INFLUENCE OF THE MACRO-ROUGHNESS OF A BANK PROTECTION BY RIP-RAP ON BED LOAD TRANSPORT AND LOCAL SCOURING IN RIVER BENDS

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Fluvial hydraulic engineering was considered for a long time from a functional point of view exclusively, with regard to flood protection. Hydraulic-engineering measures must also integrate the environmental, social and economic aspects today. In this context, experiments on a physical model were carried out to determine the influence of the geometry of a riprap in a curved flume (Chèvre 2004). Two geometries were tested, the first with a bank with regular slope as reference situation, the second with an undulated bank (Fig. 1), with the purpose to improve the hydro-morphological conditions of the river. The studied parameters are the flow discharge, the transport of the sediments, the scouring of the bed and the stability of the rip-rap.

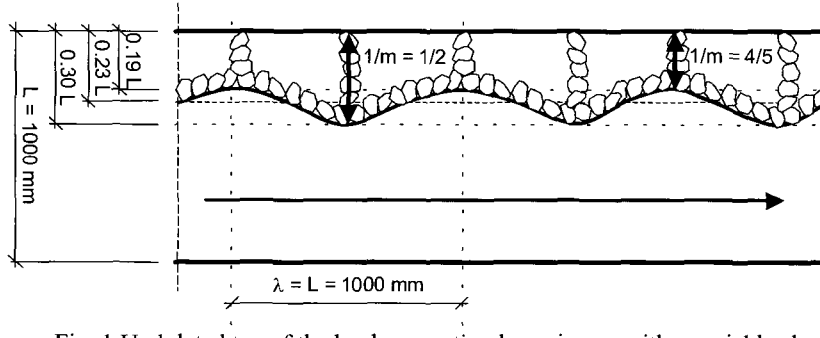

Fig. 1 Undulated toe of the bank protection by a rip-rap with a variable slope

Based on the systematic model tests the following conclusions can be made.

Compared to a rip-rap with uniform slope, the undulated rip-rap strongly increases the variability of flow velocities with highly turbulent zones at the head of the undulations and backwater zones in the coves.

The undulated rip-rap strongly increases the variability of flow velocities. Besides of backwaters in the coves also deposits of fine and coarser sediments are created. Such conditions are favorable for fish biotopes.

The undulated rip-rap reduces the discharge capacity of the flow section (about 10 % for the tested configurations) and consequently increases water depth. On the other hand

the sediment transport capacity in the bend is increased (about 25 % for the tested configuration and full section discharge).

Even if locally deeper scour holes occur in the coves of the undulated rip-rap, its stability is less endangered than for a rip-rap with constant slope for which a long and deep scour hole along the bend forms.

The rip-rap at the downstream face of the undulations is endangered by a submerged jump created on the latter. This can be mitigated by an optimized geometry of the undulations and somewhat increased block weights compared to the rip-rap with uniform slope.

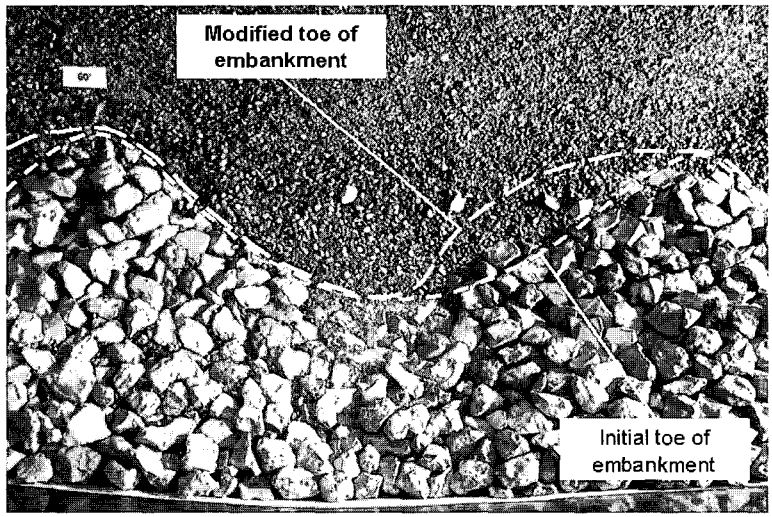

Fig. 2 Optimized geometry of an undulated rip-rap.

Furthermore based on the experimental results and observations of the flow behavior, the following recommendations in view of practical application of the new type of bank geometry can be given.

The application of the tested undulated geometry for engineering purposes is feasible. Nevertheless a modification of this geometry is proposed to improve the results concerning the erosion and the stability of the bank. The modified rip-rap geometry is presented on the Fig. 2. The main idea is to reduce the downstream slope of the undulation, which decreases the local velocity of the flow over the undulation. The scour hole in the cove will be reduced and the local and global erosion will be less superposed. Also the shear stresses on the undulation will be decreased and the blocks of the rip-rap will be more stable. On the downstream slope of the undulations, the size of the blocks of the rip-rap should be increased by about 30 % compared to regular (uniform) rip-rap. Furthermore the length of the undulations should be increased to 1-2 times of the channel width (see Fig. 1: λ=1.2L). Finally the undulations should not reduce the channel width by more than 10 %.

Chèvre, Ph., 2004. Influence de la macro-rugosité d'un enrochement sur le charriage et l'érosion de la courbe. Communication No 19 au Laboratoire de Constructions Hydrauliques (LCH), Ecole Polytechnique Fédérale de Lausanne (EPFL).