



Hydraulic Engineering and Infrastructures

Civil Engineering Department

Quantitative flow profiles

1 Irrigation channel

A hydraulic engineering company has hired you to design an irrigation channel from the field of Mr. Favre (point A, in Figure 1) to the field of Mr. Bianchi (point C, in Figure 1). Here, the channel discharges into a river under free fall conditions. The channel should convey a discharge of $Q = 10 \text{ m}^3/\text{s}$, have a uniform rectangular cross-section with base width $b_0 = 2 \text{ m}$, and Manning roughness coefficient of $n_0 = 0.01 \text{ m}^{-1/3}\text{s}$.

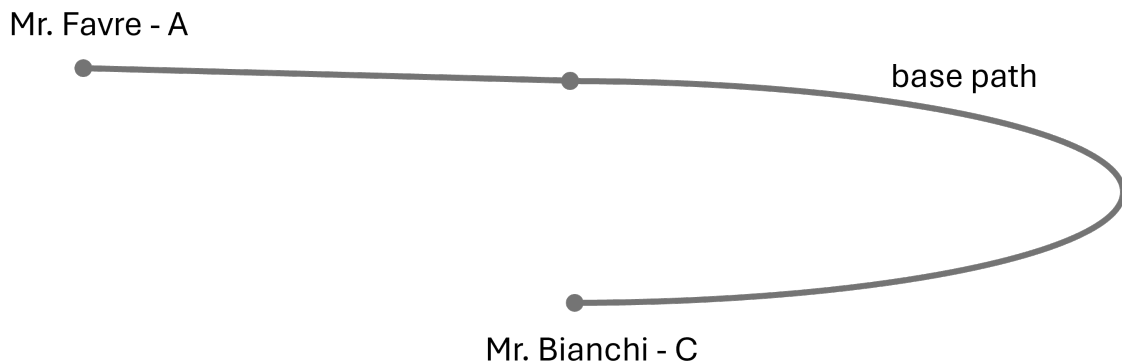


Figure 1: Planview of the base configuration.

The engineering company suggests you a base configuration and some possible alternatives, varying one or more design parameters. **Be careful with the possible changes in critical and normal depth between one configuration and another.**

a. Base configuration

The slope between the fields of Mr. Favre and Mr. Bianchi is $S_0 = 0.0002$. You can assume that the channel is long enough for the flow to develop normal conditions. Follow the four steps you learned in class to compute the hydraulic profile, i.e. (i) compute the critical and normal depth, (ii) identify the control points and the flow type conditions (i.e., M_i , S_i , uniform), (iii) draw the qualitative profile, and (iv) compute the quantitative profile with the Direct Step Method (DSM).

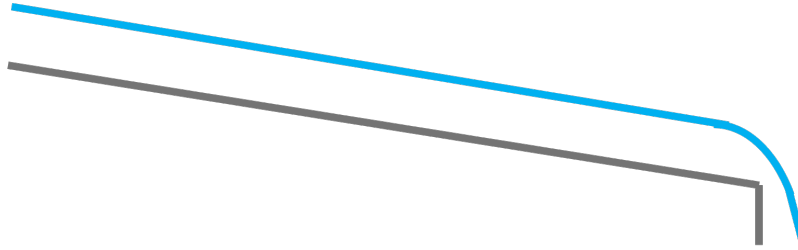


Figure 2: Longitudinal profile of the base configuration.

b. Section increase

The first suggested alternative is to increase the channel cross-section. While keeping a rectangular shape, at a certain point upstream of Mr. Bianchi field, the channel width increases to $b_1 = 4$ m for a length of $L = 800$ m. You can assume that the width increase is smooth and there is no energy loss. Follow the four steps you learned in class and compute the hydraulic profile with the DSM.

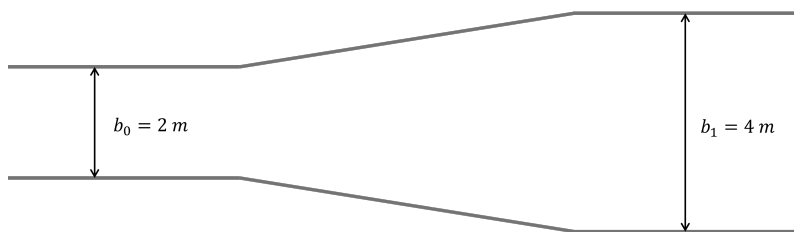


Figure 3: Width increase.

c. Slope increase

The engineering company also suggests a shorter path passing from the terrain of Mr. Schneider (point B). The first reach between Mr. Favre and Mr. Schneider maintains the same slope as the base configuration $S_0 = 0.0002$, whereas for the new reach between the house of Mr. Schneider and Mr. Bianchi the slope suddenly increases by a factor 200. Consider that the alternative path is long $L = 90$ m. Follow the four steps you learned in class and compute the hydraulic profile with the DSM.

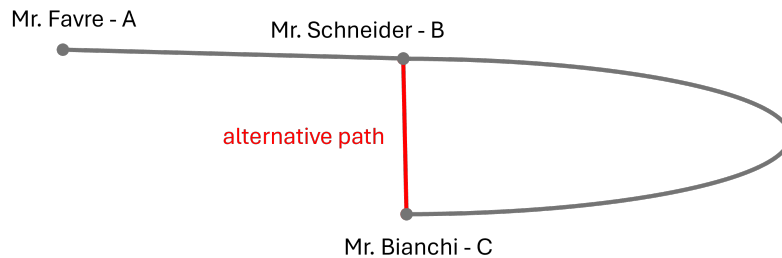


Figure 4: Planview of the second alternative configuration with a different path and a slope increase.

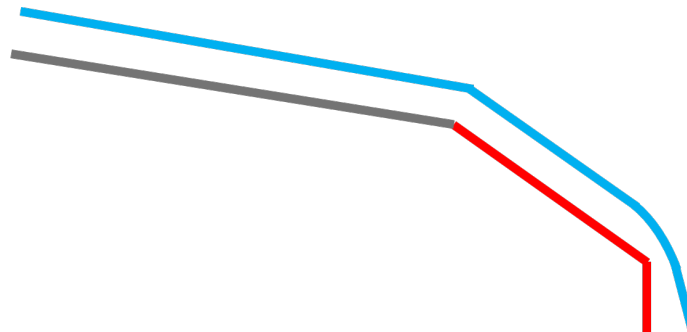


Figure 5: Longitudinal profile of the configuration with the slope change.

d. Roughness increase

Since Mr. Bianchi is particularly careful with ecology, he requires to include a more ecofriendly solution. For this, the engineering company suggests to add some vegetation to the reach between Mr. Schneider and Mr. Bianchi, which increases the Manning roughness to $n_1 = 0.12$. Consider the same channel length as for case 3. Follow the four steps you learned in class and compute the hydraulic profile with the DSM.