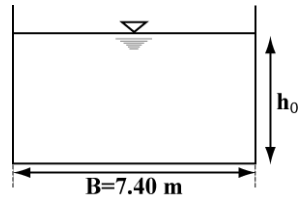


**Istanbul Technical University**  
**Department of Civil Engineering**  
**CIE 354 Hydraulic Engineering**  
**Lab Tutorial 3**  
**Open Channel Flow**

In this lab session you will model a prototype case with a series of problems to be solved.

Different types of constructions, that are very distant to each other, are planned to be built along a river the cross-section of which is shown in the figure below. This river has a bottom slope of 0.0107 and its bed is completely covered with smooth concrete.



In order to analyze the effects of these constructions under different discharge conditions, the flow of this river will be modeled in the laboratory by using a rectangular channel made of plexiglass; see Photo 1.



Photo 1. Laboratory free surface flow flume

### **EXPERIMENT I: FLOW REGIME**

A constant discharge will be set in the model and various flow parameters will be analyzed subsequently.

#### **Measurements**

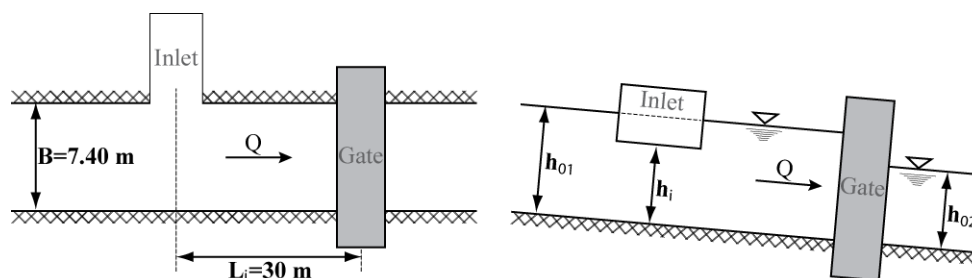
- Determine the discharge ( $Q_M$ ) of the model.
- Determine the uniform flow depth ( $h_{0M}$ ) in the model.

#### **Data Analysis**

- Determine the Strickler coefficient ( $K_M$ ) of the channel used in the model [Although the bed of the river is originally covered with smooth concrete, the Strickler coefficient of the prototype ( $K_P$ ) will be assumed to be equal to the one determined from the model for any further computations (i.e.,  $K_M = K_P$ )].
- Determine the discharge ( $Q_P$ ) of the prototype.
- Determine the uniform flow depth ( $h_{0P}$ ) in the prototype.
- Determine the mean cross-sectional velocity ( $V_M$ ) and the regime of the flow in the model.
- Determine the mean cross-sectional velocity ( $V_P$ ) and the regime of the flow in the prototype.

## EXPERIMENT II: GATE

A gate is planned to be constructed on the prototype in order to control the flow conditions in the river. This structure will also allow the transfer of water to an irrigation channel; the inlet of this irrigation channel is planned to be constructed in the upstream direction of the gate, as shown in the plan and longitudinal views below.



### Measurements

- Determine the discharge ( $Q_M$ ) of the model.
- Determine the uniform flow depth ( $h_{0M}$ ) in the model.
- Close the gate to a certain percentage (75%) and determine the uniform flow depth ( $h_{01M}$ ) at the upstream of this gate used in the model (at a constant distance  $L_M$  from the gate).
- By keeping the gate closed (i.e. at 75%), determine the uniform flow depth ( $h_{02M}$ ) at the downstream of this gate used in the model (at a constant distance  $L_M$  from the gate).

### Data Analysis

- Determine the discharge ( $Q_P$ ) of the prototype.
- Determine the uniform flow depth ( $h_{0P}$ ) in the prototype.
- Determine the uniform flow depth ( $h_{01P}$ ) at the upstream of the gate in the prototype (at a constant distance  $L_P$  from the gate; assume that the gate is 75% closed as in the case of the model).
- Determine the uniform flow depth ( $h_{02P}$ ) at the downstream of the gate used in the prototype (at a constant distance  $L_P$  from the gate; assume that the gate is 75% closed as in the case of the model).
- Determine the mean cross-sectional velocity of the flow in the model for cross-sections at the upstream and downstream of the gate, respectively (i.e.  $V_{1M}$  and  $V_{2M}$ ).
- Determine the regime of the flow in the model for cross-sections at the upstream and downstream of the gate, respectively.
- Determine the mean cross-sectional velocity of the flow in the prototype for cross-sections at the upstream and downstream of the gate, respectively (i.e.  $V_{1P}$  and  $V_{2P}$ ).
- Determine the regime of the flow in the prototype for cross-sections at the upstream and downstream of the gate, respectively.
- Determine the specific energy of the flow in the prototype for cross-sections at the upstream and downstream of the gate, respectively (i.e.  $E_{1P}$  and  $E_{2P}$ ); draw the variation of the specific energy with depth (i.e.  $E$  vs.  $h$ ).
- Determine the thalweg level ( $h_{iP}$ ) of the irrigation channel in the prototype, if a minimum water depth of 1.60 m is desired in this latter one when the gate is 75% closed.

