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Evaluation of critical shear stresses for consolidated cohesive sediment depositions by using PIV compared with field measurements

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Reservoir sedimentation is a common problem today. Due to the reduced flow velocities, turbulences and bed shear stresses the transported sediment load start to settle. These depositions reduce the worldwide average storage capacity in the range of about 1% per year. However, depending on the climate conditions and the geology in the catchment area this value may vary strongly. Therefore sediment management tasks, especially the removal of already accumulated sediments, have to be developed for each reservoir separately.
The critical bed shear stress is a key parameter used to evaluate the different management tasks and depend strongly on the grain size distribution of the inflowing sediments. However, depositions which contain fine particles like clay and silt increase the critical bed shear stress due to occurring cohesive forces and the use of the Shield curve for evaluating the critical shear stress is no longer valid. Additional data is required for estimating the valid critical shear stress at the reservoir bed. In this study the critical shear stress was evaluated for cohesive sediment samples, taken from two different reservoirs, in a flume in the laboratory. The sediment samples were placed in an installed double bottom in the research flume and the discharge was increased stepwise until mass erosion took place (determined by visual inspection). A 2D PIV device was used to measure the flow conditions (velocities and turbulences) over the sediment sample. The obtained values were used to calculate the bed shear stress for the specific discharge rate by the gravity method and the Reynolds stress method. The results of both methods showed good agreement in the comparison of the values, what indicates that nearly uniform flow conditions occurred in the flume.
The results from this study showed that the behaviour of natural cohesive sediments depend strongly on the natural conditions as a result of physical, chemical and biological processes. In this case especially the effect of the layer structure in the sediment samples was controlling the erosion mechanism. The results of the experiments showed also that the obtained average shear stress was above most of the values found in previous conducted studies, which may be explained by consolidation effects in the reservoirs. Additional conducted vane strength measurements have been carried out in situ. The in the field obtained vane strength values were set in relation to the critical shear stresses derived by the experimental tests from the laboratory and to data from a previous conducted study to develop a new relation function. This function may be used in future studies for a rough estimation of the critical shear stress, based on in situ measured vane strength values.