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Experimental Investigation on the Scour Hole Geometric Dimensions in Different Spur Dikes in 90 Degree Bend for Non-Submerged Conditions

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Introduction: Outer bank region is always exposed to destruction and scour due to secondary flow. Different methods are generally used to protect the outer bank. One of the most common and economical ways is spur dike. As an obstacle in the flow, spur dikes protect the outer bank through decreasing the velocity and forming vortexes between them and as a result sedimentation along that area. However, the spur dike increases the shear stress and local scour around the spur, especially its nose.. This study investigates the scour hole dimensions around three types of spur dike including permeable, impermeable and bandal-like spur dike which is done as a combination of permeable and impermeable spur dike. Few studies were focused on field applications and laboratory experiments to investigate the practical applicability of the bandal-like structure in natural rivers. Rahman et al. (4) Studied the prediction of main channel degradation and local scour around hydraulic structures (impermeable and bandal-like spur dikes) under non-submerged condition. Teraguchi et al. (9) Investigated the influenced of submerged condition on flow characteristics and sediment transport process caused by bandal-like structures with different spacing and alignment under live-bed scour condition through laboratory experiments.

Materials and Methods: Experiments were carried out in the Physical Modeling Laboratory of Faculty of Water Science Engineering of Shahid Chamran University, Ahwaz. The main channel consisted of a 5m long upstream and a 3m long downstream straight reaches. A 90 degree bend was located between the two straight reach. The channel was of rectangular cross section, having a width of 0.7m and depth of 0.6m, with mild bends (ratio of radius to a width equal to 4) and it was filled with almost uniform sediment with a median particle size of D_{50}=1.5 mm. The discharges were measured using an ultrasonic flow meter, which was installed on the pipe inlet of the flume. The water elevation was regulated using the sliding gate installed at the end of the flume. Plexiglas with a thickness of 0.01m was used for impermeable part of spurs and the permeable part prepared by using steel roll piles with 4mm diameter. The most erodible area along the bend was determined and after installing the spurs, the bed surface was leveled by a plate attached to the carriage mounted on the channel. Then the inlet valve was opened slowly and the gate at the end of the flume was first closed. The discharge increased to a predetermined value so that no scour occurs at the straight reaches of the flume. Each experimental case was carried out for 3 hours under clear-water scour condition. At the end of experiments, water was carefully drained out and measurement of bed topography was done using laser bed profiles.

Results and Discussion: The most erodible area along the bend was determined using the procedure described by the U.S. Army Corps of Engineers and in each experimental case specified the critical spur in terms of the maximum erosion around it that happened at the exit of the bend (sections of 80 to 90 degree of bend) and downstream straight reach in all conditions. The centrifugal force will occur has increased the water depth at the exit of the bend. This increase in flow depth is associated with longitudinal negative pressure gradient due to this maximum velocity occurs at the exit of the bend and by this high velocity flow the shear stress increases. The characteristics of the scour hole have been shown to be affected by Froude number and this parameter has a direct relation to maximum relative scour depth and dimensions of the scour hole. The results showed that by increasing the permeability percentage, the amount of maximum relative scour hole depth, length and width decreased. The amount of relative scour depth in permeable and bandal-like spur dike decreased (62% and 55%), and (87% and 76%) for permeability of 33% and 64%, respectively in comparison with impermeable spur dike.

Conclusions: The effect of hydraulic structures, with emphasis in the bandal-like structures, on the scour hole geometric dimensions were investigated in this study. Five types of structures (impermeable, permeable and bandal-like with a permeability of 33% and 64%) were tested experimentally. It was found that:

The increase of permeability, reduced scour rate significantly, such that, the maximum amount of depth, width and length of scour-hole was related to impermeable spur dike (with permeability of 0.0%) and the

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minimum amount belonged to the permeable spur dike with 64% permeability. The performance of bandal-like structures considering the erosion process around the structures show close results compared with permeable spur dikes.

Keywords: Bandale Like, Channel bend, River bank protection