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Muceku, Y.; Bozo, L.

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Bozo, L, Geotechnics Section, Civil Faculty, Polytechnics University of Tirana, Albania

Muceku,Y., Department of Engineering Geology, Center of Tirana Civil Geology, Albania

Abstract

In this paper are shortly described the results of the geotechnics studies carried out last years concerning damages of roads-bridges by river erosion in Albania. The river erosion phenomenon nowadays in our country is become very dangerous, according to:

- The destroying of many engineering objects (roads, bridges) constructed on river banks.
- The loss of many square kilometers of agriculture area.
- The environment damage.

Here we have presented some particular cases of 2 roads and 3 bridges destroyed by above mentioned phenomenon, their remedial measures and causes of this phenomenon, as well.

1. Introduction

Albania is mountainous-hilly terrain, where 75% of whole area covered by mountains - hills and 25% by fields. There are many rivers and streams, which are very vehement about on 3/4 of their lengths. The erosion phenomenon by rivers water, currently in Albania is present. It's much favored by high amounts o precipitations, which are 2000-3000 mm/year (in some regions they are 100 mm/hour and 300 mm/24 hour) and by man-made activity, especially in plain area, as well as from climatic, seismic and geologic factors. The study of this phenomenon and the hazard evaluation for the protection and rational, as well as complex exploitation of the environment , is an important direction of geotecnics-engineering geology. It could also help for solving the problems of design and construction of different objects and their protections. On the basis of the study, some theoretical and practical remarks are obtained.

2. **Result and Discussion**

2.1 ***Peshkatari bridge***

Site characteristics

The bridge is located along Tirana-Elbasani national highway, over Erzeni River linking together capital Tirana with southern Albania (Elbasan-Librazhd- Korca-Pogradec towns), as well as corridor Nr-8 connecting Albania with Macedonia and Greece.

The site where the bridge was built comprises Quaternary loose deposits and Tortonian molasses. The Quaternary loose deposits makes up the first terrace of Erzeni River, as well as its bed. They are represented by middle to coarse grain gravels, 1/2 re-worked out made up mainly limestone and less sandstone filled by sands, silts and brown clays. They are not completely compressed and are water saturated. The thickness varies from 1.0m to 2.0m in the first terrace up to 6.0 – 7.0m in the river bed. The above rocks overlay Tortonian sandstone's of molasses, which built up also the Erzeni River's banks. The sandstone's rocks are massive, constituted mainly by quartz with scarce siltstone and argillite thin layers intercalations. The sandstone rocks are coarse grains with a thickness up to 1000m.

According to geomorphology the area is almost flat (first terrace) with westwards very gentle slopes bounded to the north with Mulleti's hills with an altitude 280m to 290m above sea level, and southwards of Petrela hills 500-600m above sea level.

The hills are undulated with (watersheds and valleys), which go downward towards the lowlands. The field is crossed by Erzeni River which have created an U-shaped valley 40-100m wide and 7.0 - 10m deep (Fig. NR. 1, Photo NR. 1), as well as, a lot of meanders along its East-West stream.

Bridge structure

The scheme of bridge comprises continuous beams with piers and massive shoulders, with shallow foundations supported on gravels (Fig. NR. 1, Photo NR. 1) up to 3,5m downdip. The bridge was built during 1935-1937 (c. 65 years old) and it is a two ways highway.

Rivers activity

The approximate surface of drainage basin, where is located the bridge is 292 km^2. During the most rainfall season (October-May) the average discharge is about 118m^3 /sec and maximal one, up to 170 m^3/sec, whereas the mean discharge/year is 8.6 m^3/sec.The suspended load is 68.4 kg/sec and 2150 $\cdot$ 10^3ton/year , as well as, the bed loads 430 $\cdot 10^3$ ton/year.

Table 1.

Grain size m/m	0,01	0,05	0,1	0,2	0,5	1,0	2,0	5,0	10	20	50	100
Suspended load (%)	65	89	97	99	99,5	100	-	-	-	-	-	-
Bed load (%)	17,5	39	60	78,5	82,5	85	88	90	92	96,5	99,5	100

Suspended and bed loads (%) moved by river waters is indicated at the Table Nr. 1. Both the velocity of the river's flowing, which is generally around 0.7m/sec and suspended and bed loads (gravel filled by sands, silts and clays with a relative density from 50% up to 70%) has caused an average erosion of its bed about 1m, it does mean that the river erodes its bed about 1,5 cm/year. The bridge foundation basement consist of gravels with a bearing capacity from 350 KPa up to 400 KPa, that means it stands very good the loads, that comes from construction and river water pressure.

