INTERFACE STABILITY IN GRANULAR OPEN FILTER IN UNIDIRECTIONAL FLOWS

INVESTIGATING THE REQUIRED MINIMUM LAYER THICKNESS FOR GEOMETRICAL OPEN FILTERS

A single-grading stable geometrical open filter is a structure of granular material to protect a bed or construction against scour and erosion (figure 1). The design formula of Hoffmans (2012) can be applied to calculate the minimum required filter layer thickness to prevent transport of bed material through the pores of the filter in uniform flows (Van de Sande, 2012). The formula should theoretically be applicable in non-uniform flows, but has only been tested with scarce data (Van de Sande, 2012, Van Velzen, 2012). Another design formula, the formula of Wörman (1989), is based on experiments with a cylindrical pier (i.e. non-uniform flow) and is only tested for thin filter layer thicknesses (D_f <0.1 m) and low flow velocities ($\bar{u}$ < 0.5 m/s). Recently, a database became available with experiments conducted at the research institute Deltares. The aim of the thesis is to test the validity of the design formula of Hoffmans (2012) for flows with sill-induced additional turbulence, and for flows with a cylindrical pier and to test the validity of the design formula of Wörman (1989) for flow velocities over 0.5 m/s and for filter layer thicknesses of more than 0.1 m at flows with cylindrical piers.

Results show that tests with uniform flow are in agreement with the formula of Hoffmans (2012). Tests with flows with sill-induced additional turbulence and flows with a cylindrical pier suggest that the load damping coefficient α_d should be increased, resulting in a larger minimum filter layer thickness. A rough estimate for α_d in flows with sill-induced additional turbulence is probably within the range $1.2 < \alpha_d < 2.5$, but additional research is highly recommended due to the uncertainty in results and scarcity of tests. A new estimate of α_d for flows with cylindrical piers is probably within the range $2.4 < \alpha_d < 3.7$ (figure 2). The formula of Wörman (1989) estimates the minimum required layer thickness reasonably well for average flow velocities larger than 0.5 m/s and layer thicknesses larger than 0.1 m, but the empirical derived coefficient should probably be changed from a value of 0.16 to a value in the range between 0.22 [-] and 0.33 [-] to be in agreement with new test data (figure 2), resulting in a larger minimum filter layer thickness. Validation of both design formulas for flows with a cylindrical pier is not in agreement with the conclusions from the previous preliminary validation. A probable cause is that the classification of combined filter and bed instability as applied by Van Velzen (2012) and Van de Sande (2012) is not in agreement with the design philosophy (simultaneous erosion) of both design formulas.

Hoffmans, G .J.C.M. (2012). *The Influence of Turbulence on Soil Erosion.* Delft: Eburon Acadamic publishers.
Van de Sande, S. A. H. (2012). *Stability of open filter structures.* MSc thesis. Delft: Delft University of Technology.
Van Velzen, G. (2012). *Flexible scour protection around cylindrical piers.* MSc thesis. Delft: Delft University of Technology.
Wörman, A. (1989). *Riprap protection without filter layers.* Journal of Hydraulic Engineering, vol. 115 (12)

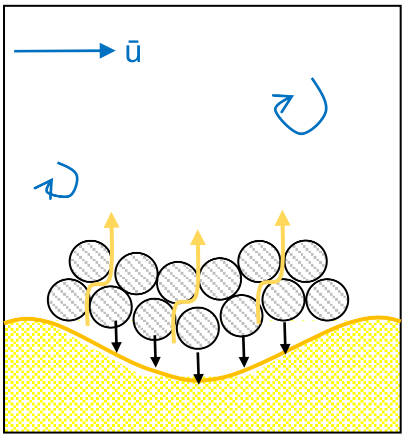

Figure 1: Geometrical open filter. Example : Layer thickness is insufficient to damp the hydraulic loads. This results in transport of bed material though the pores of the filter material.

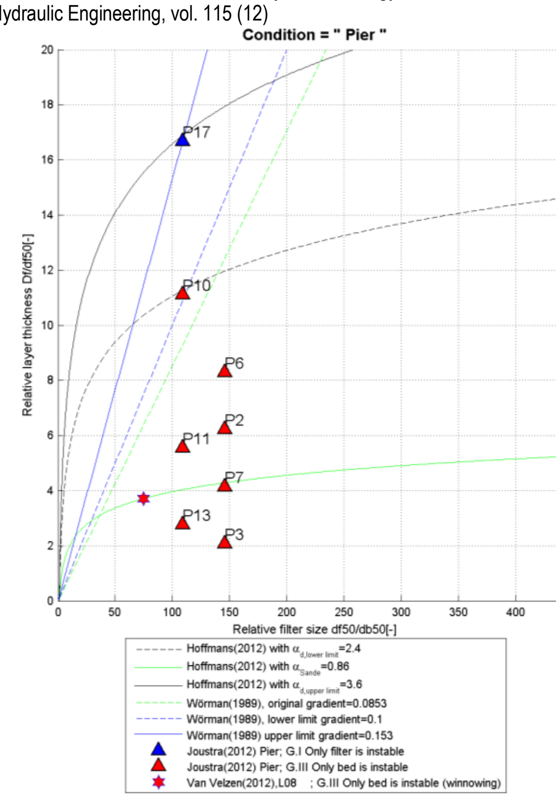

Figure 2: The simplified version of the formula of Hoffmans (2012) (logarithmic relation; green) and Wörman (1989) (linear relation; green) for flows with a cylindrical pier. In addition, test data of Joustra (2012) and Van Velzen (2012) are plotted as markers. Formulas with new proposed range for load damping coefficient α_d [-] and gradient of Wörman (1989) for flows with a cylindrical pier.

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