Effects of groins on the flow and bed deformation in non-submerged and submerged conditions

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For many years, groins were utilized as river management structures to make possible the navigation, the riverbanks protection and water supply. Recently, it's been studied other functions as to produce diversified attractive environments in river. This research presents the results of the studies with experimental and numerical modeling developed through the experimental channel under non-submerged and submerged conditions using impermeable and permeable groins with coal bed. A 3D numerical model based on unstructured meshes was developed to simulate the flow field around the groins region on fixed bed condition.

Two groins were positioned in the left side of the experimental channel (straight flume with 10m-long, 0.80m-wide and 0.28m-deep – 0.45m-deep in test region) and 4 hydraulic conditions (non-submerged and submerged conditions for each type of groins) was imposed to measure the velocity field, water surface level and bed deformation around the groins region after the dynamic equilibrium condition was obtained.

The governing equations of proposed numerical model are based on the steady 3D RANS (Reynolds-Averaged Navier-Stokes equations) and the continuity equation, which can be expressed in a Cartesian coordinate system with the tensor notation as follows.

$$u_j \frac{\partial u_i}{\partial u_j} = F_i - \frac{1}{\rho}\frac{\partial p}{\partial x_i} + \nu \frac{\partial^2 u_i}{\partial x_j \partial x_j} + \frac{1}{\rho}\frac{\partial \tau_{ij}}{\partial x_i}$$

$$\frac{\partial u_i}{\partial x_i} = 0$$

where u_i= time-averaged velocity; x_i= Cartesian coordinate component; ρ = density of the fluid; F_i=

body force; p= time-averaged pressure; ν= molecular kinematic viscosity of the fluid; $\tau_{ij} = -\rho u'_i u'_j$, are the Reynolds stress tensors, and u'_i is the fluctuating velocity component.

The results of the velocity field measurement compared with the numerical results under non-submerged condition for impermeable groins case are showed in figures 1 and 2. The bed deformation was measured under the same conditions. The final topography of the scour holes resulted deeper on the submerged condition for both type of groins and the influence of groins in the flow field is more evident. The numerical results of velocity field had a good agreement compared to the experimental measurements.
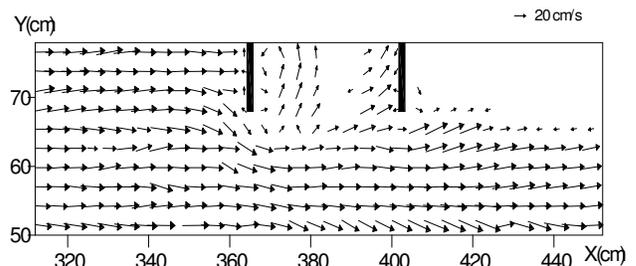

Fig.1 Velocity field around groins in XY plane – Impermeable groins under non-submerged condition (experiment).
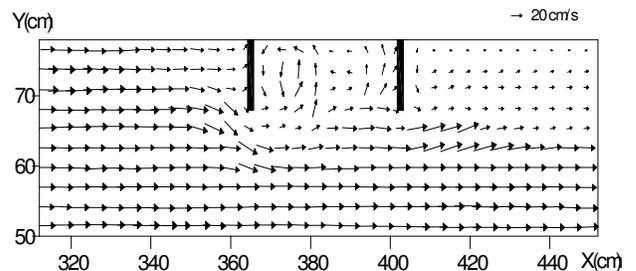

Fig.2 Velocity field around groins in XY plane – Impermeable groins under non-submerged condition (simulation).