THE INFLUENCE OF TREES IN THE MINOR RIVERBED OVER THE WATER FLOW AND STABILITY OF THE RIVERBED. CASE STUDY

Assoc.prof. COSTEL BOARIU
Technical University "Gh. Asachi" of Iaşi, Romania

ABSTRACT: *Over time, spontaneous vegetation develops in the rivers, which influence the flow of water. In general, the vegetation on the banks strengthens the riverbed and has a positive influence on the stability of the riverbeds. The presence of vegetation increases the roughness of the riverbed, reduces the speed of the water, increases the water level in the river, increases the water level in the nearby groundwater layer. Sometimes this vegetation materializes in large trees. How do they influence the flow of water and the stability of the riverbanks?. Large tree roots contribute to increased stability. Large tree body (over 2-3" diameter) become rigid and thus become a punctual resistance to water flow. Local turbulence and high local velocities of water are created which lead to erosion of the banks. These erosions develop and dislocations occur on the banks of the minor riverbank.*
There is a location in the minor riverbed of the Barlad river, where the presence of large trees has contributed to the erosion of the riverbed and the endangerment of the levees in the major riverbed. It is proposed a limitation of the stiffness of the tree body according to its diameter for the trees in the minor riverbed.

Keywords: *channel-forming discharge; brush layering; levee protection*;

1.Introduction. Considerations on the use of vegetation to protect riverbeds

The Romanian regulations (GE 027-1997, GP 129-2014) provide for the use of vegetation to consolidate and ensure the stability of the earth slopes. Vegetation also means grass but also trees. How do we manage the presence of trees in the consolidation of river banks?. NP 131-2011 normative regarding the safety of the levees does not accept trees on the slopes of the levee. Trees can be planted in the levee area as a protection against waves. The levee area is usually in the major riverbed. In STAS 9268-89 Regularization works of the riverbeds, the area in which trees are accepted is above the level that defines the formation flow. Until the 60's of the last century it was considered that the shape of the riverbed is determined by the maximum flows that flow because they have sufficient energy to modify the banks and the riverbed.

Maximum flows have a low frequency. In order to produce changes in the shape of the riverbed, the intensity and frequency of the discharge are important. Thus the notion of formation flow was introduced (USDA 2007). In the minor riverbed of a river, the phenomenon of instability (the divergence of the minor river) does not start during periods of small water, but during periods when the water levels rise, enough to cause the change of the minor river. Often, in the unstable rivers, it is found that, when the waters are withdrawn after a discharge, the course of the minor river changes. The formation flow is defined, the lowest flow at which such morphological changes can be recorded.

There are several methods for determining the training flow such as:

- discharge based on bankfull indices;
- discharge based on drainage area;
- discharge based on specified statistical recurrence intervals;
- discharge based on an effective discharge calculation;

- *the bankfull discharge is the discharge* that fills a stable alluvial channel, up to the active floodplain level. This is determined by on-site observations of the riverbed's configuration.
- *discharge based on drainage area*. Many equations are available that correlate dominant discharge to drainage area. These offer a quick technique for assessing a dominant discharge.
- *discharge based on recurrence interval.* The oldest estimate of this discharge was given by Leopold and Maddock (1953-USDA 1996) and it is the annual average flow. Specialized literature estimates the characteristic recurrence interval is somewhere between 1 and 3 years, with an average value of 1.58 years.
- *the effective discharge* is a theoretical discharge that determines an order of magnitude for the geometric parameters of the alluvial channel if it remains constant indefinitely for a section of the alluvial channel; if is the discharge that carries the most river deposits.

Regarding the presence of trees and in the specialized literature (USDA), they are located above the level that defines the forming flow(fig.1)

In the Romanian standard, the presence of trees above the level of the formng flow (hf) is accepted (see fig. 2)

According to NP 131-2011, one of the factors influencing the external erosion mechanism is the local hydraulic resistors, which can lead to the formation of currents

