SUSPENDED LOAD TRANSPORT IN SHALLOW RESERVOIRS

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Sediment deposition in reservoirs reduces the storage capacity and generates a risk of blockage of intake structures as well as sediment entrainment in hydropower schemes. Suspended sediment deposition is a complex phenomenon, particularly in case of shallow reservoirs. The intensity of silting in reservoirs depends on several main factors. One of them is reservoir geometry.

The main purpose of the present research is to better assess the physical processes behind sedimentation of shallow reservoirs by suspended load. Also, the ideal reservoir geometry, minimizing the settlement of suspended sediments, is searched for.

This paper presents the main goals and the approach that is actually conducted to achieve the objectives. The influence of the reservoir geometry will be assessed by physical and numerical modeling of the hydrodynamic flow and the suspended sediment transport behavior. An experimental setup was developed with reference to the characteristics of the Rhone River upstream of Lake Geneva (Figure 1). The complete design for the physical modeling and testing procedure are described. Furthermore, many mathematical models exist for numerical simulation of sediment behavior. A preliminary evaluation and comparison of different computer programs (both commercial and academic codes) has been performed. A 2D numerical simulation of the hydrodynamics and suspended sediment transport allowed to pre-define the different reservoir geometries to be tested on the physical model.

The study focuses on the sedimentation of shallow reservoirs by suspended sediments and studies the following questions:

How functions the process of sedimentation in shallow reservoirs by suspended load and what are the most appropriate numerical models available today?

Which geometry of the shallow reservoir has to be chosen in order to avoid excessive sedimentation and to ensure sustainable reservoir volume?

Which configuration of inflow and outflow is the best in view of minimizing sedimentation?

The solution to these questions will be found according to the following procedure:

The influence of the reservoir geometry will be studied by physical and numerical modeling of the hydrodynamic flow and the suspended sediment transport.

The ideal geometry for the shallow reservoir, minimizing settlement of suspended sediment, will be searched for and validated on the basis of pervious results.

Shallow turbulent flows such as shallow mixing layers, jets and waves, are widespread in nature and engineering. The present study particularly focuses on reservoirs with a prototype depth between 5.0 and 15.0 m. The-state-of-the-art reveals that most research on shallow reservoir sedimentation doesn't consider the influence of the geometry of the reservoir on the sedimentation process. The experimental tests carried out in a rectangular shallow basin with inner dimensions of 6.00 m length and 4.00 m width. The experiments will start with the basic rectangular geometry shown in Fig. 1, followed by different configurations with the aim to find the optimal geometry.

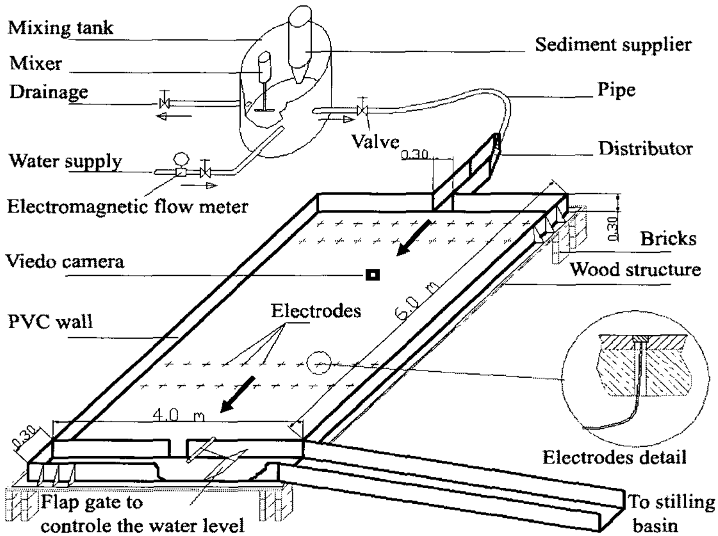

Fig. 1 Schematic view of the experimental installation

Concerning the numerical approach, first-hand simulations were carried out by CCHE2D and FLOW-3D. These computations aim at defining the geometrical shapes to be tested experimentally. Preliminary numerical simulations of suspended sediment transport in shallow reservoirs have been presented. They will be used to define which geometrical configurations will be studied experimentally.

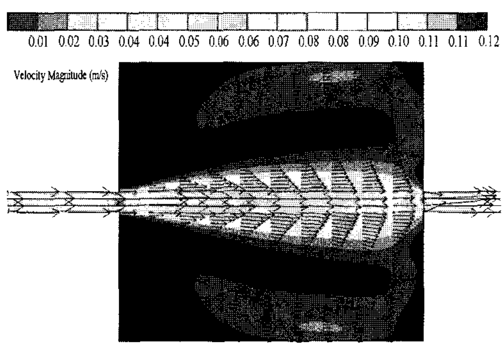

Fig. 2 Stationary flow field and velocity magnitude computed by CCHE2D for the initial reservoir conditions (plane bed, constant discharge, k-ε)

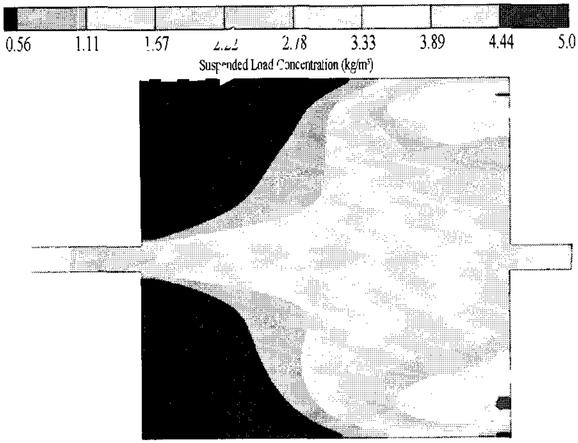

Fig. 3 Suspended load concentration computed by CCHE2D for the initial reservoir conditions (plane bed, constant discharge, k-ε)

As an example Fig. 2 presents the stationary flow field by CCHE2D, starting from an initial condition of stagnant water with a plane bed and k-ε turbulence closure scheme. It can be seen that two large recirculation eddies develop along both sides of the basin. Several scenarios have been simulated with the same geometry and changing the boundary and initial conditions in both programs. Fig. 3 shows the suspended sediment concentration calculated by CCHE2D. Although both patterns coincide in a general manner, substantial differences can be noticed locally, due to the different turbulence closure schemes.