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Engineering Geology Study For Planning And Construction Of Tirana-Elbasani Motorway

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ABSTRACT

In this paper are treated the results of the engineering geological study done for motorway construction purpose of Tirana-Elbasani cities in feasibility and project idea phases. A detailed engineering geological mapping was carried out by assessing of geo-factors for the needs of purposeful utilization of territory by means of land-use planning. It focuses on five geo-factors as lithology, geomorphology, hydrogeology, geodynamics phenomena and geotechnical characteristics, which assess the geological environment in terms of potential implementation of particular engineering project including and taking into account its anticipated interaction with the planned engineering works in the studied area. The evaluation of road's alternatives is done by geo-factors analysis in form of the "Geo- Risk" for each geo-factor unit within the projected zone. So, the studied zone was divided in forth level are first level (no risk)-no engineering measurements, second level (low risk) - no problems, feasible to build, third level (medium risk)-with increased effort, feasible to build, but needs investments, forth level (high risk)-with very high additional effort for construction, which need high investments. The geo-risk level of each unit has been taken into account for the estimation of the designed alternatives/routes and at least as one criterion for the determination of candidate routes/planning cases. So, the total geo-risk level's calculation has been compared with results of the other variants/routes. From this analyze the interest zone in the studied area results to be the eastern corridor-Tirana-Mullet-Ibe-Kusha-Bradashesh-Elbasan. It is represented by flat-hilly terrain zone. It's constructed from geological structures (synclines, anticlines and monocline), which are built by molasses and premolasses rocks. In several places these rocks are affected by tectonics and neo-tectonics phenomena. Mostly of hills slopes are occupied by quaternary deposits-soils with possibilities of landslide development in any case of the disbalance of the slopes from manmade works. According to engineering geological conditions this zone is characterized by geotechnical units are molasses-medium rocks (sandstones), premolasses-soft rocks (claystones-siltstones), inorganic silts and clays of low-medium of plasticity with sands and gravels, as well as gravels-sands mixtures.

Keywords: geo-factor, geo-risk level, lithology, geomorphology, hydrogeology, geodynamics phenomena and geotechnical characteristics, motorway, tectonic, mass movement, erosion.

INTRODUCTION

Three alternatives are taken under consideration and analyzed for planning and designing Tirana-Elbasani motorway. The resulting engineering geological mapping, areas that may be regarded as homogeneous from the lithological, geomorphological, hydrogeological, geodynamics phenomena and geotechnical conditions are useful for studies concerning geohazard

susceptibility and foundation conditions. From the point of view the engineering-geological purpose in this phase is very important special-purpose maps which are one of the most important sources for decision-making on economical utilization of zone. Nowadays is quite obvious that, along with the scientific and technological progress, the role of the engineering geology to the urban planning and development becomes every day more and more important. The engineering geology information for land-use planning is one main factor among other geo-factors for particular stages in such studies. That's why, during 2008-2010 year an engineering geological study [2] was carried out from Tirana up to Elbasani to support route planning and development. The purpose of this study was to give data related to lithology, geomorphology, hydrogeology and hydrology, geotechnical and geodynamics phenomena characteristics to support the motorway's construction from Durresi up to Elbasani for the feasibility and project ide phases. The studied area is a flat-hilly terrain and it is represented by geological structures (synclines, anticlines and monocline) are composed by molasses and premolasses rocks. Also, mostly of this zone is covered by soils deposits, which built the rivers and streams valleys and hills slopes with thickness varied from 1.5-3.0m to 6.0-8.0m.