## EXPERIMENT III: KOCH PARABOLA

Various discharge values will be set in the model and the variation of the water depth will be analyzed subsequently.

### Measurements

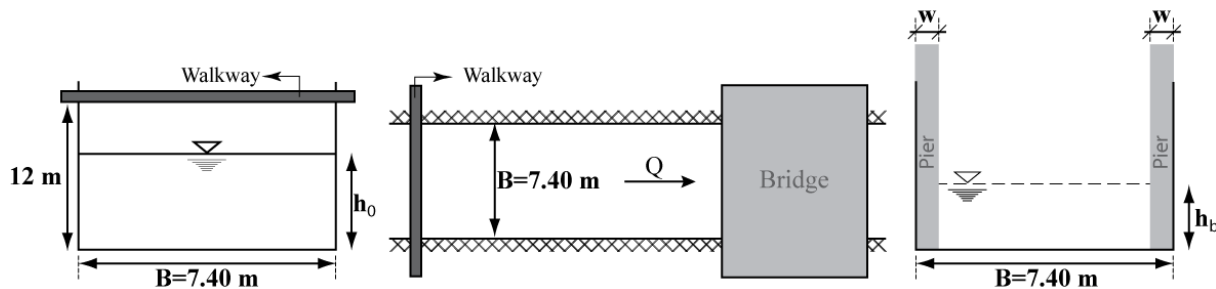
- Determine the discharges ( $Q_M$ ) set in the model.
- Determine the uniform flow depths ( $h_{0M}$ ) in the model.

### Data Analysis

- Determine the discharges ( $Q_P$ ) of the prototype corresponding to discharge values set in the model.
- Determine the uniform flow depths ( $h_{0P}$ ) in the prototype.
- Draw the variation of the discharge with respect to water depth (i.e. Koch parabola;  $Q$  vs.  $h$ ).

## EXPERIMENT IV: CONTRACTION

A bridge is to be built over the river as shown in the figures below and two of the piers of this bridge will cause the narrowing of the river cross-section. At the upstream of this bridge, there exists a walkway which is placed 12 m above the thalweg (see the cross-sectional and plan views below).



### Measurements

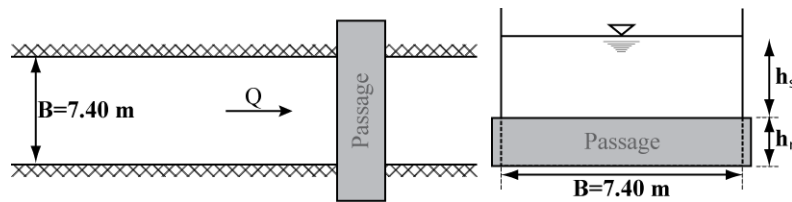
- Determine the discharge ( $Q_M$ ) of the model.
- Determine the uniform flow depth ( $h_{0M}$ ) in the model.
- Place two plexiglass pieces, having each a thickness of 1.20 cm, in the model in order to simulate the piers of the bridge in the prototype; determine the uniform flow depth ( $h_{01M}$ ) at the upstream of these pieces mounted in the model (at a constant distance  $L_M$  from the gate).
- Without making any changes in the system, determine the uniform flow depth ( $h_{02M}$ ) at the downstream of the pieces mounted in the model (at a constant distance  $L_M$  from the gate).
- Without making any changes in the system, determine the depth of flow ( $h_{bM}$ ) in the model, at the cross-section where the plexiglass pieces are mounted.