Man-made activity

After 1990 year, when the country has passed from a centralized economy (totalitarian regime) to free and open economy, nobody has taken care from the environment protection for a long time. In these conditions, when the due legislation lacked, Albania has suffered so much from ill treatment of environment, giving rise hazard besides the natural ones.

So, in constructions field especially for capital of Tirana, the great needs for the first inert materials as sands and gravels led to intensive exploitation along of Erzeni river bed . In some parts of river bed, even near by bridge foundation, the bedrock is outcropping lowering 3m up to 5m the base level of the river bed. In this case is artificially increased erosions activity of rivers water from 1,5 cm/year (normal condition) up to 8-10 cm/year.

Damages and causes

From a period of 60 year old of erosions activity, on 1990 year the foundation depth was 2,5m downdip. Whereas, the last ten years the erosion caused by man-made activity discover about 1.0 m of bridge foundation. So, during a rainfall storm (1999 year) the river water discharges (great flowing) was very much increased and in consequence a intensive erosion on river bed occurred, which caused a sinking from 1,98m one of bridge pier (foundation) (Fig. NR. 1, Photo NR. 1, 2,). Also from above phenomenon, is break down the central part of bridge and it is bent, as well as along of it are created many cracks enabled the destruction of it and put out of use (Fig. NR. 1, Photo NR. 1).

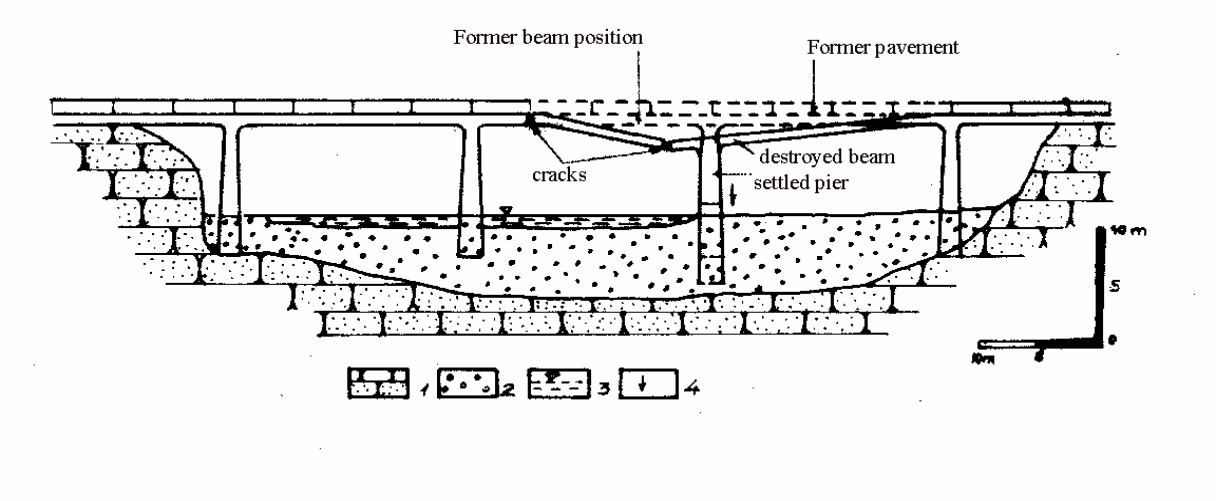

Fig. 1 Cross section of Peshkatari bridge
1. Sandstones, 2. Alluvial deposits, gravels, sands, silts and clays, 3. River water level, 4. Sinking direction

Photo nr. 1. Peshkatari bridge. It's looking to east, and shows, cracks, destroyed beam and a sinking of pier.

Photo nr. 2. Peshkatari bridge. It's looking to south, and shows, the new bridge and the destroyed bridge (right side) which is sunken 1.98 m compared with the new bridge.

Fast remedial measures for provisional use

For a quick connection of this very important highway for Albanian economy, were taken as following engineering measures:

- Grouting with pile against other movements.
- Covering with concrete for reinforcement of damage foundation.
- Covering with stores blacks (gabion).
- Stopping of exploitation of raw material on river bed.
- Construction of provisional metallic bridge over existent one.

Remedial works for highways normal function

- Construction a new bridge with three ways highway.
- Static scheme -system beam column.
- Foundation with molded piles with 1m diameter and support on sandstone's rocks.
- Piers with concrete column.

2.2 ***Mifoli bridge***

Site characteristics

The bridge (older one) links capital of Tirana and several towns of northern and central parts with south-western part of Albania (Vlora, Saranda and Gjirokastra towns). It's constructed over Vjosa River very close its delta. The studied area is built up by alluvium Quaternary loose deposits as silts with thin fine sands layer intercalation (40m thick) and gravels, which are covered by first one.