METHODOLOGY

In connection with construction project, an engineering geology study [2] has been undertaken on 2008-2009 year in the area between Tirana and Elbasani for motorway planning and construction. As part of major programme it was planned to construct in three corridor routes as eastern corridor (Tirana-Sauk-Elbasan), central corridor (Tirana-Baldushk-Paper-Elbasan and western corridor (Tirana-Peza-Peqin-Elbasan). The engineering geology investigations included the field and laboratories works done in scale 1:10 000-1:25 000. In the orientated profile along the projected motorway lines, in three corridor routes the engineering geological surface observations are carried out, from where are take data related to lithological, morphological, and hydrogeological, geodynamics phenomenon and geotechnical. Also, the engineering geology study is based in many geotechnical studies carried out in the studied area last 10 years. The purpose of this study is to give the data related to lithology, geomorphology, hydrogeology and hydrology, geotechnical and geodynamics phenomena characteristics to support the motorway's construction from Tirana up to Elbasani for the feasibility and ides project phase. The road's alternatives assessment is completed basing on geo-factors analyses, which are lithology, geomorphology, hydrology, hydrogeology, geodynamics phenomena and geotechnical features. They are analyzed in form of the "Geo- Risk" [2] for each geo-factor within the projected zone. From this analysis, each alternative in the studied zone was divided in forth level, which are first level (no risk)-no engineering measurements, second level (low risk)-no problems, feasible to build, third level (medium risk) - with increased effort, feasible to build, but needs investments, forth level (high risk)-with very high additional effort for construction, that need high investments. Finally, the total geo-risk levels of three alternatives are determined and compared each other the estimation of the designed one/routes.

RESULTS AND DISCUSSION

The studied area extends from Tiarana city up to Elbasani town. The geologic environment interfacing with human activities includes not only the basic components of soil, rock, and water, but also the associated phenomena referred to as geologic hazards, i.e., flooding, erosion, landslides and other slope failures, ground subsidence and collapse, ground heave, and earthquakes. The engineering works interfacing with the geologic environment can be constructed economically, can perform safely, and can have a non detrimental impact on other

works only if all geologic elements are accurately identified and their properties properly measured and evaluated. Reliable evaluations, however, are possible only when complete and representative data are available. Engineering geological investigation, therefore, is the most important phase of any construction or development program. Therefore, for Tirana-Elbasani motorway firstly is carried out the engineering geology study for three routes alternatives. Many complex and conflicting geo-factors have to be considered. Seeing, that projected designers requests and projects purpose, the engineering geology study in this work I've solved to evaluate several geo-factor, which are based data for this project in this phase. Among these geo-factors include lithological, morphological, hydrogeological, geodynamics phenomenon and geotechnical. The principal engineering geological concerns at the site relate to the stability of the surrounding alternatives. Global stability remains open to question because of variability in road shape, dimensions and composition. The soils deposits of the projected routes alternatives range from soft to firm, whereas the rocks deposits forming varies from soft to medium strength. Regarding the fact that unstable hills slopes are developed in several part of terrain where is planned to pas the motorway a detail engineering geology investigation-mapping on scale 1:10000-1:25 000 is completed [2]. In addition, many pits and boreholes (3.0-5.0m up to 10.0m deep), electrical resistance tomography-(ERT) measurements and laboratories tests are completed. Also, the geological and geotechnical data are taken from previous studies carried out in this area. In this paper, we have treated only the results of selected alternative are Tirana-Mullet-Ibe-Kusha-Bradashesh-Elbasan.

Geological setting

Geologically, the investigated area consists of different types of rocks are Quaternary deposit, Molasses and Pre-molasses formations [3].

Quaternary deposit

These deposits are widespread in whole of the studies area. They are found on middle and bottom of hills slopes (diluvium) and along rivers and streams valleys (alluvium and proluvium), constructing their slopes and terraces.

Molasses formations

The mostly of the studied area is occupied by the molasses formations. From the age point of view this rocks belong in Serravallian, Burdigalian up to Tortonian age, whereas from the litological unit point of view this rocks represented by siltstones, claystones and sandstones rocks. These formations are included in the Preadriatic Depression.

Pre-molasses formations.

These formations in the studied area are extended from Tirana-Krraba villages up to Bradasheshi village. Their age belong from Burdigalian are part of Ionian tectonics zone. They built the folder structure with anticline syncline of low level, extending northwest to southeast. They are the combination of layers, which consist of marl, clays marls, carbonated clays and sandstones rocks.

