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Acta Geophysica
vol. 64, no. 3, June 2016, pp. 694-710
DOI: 10.1515/acgeo-2016-0024

Scour Downstream of Grade Control Structures under the Influence of Upward Seepage

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Abstract

The installation of free falling jet grade control structures has become a popular choice for river bed stabilization. However, the formation and development of scour downstream of the structure may lead to failure of the structure itself. The current approaches to scour depth prediction are generally based on studies conducted with the absence of upward seepage. In the present study, the effects of upward seepage on the scour depth were investigated. A total of 78 tests without and with the application of upward seepage were carried out using three different sediment sizes, three different tailwater depths, four different flow discharges, and four different upward seepage flow discharge rates. In some tests, the three-dimensional components of the flow velocity within the scour hole were measured for both the cases with and without upward seepage. The scour depth measured for the no-seepage results compared well with the most accurate relationship found in the literature. It was found that generally the upward seepage reduced the downward velocity components near the bed, which led to a decrease in the maximum scour depth. A maximum scour depth reduction of 49% was found for a minimum tailwater depth, small sediment size, and high flow discharge. A

decay of the downward velocity vector within the jet impingement was found due to the upward seepage flow velocity. The well known equation of D'Agostino and Ferro was modified to account for the effect of upward seepage, which satisfactorily predicted the experimental scour depth, with a reasonable average error of 10.7%.

Key words: fluvial hydraulics, grade control structure, open channel flow, scour, sediment transport, seepage.