INDEXING BY FREE SURFACE VELOCITY: A PROSPECT FOR REMOTE DISCHARGE ESTIMATION

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Discharge estimation is the essential part of any hydraulics problem related with rivers. A non-contact method, with lower cost, better accuracy and less hazards than those of traditional stream-gaging method, is currently being investigated. The idea behind the remote discharge measurements is to remotely obtain channel bathymetry and velocity distribution information, and subsequently integrate them according to the physics of the open-channel flow. For this purpose, it is crucial to have a unique and accurate relationship between the velocity distribution and flow conditions, i.e., channel geometry, secondary currents, and wind effect.

The concept of relating depth-averaged velocity to a single, pointwise velocity measurement is called as *indexing*. This method has become important from the perspective of new measurement technologies that are using one point velocity measurement to characterize velocity distribution over the depth. Free surface velocity, as indexing velocity, has advantages in the aspects of convenience in finding location and magnitude of the free surface velocity and aptness to non-contact measurements. Due to the limitations of the measurement techniques, the free surface velocity could not be measured at the past. However, recently developed methods such as radars and image velocimetry methods make it possible to measure free surface velocity, and subsequently determine the discharge.

By taking free surface velocity as the indexing velocity, a velocity index, α, can be defined as the ratio of depth-averaged velocity to the free surface velocity. The magnitude of α can be taken as constant for a given river cross-section, and can be found mathematically for a known distribution function. The state of the free surface in open channel flows has a unique relationship with the velocity distribution and other flow conditions. If this relationship can be identified, a direct discharge measurement can be possible by only one velocity measurement at the free surface. With this perspective, the search for non-contact discharge measurement takes the direction of seeking the relationship between the free surface velocity and depth-averaged velocity.

In the present research velocity indices, α, for open-channel flows over various bed roughnesses and flow conditions (e.g. Froude number and aspect ratio) are experimentally obtained to seek the relationship between free surface and depth-averaged velocity. For this purpose, a set of experiments was conducted, in which the effects of aspect ratio and bed characteristics could be investigated. In accordance with the motivation of non-contact measurements, both free surface velocities and velocity distributions were measured remotely in the laboratory. To measure the free surface velocity Large Scale Particle Image Velocimetry (LSPIV) method was selected since it is the most suitable technique available. To obtain the velocity distribution, Laser Doppler Velocimetry (LDV) method was used due to its non-intrusivity, accuracy, and directional sensitivity.

In this study, the velocity distribution in a laboratory flume has been investigated to

obtain the relationship between free surface and depth-averaged velocity. The experiments demonstrate that ratio of free surface velocity to depth-averaged velocity depends on the channel bed roughness. For the given flow conditions, even though aspect ratios are smaller than the values seen in natural rivers, the surface velocity reacts to spatial changes in channel bottom. Thus, it is recommended to consider the channel bed roughness while estimating discharge by indexing. Despite the substantial changes in the channel bed characteristics, velocity indices are found to vary in a range of 0.789 and 0.928. The consistency in the obtained trends of velocity indices with the flow depth supports the concept of using free surface velocity as the indexing velocity.

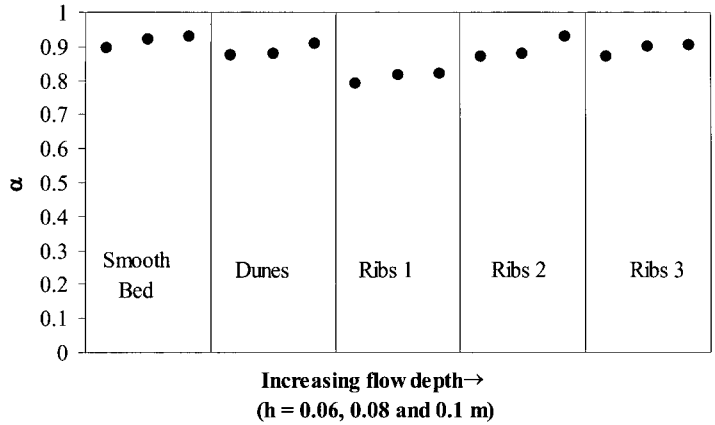

Fig. 1 Variation of velocity indices