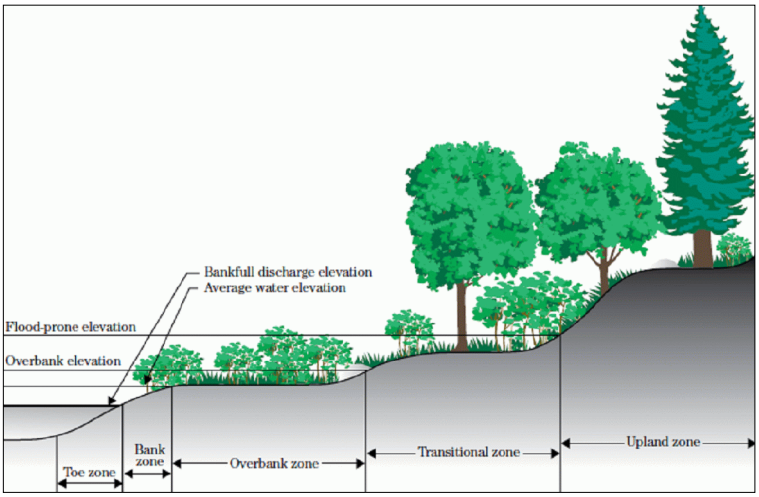

Fig.1. Regulation of a river bed according to the USDA manual

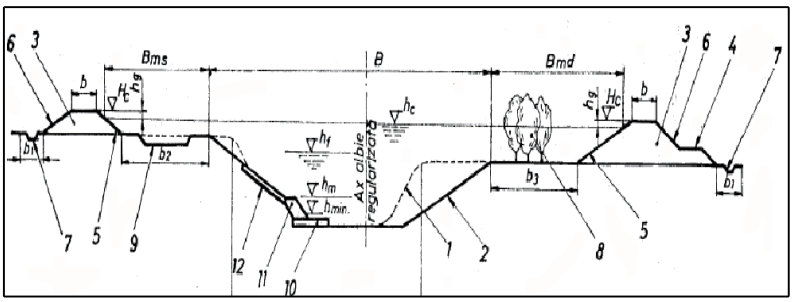

Fig. 2. Section for river bed regulation according with STAS 9268

and swirls with local speeds higher than the local average speed of the section. Thus trees, high water speed and bank vulnerability are important sources of erosion at the toe of the bank.

All these considerations lead to the conclusion that trees do not have a stabilizing effect of the riverbed if they are located in the minor riverbed.

2. Case study

2.1. The existing situation

Barlad River is in the east of Romania, it is the most important tributary on the left side of the Siret river. The damming of the Bârlad river in the Dumeşti sector is carried out with earth levees (dikes) with the following configuration:

Crown width (m) 2.60

Average height (m) 1.40

Indoor slope (1: m1) 1: 3

Outside slope (1: m2) 1: 2

The body of the dike is of fine homogeneous soil, undrained, unprotected. The slopes and the crown are grassy. The structure of the foundation ground of the dike is made up of dusty clays and clay sands. The class of importance according to STAS 4273-83 is IV

According to the class of importance the sizing of the dikes was done for the flow with the probability of 5%. In the forest area Lunca Dumeşti the river Bârlad is arranged with protective dikes on the ground on both banks. In this area there is an erosion of the right bank partially stabilized with vegetative works (acacia plantation). As seen in the sequence of images, the right bank erosion has been initiated since 2010.

Specific to this area is the presence in the minor bed of large trees with stems of sufficiently large size to be rigid

In time, the manager of the riverbed planted acacia trees in the eroded area to stop erosion. As shown in the sequence of images from 2010 to 2019 (fig. 3-6) the area planted with acacia has expanded but the erosion of the riverbed has not ceased. On the contrary it extended to the right bank

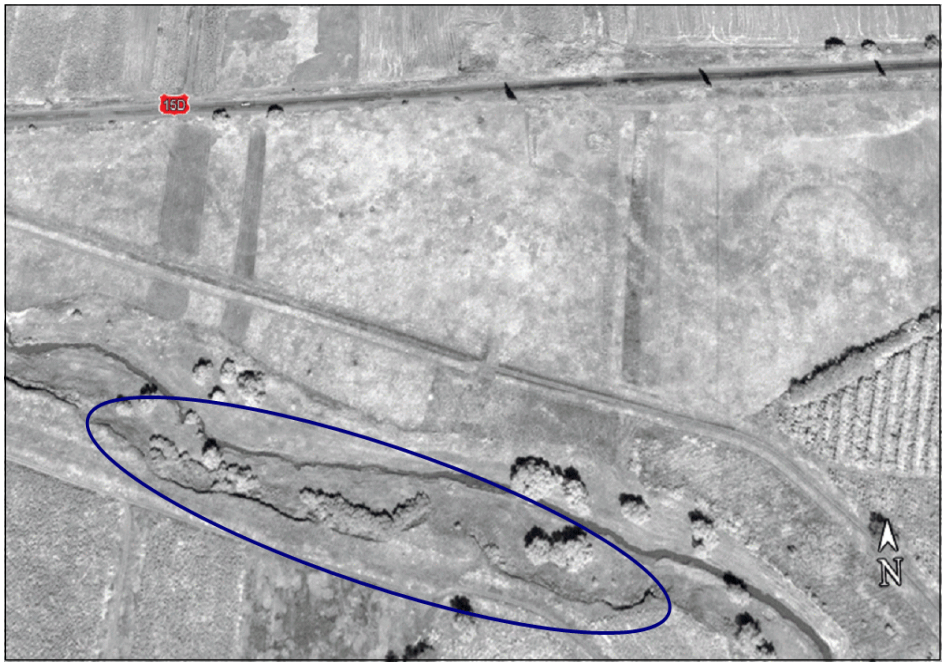

Fig. 3. Eroded area in 2010

Fig. 4. Eroded area in 2015

Fig. 5. Eroded area in 2017

Fig. 6. Eroded area in 2019

dam and in the area of the crown. It turns out that planting trees in the riverbed is not a solution in itself.