Morphological setting

The morphology of the studied area is closely related to the lithology. It represents a hilly and flat zone, which is built by soils (Quaternary), molasses and premolasses formations with above sea level, varies from 10-50m to 150m in flat area and up to 250-350m up to 550m in the hilly area. The hills extend from northwest to southeast in chains form divided by the streams and rivers valleys. Along of this region from east to west direction has established their valley the Erzeni River and from south to north direction Murdhari and Kusha streams. In southern part of the

south of studied area extend the wide valley Shkumbini River. They have generally a valley like "U" shape. Based on morphology features the studied area is divided in two morphological units as flat morphological and hilly morphological units. Based on morphology on features each morphological unit is divided in several subunits.
Flat morphological unit with inclination angel smaller than 5^o (very gently) is divided in several subunits as first terrace of Erzeni and Shkumbini rivers and terrace of Murdhari and Kusha streams.
Hilly morphological unit with inclination angel 6^o - 15^o (gentle), 16^o - 25^o (moderately gentle), 26^o - 35^o (moderately steep), 36^o - 45^o (steep) and > 45^o (very steep). In this unit take part the Sauku-Petrela-Berzhita-Kusha-Bradasheshi hills zone extending from northwest to southeast in form chains.

Hydrogeology
The studied area related to hydrogeology is constructed by several rocks and soils complexes with different water bearing capacity. They are Quaternary deposits-soils and molasses and pre-molasses rocks. The Quaternary deposits are built by poor aquifer up to very rich aquifer. In the first group are included all types of soils, which are impermeable like silts-clay soils and rivers-streams terraces gravels. These formations have occupied mostly of the studied area. Whereas, the rocks are represented by sandstones formation (Krraba village) are a good aquifer, and combination of siltstones-claystones layers with sandstones layers. These formations are poor aquifer.

Geodynamics phenomena
Tectonics-Tirana Region consists of Tirana molasses syncline and Kruja zone structures to the east. Tirana syncline bounds from the west by an active backthrust and from the east by an active thrust. The above-mentioned faults are expressed on the relief with escarpments. Tirana fault zone is generally an active fault zone up to nowadays, that is testifying by many earthquakes generated from it [1].

Active faults-The Tirana-Elbasani fault zone consists of more than four reverse faults up to thrusts [1]. Tirana syncline, NW extending, 80 km long and 10-12 km wide, is an asymmetric syncline with its steep dipping western flank, complicated by an active back thrust. Preza monocline is lied with back thrusts over Tirana syncline. Kruja zone structures are outcropping to the east of Tirana syncline. The Dajti linear anticline, built mainly by neritic Cretaceous carbonates and Oligocene premolasses deposits, represents an isoclinal anticline, complicated by an active thrust along its western overturned flank. Minimum two other reverse faults are buried beneath the Tirana syncline. These ones may also be active. The back thrust along the western flank of Tirana syncline, about 45 km long, is with contrast expressed on the relief. Here it is observed an escarpment between the hills of Preza monocline on a height of about 300m and Tirana Holocene plain extended on a height up to some tens meters above sea level. The thrust along the western flank of Dajti linear anticline, about 50 km long, is also expressed with contrast on the relief. The escarpment observed here has great vertical amplitude of about more than 1.0 km. We can say that Tirana fault zone is generally an active fault zone up to nowadays. From this fault zone are generated many earthquakes such as 1617 year with Io=VIII degrees of seismic intensity (Kruja town); August 26, 1852 with 10= VIII (Kepi Rodonit); May 16, 1860 with Io=VIII (Ura Beshirit, near Tirana); September 16, 1975 with M=5.3 (Kepi i Rodonit); January 9, 1988 with M=5.7 (Tirana).

Tirana fault zone is also well detected by sequences of lineaments of consecutive earthquakes epicenters during the period 1982-1992, with magnitude range 2.0-5.1.
After recent studies result in the studed area are identified three main longitudinal tectonics active zones:

· The Ishem-Vaqari-Pical-Vishaj-Mumajesi longitudinal tectonics active zones, which marks the boundary between the Tirana syncline and Shijaku syncline. It's represent by backthrust fault.

