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POSSIBILITY OF UTILIZATION DIRECTING STRUCTURES IN RIVER REVITALIZATION

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ABSTRACT

Directing and concentrating structures are mainly used on water courses with unstable channels and major sediment transport or in areas with major bank erosion. The main purpose of these structures is to redirect water flow from the stressed and very often eroded bank to the centre of the channel or other parts of the channel, where the water flow may be used, e.g., for dispersion of unsuitable deposits before its eventual stabilization by natural succession. Another important goal is to achieve a desired change in a stream channel by using the transporting power of the water flow and targeted deposition of any sediment. The area of a deflecting structure, a so-called hydraulic shadow, also appears where sediment is deposited (deflector). The objective is to achieve the deposition of sediments at desired places in the stream. It is possible to design a whole range of suitable or less suitable types of flow deflectors. In our article, we will particularly focus on problems of revitalizing a water course; i.e., the design of structures from biological or biotechnical elements for channel stabilization.

KEY WORDS

- *Stabilization,*
- *river,*
- *river revitalization,*
- *biology,*
- *hydrology,*
- *water,*
- *bank*

INTRODUCTION

When we speak of deflecting structures on a water course, these particularly include deflectors that direct the water flow to the desired area of the channel. With the suitable placement of deflectors in a channel, it is possible to direct the water flow very well or to deflect it from an area with a hydraulic shadow.

These structures may fulfil several functions in a water flow – the basic function is to direct the flow or "churn up" the flow-line, although they can also help as a remedy for bank scours, when permeable deflectors significantly slow down the rate of flow in a given area and lead to a targeted deposition of sediments, silting and the natural rehabilitation of scours. Building deflectors also increase the shelter capacity of a river by accentuating its flow speed division as hydraulic shadow areas and areas with faster flow rates form. Deflectors can also significantly change the original shape of a channel bed this allows for the targeted formation of scour pools, deposits and the targeted transfer of fluvial material.

According to the ground plan, we can distinguish three basic types of deflectors – perpendicular to the streamline, oblique against the current (inclined deflators) and oblique with the current (declined deflators). The distance between deflators depends on the local situation – the channel gradient, the type and amount of sediments, the nature of the stream being regulated and revitalized, etc. According to (Patočka, Macura 1989; Šlezingr 2005, 2007), deflators are placed more densely in concave areas, with bigger spaces in direct and convex areas. When the banks full width at flow rate Q_N is B, then we can design deflectors in a direct course

SLOVAK JOURNAL OF CIVIL ENGINEERING

2010/3 PAGES 33 – 36

at a distance B in a concave area at approximately 0.5 B and in a convex area at approximately 1.25 B.
Before designing a directing structure, it is necessary to assess the current condition and stability of the channel and assess whether a revitalizing intervention will not significantly disturb this stability (a disturbance will occur anyway – that is the purpose of revitalization – but it must not pose a risk to anything standing on a bank and must not lead to a significant disturbance of the banks and channel bed resulting in property damage).
When these structures are built on narrow rivers and streams, it is also important to assess the necessity for the local stabilization of the opposite bank; i.e., the bank where the deflected flow will be directed. Therefore, their main use is on wider rivers – for example, let us mention the direction of the flow line on the lower Elbe in Germany.
It is important to stress that bed deflectors can reach a maximum of 1/5 to 1/3 of the bankfull height at a designed flow rate and are fully functional, particularly at lower flow rates of up to approximately $Q_{150} – Q_{90}$ (Q_{30}). As part of a designed flow rate, they should not form an obstacle in a stream that causes the water to overflow, even though in many cases river revitalization interventions anticipate overflowing.
Deflecting structures may be built in many ways. Their selection depends above all on the purpose of the construction. Let us have a look at two basic types of these structures: wood and stone deflectors. The designs and monitoring were done for deflectors intended for a medium stream with a bed width of approximately 10 m.

