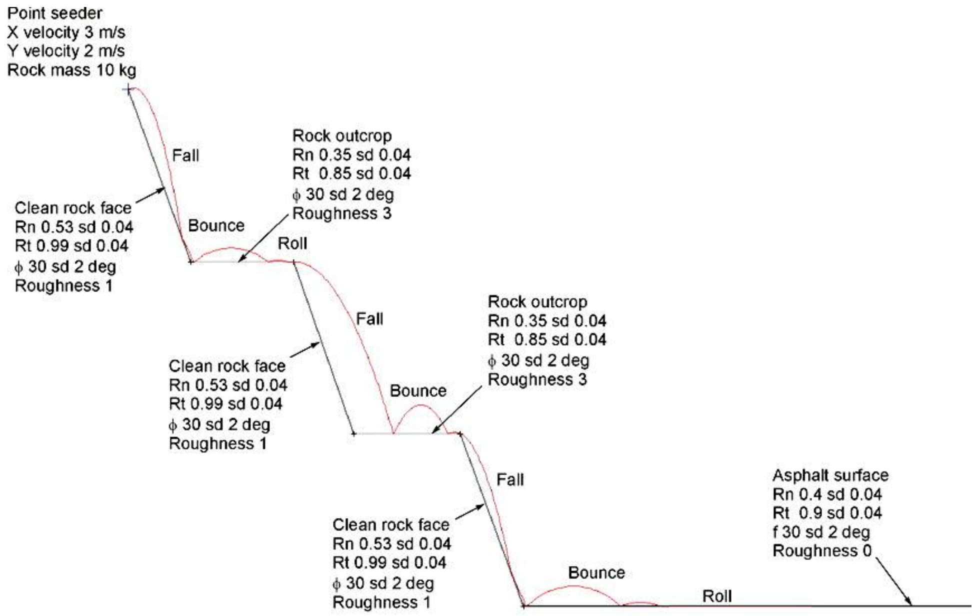

Figure 2. Trajectories for a one hundred 10 kg rocks falling on a slope with two benches [14]

We will see that the rain falls in areal rain period it goes up to 100 mm autumn and winter, below 50 mm in the summer time. Even the climate also in our area of study plays a role in the rock fall phenomena, because as it is shown in the table it shows that the summer is relatively hot and the winter is cold with temperatures that goes from 25°C and more in the summer and 0°C and less in the winter, so these table makes us known that the problem in the freeze-thaw processes in the climate causes the rock fall (Figure 3).

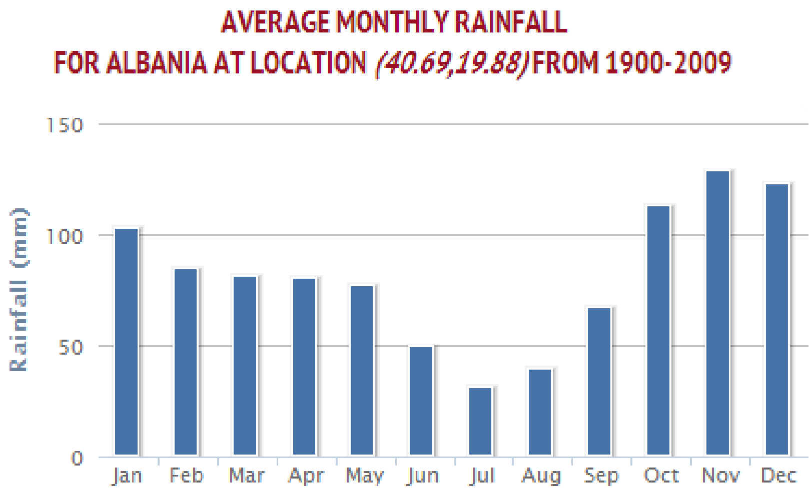

Figure 3.Rainfall Intensity of Berat, Magalen 1990-2009

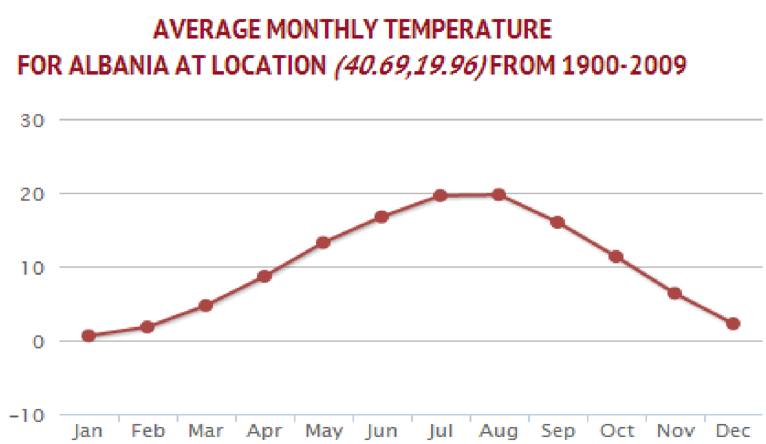

Figure 4.Temperatures of Berat, Magalen 1990-2009

One of the problems that might cause the rock fall was also root growth or moving in high wind, if we see the (Figure 4), we may arrive to these conclusion and we may also add that really it is a big problem and that the people and the state should take the needed preoccupation that is granted by law (Figure 5).

Figure 5.Root growth on the mountain near to Mangalem

Erosion on the rocks happens for the only reason of the heavy rains that fall in Berat (Mangalem) us we saw upstairs at the table given for the areal raining, also the other thing that causes erosion is even the poor drainage system that the mountain near to the area has, and this is shown even in the (Figure 6) below.

Figure 6.Erosion and poor drainage system in the mountains of Berati

The other thing that it preoccupies us is even the protections that should be prevented by the state for the rock falls, that it doesn't ask for a lot of funds to do it, because it is something very simple and it really grows the security for the persons that pass in the road that it is near to the mountain where the rock fall phenomena it happens most. If we see the table it is something that it should preoccupies us, because from Monday to Friday there passes approximately 350 persons/day and in the Saturday and Sunday there passes approximately 500persons/day, so a lot of human lives may be in danger (Table 1).

Table 1.Persons/Day for one month [15]

August 2013														
	WEEK 1				WEEK 2				WEEK 3				WEEK 4	
Day	Persons	Average		Day	Persons	Average		Day	Persons	Average		Day	Persons	Average
Monday	290			Monday	287			Monday	250			Monday	294	
Tuesday	310			Tuesday	306			Tuesday	243			Tuesday	302	
Wendesday	304			Wendesday	318			Wendesday	305			Wendesday	321	
Thrusday	298			Thrusday	300			Thrusday	267			Thrusday	317	
Friday	312			Friday	302			Friday	320			Friday	289	
Saturday	470			Saturday	496			Saturday	433			Saturday	499	
Sunday	503			Sunday	513			Sunday	536			Sunday	539	
Total	2487	355.3		Total	2522	360.3		Total	2354	336.3		Total	2561	365.9
							ΣTot=9924							
							Σavg=354.5							

If we use the fences for the protection that prevent the falling of the rocks from the mountain, that is something simple. This protection may occur in different ways like, fences etc. One of the ways is the, simple drapery fence, barrier catch fence (Figure 7, 8).

Figure 7.Simple Drapery Fence

Figure 8.Barrier Catch Fence [16]

If we use these kind of protections we will see that when the peoples will pass at the road they will feel more sure, even that in our area of study the peoples of the city if they want to go the cities that are north to it they don't have other road then passing to the road near to the mountain when the rock fall is more higher. The most common problem that it cannot be solved is the geology of the mountain that there is nothing that a person can do about it, and if we see the geological map of the Berat (Mangalem) for the rock falls we will see that it is very unstable (Figure 9).

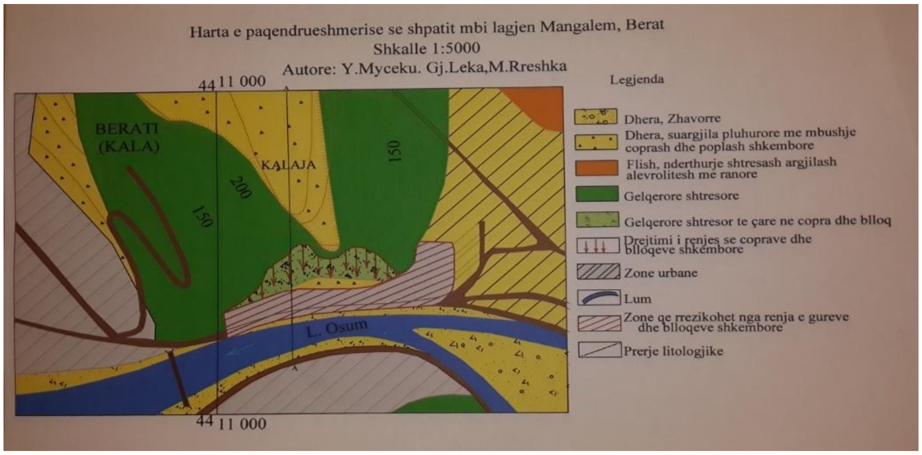

Figure 9.Rock unstability in the Berat, Mangalem Scale 1:5000 [17]

In an active construction environment, the potential for mechanical initiation of a rock fall will probably be one or two orders of magnitude higher than the climatic and biological initiating events described above. Once movement of a rock perched on the top of a slope has been initiated, the most important factor controlling its fall trajectory is the geometry of the slope. In particular, dip slope faces, such as those created by the sheet joints in granites, are important because they impart a horizontal component to the path taken by a rock after it bounces on the slope or rolls off the slope. The most dangerous of these surfaces act as 'ski-jumps' and impart a high horizontal velocity to the falling rock, causing it to bounce a long way out from the toe of the slope. There is no universal standardized procedure for rock mass characterization because each site is different (Figure 10).

