Chespí-Palma Real, Ecuador, physical model tests for flood and sediment bypass (2011)

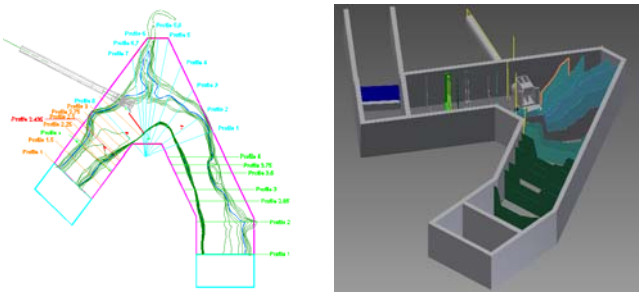
Milad Daneshvari, Giovanni De Cesare

Client: Chespí consortium (Lombardi SA Consulting Engineers, Switzerland, SP Studio Ing G. Pietrangeli Srl, Italy, Carrillo Carrillo & Consultores, Ecuador) Commissioned by HidroEquinoccio, Ecuador

Introduction and objectives

The Chespí-Palma Real hydro power plant is located in the north-western part of Ecuador on Guayllabamba River, about 30 km north of the capital, Quito. The plant consists of a double curved arch dam 63 m height, with a reservoir capacity of 4.4 x 10^6 m^3 that covers 22.2 ha. The reservoir collects the water of an approximate 4'500 km^2 basin. Sediment management is a fundamental aspect of this project. Till this stage, around 1.8 x 10^6 tons are transported to the site representing an annual flux of 820'000 m^3.To avoid regular flushing of the reservoir and subsequently the plant shutdown, a sediment bypass structure is planned upstream of the reservoir. A drowned sill, located downstream of the inlet structure allows the use of this structure to avoid emptying the reservoir. Two alternatives are defined as the possible positions of the sill, the first one is, situated just after the inlet structure and the latter one is placed further downstream. A physical model of the river, sediment bypass, two sills and the reservoir are built at a scale of *1:38*. The hydraulic model tests verify and optimize the following aspects:

- *The hydraulic performance of the bypass in the established configuration,*
- *Identification of potential deposit zones in the river,*
- *The proper sediment evacuation during floods (sediment flushing procedure),*



Prepared profiles *3D digital snapshot*

Figure 1 : Snapshot of the model and cross sections initially prepared in 3D digital environment

Bypass inlet and gallery *Upstream sill*

Figure 2 : Different parts of the physical model

Figure 3 : Chespí model constructed in the laboratory with the two water supply pipes for river and reservoir (Sc = 1:38)

Physical tests

The tests were carried out in two major phases, clear water tests and tests with sediment for different flood return periods. Water profile, approach condition through the inlet, sediment deposition and evacuation process as well as flow velocity in the bypass gallery and over the sill's vicinity are measured for the defined scenarios.

Upstream sill *Downstream sill*

Figure 4 : deposited sediment retained by the sills

Test results

The inlet structure is well designed and able to bypass the required discharge without observable problems on the physical model. The transition from the gated section to the free flow gallery allows a correct acceleration and smooth evolution of the flow. The inlet structure works well for all the tested scenarios, with variable reservoir water surface elevation, sill position and elevation.

Regarding the model tests with sediment, in a first step, the flow in the undisturbed river (closed inlet structure and free outflow) showed a significant sediment transport capacity with some minor deposits at the inner bank of the bend. Therefore, for lower reservoir level, practically all sediment would flow into the reservoir and consequently fill it over a short period of time. The bypass structure allows efficient sediment evacuation with the upstream sill in its proposed initial position and elevation. To prevent the remaining sediment enter the reservoir, back flushing from the reservoir should be performed. This flow flushes the sediments through the inlet structure and clears the inlet entrance.