MATERIAL AND METHODS

1. Deflecting wood structures

Wood is an easily available material in areas of forest courses, mountains and foothills, and it is often advantageous to use it just because of its easier availability.
On smaller, unsuitably straight and stable streams, it is possible to design a flow line churn-up by building pole timber deflectors supported by stones and piles in the flow; it is also possible to install pole timber and bigger stones, again fixed with piles and additionally weighed down with bank earth. The designs presented were verified in the Laboratory of Water Works in 1995 and in Wasserlabor TU Dresden in 2005-07, and they are intended for use in experimental areas (the Svratka River above the end of the backwater of the valley reservoir of Brno and selected streams of the Odra catchment area).
Another possibility, which was monitored within the framework of designing the revitalization of water courses (Synková 2008; Šlezingr 2009), is the use of entire parts of trees, especially spruce crown tops. Here, it is important to properly fix the trunk to the stump (pile) on the bank (e.g., with a chain), so that the top reaches the stream and becomes an obstacle that replaces a natural deflector (for example, a tree that has fallen into a stream).
This type of deflecting structure is most frequently used intentionally for a short period; again, it is possible to use local wood, unprocessed remains after thinning, and the like.
Within the framework of assessing proposals for the use of wood after windthrow in a difficult – to – access terrain, a forested foothill course, etc., roundwood deflectors were designed in combination with adapted stumps; eventually, it is possible to use a whole root ball. After a windthrow on river banks, fairly significant bank erosion occurs; in such cases we may directly use

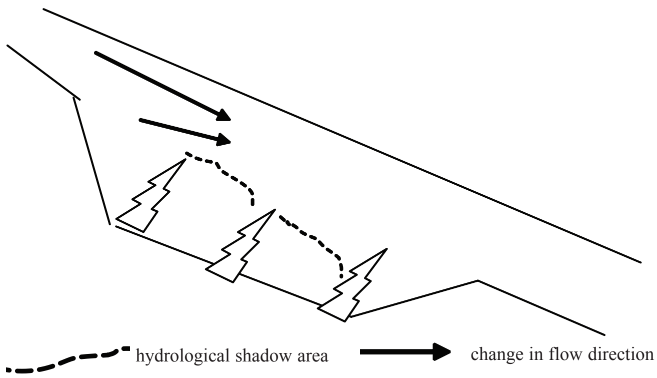

Fig. 1 *"Movable" deflectors formed from the crown tops of fallen spruces direct the water flow from a damaged bank; the locally slowed-down flow rate leads to a settlement of the sediment*

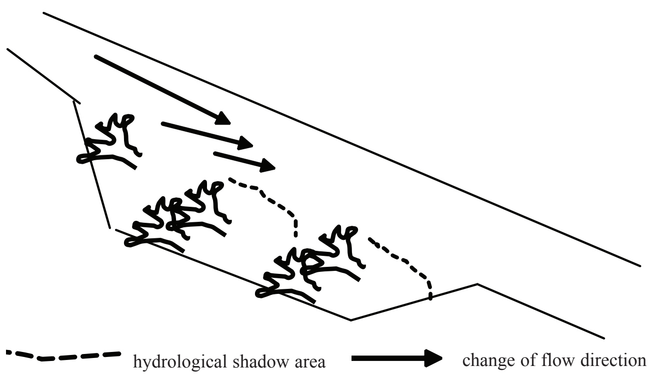

Fig. 2 *Placement of root balls after a windthrow of spruces as temporary permeable deflectors to slow down the flow in the area of the scour and help with its rehabilitation (by depositing sediments)*

SLOVAK JOURNAL OF CIVIL ENGINEERING

2010/3 PAGES 33 — 36

damaged, fallen trees – in a given case, a stem base with a root system. The diameter of the root system of the stump must be adjusted to not exceed approximately 1.5 m, so that it can be placed in the damaged bank zone.

2. Deflecting stone structures

Probably the most frequently used type of deflector is a stone deflector or a combination of stone and "dead" wood. The building and design of a stone deflector is relatively undemanding. The height should not exceed 1/3 of the water depth at Q_N (unless it can be justified); the cross section of a stone deflector should be a trapezoidal profile. This section need not be symmetric; a larger grading is proposed versus a current, milder grading with the current. The "root" of the deflector, i.e., the place it connects to the bank, should not extend above the terrain; the deflectors crown should grade down slightly to the centre of the channel. The head of the deflector is also suitable for the reinforcement to be stable in any turbulent flow which emerges and develops there. The height of the deflector in the head area should approximately be at the flow level where sediments start moving or a little bit higher.