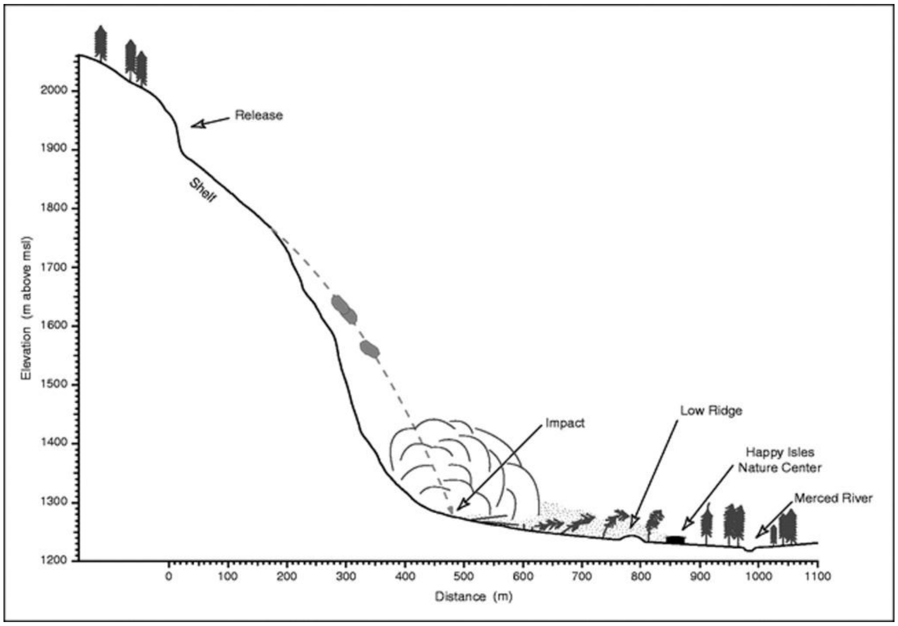

Figure 10.The way that a rock follows to fall [18]

Generally, however, this can be done by mapping of exposed rock masses (e.g. Starr et al, 1981) and carrying out of subsurface ground investigation, including the use of downhole measurement techniques such as the impression packer test and televiewer [19]. Zoning of the rock mass into areas of similar engineering behavior may be necessary according to rock type, weathering, structural domain and density of fractures.

The geometry of the fractured rock mass and the shear strength of discontinuities are assessed with reference to the basic discontinuity parameters, [20] provides guidance on the description of discontinuities; more detailed information is given in International Society for Rock Mechanics (1978). Orientation relative to the free, allowing block movement through sliding, toppling or free fall, is the most important meter controlling rock fall. Even though there aren't a lot of scientific ways to stop this phenomenon, there is one simple way that can be used for this kind of problem and that is by putting protective walls in the lower part of the mountain, or the other methods that are mentioned above, but also for the cities or villages that are built near to the mountain this method can be used to.

On the other hand rock falls and topples can occur both in natural and artificial slopes and their frequency, magnitude and location are very difficult to be predicted because of their small size and limited precursors. Furthermore, rock falls occur in very steep slopes, therefore they are very difficult to be investigated and, as a consequence, stabilized. In the case of inaccessible cliffs, innovative remote sensing techniques represent the only available solution for the analysis and the monitoring of rock falls. For instance, the geo-mechanical investigation of rock scarps, which is considered a key step in the identification of susceptible areas or jointed blocks, can be supported by the use of Terrestrial or aerial Photogrammetric and LiDAR. By such a methodology, "potentially unstable" blocks can be identified by looking at their predisposing factors, like thermal stresses on open cracks. Some studies demonstrated that one of the main triggering factors is the water infiltration into cracks, and its subsequent freezing [21], and the temperature cycles (although causing lower magnitude widening). However, no information can be gained on the state of activity of potentially unstable blocks without a suitable monitoring of displacements. Conventional techniques (e.g. extensometers), can be used only for the monitoring of single (and already detected) unstable blocks; hence, they cannot be used as a tool for susceptibility analysis.

Our country Albania is considered as a hilly-mountain country. So here since our relief is mostly hilly-mountain there of course will happen rock falls but also landslides happen too. These two problems always indicate in the construction of the place as we have stated in the pages before, and also we have tried to take our protective masses even though those aren't much specified as everywhere around the world, but always we are trying to get new protective masses for this kind of phenomena. We are a country that it is being developed day by day and so a lot of new constructions are being constructed and will be constructed, even in our area of study that is an area that plays a big role in the culture of our country. But by having this kind of problem that we face in Albania in the place where the construction will be constructed a lot of economical and human lives may be risk. So, being such a country the need of building cities and mega construction objects is necessary to make studies regarding to rock fall and landslides.

Muceku Y. has revealed some studies made regarding the area of Berat (2000, 2003, and 2011).The present classification of landslide in Albania [20]:

- The development of hydropower plants in weather bedrocks and overburden beds of instable slopes and intensive landslides.
- Oligocene flysch formation gave grouth to instable slopes and intensive landslides.

- The loosing of Quarternary deposits developed landslides.
- Downfalls in weathered rocks.

2.4 Field work

Obtaining the engineering geology map of Magalen in Berat city made us observe every part of the studies in the terrain. Then, we started to draw the georisk zone map. Soil samples from different boreholes are taken from different areas in different depths. Each of the soil samples characterizes part of the area. Also during the field work are done several investigation in terrain related to:

- Lithological properties of area
- Assesment of area gemorphology
- Crack assesment
- Assesment of rock mass

2.5 Laboratory work

We analyzed the soil samples in the laboratory by hereunder experimental tests:

- Uniaxial compress strength
- Bulk density
- Specific gravity
- Water content

- Wethering

Then, after performing these tests in laboratory, the geotechnical properties of the building area were defined. Taking as the bases these results we draw some lithological profiles.

CHAPTER 3

3 PHYSICAL-GEOGRAPHICAL FEATURES OF ZONE

3.1 Geographical position

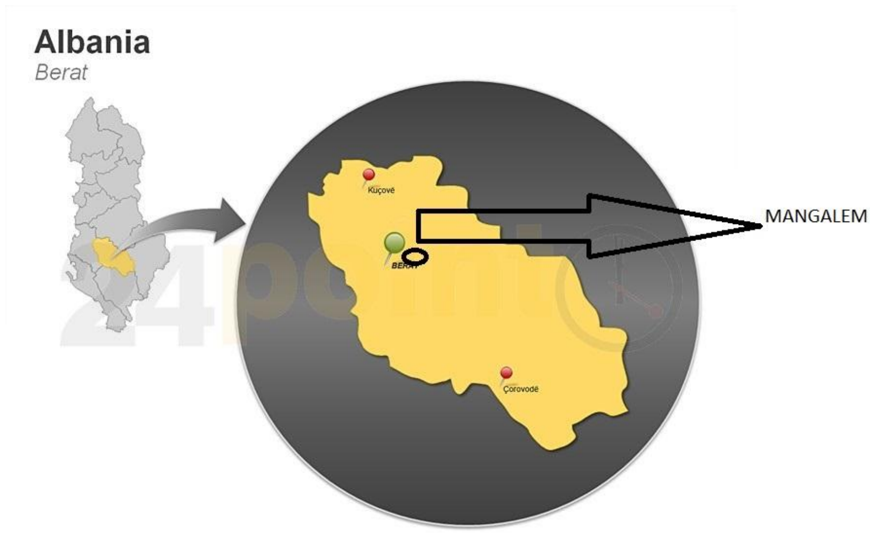

Figure 11.Study area Berat, Mangalem (Muceku, 2010)

Berat, just like in the past and even nowadays, plays an important role regarding to the economic life of the country. This role is conditioned by population, density, natural resources etc... It is bounded by Lushnja in the north, Polican in the south, Vlora in the west and Korca in the East (Figure 11).

3.2 Physical geographical characteristics

Berat part it begins from Lushnje and Elbasan in the north ending in Skrapar in the south. The plain is traversed by the Osumi River, flowing to Adriatic Sea but, before that passing through the plains. Swamps and marshes are formed by its frequent floods. Berat flow has a very low altitude above the sea level. It's major having an altitude of 0.7 – 2.0 m. This plain is mostly formed by the solid materials which are accumulated from the streams of river Osum. Alongside it we have a territory which is part of the hilly-morphological area named "Shpirag". In the west part of it hills are separated. They seem to have a lower height in general.