· The Kruja longitudinal tectonics zone, which marks the boundary between the molasses and pre-molasses formations with premolasses formations.

· The Lushnja-Elbasani-Diber transversal seismogenic zone, which are located in southern part of studied area.

Mass movement-The hills zone of studied area partly is affected by the active landslides, from which parts of the hills slopes area have lost. The mass movement occurrences on this zone and their spreading point out that, their activity here is closed related to geomorphology, lithological formations, geological structure, geotechnical properties of bedrocks and soils, neotectonics active faults, seismicity, relationship between slopes angle direction and dip & inclination angle of molasses and premolasses strata, precipitation events and manmade works. As above mention it, mostly of these areas are generally built from rocks with low geotechnical parameters-soft rocks, which favor the mass movement phenomena. From field works results that studied zone are subjected to earth flow and erosion phenomena.
Earth flow-this type mass movement are found on Berzhita hills and Kusha stream valley. Both of earth slides bodies materials are consisting of mixtures of silts and clay with rubles, broken stones and cobbles. The rupture surface extends in direction of movement, whereas the state of activity of this type of mass movement is very active. Most of these earth flow occurrence, during heavy rain periods are moving down slope.
Erosion-As results of high quantities of precipitation in the studied area, besides mass movement occurrences are developed and an intensive erosion like an erosive centre, gully, etc., which was extremely rapid. So, this phenomenon occurred in Shijon village up to Kusha village and in upper part of Kusha stream.

Table 1: The Geo-risk analysis of variant "A"-Durres-Limuthi-Kashar-Tirana Ring-Peshkatari Bridge-Krrabe-Elbasan

Nr.	**Location**	**Geo-factors**			
		Lithology	**Morphology**	**Hydrogeology**	**Geodynamics phenomena**
1	Tirana Ring	Quaternary diluvium deposits, represented by combination of silts and clay formations intercalated by sands layers with thickness range from 7.0-10.0m up to 15.0m	Flat unit, represent by flat area of Tirana's artificial lake banks.	Underground water table below 5.0m deep. No aggressive.	-
2	Tirana Ring - Peshkatari Bridge	Quaternary diluvium deposits, represented by combination of silts and clay formations with	Hilly unit with Slope angle 6-15^{o}	Underground water table below 5.0m deep.	-

		thickness range from 1.0-2.0m up to 3.0m, molasses-siltstones and sandstone is construted the bed rocks.		No aggressive	
3	Peshkatari Bridge-Berzhite	Quaternary alluvium and diluvium deposits, represented by combination of silts and clay formations intercalated by sands-gravels layers with thickness range from 2.0-3.0m up to 7.0m, as wll as sanstones.	Flat unit, represent by first terrace of Erzeni River and terrace of Murdhari stream.	Underground water table below 3.0m deep. No aggressive	-
4	Berzhite - Krrabe	Molasses formations represent by sandstones rocks.	Hilly unit with Slope angle 26-35^o, moderately steep	Underground water table below 5.0m deep. No aggressive.	The studied area is affected by the active landslides
5	Krrabe-Upper part of Kusha stream	Molasses formations represent by sandstones rocks and premolasses formations that are combination of marl, clays marls and carbonated clays layers.	Hilly unit with Slope angle 36^o - 45^o, steep	Underground water table below 5.0m deep. No aggressive.	This area is characterized by erosion and landslides occurrences.
6	Upper part of Kusha stream-Shijoni village	Pre-molasses formations that are combination of marl, clays marls and carbonated clays layers covered by diluvium deposits, represented by silts formations with thickness range from 3.0m up to 7.0m sandstones.	Hilly unit with Slope angle 26-35^o, moderately steep	Underground water table below 5.0m deep. No aggressive.	The projected area is much effected by erosion phenomena, where are created many erosion place.
7	Shijon village-Elbasan	Quaternary prolluvium deposit represented by combination of silts and sands-gravels layers with thickness range from 5.0m up to 15.0m	Flat unit, represent by first terrace of Kusha stream	Underground water table below 1.5m deep. No aggressive	All the projected area from Shijon village up to Elbasan is situated on the Lushnja-Elbasani-Diber transversal seismogenic zone.

