LABORATOIRE DE CONSTRUCTIONS HYDRAULIQUES

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Replenishment of sediment downstream of dams – Erosion and transportation process of artificial deposits (2013)

PhD candidate: Elena Battisacco
Thesis supervisor: Anton J. Schleiss
Thesis co-supervisor: Mário J. Franca

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Problem statement

Over the last decades, a reduction on the supply of sediments has been observed downstream dams existing in several alpine rivers. The transport of these sediments by water, along river basins from steep slopes regions to flood plains, is an important feature of the natural river conditions with a role on the ecology of watercourses. Many studies highlighted that the presence of a dam strongly modifies the river behaviour in the downstream reach, in terms of morphology and hydrodynamics, with consequences on aquatic ecology. In particular, river incision, bank instability, bed armoring and sediment deficit are the main effects, which affect negatively the aquatic habitats, riparian vegetation and the water quality. In Switzerland, there are more than 500 hydropower plants and more than the 40% have a significant disturbance of the bed load transport *(Figure 1)*. Until now, one of the proposed techniques to solve the problem of sediment deficit downstream dams is to do the replenishment. This research project is part of the "Wasserbau und Ökologie" research initiative, which focuses on finding an engineering answer to dam impact in the downstream river using this method.

Figure 1 : Situation downstream a dam where fine sediments are missing (Eawag.ch)

Objectives

The technique of replenishment of sediments consists on supplying these by bypassing them directly from the reservoir or collecting grains from other close sites. This technique was already adopted in a few Japanese and German rivers (*Figure 2*). The results, so far from these experiences, indicate that the replenishment helps maintaining a stable bed and mitigating bed armoring. The goal of this research is to improve the procedure to be applicable in the alpine sites aiming at developing adequate morphology for restoration of suitable habitats conditions downstream dams in order to ensure fish reproduction. Hydrodynamics around river replenishment geometries and erosion evolution of these will be assessed in order to define a better design of the replenishments.

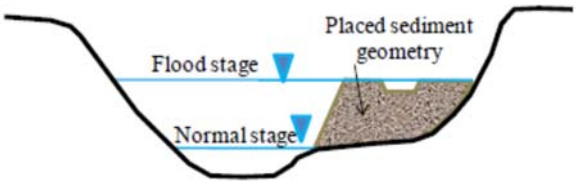

Figure 2 : Example of replenishment technique (Geomorphic response of rivers below dams by sediment replenishment technique, S.A. Kantoush, T. Sumi. River flow 2010)

Methodology

Three series of test are planned. Experiments will be carried out in a 15 m long and 1.25 m wide channel. The cross section has a 0.4 m bed width and a 2:3 of bank slope *(Figure 3)*.The first series of laboratory tests are run as preparatory study to understand hydrodynamics of the river flow when the replenishment is made. Non-erodible volumes, with different lengths and submerged conditions, reproducing the replenished sediment shape, are positioned along a river bank. The second series deals with erodible volumes and the third will estimate the contributions of a combinations of parameters. The influence of multiple parameters will be studied in the laboratory model.

Figure 3 : Laboratory model, first test with water

The following parameters are measured during the experiments:
- velocity
- water depth
- temporal evolution of the erosion
- bed morphology.

The influence of the following parameters on erosion and transportation of replenished deposits is studied:
- Slope
- Volume geometry (single or multiple volumes)
- Deposition pattern of sediments

Expected results

The purpose of this research is to define:
- which deposits are more favourable for a natural transport, considering discharge relases linked to flushing operations of dams;
- where and how to place sediments in order to obtain the expected transport of sediments;
- which discharge (duration, period and amplitude) is necessary to mobilize the deposits and to create bed forms along the section to revitalise of watercourses.