3.3 Natural conditions

3.3.1 Climatic Features

Being affected by the Adriatic Sea climate, and having before it a low-lying or flat syncline like that one of Myzeqe and some hills around Berat makes possible its protection by the continental winds. But, the sea still has a great influence on Berat's climate with the tropical and polar air masses. Latitude, being the fundamental factor of climate formation the activity of this factor is quiet low. As the whole lowland has a latitude of 2°, this factor's activity is very low. The Adriatic's influence is above the absolute minimums which begin to increase from coat to inland. January is the coldest period of the year in Berat. Its average temperature consists of a range of 5° C. During the summer and mid-year period is affected by warm, compared to other parts of the country. Below zero, the temperatures are rare.

Winds are typical elements of these areas. In the lowland the wind's direction changes frequently. Regularity is noticed regarding to the winds in the southern part of Berat due to the influence that Tomorr Mountain has over the region.

As for the rainfall, in the lowland it undergoes regularly during all the year with few summer exceptions. By analyzing the height of the rainfall in the lowland region we conclude that they seem to have an increasing tendency from west to east. Cold half of the year is seen by large amounts of rainfall, whereas; the warm half of the year is seen with little amount of rainfall.

3.3.2 Relief

Relief of Berat seems to be somehow a mixed one. Being surrounded by the hills and having a plain part in the center of Berat, makes its relief somehow diverse. The Myzeqe plain and the streams of Osumi River are deposited in the **coastal lands**. Erosion has played a major role regarding to relief. Especially in morphological processes of the hilly parts of Berat. Despite of their genesis, all the types of reliefs are tightly connected with erosion. Also, many water networks are created due to the fact of the diversity of the rocks. This geodynamic phenomena has made possible the comprising of many natural hazards. Recalling once again, the hills and the Myzeqe plain, play a huge role in defining Berat's relief.

3.3.3 Hydrology

Water resources are a huge natural wealth to Berat. Many fountains flowing round the boundaries of Berat. The territory of Berat has many developed natural water. But, elements of hydrology are not only rivers, or streams, or canyons, but also the artificial reservoirs and the irrigation system. The last two ones are built during the communism era that ruled in Albania for almost 45 years. Even nowadays these systems are well known as they still are used nowadays.

Osumi River is the main water source for Berat. There are found a few artificial reservoirs in the region of "Uznova" and also a very good irrigation system. The canyon of Berat is well-known and used a lot by the outlanders especially. As for the other fountains we can mention that one of "Bogova" and the one which flows from the Tomorr Mountain. They are both being the basis which makes possible the distribution of clean water in the entire Berat region.

Rainfall is also an important factor to mention regarding to hydrology. The autumn and winter season, respectively November and December are the months with the largest rainfalls. 24-36% of annual rainfall and 12-14% of annual rainfall respectively.

CHAPTER 4

4 GEOMORPHOLOGIC, GEOLOGIC AND HYDRO-GEOLOGICAL CHARACTERISTICS OF BERAT (MANGALEM) REGION

4.1 Geomorphology

High tectonic, seismic and human activities characterize lowland line of Albania. The major geological hazards are found to be, erosion, demolition, water pollution etc... Factors like, geo-natural, lithological, hydrogeological and geodynamic are studied on geo-engineering properties of soils and rocks. All these factors will be seen in this chapter. This area is divided into two units being them: field of morphological unit and hilly morphological unit (Figure 12).

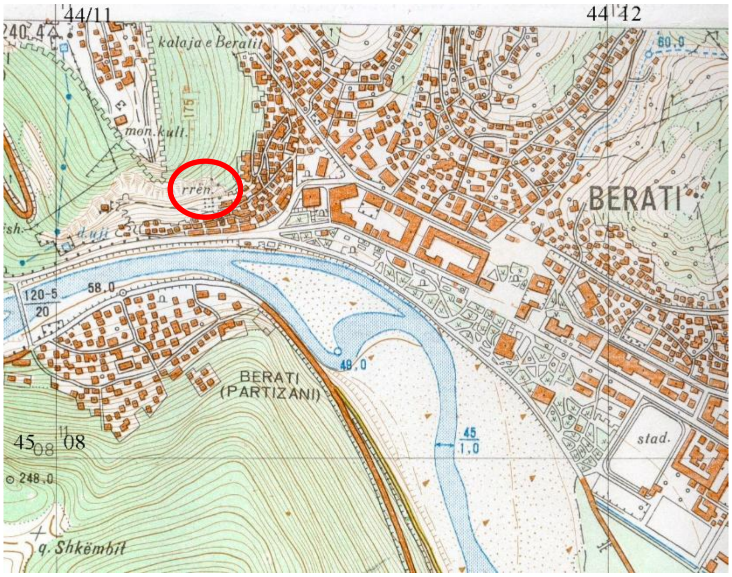

Figure 12.Representation of study area [23]

4.2 Hilly morphological unit

Hilly part of Berat, are in large numbers as they seem to surround the entire Berat region. They track down the entire geological structure. Even in the hilly morphological unit we can see a mixture of positive and negative shapes. Numerous hills are separated by various transverse and longitudinal valleys and saddlebacks, deep and shallow and followed by large and small streams. The average height of these hills derives from 130-140 m. Here we can mention the Uznova hill, which starts from 123m up to 321 m and moving on with hills like Vodica, or Gorica.

By geological surveying - perform engineering field have concluded that we are dealing with non-uniform sloping slopes, ie. Slopes do not have the same slope slopes rays until the ridge. As known, this type slopes divided into two subtypes, which spread to both find the study area. The first subtype of irregular slope slope is he who when his radiation up to a certain altitude has subvertikale vertical slopes to the knife, drop the angle Pla 850, and in terms of higher quotas to ridge, 350 sloping cliff continues (Figure 13).

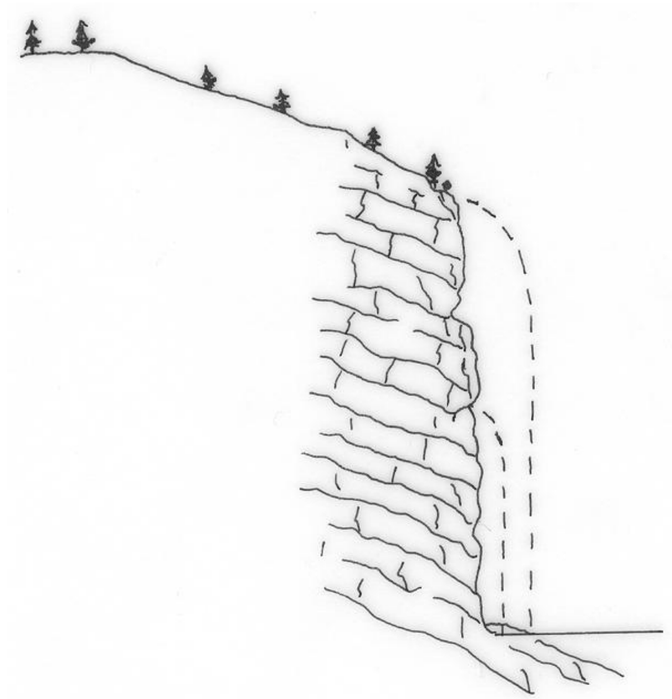

Figure 13. First type of non-uniform slope scheme

The second subtype of non-uniform slope, which finds dissemination in the study area, is that tip which slopes from the foot of the slope of up to a certain height with the angle 35^0 to 65^0, and further, to the ridge with whom over 85^0 (Figure 14).

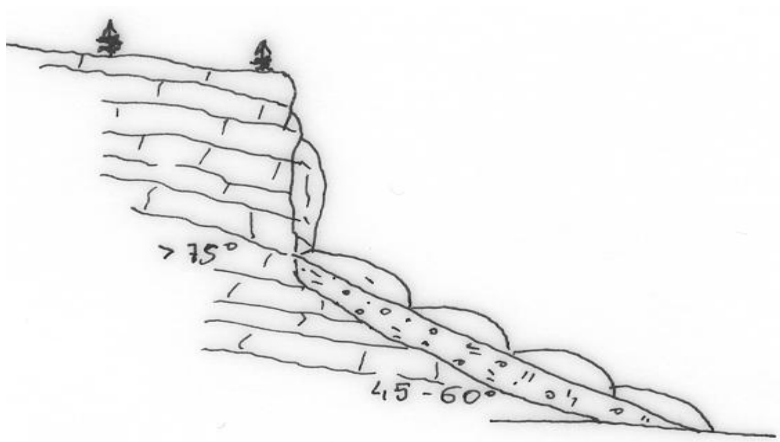

Figure 14. Second type of non-uniform slope scheme

4.2.1 Morphological Unit No.1

Situated between engineering facilities (national road and neighborhood dwellings “Mangalem ") and part of the bluff. Part of its terminal, near the main road, the apartment is occupied with the neighborhood “Mangalem”, which are characteristic of this neighborhood apartment 2-3 floors.

