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Study of Revetment Safety Monitoring and Early Warning in Urban Area Drainage Systems

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Failure of revetment during a rainstorm event will cause serious damage especially for urban area. However, most studies regarding early warning only focused on the issue of overtopping. The purposes of this study are (1) design a real-time automatic revetment safety monitoring system; (2) analyze the revetment failure potential in the study river; and (3) propose a framework to define the warning water stage for revetment failure early warning. The Deshang drainage line located in the northern Taiwan was chosen as the study river. We installed the proposed automatic monitoring system at two sites with thalweg lengths 4,800 m and 5,670 m. The system includes vertical distributed pore water pressure sensors, Time Domain Reflectometry (TDR) to measure the displacement of revetment, a heavy weight to record the erosion at the toe of revetment, and a water level gauge. A 3D hydrodynamic model coupled with a 2D subsurface flow model was applied to simulate the revetment failure potential under the 610 flood in 2012 along six channel reaches of Deshang Drainage line where the revetments failed during this event. The simulation results agreed with the field situations which indicated that the model can properly evaluate the revetment failure potential. Thus, we further evaluated the revetment failure potential under 19 extreme typhoon events at the two sites where the monitoring system was installed. According to the simulation results, we found that the water stage could be a major index to judge that the revetment will fail or not in the following hours. Therefore, a framework was proposed which enables the pre-determination of thresholds of water stage for revetment failure early warning under various combinations of toe erosion, pore pressure behind the revetment, and stipulated probability of type II error (i.e. failure to warn). During a rainstorm event, for a stipulated probability of type II error, we can judge that if a warning of revetment failure should be issued or not according to the pre-defined threshold and real-time monitored toe erosion, pore pressure behind the revetment, and water level. Once the water level is higher than the pre-defined threshold, the revetment would be failed in the following hours.