The basic ground-plan shape (perpendicular, declining and inclining deflectors) may be combined with an additional skew structure, as need be, approximately at an angle of 45°; we suggest a deflector angle from the bank at 60 - 80°. A so-called J-deflector, a system of T-shaped deflectors, etc., may also be designed. For details on their design and hydraulic calculation, see e.g. (Patočka, Macura 1989).

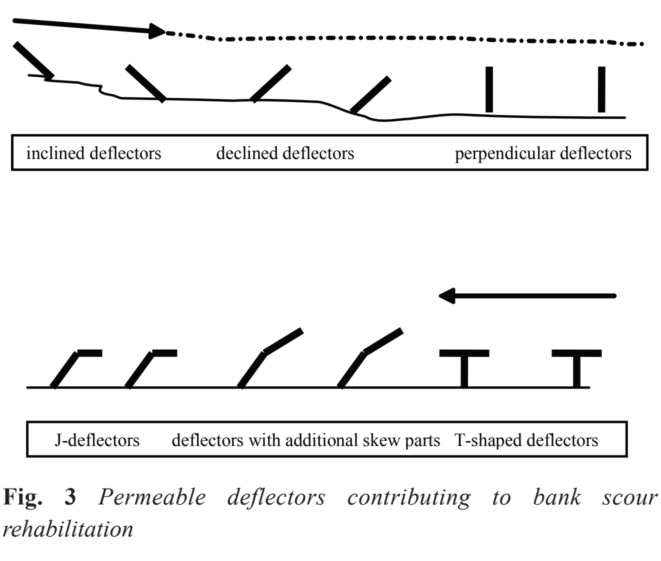

Fig. 3 *Permeable deflectors contributing to bank scour rehabilitation*

RESULTS

The basis for the design of deflecting structures on rivers came from the results of the observation of physical model prototypes in a water works laboratory and subsequent measurement in experimental streams. At present, further experimental localities are being prepared that focus on sills and breakwaters (the areas of Osada and the Rokle at the valley dam of Brno, the Svratka River).

The results – any change in sediment transfer in the area being investigated - will become evident after several years. According to the results of the model research and terrain implementation, the deflecting structures fulfil their function; they do not disturb the landscape and the water environment; on the contrary, they will help revitalize the river, increase the shelter capacity of the stream, and increase the length of the actual wetted perimeter (important for the self-purification processes of the stream).

They may also be of substantial benefit for economic reasons, because they maximally use local material, do not require a road to the stream to be built and avoid the necessity of "wet construction processes".

DISCUSSION AND CONCLUSIONS

In the present article, we focused on selected types of deflecting structures. During the revitalization of water courses, it is possible to use such other types of structures such as double or multiple splicing fences, fascine and gravel-fascine drums or gabions (wire baskets with stones, mattresses), etc. These structures have been known and used for dozens of years, but they require many more manual workers. There is also a problem with their use in eroded bank localities (the need for more workers and their training and transportation). However, these stabilization elements can be the subject of study for the preparation of designs and their realization on selected streams.

For details of the proposed deflecting structures and their use and issues involved in the stabilization of banks during the revitalization of water courses, see the recommended and source bibliography.

SUMMARY

The design of deflecting structures based on the use of biological material or biotechnical deflecting structures is an important contribution to the revitalization of rivers; at present, rapid technical interventions are mainly used to remedy bank scours. These are also where our proposed stabilization structures could be used.

SLOVAK JOURNAL OF CIVIL ENGINEERING

2010/3 PAGES 33 — 36

In the article, we particularly focused on examples of how to use the biological material found in a forest course after windbreaks, floods, etc. – i.e., in a situation when river (stream) banks as well as forest stands are damaged. We propose to use entire damaged trees – the trunk, parts of the crown and the root system. Flow deflectors using these materials are fully functional; their construction in a stream is relatively easy and doesnot interfere with the existing ecosystem. Bank scours may therefore be repaired in a natural way with a minimum impact on the surroundings.

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