This unit has three angular shape of a triangle, extending 2 brinjenjeshem with great base located on the lower quotas slope to the banks of the River Osumi . The side of the base has length 300 m and the level of quotas Osumi River 52.0 to 53.5 m above sea level. But two other ribs expect elevation lines , more or less in contact with the unit morphological No.1 No.2 morphological unit , joining both together at the height of this triangle , which is the culmination of a stream bed slope separates in two parts (east and west) , the quota 150 m above sea level . Removed from the roof height of the triangle formed by that morphological unit No.1, to base Osumi River, has a length of about 150 m.

No morphological unit. 1 traversed across from a ravine, which has its origins from down the walls of the castle and after permeates the three morphological units, the Osumi River flows into the ravine. Water regime of this ravine appears more ambiguous and unstable. Dry time without precipitation, in total groundwater flow lacks surface and the opposite happens in time of rainfall, where it collects water that have great power to transport material copepod.

Direction of flow waters of this ravine is south - southeast. This morphological unit’s ravine divides into two parts: the eastern and the western part (Figure 15).

Figure 15. Torrent bed that separates the two parts of morphological unit

The eastern part of the morphological unit No.1, is more complicated, as a result of the presence in the form of a nose lifter, which is located about 20 m from the bed of the stream eastward. This morphological increase in this part of the morphological unit No.1, has decline toward the north for the south and near the housing decline slope from 40 to 50^0, has decreased by vertical. The rest of this slope has decreased mainly south - southeast at angles from 40 to 50^0 (Figure 16).

Figure 16. Images from the eastern part of the morphological unit

The western part of the morphological unit No. 1, is developing uniform and smaller dwellings. Fall is mainly its southern angles from 40 to 550, then the steep eastern portion of this morphological unit. The entire slope that constitutes morphological No.1 unit is forested, mostly with bushes with fruit trees planted by residents. Morphological relations unit No.2 No.1 with morphological unit, are the immediate cutting. Terrain from declines with angles from 40 to 550, passes immediately to falling angles over 85^0 (Figure 17).

Figure 17. Morphological transition from unit to unit no.1 morphological

Morphological Unit No. 2 is located between two other units represented by morphological and slopes to slopes with decline. This unit has the form of a half arch, which is divided into two parts by the dry coulee mentioned above, in the eastern part of the western part. The eastern part of the morphological unit, starts from the middle of the neighborhood Mangalem and continues west to the stream bed. This part has decreased toward the south - southwest and elevation units from contact with morphological unit no. 1 to ridge ranges from 20 m to 55 m (Figure 18).

Figure 18. View of the eastern portion of the morphological unit

The western part of the morphological unit No. 2, starts from the bed of the stream and continues up to the national road, near the tunnels. This part has stretch northeast - southwest and southeast toward decline. Its quota elevation is 20-40 m (Figure 19).

Figure 19. View of the western part of the morphological unit

Morphological Unit No.3 Even this unit is divided into two parts, which are not only not related to each other, but also have elements of morphological morphometric otherwise. Its division into two parts, east and west, makes the southern tip of Castle survey. The eastern part of the morphological unit no. 3 (see topographic map), placed on morphological unit No.2 was not organically linked with. This has decreased the eastern part angles less than 350 and starting from about 30 m from the ridge beyond, it is forested with pines high. While the western part of the morphological unit no. 3 is the continuation of the steep part of the morphological unit No. 2, while maintaining the direction of the fall of the slope (southeast), but the slope angle of the fall, that when running no.2 morphological unit until we crest the hill has values angle of fall from 35 to 500. Maximum quota value of this slope is 220 m above sea level. This slope is partly forested with pine low bushes and partly undressed.

4.3 Geological structure

The region which is studies is included in the Adriatic tectonic zone. It is strange but, the Adriatic tectonic zone is very large. They spread in the northwest-southeast direction. The peak creation is determined by anticline structures from hilly ranges. Also an abrasive marine line is created too. The following rocky formations participate in the geological construction of the territory (Figure 11):

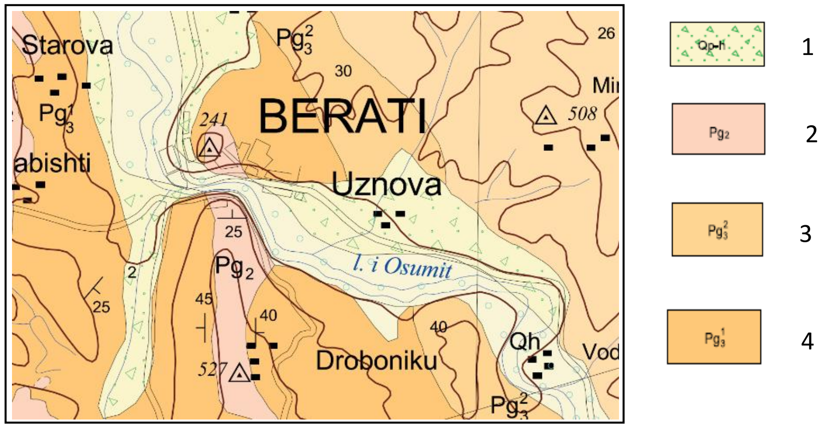

Figure 20. Quaternary deposits, alluvial and diluvium soils, 2. Eocene deposits-limestone, 3 and 4. Lower-Medium Oligocene deposits-Flysch rocks, [24]

- Eocen

Limestone biome critic and turbid critic with clayey- sandy flysch conglomerate of limestone.

- Paleocene

Mainly limestone turbidities horizons subsidence in the Jonian zone, limestone biomicro and flysch and stone-clay with conglomerate of horizons subsidence in Krasta zone.

- Permian-lower triassic

Conglomerate and reddish sandstone.

- Uppers jurasic

Siliceous, apoka, trepele, clay, shale and limestone.

Rocky foundation of the entire study area, represented by Eocene limestone (Pg2). These limestones are organogjeno - copezore, containing crystalline pelitomorfe strajesh konkrecionesh shaped reddish color .From the lithological point of view they are described as:

Organogjeno limestone - the gray coprizore have blown in Beige and mikroforaminifere are rich. Coprizat millimeter in size up to 3-4 cm, qoshore forms or semi- rounded.

Crystalline limestone are thin layer of bright white color .Pelitomorfe limestone are 7-15 cm thick layer with white color in Beige, with visually distinct fauna. These predominate in cutting .From the structural point of view, the study area, the Eocene limestone form an anticline lying about, which is the axis of extension direction South - North. In the center of the anticline has operated a vertical lifting force, the center of which coincides with the dry stream bed , which has led to an area of approximately 70 m limestone and undergo mikrorrudhosje small breakaway by local mikrotektonikave .

Eastern flank of the anticline constructed from crystalline limestone tiles, pelitomorfe thickness from several cm to 30 cm. In any event, the layers appear to 2.0 m thick, limestone ridge that the eastern bluff. These limestones have elements fall:

Az. Decreasing angle = 750 and 500 declining. Limestone systems are affected by cracks which we grouped into three types:

a) - the first type Cleavages placed by lining . Kane opening of 3-5 mm up to 2-3 cm . These cracks , fill with soil near the surface , while in depth they filled with carbonate cement .

- The rift second type are the least developed of the three types of fractures. Elements have decreased: Az. fall 2050 and fall angle 700. In this type of karst phenomena do not develop cracks, the fact that they are opening millimeter (max up to 2 mm). These cracks are placed away from each other every 40 to 60 cm.

c) - The rift the third type Az. stretch = 40-2200 and vertical angle of decrease tendencies in both directions of the fall. Placed away from each - other every 0.7 to 1.2 m. These cracks have openings from several cm to 10 cm and are affected by karst phenomena developed. Filling mechanical - chemical composition of limestone cracks is copezore with carbonate cement. Western flank of anticline built by the same limestone build its east side (Figure 21).

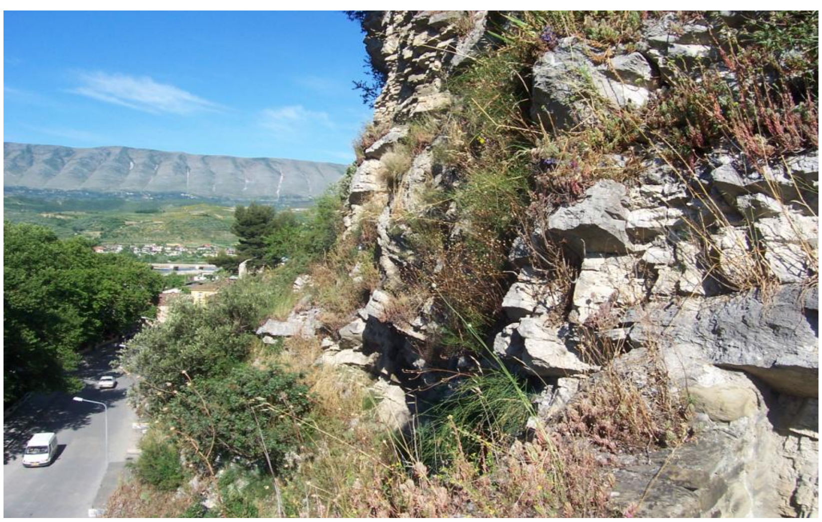

Figure 21. Limestone western side of the anticline

Even these limestone's are affected by rift systems have grouped into three types:

d) - the first type Cleavages fully comply by lining, while maintaining its elements. Kane opening of 2-3 cm to 5 cm. These cracks, in the area of fill material - carbonate, while in depth they filled with carbonate cement.

e) - second type rift in the side of the anticline they are less developed of the three types of fractures. Elements have decreased: Az. 670 falling and 790 declining angle. In this type of karst phenomena do not develop cracks, the fact that they are opening millimeter (max. up to 1 mm). These cracks are placed away from each other every 5 to 10 cm to 40 cm.

f) - The rift third type these cracks have openings from several cm to 10 cm and are affected by karst phenomena developed. Kane AZ. Angle decrease = 1500 and 620 decrease, being related to the elements of the fall of the slope. Placed away from each - other every 0.7 to 1.2 m... Filling mechanical - chemical debris represented by limestone cracks in the corner of the associated altered carbonate cement. We share this material near the surface and mixed with suargjilor.

