EXPERIMENT J

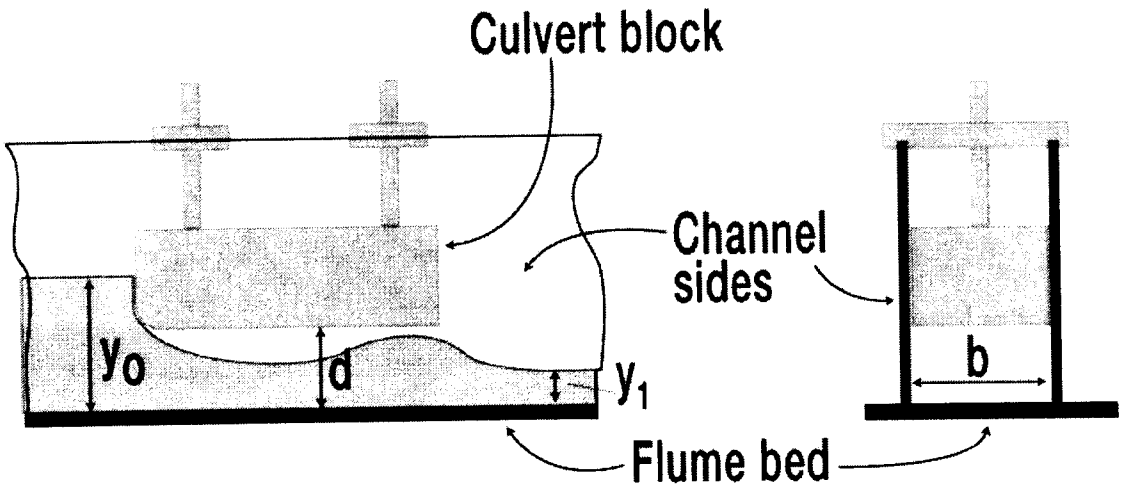
Characteristics of flow through a Culvert

To determine the characteristics and observe the flow patterns obtained for water flowing through a Culvert with different heads upstream and downstream.

EQUIPMENT SET-UP

Multi-Purpose Teaching Flume, C4

Culvert block assembly, C4-62 (optional accessory)
Hook and point gauge, 300mm scale – 2 required
Stopwatch if measuring flowrate using the volumetric tank (not supplied)



SUMMARY OF THEORY/BACKGROUND

The culvert is a covered channel of comparatively short length which is typically installed to drain water through an embankment. The culvert acts as on open channel, as long as the section is partly full, and is normally used in this condition. However, under flood conditions the inlet or outlet may become submerged and a variety of flow patterns can exist. A culvert will run full, like a pipe, when the outlet is submerged or when the upstream level is sufficiently high.

The objective is to view the range of patterns which can exist, to determine the head/discharge characteristics and to determine the conditions necessary for the culvert to run full.

The performance of a culvert is defined by the ratio $\frac{y_0}{d}$ (typical values are in the range 1.2 to 1.5 depending on geometry and conditions).

where:

y_0 = Depth of flow upstream of the culvert at the point where the culvert runs full (m)

d = Height of the culvert (m)

PROCEDURE

Ensure the flume is level, with no stop logs installed at the discharge end of the channel. Clamp the culvert block securely to the sides of the channel at a position approximately mid way along the flume with the rounded edge of the culvert facing upstream. For accurate results the gaps between the block and the channel should be sealed on the upstream side using Plasticine. Measure and record the actual breadth b (m) and the height d (m) of the culvert created.

Position two hook and point level gauges on the channel sides, one upstream of the culvert and one downstream of the culvert, each with the point fitted. Record the distance x (m) between the gauges to allow level measurements to be corrected for inclination of the bed. The datum for all measurements will be the bed of the flume. Carefully adjust the level gauges to coincide with the bed of the flume and record the datum readings.

Gradually open the flow control valve and admit the water into the flume. By altering the flow, gradually increase the depth of water upstream of the culvert until the culvert runs full. Observe and sketch the changing profile of the water flow as it passes through the culvert. When running full, measure and record the depth of flow y_0 upstream of the culvert, the flow depth y_1 downstream and the corresponding flowrate Q.

Drain the culvert, add one stop log at the discharge end of the channel then repeat the above observations and record y_0, y_1 and Q when the culvert runs full.

Repeat the procedure adding stop logs at the discharge end until the culvert remains full with no flow.

Remove the stop logs, drain the culvert then incline the channel bed slightly (flow downhill). Gradually increase the flowrate until the channel runs full as before then record y_0, y_1, Q and S (slope of the bed).

Repeat the procedure for increasing slope of the channel bed.

If time permits repeat the above experiment for a different height of culvert by adjusting the vertical position of the culvert block. The change in flow profile when the square corner is positioned upstream could also be investigated.

RESULTS AND CALCULATIONS

Tabulate your readings and calculations as follows:

Breadth of culvert, b =.....(m)

Height of culvert, d =.....(m)

y_0	y_1	Q	S	y_0/d

CONCLUSIONS

How many different profiles did you observe as flow through the culvert changes from partial to full flow?

What is your value for $\frac{y_0}{d}$ when the exit is not submerged?

How does this ratio change when the exit becomes submerged?

How does the slope affect the performance of the culvert?

Are there any similarities between the culvert and the undershot weir and if so under what conditions of flow do they occur?