LABORATOIRE DE CONSTRUCTIONS HYDRAULIQUES

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Monitoring and Prediction Methods for sedimentation in pumped storage plants

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Introduction

Sedimentation of dam reservoirs is one of the most challenging problems of the XXI[st] century in hydraulic engineering. On a worldwide scale, dam reservoirs silt up at a rate of about 1 % of their useful storage volume every year. Furthermore, sediments can settle in front of essential elements of the hydropower schemes, such as intake structures or outlet works (Figure 1). Thus, sedimentation processes seriously affect the reliability and the lifetime of hydropower structures, but also their structural safety.

Figure 1: Sedimentation of Tourtemagne Reservoir

To satisfy a continuously increasing energy demand, pumped storage hydropower projects become more and more relevant. Such projects generally consist of an upper and a lower reservoir in order to pump and/or turbine water between them. Long-term sedimentation issues of such reservoirs due to fast and repeated change of operations between generating and pumping modes are relatively unknown compared to traditional hydropower schemes.

Objectives

The present PhD thesis aims to develop solutions guaranteeing sustainable sediment management in pumped storage hydropower plants by answering the following key questions:

- How can we use the turbulence introduced by the pumping and generating mode for preventing the suspended sediments to be settled?
- How do parameters like intake/outlet geometry, discharge and duration of alternating pumping and generating mode affect the sedimentation processes in the reservoir?

The work will be structured as follows: After a detailed literature study, theoretical basis on reservoir sedimentation issues will be outlined. Prototype measurements, physical scaled modeling and numerical modeling will be carried out. The analysis of test results will lead to the development of a theoretical model and new design guidelines describing the influence on turbulence by intake and outlet geometry and long-term behaviour of sediment transport and deposition in a pumped storage hydropower scheme.

State of research

Literature review : Literature concerning reservoir sedimentation has been studied. Further reading will concentrate on topics related to sedimentation in front of intake structures, sedimentation in Alpine reservoirs, turbidity currents, turbulence and sediment balance between two connected reservoirs.

Prototype measurement : Prototype measurements and monitoring are an important part of the PhD work. Such recording of data is carried out at the Grimsel II pumped storage scheme (Figure 2). It will provide results of phenomena observed in situ and allow adjusting physical and numerical models.

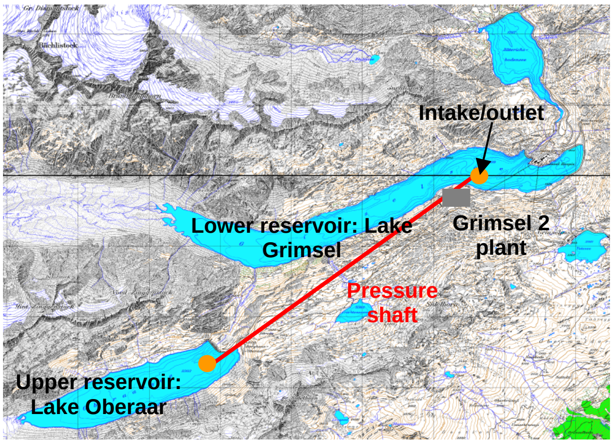

Figure 2: Hydraulic model of the diversion works

In a preliminary campaign in July 2008, the candidate became familiar with instruments and in situ working conditions. Then, two measurement campaigns were carried out in September and November 2008, allowing to record flow velocities in front of the Lake Grimsel intake/outlet structure, using acoustic Doppler profilers (ADP). Vertical velocity profiles on three axes, as well as flow fields in the reservoir were established (Figure 3).

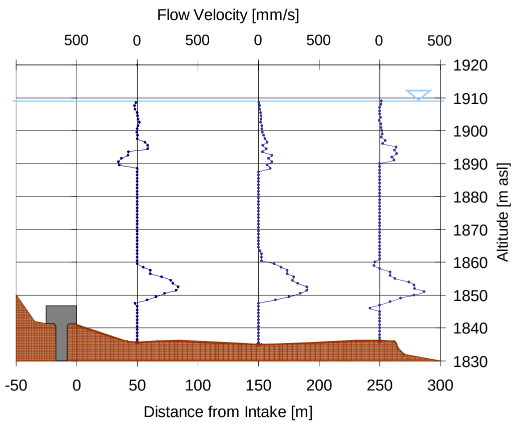

Figure 3: Example of a vertical velocity profile during turbining mode in front of the intake/outlet in Lake Grimsel

Outlook

Prototype records of the November campaign will be analyzed in order to obtain more information about the influence of the pumping/generating mode on flow fields in the reservoir. The numerical model of Lake Grimsel will be established and calibrated. First simulations of a simple sediment transfer/settlement configuration in the physical model will start in summer 2009.