Anticline axis, which has a width of about 70 m, as a result of the exercise of vertical lifting forces, has suffered mikrorrudhosje limestone layers, making them not represent elements of sustainable downtrend. Mikrorrudhave reach widths of up to several meters and their roofs, often occur even disconnect from several cm to 2 m. All this sector appears more fragmentary and distorted. In most of the space you occupy geomorphological units No. 1 and No. 2, the spread find the slope Quaternary deposits, which are mostly colluvial type of less proluvial. We koluvionet slopes, or brekçiet limestone slope, have a thickness from 0.2 m to 1.5 m. Near the stream bed, koluvionet joining with proluvionet , reach up to 2.0 m thick . The composition of these deposits is the limestone slope. They are unrelated kohezionale, or about kohezionale very weak, if we are found inside the soil suargjilore (usually in developing countries where the vegetation) (Figure 22)

Figure 22. Quaternary colluvial deposits

CHAPTER 5

5 LITHOLOGICAL AND GEOMORPHOLOGIC STRUCTURE OF THE SURVEYED AREA

The study area is extended all around the city of Berat and comprises the hilly morphological unit that starts from the town of Berat to continue southward up to Skrapar. We will elaborate the litho logy, geomorphology and hydrogeology of the area in this chapter.

5.1 Lithological structure

During the field work carried out in the studied area, deposits represented by terrogenous and continental formations were encountered. They have been subject of physical and geological processes in various stages of geodynamic evolution of this region. As we have undertaken to provide solutions to many dilemmas, we are going to treat this chapter on the basis of litho logical concept. So we come across the following elements in the area we are going to perform studies:

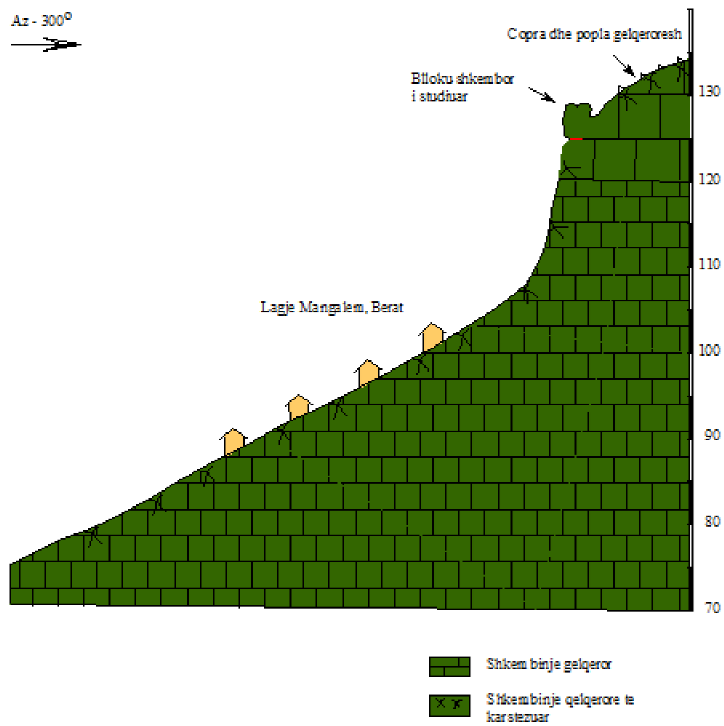

Figure 23.Lithotological profile of Berat, Mangalem

5.1.1 Eluvial - deluvial slopes depositions

Eluvial-deluvial slopes depositions are broadly encountered across slopes, which are made up of limestone rocks and a mixture of clayey and sandy layers mainly represented by clay soils of gray color containing snippets and gravel with thickness ranging from 0.8-5.5 m to 8.0 -10.0 m. It should be mentioned, that the decay crust of limestone rocks known as eluvial deposits beneath deluvial soils is formed. It is developed throughout the hilly slopes in the area of study. The decay crust of limestone rocks in the study area has a thickness ranging from 1.5-2.0 m 3.5-5.0 m. There are always handover interchanges among them as the result of eluvial and deluvial formations. They consist of a mixture of soils with snippets of limestone rocks (sands and conglomerates of tiny grain). In the area if we do a lithological cut of it we will see that the area has even water clay and sand in the part of the river, this all are shown in (Figure 11)

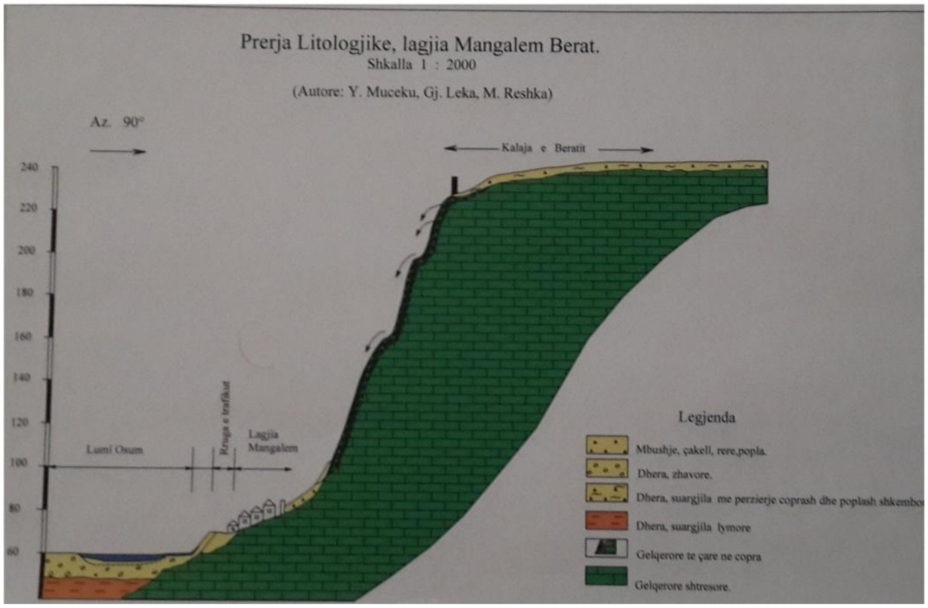

Figure 24.Lithological cut of Berat, Mangalem [25]

It is worth mentioning that in our study these types of formations and the decay crust of molasses rocks have been treated and evaluated in terms of geo-technology.

5.2 Hydrological information

The hydrological structure of the studied area is very reach thanks to the river that passes near to it. The area has considerable ground waters and upper surface waters as it is mentioned the river. The underground water it assembles mostly in the period of rainfalls. The area it has a dry season and these mostly happens in the period of summer when the rainfall intensity is to low and for these reason the underground water and the upper surface water (Osumi River) will not be supplied enough. For the reason that is an alluvial zone the land it doesn't have a good drainage.

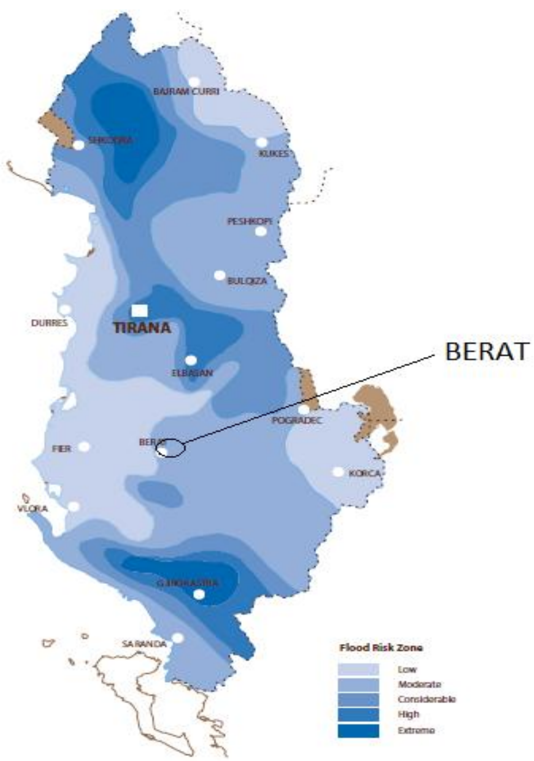

Figure 25.Flood map of Albania in particular Berati [26]

As it is shown even in the map above the floods in Berat (Figure15) are relatively average, even that have and pluvial origin. The Osumi River doesn’t have a big flow, but once in the years 1962-1963 it had a big flow, when it flew in the city and the villages near to it with an area of 30000 ha which got totally under the water of the Osumi River. If we do a cut of the river we will see that it has sand, gravel etc. It also has good geological-structural and geomorphological conditions.

