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Estimation of Flood Discharge in a Vegetated River Using Multipoint Water Level Hydrographs

ESTIMATION OF FLOOD DISCHARGE IN A VEGETATED RIVER USING MULTIPOINT WATER LEVEL HYDROGRAPHS

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Discharge estimation has been one of the most important technical issues in river engineering. In spite of many studies to increase the measurement accuracy of flood discharge using advanced devices, there remains difficulty in obtaining flood discharge hydrograph with high accuracy. Recently Fukuoka and Watanabe (2002) demonstrated that the coupling of a 2D shallow water equation model with measured water level hydrographs can provide an accurate discharge hydrograph. Morishita, Uchida and Kawahara (2006) improved their approach by utilizing the measured traveling velocity of the water level to estimate the vegetation roughness, which made the discharge estimation method more practical. However, Fukuoka and Watanabe (2002) and Morishita et al. (2006) did not consider the effects of deformation or toppling of vegetation during floods, which frequently occurs in natural rivers. Our previous studies have shown that herbaceous plant communities in rivers strongly affect the flow resistance and the flood spreading over bars. Hence in this study we introduce a refined vegetation model that can account for deformation of vegetation and discuss its importance for discharge estimation in a vegetated river.

Our numerical model consists of the continuity equations of water and sediment, and depth-integrated momentum equations incorporating a vegetation model. The vegetation model explains the changes in height and permeability of vegetation communities, which are caused when the hydrodynamic moment around the vegetation root exceeds some critical value. The numerical model is applied to a flushing flood in 2010 at downstream of the Haizuka dam, Japan. Figure 1 shows the plan view of the measurement stations from No.1 to No.16 in the target reach where reed grows thickly and the bed slope is about 1/300. The calculation domain extends from Station No.2 to Station No. 16 where the measured water level hydrographs are specified as boundary conditions. A virtual reservoir is prepared in the numerical simulation at the upstream of Station No.1. The water level in the reservoir is adjusted to match the water level hydrograph at Station No.2 as well as a surface slope there, which controls the incoming flow rate at Station No.2. The numerical results are compared with the measured water level hydrographs at 14 stations and the discharge at Station No.11 located upstream of a weir. The calculated zone of toppled vegetation due to the flood is also compared with the detailed field survey data before and just after the flushing flood.

Figure 1 shows the water level hydrographs at No.4 and No. 9. It is seen that the present numerical model fairly reproduces the measured water level hydrographs. It is confirmed but not shown here that 78% of the area where vegetation toppled is reproduced in the numerical simulation. Figure 2 compares the discharge hydrograph, showing reasonable agreement. It is found that our vegetation model accounting for the deformation increases the accuracy in the

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maximum discharge by around 5 % compared with the vegetation model that assumes the vegetation is rigid during the flood. Further research is necessary to specify the critical moment for vegetation toppling in relation to the type of vegetation and its density.

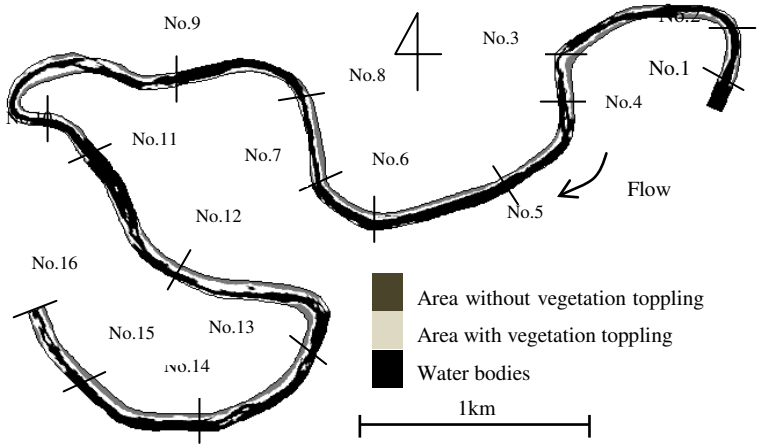

Figure 1 Location of measuring stations in the downstream reach of Haizuka Dam.

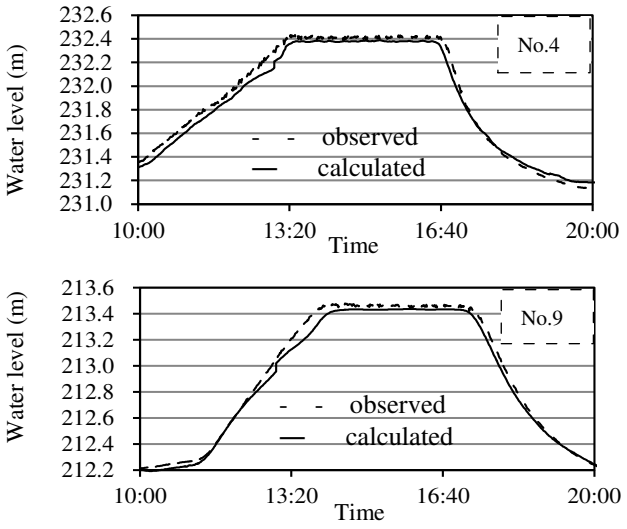

Figure 2 Comparison of water level hydrographs. hydrograph

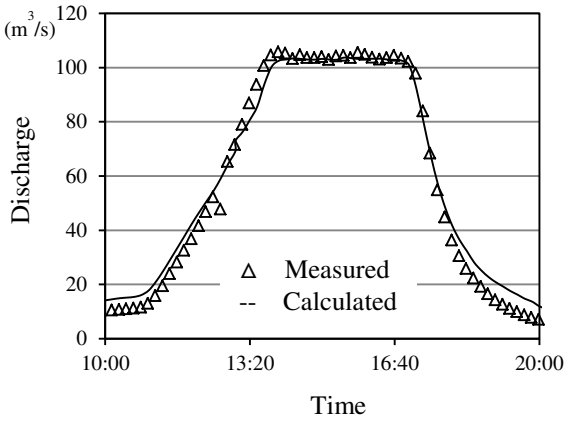

Figure 3 Comparison of discharge at Station No.11.

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