On the initiation and evolution of von Karman vortex behind rectangular vegetation canopies with different aspect ratios and densities

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Vegetation canopy patches are widely existent in natural rivers and streams, whose presence can modify to different extents the flow structure and deposition pattern, ultimately affecting the channel morphological evolution. Previous studies have noted that the formation of canopy-scale von Karman vortex is highly related to the velocity difference between the wake region behind the canopy and the free stream region. When flow enters the canopy, it will be diverted into the outer regions due to the vegetation-induced resistance, leading to velocity reduction. Moreover, it is also demonstrated that this resistance is highly dependent on vegetation density and dimensions. However, it is not very clear from these previous studies on the threshold value of different vegetation canopy characteristics (such as shapes, aspect ratios and vegetation densities) for the initiation and evolution of von Karman vortex behind the canopy.

To this end, this study carried out a laboratory experiment to describe the generation of von Karman vortex behind a two-dimensional (2D) vegetation canopy. The methods of dye visualization and Acoustic Doppler velocimetry (ADV, Nortek Vectrino Profiler) were applied for experimental testing and velocity measurement. For this investigation, the vegetation canopy consisted of a rectangular array of cylinders extending from the channel bed through the water surface, and twenty-five canopies with varying aspect ratios (the ratio of canopy length to canopy width, L/W) and solid volume fractions (Ф) were considered and tested.

Overall analysis of the experimental results showed that the density threshold for transition is lower for canopy with larger streamwise length. To analyze the results and generalize the findings, a nondimensional threshold value considered vegetation density and canopy aspect ratio has been proposed to describe this transition based on the extensive experimental tests in this study. The achievement of this research is expected to provide useful insights and fundamental basis on understanding and quantifying the formation and variation of von Karman vortex and flow-vegetation interactions in channel canopy system.