CHAPTER 6

6 GEODYNAMIC PHENOMENA

In this chapter are treated the main Geodynamic phenomena occurring as a result of the physical and geological processes. Except the exogenous processes that occur in the territory of Berat, we are going to analyze the phenomenon of erosion and stability of the slopes. Corrosive activity or running water erosion plays a major role in the destruction and conversion of the land surface in this territory especially during the spring season when the amounts of running water increase.

6.1 Erosion of hilly slopes

Destructive and transporting activity of waters has caused intensive displacement of material from higher places to lower ones, degradation of the surface, filling of reservoirs, irrigation channels and streams etc. Among the key factors affecting the development of water erosion of a country are climate, geological, pedagogical, and geomorphologic conditions (relief and its features) as well as vegetation and human activity. Among the climatic factors, the annual rainfall, their intensity, density, and time of their fall play the decisive role and the regime, size, speed of surface waters flow, including their corrosive power depend on this factor a great deal. In this framework, sensitive imbalances up to

180.0-250.0 m identified in hilly morphological unit of Berat, the slope inclination and continental winds that trigger rainfall, the climate with relatively abundant and rainfall and other factors are causes of the powerful development of water erosion. Erosion is generally being developed in the whole of elevated surface in hilly morphological unit, wherever an imbalance in the relief is created, but it mostly conspicuous in molasses soft rocks and also in moderately strong rocks, in water outflows just like torrents, brooks, streams and rivers (Figure 26).

Figure 26.View from the mountain and the hills

6.2 Geotechnical Classification of Rocks

Rock mass classification, which is a useful tool for rock engineering, was initiated in Europe in 1940s. Terzaghi has proposed nine categories of rock mass associated with rock load on tunnel supports. After long time passes, Q-system (Barton et al.1974), RMR (Bieniawski, 1976), and others were proposed in 1970s, in which the classes are expressed as numerical values like ratings through the research on the relation between rock condition and tunnel support design. The main criteria of the physic-mechanical classification of the rocks where the lithological composition and physic-mechanical properties of them. To merge the rock groups analyzed in the above paragraphs according to the zones had some indicators, such as:

- Conglomerate area
- Siltstone area
- Limestone dolomite

6.3 Conglomerate area

The conglomerate area it is a zone that have even five other types like, marine, fluviatile, estuarine, lacustrine and glacial. In area of study I is found only fluvialite (Figure 27).

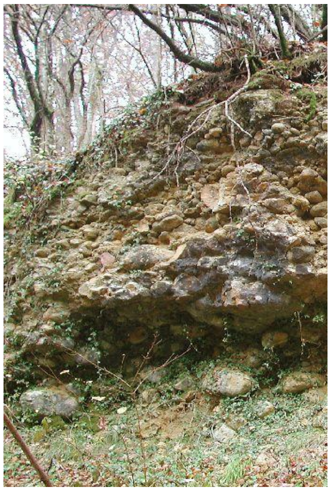 

Figure 27.Conglomerate rock and flysch rock

6.4 Siltstone area

It is slightly weathered, it has a blue-grey color and it is extremely (Figure 28).

Figure 28.View from siltstone mountain

6.5 Limestone area

Limestone is an organic, sedimentary rock. This means it was formed from the remains of tiny shells and micro-skeletons deposited on the sea bed. They were compressed to form solid rock. Limestone is made up of calcium carbonate and reacts with diluted hydrochloric acid. Limestone is formed in layers - called bedding planes. These bedding planes contain vertical cracks called joints. Joints and bedding planes make the rock permeable. In area of studding we have mostly dolomite limestone (Figure 29).

Figure 29.Dolomite limestone

6.6 Safeguards against geodynamic phenomena

Currently, the study area, are some of the measures taken and the partial function to be protected by the phenomenon of the fall of stones around the slope (topofrafike map marked with yellow). These existing measures are addressed in part by protecting only the phenomena of local risk, without taking into account the slope in its entirety.

Mangalem apartments above the neighborhood, once a place called “rock dependent “protective measures are applied to the cable connection. Before 5 years these cable are removed because of their depreciation and protection against fall of stones in this sector was made with concrete retaining walls. Also in morphological unit no.1, between housing and in the upper part of their bottom, retaining walls were built local (map with yellow). Interference with powerful container walls is done in the western part of the study area on the national road. This wall has a length of about 60 m thick and 1.2 m height above ground level 6 m. between it and the rocky slope was left an empty space horizontal width 8 m. From local and world experience, geodynamic phenomena protective measures against the fall of stones around the slope, based on the purpose they have, protective measures are divided into active and passive protective measures. Active protective measures intended to stabilize the sustainability of the measures of potentially unstable rock blocks, thus eliminating the danger that they cause engineering works. Among these measures may include:

- Planting of shrubs
- Construction of fences
- Forestation
- With torcret
- Clothing slope with stone tiles
- Clothing slope mesh networks

- Inside the massif concrete

Passive protective measures are intended to eliminate the consequences of risk in engineering works, allowing the development of the phenomenon of collapsing stone across slope. Among these measures may include:

- Screen mesh networks
- Screen with concrete blocks
- Construction of concrete wall
- Construction of embankments
- With wall elements
- Honoring columns at the bottom of the slope protection
- Construction of retaining walls at the bottom of the slope
- Active or passive anchoring

- With host screen
- With retaining walls
- The channels in the upper part of the engineering works
- With adjustments to the slope
- With transitional works
- With the softening slope
- With deviations

To create a unique system of protection for the entire slope, in order to protect the neighborhood housing facilities engineering mangalem and national road, relying on data obtained in the field and contemporary literature, is thought and recommended in the context of this study to take these protective measures:

A) Morphological second unit represented by steep limestone slopes, the spins mesh networks. This network of this size the holes 50x50 mm to 80x80 mm and anchored in the rock with iron rods with diameter 12 -16 mm in length from 2 to 3 m . These rods to cling to rock every 1 to 2 m from each - other.

B) We first morphological unit, between flats and slopes, to settle pillars (columns) associated with the end of fabio networks. Be pillars and iron profiles have height above ground level to 2 m and radical in fresh rock. They should be placed every 5 m. Fabio wire nets placed at the bottom of columns at height 1.5 m from the surface of the soil and commonly associated in the bottom of her head with steel cable that connects the pillars.

C) In the western part of the third morphological, at the end of its first contact with the second unit morphological be placed columns (column) associated with the end of fabio networks. The method of establishing their life as described above, in the preceding paragraph.

D) Once the above measures are taken, become skarifikimi and disposition of stone blocks occurring in equilibrium points.

Are supposed to use these measures mitigated, for the fact that their application is easy, safe and not ruin the scenic view of the slope. So pillars as well as wire nets may have the colors of the terrain, which will make them not distinct from the national road. Torkretimi the slope would undermine its picturesque appearance. While cementing cracks with depth probe is very costly, if we consider the fact that in the vertical direction have karsti intensive development and layers of limestone falling backwards with the fall of the slope, which require deepening of drilling in double value, beneath the grout.

CHAPTER 7

7 GEOTECHNICAL PROPERTIES OF SOILS AND ROCKS

After all this work done in plains, it has resulted that the area that it is studied it is constructed from rocks and soils which we have treated in this chapter. We may say that the physic-mechanical properties of rocks and soils play the main role in the geotechnical properties assessment of the studied area. To say these we are based in the laboratory results, the physic-mechanical properties of rocks and soils, in the geotechnical assessments of the site made in the everyday natural changes during the work, even in the studies that have been taken place in these study area before. This section will be used to make the study more clearly in which will be given the general geotechnical properties of the soil in these area, and in particular the slide properties we have treated.

7.1 Influence of existing and future conditions on soil and rock properties

Many soil properties used for design are not intrinsic to the soil type, but vary de pending on conditions.

Insitu stresses,the presence of water, rate and direction of loading can all affect t he behavior of soils.Prior to evaluatingthe properties of a given soil, it is importa nt to determine the existing conditions as

well s how conditions may change over the life of the project. Future constructio n such as new embankmens may place new surcharge loads on the soil profile or the groundwater table could be raised or lowered. Often it is necessary to det ermine how subsurface conditions or even the materials themselves will change over the design life of the project.

Normally consolidated clays can gain strength with increases in effective stressandoverconsolidated clays may lose strength with time when exposed in c uts.Some construction materials such as weak rock may loose strength due to w eathering within the design life of the embankment.

7.2 Methods of determining soil and rock properties

Subsurface soil or rock properties are generally determined using one or more o f the following methods:

• In-situ testing during the field exploration program,

• Laboratory testing, and

• Back analysis based on site performance data.

The two most common in-

situ test methods for use in soil are the Standard Penetration Test, (SPT) and th e cone penetrometer test (CPT). The laboratory testing program generally consists of index tests to obtain general information or to use with correlations to estimate design properties, and performance tests t o directly measure specific engineering properties. The observational method or use of back analysis, to determine engineering properties of soil or rock is often used with slope failures, embankment settlement or excessive settlement of exis ting structures.