Table 2: The Geo-risk analysis of variant “A”-Durres-Limuthi-Kashar-Tirana Ring-Peshkatari Bridge-Krrabe-Elbasan

Nr.	**Location**	**Geo-factors**	**Level of Geo-Risk**	**Reason / Comment**
		Geotechnics charachteristic		
1	Tirana Ring	Silts, clays silts, silty clays and clays in stiff -very stiff up to hard conditions	First Level No risk	Projected area is well suitable for new construction, no active tectonic zones, underground water in low

				level, need no engineering's measurements.
2	Tirana-Peshkatari Bridge	Silts, silty clays and clays in very stiff up to hard conditions and soft rocks (basement)- siltstones and sandstones molasses.	Second level, Low risk	Projected area is well suitable for new construction, no active tectonic zones, underground water in low level, but in some part need engineering's measurements like retained walls.
3	Peshkatari Bridge-Berzhite	Silts, silty clays in stiff conditions and gravels in medium conditions, as well as medium strength rocks-sandstones.	First Level No risk	Projected area is well suitable for new construction, no active tectonic zones, underground water in low level, but in some part need engineering's measurements like retained walls.
4	Berzhite - Krrabe	Inorganic silts and very fine sands with gravels contents, low-medium of plasticity, beige colors, medium consistency and saturated. Molasses formations represent by sandstones rocks.	Third level Medium risk	Projected area is characterized by medium geo-risk related to erosion and landslides phenomena. Also from excavation of hills slopes can be create the landslide. For this area need intervention to improve the foundation of route and taking of engineering measures to stable it.
5	Krrabe-Upper part of Kusha stream	Medium strength rocks sandstones up to soft rocks- marl, clays marls and carbonated clays layers.	Second level, Low risk	Projected area is well suitable for new construction, no active tectonic zones, underground water in low level, but in some part need engineering's measurements like retained walls against rockslide can be created by on hills slopes and tunnel excavated.
6	Upper part of Kusha stream-Shijoni village	Soft rocks- marl, clays marls and carbonated clays layers, whereas silts soils are in stiff conditions.	Forth Level High risk	Projected area is characterized by high geo-risk related to erosion and landslides phenomena. Also from excavation of hills slopes can be create the landslide. It means this area need very high additional effort become suitable to build and high cost, as well.
7	Shijon village-Elbasan	Silts in stiff conditions and gravels in medium conditions, as well as medium strength rocks-sandstones.	Forth Level High risk of active tectonic zone	Projected area can be build new construction, like motorway pavement, but no big constructions to build, because it has high risk.

CONCLUSIONS

1. The contribution in this paper is expected to be pivotal in road design for feasibility and idea project phases.

2. The overall objective of this work is aimed to road design and alignment optimization procedure by minimizing the total cost of alignments and construction of transportation facilities-motorways by using of the engineering geology data.

3. The evaluation of road's alternatives is done by geo-factors assessment related to lithology, geomorphology, hydrology, hydrogeology, geodynamics phenomena and geotechnical features that are given in form of the "Geo- Risk" for each geo-factor unit within the projected zone.

4. The studied zone was divided in forth level are first level (no risk)-no engineering measurements, second level (low risk) - no problems, feasible to build, third level (medium risk) - with increased effort, feasible to build, but needs investments, forth level (high risk) - with very high additional effort for construction, which need high investments.

5. The geo-risk level of each unit has been taken into account for the estimation of the designed alternatives/routes and at least as one criterion for the determination of candidate routes/planning cases.

6. On the basis of analyzed relevant geo-factors the interests zone the interest zone in the studied area results to be the eastern corridor-Tirana-Mullet-Ibe-Kusha-Bradashesh-Elbasan.

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