### Data Analysis

- Determine the discharge ( $Q_P$ ) of the prototype.
- Determine the uniform flow depth ( $h_{01P}$ ) at the upstream of the bridge in the prototype (at a constant distance  $L_P$  from the piers).
- Determine the uniform flow depth ( $h_{02P}$ ) at the downstream of the bridge in the prototype (at a constant distance  $L_P$  from the piers).
- Determine the depth of flow ( $h_{bP}$ ) in the prototype, at the cross-section where the piers will be constructed.
- Determine the critical depth of flow ( $h_{crP}$ ) in the prototype; compare this value with the depth of flow ( $h_{bP}$ ) at the cross-section where the piers will be constructed.
- Determine the mean cross-sectional velocity of the flow in the model for cross-sections at the upstream and downstream of the bridge, respectively (i.e.  $V_{1M}$  and  $V_{2M}$ ).
- Determine the regime of the flow in the model for cross-sections at the upstream and downstream of the bridge, respectively.
- Determine the mean cross-sectional velocity in the prototype for cross-sections at the upstream and downstream of the bridge, respectively (i.e.  $V_{1P}$  and  $V_{2P}$ ).
- Determine the regime of the flow in the prototype for cross-sections at the upstream and downstream of the bridge, respectively.
- Determine the specific energy of the flow in the prototype for cross-sections at the upstream and downstream of the bridge, respectively (i.e.  $E_{1P}$  and  $E_{2P}$ ).
- Determine if the walkway will be flooded by water after the construction of the bridge or not, by considering that the design width ( $w$ ) of each pier is 1.20 m.
- Determine the maximum width the bridge piers can have (i.e.  $w = w_{max}$ ), for the walkway not to be flooded by water after the construction of this bridge is finished.

## EXPERIMENT V: HUMP

A box culvert (rectangular passage) for a new sewage system branch is to be built on the river bed as shown in the figures below.



### Measurements

- Determine the discharge ( $Q_M$ ) of the model.
- Determine the uniform flow ( $h_{0M}$ ) depth in the model.
- Place two metallic rectangular prisms, having each a height of 2.50 cm, in the model in order to simulate the rectangular sewage passage in the prototype; determine the uniform flow depth ( $h_{01M}$ ) at the upstream of these prisms mounted in the model (at a constant distance  $L_M$  from the prisms).
- Without making any changes in the system, determine the uniform flow depth ( $h_{02M}$ ) at the downstream of the prisms mounted in the model (at a constant distance  $L_M$  from the prisms).
- Without making any changes in the system, determine the depth of flow ( $h_{sM}$ ) in the model, at the cross-section where the rectangular prisms are mounted.

### Data Analysis

- Determine the discharge ( $Q_P$ ) of the prototype.
- Determine the uniform flow depth ( $h_{01P}$ ) at the upstream of the passage in the prototype (at a constant distance  $L_P$  from the passage).
- Determine the uniform flow depth ( $h_{02P}$ ) at the downstream of the passage in the prototype (at a constant distance  $L_P$  from the passage).
- Determine the depth of flow ( $h_{sP}$ ) in the prototype, at the cross-section where the passage will be constructed.
- Determine the critical depth of flow ( $h_{crP}$ ) in the prototype; compare this value with the depth of flow ( $h_{sP}$ ) at the cross-section where the passage will be constructed.
- Determine the mean cross-sectional velocity of the flow in the model for cross-sections at the upstream and downstream of the rectangular passage, respectively (i.e.  $V_{1M}$  and  $V_{2M}$ ).
- Determine the regime of the flow in the model for cross-sections at the upstream and downstream of the rectangular passage, respectively.
- Determine the mean cross-sectional velocity of the flow in the prototype for cross-sections at the upstream and downstream of the passage, respectively (i.e.  $V_{1P}$  and  $V_{2P}$ ).
- Determine the regime of the flow in the prototype for cross-sections at the upstream and downstream of the passage, respectively.
- Determine the specific energy of the flow in the prototype for cross-sections at the upstream and downstream of the passage, respectively (i.e.  $E_{1P}$  and  $E_{2P}$ ).
- Determine the maximum height of the rectangular passage (i.e.  $h_r = h_{rmax}$ ) in the prototype, if the maximum height of water allowed in the channel is 12 m.

## REPORTING

Make sure that your report reflects the work you have conducted properly. It must be comprehensive but also brief. It should include the following sections: Title Page, Table of Contents, Introduction (Objectives) Background (Theory), Lab Procedure, Results (Including calculations, graphs, animation, etc.), Discussion and Conclusion, Appendix and Bibliography. The report should include necessary photos, sketches, figures, etc. No handwriting is allowed. Before the deadline, a hardcopy should be submitted and a softcopy (pdf,doc, etc.) should be e-mailed to the instructor ([kircave@itu.edu.tr](mailto:kircave@itu.edu.tr)).