Hydraulic Engineering and Infrastructures

Civil Engineering Department

Flow profiles

1 Hydraulic jump at slope change

A long spillway (slope of 10 % and Manning coefficient 0.025 $s/m^{1/3}$) discharges into a flat stilling basin. There, the water depth is controlled by a step before the water flows into a steep river. A small step height will change the flow lightly, but a larger step will force a subcritical flow further upstream of it and generate a hydraulic jump in the stilling basin. The channel is reactangular with a width of 2 m, has a discharge of 50 m^3/s and the stilling basin is 40 m long. What is the maximum step height before the hydraulic jump affects the spillway?

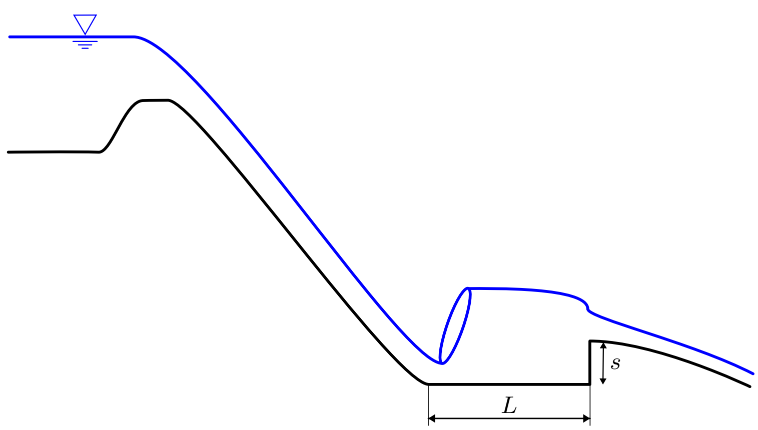

Figure 1: Schema of the problem

Objectives and guidance:

The aim of this exercise it to understand the concept of a conjugate height and use it to find the position of a hydraulic jump using the direct-step method.

Hints :

- For the spillway to be free, the hydraulic jump has to happen at the slope change or further downstream. Thus, there is a condition at the slope change: the depth directly downstream is the conjugate of the supercritical depth directly upstream.
- The direct step method can be computed both ways (upstream $\leftrightarrow$ downstream) independently of flow conditions.
- The depth of the step is defined by the jump in energy around the step. Consider that there is no energy loss at the step: $E(x = L - \varepsilon) = s + E(x = L + \varepsilon)$ with ε being a small distance.

2 Hydraulic jump with gate and weir

A group of students is setting up a laboratory experiment to reproduce the formation of a hydraulic jump. They use a flume having a width $b = 0.15$ m, a slope $S_0 = 0.001$, and a Manning coefficient $n = 0.0092$ m$^{-1/3}$s (Plexiglass). In the setup, they place an upstream gate with a constant water level and a constant discharge $Q = 0.011$ m^{3}s^{-1}. The gate vertical opening is $h_{gate} = 0.051$ m, and the minimum water depth reached downstream of the gate (vena contracta) is $y_2 = 0.025$ m. 15 meters downstream of the gate, they also place a $d_{weir} = 0.03$ m long-crested weir where choking occurs. Assume there are no losses at the transition on the weir.

Determine the location of the hydraulic jump x_{jump} and draw the resulting hydraulic profile.

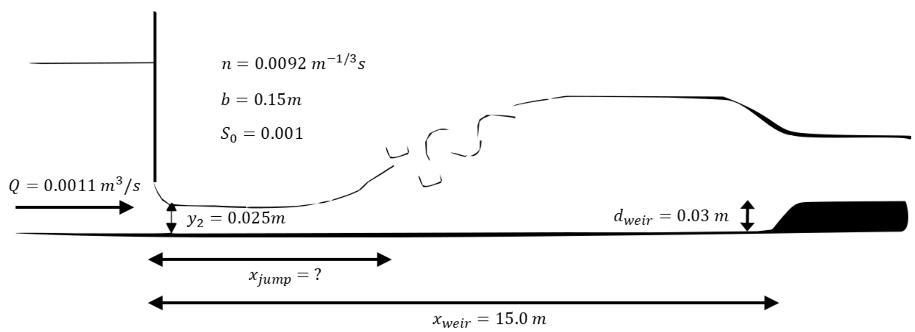

Figure 2: Setup of the flume experiment and expected outcome.