Bridge structure

It has a combined structure, concrete arch with metallic beams. The foundations are made by metallic piles in tubular shape (Photo NR 3).

River activity

The drainage basin surface of Vjosa River, over which is constructed Mifoli bridge is 6680 Km^2 and its mean altitude above sea level is 858m. The suspended and bed load of this river is 190kg/sec and $5.99 \cdot 10^6$ /year.

Damages and causes

The interaction of seismic vibrations (sands liquefaction) and rivers erosion activity phenomena enabled discovering of bridge foundation (earthquakes of 1967 and 1969

Photo nr. 3. Mifoli bridge. It's looking to north-east, and shows, its structure

Photo nr. 4. Mifoli bridge. It's looking to north, and shows, the sinking of its pier

years), from which a bridge sinking occurred (Photo NR. 4), and simultaneously a horizontal movement on one of its shoulder is done.

Consequences : It is out of use.

Remedial works for highways normal function

Construction of new bridge for the highway and railway purpose with molded pile foundation (38-42m length and 0,8-2m diameter) supported on gravel deposits.

2.3 ***Kallmeti's bridge***

Site characteristics

It's located on Lezha-Shkodra road (old), over one of Drini river branch (Gjon Zefi Stream).

Concerning the geology in the studied area are recognized two major groups of rocks (Fig. NR. 2):

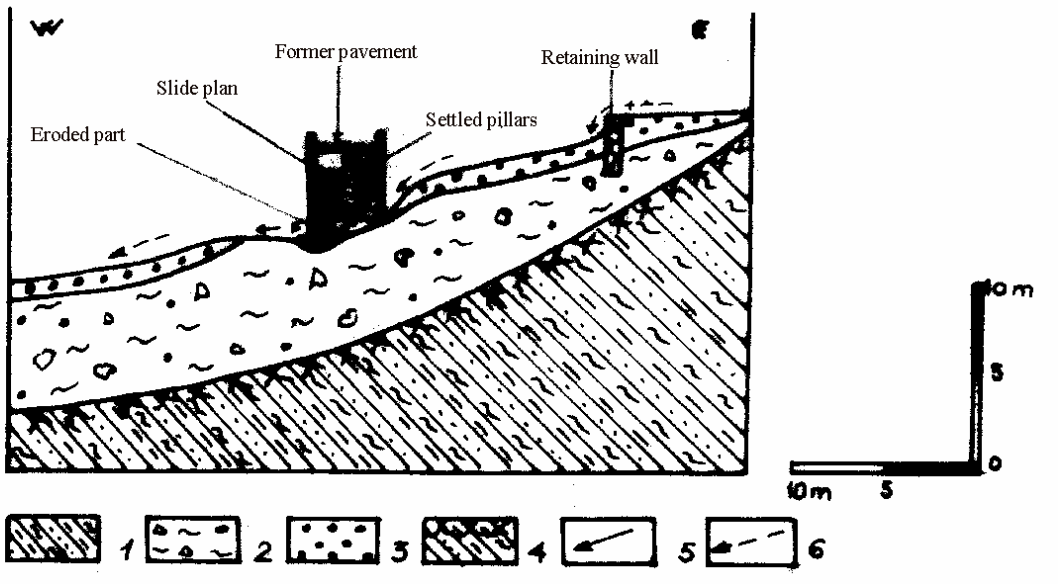

Fig. 2 Cross section of Kallmeti bridge
1. Flysch, 2. Alluvial deposits, clays, sands, gravels, and cobbles, 3. Alluvial deposits, gravels and cobbles, 4. Weathering crust of flysch rocks, 5. eroded soil movement direction, 6. Stream water flow direction

- Quaternary loose deposits comprises proluvium-first terrace and beds deposits of Gjon Zefi stream. The first one consist of silts with 30-35% with the limestones and

sandstones rubble-stones content, that have dimension ranging from 0,05m up to 0,5m. On west bridge they have e fan shape (10-15m thick), whereas on east they lying along stream valley (1-2 m thick). The beds deposits consist of gravels and less stones filled by sands, silts and clays. They have a thickness varies from 0,5 up to 1,5m .

- Oligocene flysch deposits comprises by thin intercalated layers of claystones, siltstones and sandstones, which have a dip angle 40-45^0 on east direction. They overlain by proluvium deposits.

According to morphology the Gjon Zefi stream valley have a 'V' Shape, with steep banks slope and 4-12m wide and 5-6m deep.

Bridge structure

It's a bridge with cement stone masonry pillars (length L=8m) and concrete armored beam. This bridge is about 70 year old (Fig. NR. 2, Photo NR. 5, 6).

