Sprinkler System

Submission date 21/10/2025 at 16:00

Exercise 1 - Aqueduct

An aqueduct with circular cross-section and 2 m internal diameter has a constant slope and delivers water under free-surface flow conditions (see Figure 1). It carries a flow rate Q_a=1.39 m^3/s. At a valley crossing, it is replaced by a siphon consisting of two identical pressurized pipes, each with a diameter of 1.25 m and a length of 2200 m. The elevations of the bottom of the aqueduct at the siphon heads are:

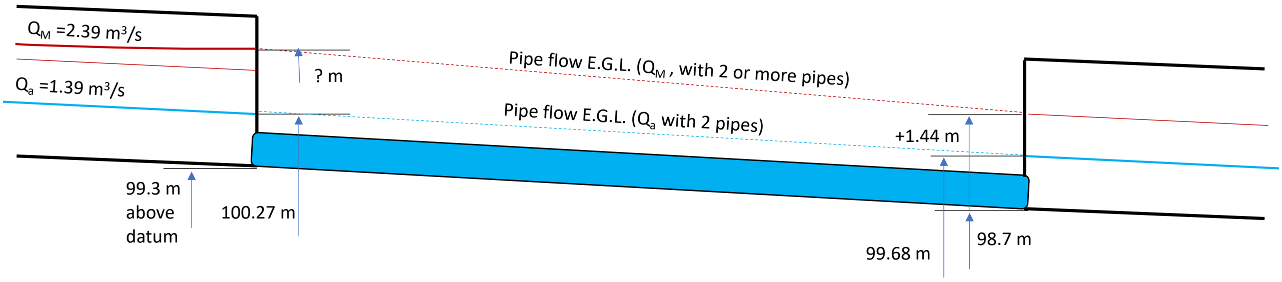

Figure 1: Schematic of the pipe system

- Upstream head: 99.30 m
- Downstream head: 98.7 m

For the specified flow rate Q_a, the water elevations are:

- Upstream head: 100.27 m
- Downstream head: 99.68 m

It is considered the possibility for the aqueduct to carry a flow rate up to Q_M=2.39 m^3/s. Under normal flow conditions, this would bring the water depth in the aqueduct up to 1.44 m with respect to the bottom. The aqueduct can thus obviously handle the increased flow. However, given that the max water elevation inside the aqueduct should not exceed 85% of the pipe diameter for security reasons this condition should be verified for the upstream pipe end where the hydraulic head for establishing pressure flow conditions is generated.

Assuming that for a flowrate equal to Q_M the downstream water elevation in the aqueduct starts from the normal flow condition, and assuming the pipe can be considered as "hydraulically long" (i.e., $U^2/2g << iL$ and is therefore negligible), it is asked to verify that the water elevation in the upstream section of the pipe respects the safety condition above. Should the solution with two pipes not be sufficient to carry the new flow rate, then assess whether an additional identical pipe will be sufficient (three pipes solution).

Exercise 2 - Anchoring of a curved pipe

A pipe with an inner diameter of 110 mm is used to transport water (ρ=1000 kg$\cdot m^{-3}$) for irrigation from the reservoir to the crop fields. The pressure in the pipe is 6 bar and the flow rate is 28 l/s. The reservoir is 15 m higher than the fields, and the angle α of the pipe bend is 50°.

Assumptions:

- Both localized and distributed losses are negligible;
- At the first bend: $p_{\text{inflow}} = p_{\text{outflow}}$;
- At the second bend: $p_{\text{outflow}} = p_{\text{inflow}}$;

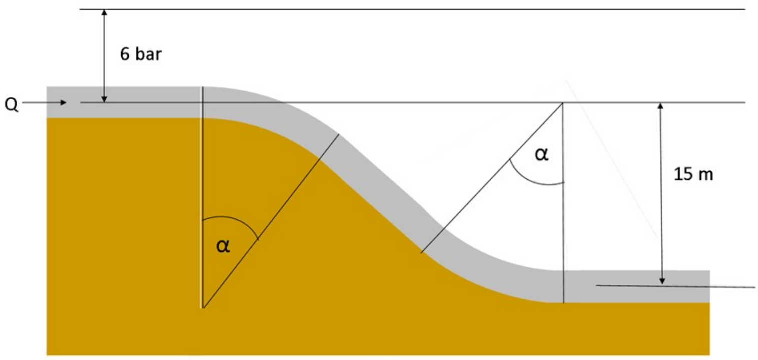

Figure 2: Schematic of the pipe system

It is asked:

1. To calculate the resulting force on the pipe bends while taking into account the conservation of momentum and make a drawing with the direction of the resulting force;

   Hint:
$$|F| = \sqrt{F_1^2 + F_2^2 - 2F_1F_2\cos\alpha}$$

2. To calculate the resulting force using the formula given in the lecture (i.e., neglect changing direction of the momentum):
$$F = KPS$$
   and make a drawing showing the direction of the resulting force. Discuss the results.