In terms of rockfall hazard assessment, one of the most widely accepted[4] is the Rockfall Hazard Rating System (RHRS) developed by the Oregon State Highway Division (Pierson et al. 1990). Table 1 gives a summary of the scores for different categories included in the classification while Figure 9 shows a graph which can be used for more refined estimates of category scores.

The curve shown in (Figure 30) is calculated from the equation y=3x where, in this case, x= (Slope height- feet)/25. Similar curves for other category scores can be calculated fromthe following values of the exponent x.

Slope height x = slope height (feet) / 25

Average vehicle risk x = % time / 25

Sight distance x = (120 - % Decision sight distance) / 20

Roadway width x = (52 - Roadway width (feet)) / 8

Block size x = Block size (feet)

Volume x = Volume (cu.ft.) / 3

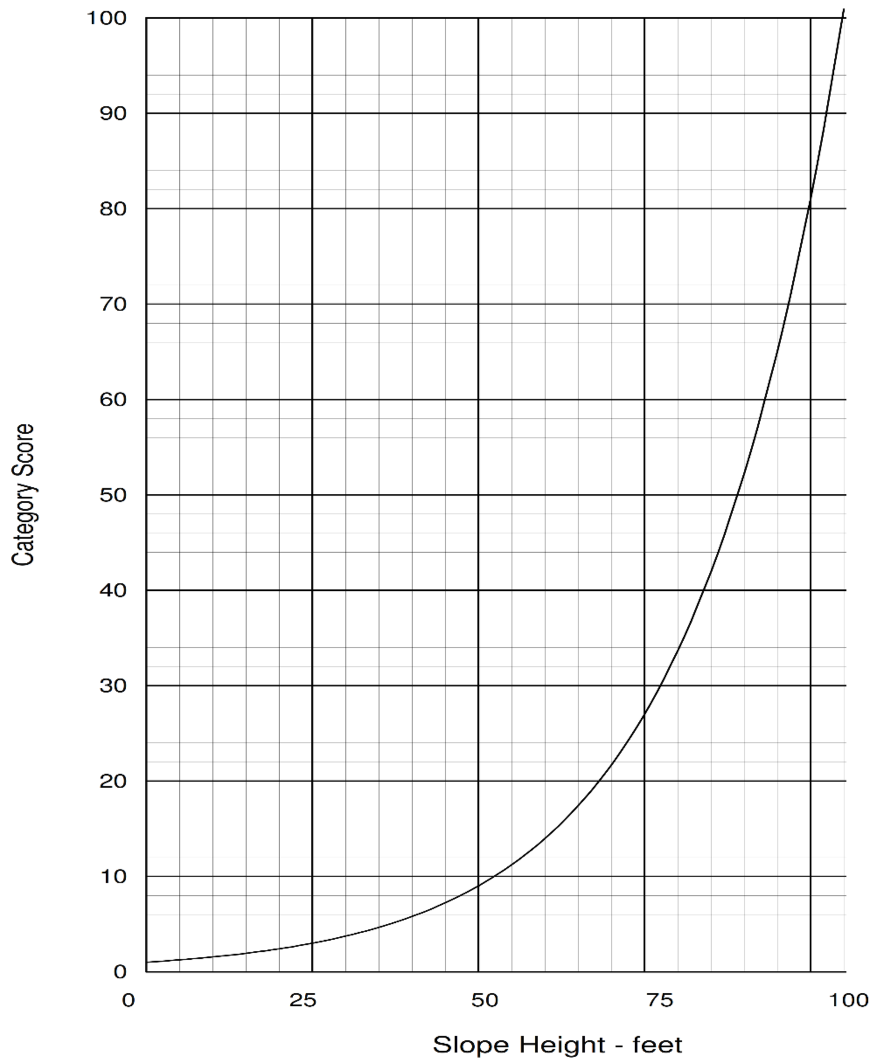

Figure 30.Category score graph for slope height [27]

With landslides or slope failures, the process generallystarts with determining th e geometry of the failure and then determining the soil/rock parameters or subsu rface conditions that cause the safety factor to approach 1.0. Often the determin ation of the property is aided by correlations with index tests or experience on ot her projects(Table2). For embankment settlement, a range of soil properties is g enerally determined based on laboratory performance testing on undisturbed sa mples. Monitoring of fill settlement and pore pressure in the soil during constructi on allows the soil properties and prediction of the rate of future settlement to be r efined.

Table 2. Rockfall Hazard Rating System [28]

<table>
<tr><td colspan="3" rowspan="2">CATEGORY</td><td colspan="4">RATING CRITERIA AND SCORE</td></tr>
<tr><td>POINTS 3</td><td>POINTS 9</td><td>POINTS 27</td><td>POINTS 81</td></tr>
<tr><td colspan="3">SLOPE HEIGHT</td><td>25 FT</td><td>50 FT</td><td>75 FT</td><td>100 FT</td></tr>
<tr><td colspan="3">DITCH EFFECTIVENESS</td><td>Good catchment</td><td>Moderate catchment</td><td>Limited catchment</td><td>No catchment</td></tr>
<tr><td colspan="3">AVERAGE VEHICLE RISK</td><td>25% of the time</td><td>50% of the time</td><td>75% of the time</td><td>100% of the time</td></tr>
<tr><td colspan="3">PERCENT OF DECISION SIGHT DISTANCE</td><td>Adequate site distance, 100% of low design value</td><td>Moderate sight distance, 80% of low design value</td><td>Limited site distance, 60% of low design value</td><td>Very limited sight distance, 40% of low design value</td></tr>
<tr><td colspan="3">ROADWAY WIDTH INCLUDING PAVED SHOULDERS</td><td>44 feet</td><td>36 feet</td><td>28 feet</td><td>20 feet</td></tr>
<tr><td rowspan="4">GEOLOGIC CHARACTER</td><td rowspan="2">CASE 1</td><td>STRUCTURAL CONDITION</td><td>Discontinuous joints, favorable orientation</td><td>Discontinuous joints, random orientation</td><td>Discontinuous joints, adverse orientation</td><td>Continuous joints, adverse orientation</td></tr>
<tr><td>ROCK FRICTION</td><td>Rough, irregular</td><td>Undulating</td><td>Planar</td><td>Clay infilling or slickensided</td></tr>
<tr><td rowspan="2">CASE 2</td><td>STRUCTURAL CONDITION</td><td>Few differential erosion features</td><td>Occasional erosion features</td><td>Many erosion features</td><td>Major erosion features</td></tr>
<tr><td>DIFFERENCE IN EROSION RATES</td><td>Small difference</td><td>Moderate difference</td><td>Large difference</td><td>Extreme difference</td></tr>
<tr><td colspan="3">BLOCK SIZE
______
QUANTITY OF ROCKFALL/EVENT</td><td>1 FT
______
3 cubic yards</td><td>2 FT
______
6 cubic yards</td><td>3 FT
______
9 cubic yards</td><td>4 FT
______
12 cubic yards</td></tr>
<tr><td colspan="3">CLIMATE AND PRESENCE OF WATER ON SLOPE</td><td>Low to moderate precipitation; no freezing periods, no water on slope</td><td>Moderate precipitation or short freezing periods or intermittent water on slope</td><td>High precipitation or long freezing periods or continual water on slope</td><td>High precipitation and long freezing periods or continual water on slope and long freezing periods</td></tr>
<tr><td colspan="3">ROCKFALL HISTORY</td><td>Few falls</td><td>Occasional falls</td><td>Many falls</td><td>Constant falls</td></tr>
</table>

For structures such as bridges that experience unacceptable settlement or retain ing walls that have excessive deflection, the engineering properties of the soils c an sometimes be determined if the magnitudes of the loads are known.

CHAPTER 8

8 CONCLUSION AND RECOMMENDATIONS

8.1 Assessment of slopes stability in the studied area

The studied area it is not that very active in terms of rock fall and landslides, according to our study, rock fall happens commonly in the area of Berat, near to the mountain where the castle is, which it is related to the slope morphology, lithology, geological structures, geotechnical properties of soil, rocks and also has some tectonic zones, and also the relation that exist between the slope inclination and the environmental conditions, and the human intervention.

A good part of the study area consists of hilly slopes at the city and these slopes vary from 10-23 º to 37-49 º. In this area as we have mentioned before, the elevated part of the relief it is constructed from smooth rocks, which if we see their physic-mechanical properties, the action of physical processes and phenomena and the decaying crust of rocks, which it is 1.0-2.0m to 4.5m thick formed. The soil deposits which are gathered in hill slopes, have a considerable thickness ranging from 3.3-5.2m up to 10m. Decaying crust after rainfalls form a state that makes the soil to move down, because of the water saturation which it places the steep slopes and makes a breaking of balance. We have a series of field works to identify the outlining rock fall on hilly slopes, firstly to identify these problems and to prevent them we studied the maps that we had like geological engineering maps, and then we went on with the other faze according to our project which was the excavating of the soil to make a deep survey of lithological analysis for the physic-mechanical properties of the rock, all these analysis were made at the laboratory and also the geophysical workings by tomography method.