Damages and causes

Several factors took part in damaged of bridge, which are as following:

- During 1992,1994,1996 and 1998 year, as results of high quantities of precipitation and without protective measures getting in due time, on stream bed occurred a intensive erosion like a gully, which was extremely rapid. The stream bed erosion from 1992 year up to nowadays is about 1.8m, and below of bridge foundations was created a cavity with 1.4 diameter, as result of it, the bridge foundations has moved downwards (Fig. NR. 2, Photo NR.5, 6).

- The dynamic loads actions induced by motor-car traffic, when in the bridge were appeared a lot of cracks.

Photo nr. 5. Kallmeti bridge. It's looking to north, and shows, the sinking of its pillars and pavement

Photo nr. 6. Kallmeti bridge. It shows cracks of pillars from erosion phenomenon

Consequences

The bridge foundation moved 1,4m (Fig. NR. 2, photo NR. 7, 8) downward and simultaneously it is associated a horizontal movement, where several failures occurred on bridge pillars walls.

Recommendation for remedial measures

- Construction of weirs and groynes.
- Reinforcement of bridge foundation by its grouting.
- Filling of cavity by durable and less deformation materials.
- Construction a new bridge.

2.4 ***Bogova landslide***

It is located on eastern part of Albania along Berati-Corovoda road, on right side of Osumi River valley. On this landslide is constructed above mentioned road, which is affected by this phenomenon. The river valley slope, where the landslide occurred (photo NR. 9), built up by flysch rocks (much weathered) with dip angle 50-60^0 in the same direction with the valley slope inclination, favoring it. Also on bottom of valley slope, flow the Osumi River waters, which continuously contribute to the erosion process, that is one of main factor of landslides creation. The landslide is moving slowly downwards through the valley slope to river bed (Photo 7), together with 200 m of road constructed over its body.

Photo nr. 7. Bogova landslide. It's looking to east, and shows, a destroyed retaining wall (deformed) by mass movement

A lot of factors influenced to mass movement on the studied area, are as following:

- The velocity of river water flow, which is from 0.4m/sec (summer) up to 1.29 m/sec (winter) and its discharge 49.7m^3 /sec together with its suspends and bed loads that are 17.4 kg/sec, operate on the outer bank, causing erosion of it.

- The river banks are built up by flysch rocks are much weathered.

- There is poorly drained. One drained ditch (constructed 20 year ago) for collected of surface water coming from rainfall or other sources was buried. So, much water running throughout, along and cross of the road, as well as down the bank slope of Osumi River. The other water quantities infiltrate and seep in small cracks of weathered flysch rocks. From high value of hydraulic gradient are created many new cracks. The natural gradient value exceed the critic gradient value. Therefore, in this case we have the mechanics suffusion development, where small cracks are become wider and deeper, which have helped landslide development.

- The cutting of many trees on this are during last 10 years is an other factor.

- In the studied area, there are many water springs, and high rain falls, that favored degradation of bank slope of Osumi

Remedial works

For improving of general stability conditions of Bogova landslide have to make engineering measures :

- Construction of weir and groynes.

- Improving of general stability condition by installing a drainage system (2 ditches) to collect surface runoff, which reduce seepage and infiltration in the soil and this exert a positive influence on the main factor of slope stability.

- The stability of landslide by molded piles.

- Planting of trees.

- Construction of retaining wall with drainage system.

- The slope protection by using of gabions or geotextile against surface erosion.

- Protection interior erosion (systematize of two streams close of landslide.

2.5 ***Shkopeti landslide***

Site characteristics

It's located on north-eastern part of Albania along national road linking the Miloti and Burreli towns. This road is constructed on banks of Mati River valley and it is affected by landslide phenomenon. The studied area represents a narrow and deep valley (Mati

River) formed a "V" shape have a slope inclination from 25-35^0 up to 60-80^0 and it is built up by loose Quaternary deposits (deluvium and alluvium) and by melange deposits(Fig. NR. 3, photo NR. 8),. Deluvium consist of rubbles up to stones filled by silts. They have a thickness from 1-2m (upper parts of valley slope) up to 10-12m (down valley slopes). These deposits are situated unconformity over melange deposits. Alluvium deposits are situated along Mati River bed and consist of sands ands gravels, whereas the melange deposits are compassed bay rubbles-stones and pebbles cemented by argillaceous material. They on surface are weathered 0,5m up to 2-3m.

