Numerical simulation of hydro- and morfodynamic effects of side channels design parameters

P.K. Schuurman [1]

[1] *University of Twente, Faculty of Engineering Technology, Water Engineering and Management, PO Box 217, 7500 AE Enschede*

Four side channel design parameters are analysed by two-dimensionally modelling the extremes with the numerical software package Delft3D. In order to advise how to minimise the maintenance activity dredging in rivers due to the construction of side channels. These four parameters are bifurcation angle, originate place in the groyne compartment, width/depth ratio and inflow barrier. The amount dredging volume seems most sensitive to the bifurcation angle and the side channel width. Whereas the bifurcation angle also affects the length ratio of the side and main channel, the latter one can also be the dominant parameter. Further research is recommended.

Introduction

For increased flood safety in The Netherlands, side channels are being planned. The management and maintenance effort and costs for these side channels have to be minimised. The goal of this research was to gather insides in the hydro- and morphodynamic effects of design parameters with respect to the management and maintenance efforts in both the side channel and the main channel. The design parameters researched in the study are: bifurcation angle, originate place in the groyne compartment, width/depth ratio and inflow barrier. According to literature, such as Bulle (1926), Mosselman et al. (2004), Gerritsen and Schropp (2010), and Van Putten (2011), these parameters have the strongest hydro- and morphodynamic effects.

Method

A suitable model location for a side channel was selected in the existing two-dimensional numerical Delft3D model of the River Rhine, based on several wishes from the research point of view (e.g. no influence of other flow risk interventions or bend in the main river) and expert judgment. Noted must be that the secondary flow is parameterized in the depth-averaged advection-diffusion equations, river bank erosion and eddy simulations where not included in the model, and the banks of the side channel follow the structure of the grid cells. The upstream boundary condition for flow is the stationary discharge Q=2360 m^3/s, which is the discharge where the side channel is bank full. The bed level at the upstream boundary is supposed to be fixed (based on multi-beam bed level measurements). A water level, based on a Q/h-relation, is used as downstream boundary condition. Several variants of the side channels were modelled, ranging from the minimum of each of the four parameters to the maxima. The simulation outcomes of each of these variants where compared. With these results, the influence of the four design parameters on the dredge volume was analysed.

Results

In general, the side channel variants which withdraw a larger amount of the discharge, affect the hydro- and morfodynamics most. Larger side channel withdrawals occur due to the fact that water can enter more easily the side channel (e.g. larger cross sectional area, no hindrance from upstream groynes). This leads indirectly to more erosion at the outflow of the secondary channel, more sedimentation in the main channel, a deeper side channel, and stronger secondary flow effects within the side channel. Noted must be that the bifurcation angle also affects the length ratio of the side and main channel. So, model results of the bifurcation variants must be handled carefully.

Of the four analysed design parameters, the model results show that the bifurcation angle and width of the secondary channel have most influence on sedimentation in the main channel, and therefore the dredging volume. A choice between the two extreme bifurcation angles may even lead to a four times difference in dredging volume. A bigger angle will result in less volume of dredging. The dredging volume for the simulated widths (45m and 150m) differ a factor 3. Whereby, a larger width lead to a bigger amount of sediment that needs to be dredged. Therefore, it is recommended to focus, during the side channel design, on the proper choice of these two design parameters. For coupled design parameters, it is important to give priority of the choice to bifurcation angle or side channel width. For example, if both, a different bifurcation angle or a change in branching location, can result in a better side channel course, it may be important to give priority to the designed bifurcation angle and chose to adjust the branching point.

Finally, a threshold structure is most limiting the dredge efforts in the main channel. When choosing an inflow barrier, erosion prevention (e.g. rock fills) is necessary.

Conclusion

Noted must be that changing the bifurcation angle, also affects the length ratio of the side and main channel. Comparing the sedimentation effects of the four side channel design parameters (bifurcation angle, originate place in the groyne department, width/depth-ratio and inflow barrier), it can be concluded that the influence of the bifurcation angle and the channel width is strongest.

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