ESTIMATION OF FLOW RESISTANCE DUE TO WOODY VEGETATION BY DRAG FORCE MEASUREMENTS IN LABORATORY

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The ecological and aesthetic values are given much attention in modern river management and the river banks and flood plains in rivers are covered with natural vegetation. The understanding of the flow resistance caused by this vegetation is very important in flood control planning.

The flow resistance caused by the vegetation is due to the drag offered by the overgrown vegetation. The vegetal drag coefficient depends on the Reynolds number, energy slope, the vegetation density and the depth of flow. For a given vegetation pattern in the flood plain, an estimated Manning's roughness coefficient (n) is used for flood flow computations. To estimate the roughness coefficient for a different woody vegetation pattern it is necessary to conduct a laboratory flume experiment, however, the procedure is time consuming and complex. Manning's roughness coefficient in an open channel flow with woody vegetation is related to the drag coefficient.

In the present study, a simple method to estimate Manning's coefficient by the measurement of vegetal drag force using a laboratory towing tank experiment is introduced. Series of experiments were conducted in a 60-meter long laboratory-towing tank by towing a cluster of vertical rods to simulate flow relative to un-submerged woody vegetation in a channel. The drag forces were measured using a calibrated load cell connected to a computer and data was acquired at a sampling frequency of 20Hz.

The vegetal drag coefficients (C_d') obtained by the towing tank experiment and the flume experiments were similar. The regression model for the pattern towed, where projected area of roughness elements per unit volume of flow is 0.51, yielded the following relationship with $R^2 = 0.9671$.

$$C_d' = \frac{f}{\mathrm{Re}}$$

where, Re = Reynolds number; $f = f\left(h/d\right) = 665\left(h/d\right) + 4250$; d = diameter of rods and h = rod submergence depth. The Manning's roughness coefficient,

$$n = \left(\frac{1}{2g}\right)\left(\frac{f\nu}{h^{1/3}S^{1/2}}\right)$$

where, ν = kinematics viscosity, $S = F_D/h\rho g$; F_D = drag force per unit plan area and ρ =density of water.

Manning's roughness coefficient to represent the roughness offered by different woody vegetation patterns in the flood plain can be obtained by the towing tank experiment.