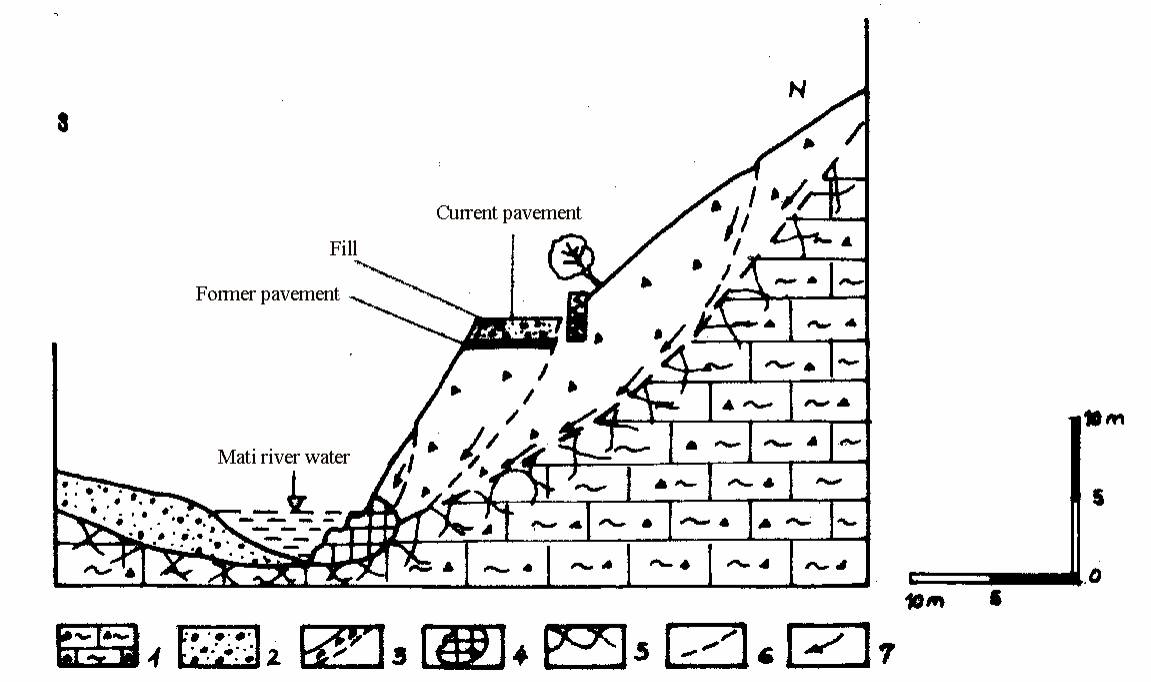

Fig. 3 Cross section of Shkopeti landslide
1. Melange deposits, 2. Alluvial deposits, sands, gravels, 3. Landslide body, 4. Erosional part, 5.Weathering crust of mélange deposits, 6. Slide plain, 7. Slide direction

Photo nr. 8. Shkopeti landslide. It's looking to north-east, and shows, the movement of Miloti-Burreli road filled by gravels and landslide body

Analysis of phenomenom.

As result of lateral erosion on right side of lower part of Mati River bank slope on which is constructed the road Milot-Burreli, a landslide has occurred. It is 250-300 long, 300-350 wide and 5-10m deep.

One of main factors in the active of landslides is the impact of changing ground water conditions as result of rainfall. By investigation carried out in the area, results that, during high rainfall periods, the river water discharge are much increased, which associated with intensive of bank erosion where the landslide re-initiating going downwards (after 1990 it's moved downward 2.0m).

Landslide has occurred on the boundary between of the loose Quaternary deposits (deluvions) and the melange deposits. As indicated in Fig. the landslide is developed on a steep slope and it is moving on steep slide plain. For that reason favored and from high quantities of rainfall, which infiltrate in slide plain and from bank toe erosion of river water, it begin slowly moving downwards up to reaching of a stationary equilibrium but with possibility to be reactivated from the changing of the environment conditions.

Remedial Measures

The stability of landslide can be done in 2 ways:

a. Construction of concrete wall, which have to support on melange rocks.

b. If the first one is impossible to done, then for stability of landslide needs to construct:

- Two ditches for collect surface runoff, just there where seep and infiltrate in slide plain.
- Construction a new retaining wall with drainage system on upper part of road.
- The protection of the road lower part of the bank slope by using of gabion or geotextile against surface erosion.

3. **Conclusion**

- The damages of the roads and bridges due to rivers erosion activity is a present and continual phenomenon in Albania.
- Analysis of erosion phenomenon is complex, because of in damages of engineering objects from erosion of rivers waters have taken place a lot of factors.
- Engineering measures for stability of situation, created by the above phenomenon are complex, as well. Generally, the solution of this problem, can be done from a specialists team.

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