8.2 Conclusions

Some factors that have led to the activation of the rock fall in the study area as follows: The Rock fall Hazard Rating System and the Event Tree risk assessments, discussed on the previous pages, are very crude tools which can only be regarded as semi-quantitative. However, the trends indicated by these tools together with common sense engineering judgment, give a reasonable assessment of the relative hazards due to rock falls from cut slopes adjacent to highways and railways.

- All the groundwater presence in the hill has weakened the alevrolite layers the hill has, by reducing their geotechnical values and it has increased the weight of sliding body.
- Weather conditions were even a common factor that helped the presence of groundwater in the hills.

- Geological structure of slopes is the main factor that favored the slopes and slide phenomena, even that the land layers had the same decline direction.
- The existence of old slides that have affected slopes even previously is one of the factors that lead to activation of new slides in the area of study.
- Human engineering activity was an active factor that caused the activation of slides in this area. Their activity is related to engineering buildings (houses, roads, etc.) erected along the hilly slopes, which have caused the braking of the hilly slopes balance. Zone "to Castle Rock", which is located south of Berat Castle, built by rocky slopes with slopes between 35 500 and thiketa slopes with vertical drop or subverticale with whom fall on 80^0. Have been allocated three morphological units with different features from each other. Find Lithological tier spread carbonate deposits (limestone) to Eocene (Pg2) 10 cm thick up to 2.5 m, and their products to the slopes. From the structural point of view, we are dealing with an asymmetric anticline lying, which micro wrinkled is twisted his peak in an area with a width of 70 m. Fall of layers is way down the slope to fall .

Allows the system to escape cracks blocks from the slopes, which have less than the volume of 0.1 m^3 to 1.5 m^3. Vertical cracks up us developed karst phenomenon intensively, especially in the cracks of the third type. Surface and ground waters flow increases the degree of instability that blocks digestion and transportation making finer material .The existing protective measures are partial, passive type and amortized. They are applied only in morphological unit No.1 and not across the slope.

8.3 Recommendation

Our work as it is shown in the pages that I wrote and the thing that I would say are a few of recommendations that I consisted:

- To do more field investigations for these part of Albania that it is very interesting and it has a big part of our cultural values.
- It should have more preoccupations from both the state and the peoples to be more careful for their cultural values and to protect them.
- In the protection of the civilians that pass every day in the road near to the mountain that has a high risk of rock fall, it should use more protective walls.
- The risk assessment should be greater for the old houses that are in the neighbor for the simple reasons, one is the cultural values and the other the live of the peoples that live in them.
- Conduct a water settling human activity inside the castle and leave them with sewer systems outside the study area.
- Make deforestation of afforestation under a project compiled by specialist forests, given that in the territory affected by the fall of stones phenomena have only woody low to medium altitude, which have roots xhufkore .

- We morphological No.1 unit , the part above the neighborhood housing Mangalem throughout the length of the slope , the passive protective measures by placing iron pillars gabian networks to their end .
- No morphological unit. 2, which belongs to decrease vertical slope, active protective measures taken by placing mesh networks.
- e) In the western part of the morphological unit No. 3, the passive protective measures, establishing networks gabian iron pillars in their end.
- Safeguard measures imposed under the proposed scheme topographic map and have the colors of the terrain, in order to be invisible from the national road.

References

1. Higgins, J. D., Fragaszy, R. J., Martin, T. L., 1987, Engineering Design in Loess Soils of Southeastern Washington , WA-RD 145.1.
2. Hoek E., Kaiser P.K. and Bawden W.F. 1995. Support of underground excavations in hard rock. Rotterdam, Balkema.
3. Hoek, E. and Brown, E.T. 1997. Practical estimates or rock mass strength. Int. J. Rock Mech. & Mining Sci. & Geomechanics Abstracts. 34(8), 1165-1186.
4. Hoek, E., Marinos, P. and Benissi, M. (1998) Applicability of the Geological Strength Index (GSI) classification for very weak and sheared rock masses. The case of the Athens Schist Formation. Bull. Engg. Geol. Env. 57(2), 151-160.
5. Jaeger, J.C. 1971. Friction of rocks and stability of rock slopes. The 11th Rankine Lecture. Géotechnique 21(2), 97-134.
6. Eftimi R., etj. (1985): Harta Hidrogjelogjike e Shqiperise 1 : 200 000, Sherbimi gjeologjik i Shqiperise, Tirane.
7. Kuka N., Duni Ll., Aliaj, Sh., Sulstarova, E., (2003): Seismic Hazard Assessment of Albania by Spatially Smoothed Seismicity Approach". Int. Conf. on Earthquake Engineering, Ohrid, Fyrom.
8. Muceku, Y., (2011): Engineering geology study of slopes subjected to mass movement in the Durresi area, Albania. Second workshop of the monitoring and analyses for disaster mitigation of landslides, debris flow and floods, 15-17, December 2011, Rijeka, Croatia, p. 141-143.

9. Muceku Y., etj. (2003): Raport Shkencor, Administrimi i territorit dhe i resurseve natyrore ne rajonin Tirane-Durres-Kavaje, Hartografimi gjeologo-inxhinierik, shkallë 1:25000, 27 plansheta, Shërbimi Gjeologjik Shqiptar,Tirane.

10. Shkupi D., etj. (2002): Harta e Rrezikut Gjeologjik te Shqiperise 1 : 200 000, Sherbimi gjeologjik i Shqiperise, Tiranë.

11. Sulstarova E., Koçiaj S. & Aliaj Sh. (1980): Rajonizimi sizmik i Shqipërisë, Shtypshkronja "M.Duri" Tiranë, Monografi, Arkivi Institutit Gjeoshkencave, fq. 297.

12. Sulstarova E., Muço, B., Aliaj Sh., Kuka N., Duni Ll. (2003): Tërmetet, rreziku sizmik dhe risku sizmik në Shqipëri" (Kap. 1-5), Studim, Arkivi Institutit Gjeoshkencave, Tiranë, fq. 82.

13. Sabatini, P. J., Bachus, R. C., Mayne, P. W., Schneider, T. E., Zettler, T. E., FHWA-IF-02-034, 2002, Evaluation of soil and rock properties, Geotechnical Engineering Circular No. 5.

14. Mayne, P. W., Christopher, B.R., and DeJong, J., 2002, *Subsurface Investigations – Geotechnical Site Characterization*, Publication No. FHWA NHI01031, National Highway Institute, Federal Highway Administratio,Washington, DC, 300 pp.

15. Zaçaj M, Muceku Y., (2006): Vleresimi i Gjeorreziqeve ne zonen e Tiranes, Ministria e Mjedisit, Pyjeve dhe e Administrimit te Ujrave.

16. Zaçaj M, Muceku Y., (2007): Hartografimi gjeomjedisor Gjiri i Lalzit – Velipoje, Ministria e Mjedisit, Pyjeve dhe e Administrimit te Ujrave.

17. INSTAT, “The Population of Albania in 2001 – Main Results of the Population and Housing Census”, INSTAT, November 2002.
18. Alijaj, Sh., “The Map of Active Faults in Albania in Scale 1:200,000”, Seismological Institute, Tirana, 2000.
19. Alijaj, Sh., “Neotectonic Structure of Albania”, AJNTS, Nr. 4, 1998, pp. 79-97.Sulstarova, E., S. Kociaj, and Sh. Alijaj, “Seismic Regionalization of Albania”, KombinatiPoligrafik. Shtypshkronja “Mihal Duri”, Tirana, 1980.
20. Aliaj, Sh., “Harta e thyerjeve active te Shqiperise, ne shkalle 1:200,000”, Seismological Institute, Tirana, 2000.
21. Muco, B., F. Vaccari, G.F. Panza, “Seismic Zonation of Albania using a Deterministic Approach”, AJNTS, 2001, pp. 5- 20.

22. M.J. Kazemzadeh-Parsi, F. Daneshmand, Cavity shape identification with convective boundary conditions using non-boundary-fitted meshes, Numer. Heat Transfer, Part B 57 (2010) 283–305.

23. M.J. Kazemzadeh-Parsi, F. Daneshmand, Inverse geometry heat conduction analysis of functionally graded materials using smoothed fixed grid finite elements, Inverse Probl. Sc. Eng. (2012), http://dx.doi.org/10.1080/ 17415977.2012.686998.

24. M.J. Kazemzadeh-Parsi, F. Daneshmand, Unconfined seepage analysis in earth dams using smoothed fixed grid finite element method, Int. J. Numer. Anal. Methods Geomech. 36 (2011) 780–797.

25. J. Caffrey, J.C. Bruch Jr, Three-dimensional seepage through a homogeneous dam, Adv. Water Resour. 2 (1979) 167–176. [18] C.S. Desai, J.G. Lightner, S. Somasundaram, A numerical procedure for three-dimensional transient free surface seepage, Adv. Water Resour. 6 (1983) 175–181

26. C.S. Desai, G.C. Li, Residual flow procedure and application for free surface flow in porous media, Adv. Water Resour. 6 (1983) 27–35.

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