EXPERIMENT R

Characteristics of flow over a Gravel Bed

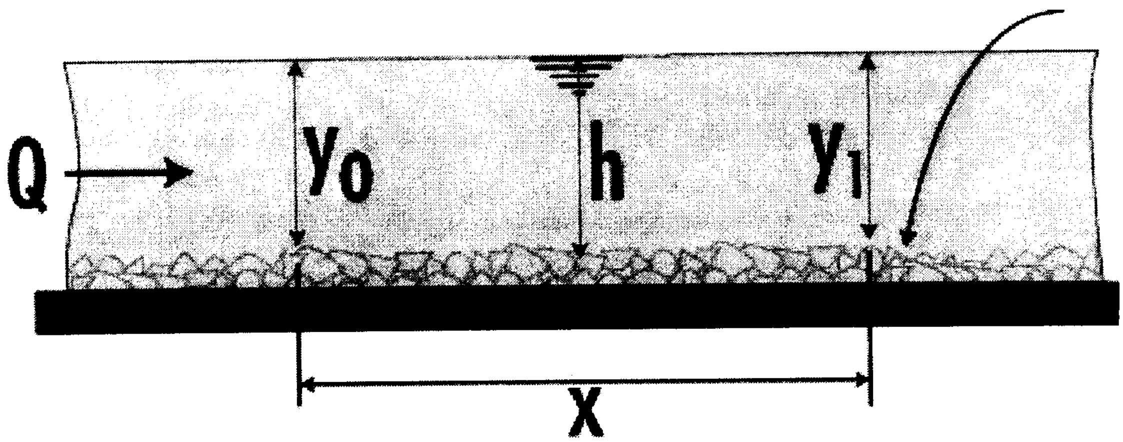
OBJECTIVE

To determine the effect of a roughened bed on the depth of water at different flowrates and to obtain appropriate coefficients to satisfy the Manning Formula.

EQUIPMENT SET-UP

Multi-Purpose Teaching Flume, C4

Artificially roughened bed, C4-69 (optional accessory)
Hook and point gauge, 300mm scale – 2 required
Stopwatch if measuring flowrate using the volumetric tank (not supplied)



Note: If available, the Pitot tube and manometer, C4-61 (optional accessory) can be used to measure velocity of the water directly.

SUMMARY OF THEORY/BACKGROUND

For uniform flow in an open channel the Manning Formula states that:

$$V = \left(\frac{1}{n}\right) R^{\frac{2}{3}} S^{\frac{1}{2}}$$

where:

n	= Coefficient of roughness (Manning's n)	(Dimensionless)
V	= Mean fluid velocity	(ms^{-1})
R	= Hydraulic mean radius	(m)
	= Flow area A (m^2)/Wetted perimeter P (m)	(m)
S	= Slope of energy line = $\sin\theta = (y_u - y_d)/x$	(Dimensionless)
x	= Distance between level measurements	(m)
y_0	= Upstream depth of flow	(m)
y_1	= Downstream depth of flow	(m)

Note: For simplicity the slope S can be assumed to be the slope of the water surface if the small change in the velocity head between inlet and outlet is ignored. When using the flume with the bed inclined, the slope of the bed must be added to calculations of S when using the hook and point gauges which use the bed as a datum.

The actual fluid velocity can be calculated as follows:

$$V = \frac{Q}{A} \qquad (ms^{-1})$$

where:

V	= Mean fluid velocity	(ms^{-1})
Q	= Volume flowrate	(m^3s^{-1})
	= Volume/time (using volumetric tank)	
h	= Average depth of flow above gravel bed	(m)
	= $(y_0 + y_1)/2$	(m)
A	= Area of flow	(m^2)
	= Breadth of channel b (m) x depth of flow h (m)	

PROCEDURE

Line the bottom of the flume with the gravel bed sections. To stop them sliding clamp the stretcher screw between the channel side walls at the downstream end. Level the flume by adjusting the jack if necessary.

Position a hook and point level gauge on the side walls at each end of the channel and record the fixed distance apart x (m). The datum for all measurements will be the average height of the roughened bed. Carefully adjust the level gauges to coincide with the top of the bed and record the datum readings.

Ensure that no stop logs are fitted at the downstream end then open the flow control valve and admit the water into the flume. Having achieved a small head of flowing water above the gravel, do not adjust the flow control valve again to maintain a constant flowrate throughout the experiment. Measure the volume flowrate Q using the direct reading flowmeter or volumetric tank with stopwatch. Adjust the level gauges to coincide with the surface of the water then record the depth of flow y_0 and y_1 above the roughened bed at each end.

Fit one stop log to increase the depth of water and repeat the measurements. Continue adding stop logs, recording the measurements for each step.

Further sets of readings can be obtained by repeating the above measurements with a different flowrate or with the bed of the flume sloping.

RESULTS AND CALCULATIONS

Tabulate your readings and calculations as follows:

Distance between level gauges, x =...........(m)

Q	y_0	y_1	h	x	S	A	P	V	R	n

Calculate A, V, S and R then determine n using the Manning Formula for each condition.

CONCLUSIONS

How accurate is the n value obtained likely to be?

Does the value of n obtained vary with flow conditions in the flume?

Comment on the suitability of your values for n when calculating fluid velocity along a meandering river with a gravel bed.