INFLUENCE OF SIDE OVERFLOW INDUCED LOCAL SEDIMENTARY DEPOSIT ON BED FORM RELATED ROUGHNESS AND INTENSITY OF DIVERTED DISCHARGE

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In irrigation and flood protection engineering an efficient control and management o f flow processes along the channel or river course is required. Lateral side weirs a nd fuse plugs are a feasible and widely used device to cope with this challenge. They are installed at the wall along the side of the main-channel to divert or spill water over them when the water level in the channel rises above their crest. This lateral loss of water is responsible for the reduction of sediment transport capacity in the main-channel by decreasing the bottom shear stress. This yields to the formation of a local sediment deposit in the weir alignment, thus reducing the cross section. Consequently, the upstream water level rises and the head over the side weir as well. In addition with supplementary roughness induced by the development of bed forms, the design discharge to be diverted over the side weir is also increased and sediment transport capacity is further decreased. This interaction between lateral overflow and sediment transport has to be known in order to avoid uncontrolled behavior. Without paying attention to side overflow induced morphological river bed changes, resulting errors in calculating spilled side overflow discharge may be in the order of 40 %.

By the help of an experimental setup the physical processes in the main-channel and on the side weir were analyzed systematically. Starting from an initially flat bed the ratio diverted discharge/upstream discharge rapidly increases towards a rather stable ratio with elapsing experiment time. Simultaneously, a local sedimentary deposit and bed undulations, namely dunes, are forming. Introducing the ratio $Q_{diverted,final} / Q_{diverted,\ initial}$, a value of 1.70 is obtained. This increase is investigated considering additional effective bed roughness induced by bed forms on the one hand and the formation of a local sediment deposit on the other.

Firstly, measured effective bed roughness is compared with two theoretical concepts. The first one is based on grain and bed form related parameters, the second one on integral parameters such as mean velocity and bed material size. With regard to the first one, the approaches of Van Rijn (1984) and Yalin and da Silva (2001) are considered herein. As far as the second method is concerned, the relations of Engelund and Hansen (1967) and Smith and McLean (1977) are taken into account. Both concepts rather overestimate effective bed roughness and related flow depth. However, the grain and bed form related

methods appear to be more appropriate than the integral parameter based ones.

Secondly, both measured and computed water levels as well as measured side overflow intensity at the beginning and at later stages of the experiment are used revealing a bed form related ratio $Q_{diverted,final} / Q_{diverted,\ initial}$ of 1.28. Looking at the sediment deposit, the cross section is reduced approximately by 1/3. This condition provides a sudden channel contraction and expansion, thus the local head losses might be estimated by a head loss coefficient and the Borda-Carnot formula. For this condition $Q_{diverted,final} / Q_{diverted,\ initial}$ reads 1.39. Consequently, the total measured ratio of 70 % can be fairly well explained by bed form and sediment deposit induced head losses amounting to 67 %.

In summary:

total: $$\frac{Q_{D,final}}{Q_{D,initial}} = \frac{0.051}{0.030} = 1.70$$ (measured, all-in)

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bed forms: $$\frac{Q_{D,final}}{Q_{D,initial}} = \left(\frac{0.039}{0.033}\right)^{3/2} = 1.28$$ (measured and computed, w ith dunes)

deposit: $$\frac{Q_{D,final}}{Q_{D,initial}} = \left(\frac{0.041}{0.033}\right)^{3/2} = 1.39$$ (computed, with d eposit)

total: $$\frac{Q_{D,final}}{Q_{D,initial}} = 1.28 + 1.39 = 1.67$$ (measured and computed, with deposit)

Computed water levels for effective roughness are highly overestimated. The main reason is due to the presence of the lateral overflow and its significant influence on flow pattern. The centre of maximum velocity is shifted from its central position in the middle of the channel towards the weir. Furthermore, dune length is considerably longer than predicted. Both, Van Rijn (1984) and Yalin and da Silva (2001) use the bed form steepness δ_d as an important parameter to describe form roughness. Since δ_d is defined as $\delta_d = \Delta_d / \Lambda_d$, Δ_d being dune height and Λ_d dune length, and measured dune lengths exceed computed ones, computed δ_d becomes comparatively large. In addition, dune crests are no longer transverse to the direction of main flow but inclined (Fig. 1). Both effects tend to rather reduce effective roughness.

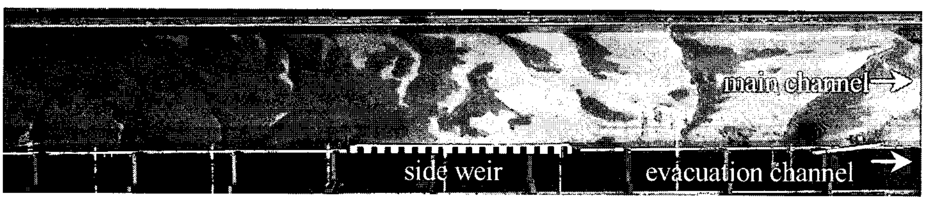

Fig. 1 Bed morphology after test run B02. The dotted line represents the side weir

The increase of diverted discharge of 70 % compared to a flat immobile bed can be partially explained by additional roughness created by bed forms providing an elevation of side weir head in the order of 28 %. The most important contribution to increased diverted discharge is due to a local sediment deposit forming in the downstream reach of the weir. This deposit is the source of local energy loss revealing values in the order of 39 % for the present study.

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