To be efficient the use of vegetation must be done according to specific procedures.

2.2. Proposed remediation solutions

Two ways can be approached to protect the right bank dike:

- Consolidation of the river bank in the eroded area;

- Moving the right bank dike at a reasonable distance from the affected area and allowing erosion to consume its development potential.

Moving the dike, with appropriate connections, may take a long time to complete the legal forms for taking over the work (land) from the current owners. Remains as a solution the consolidation of the banks of the lower bank. The Barlad River has an average slope of 0.05% in this sector. The average water velocity at the calculation flow does not exceed 1.5 m / s.

In order to protect the dike, at the right bank a land fill should be made to allow the cracked body of the dike to be restored. The distance between toe of the dyke and the crown of the bank of the minor riverbed will be at least 4 m. The filling will be made with a slope of 1/2. This filling should be protected from water erosion. Several types of shore protection can be made. These protections must include the acacia plantation already made in the minor riverbed.

A first type of protection can be achieved with biostructures. These are earth structures reinforced with plant elements whose development over time ensures the stability of the shore. The vegetal elements are willow sprouts, which planted in the soil that is deposited on the slope, will reinforce the slope after the vegetation development (and become brush layering). In order to have the expected effect the planting must be done late autumn or early spring. Before starting the landfill, the acacia trees on the slope will be cleaned (see fig.7).

The distance between the rows of sprouts should be about 1m.

Following are examples of how to apply this solution in the USDA handbook.

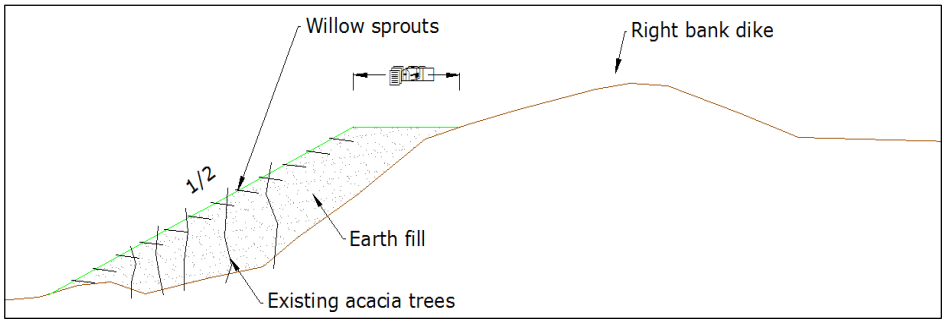

Fig.7. Bank consolidation with biostructures

3. Conclusions

The erosion of the right bank of the minor riverbed in the Dumesti area of the Barlad river, has developed over time and has been a slow evolution. To this slow evolution (reducing the speed of erosion production) contributed the planting of acacia trees in the eroded area.

In order to favoring erosion contributed the massive trees on the left bank which had the effect of groynes in directing the flow to the right side. It is obvious that the presence of massive trees in the minor riverbed is not beneficial for the stability of the riverbed.

In the technical literature, vegetation with a flexible stem (up to 2 "in diameter) is accepted in the minor stream.

The massive trees existing in the minor riverbed of the studied area must be cut, otherwise they will contribute to the erosion accentuatio. After cutting the trees, the filling and the protection of the river bank will be realized on the right bank. The filling will be done with manual means and small machining so as not to destroy the existing acacia plantation on the right bank. This clean plantation will remain in the filling and will strengthen the bank.

This method of river bank consolidation although well documented in the specialized literature has not been systematically applied in Romania. By realizing it and following the behavior in time, conclusions can be formulated for future applications.

References

1. GE 027-1997. *Ghid pentru proiectarea şi execuţia lucrărilor de apărare şi consolidarea taluzurilor la canale şi diguri*.
2. GP 129-2014. *Ghid privind proiectarea geotehnică*.
3. STAS 9268-89. *Lucrari de regularizare a albiilor*.
4. NP 131-2011. *Normativ privind evaluarea starii de siguranta a digurilor de aparare împotriva inundatiilor*.
5. Boariu C., (2013) *Structural Bioengineering Techniques For River Erosion*, Control Lucr. Sem.geogr. Dimitrie Cantemir , nr. 36, pag. 55-63.
6. NP 067-2002. *Normativ pentru proiectarea lucrarilor de aparare a drumurilor, cailor ferate si podurilor, impotriva actiunii apelor curgatoare şi lacurilor*.
7. U.S. Department of Agriculture, *Natural Resources Conservation Service National Engineering Handbook*, Part 654 Stream Restoration Design, TS 14I, Issued August 2007.