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Longitudinal training walls: optimization of river width subdivision

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Introduction

Recently, engineers propose longitudinal training walls to replace traditional transverse groynes. This new intervention is expected to maintain a navigation route under low flow conditions while not hampering flow conveyance of the river channel. Navigation occurs mainly in low-land river channels where the formation of alternate bars constitutes a problem which requires mitigation measures like dredging. Le et al. (2015, 2016) found that the starting point of the longitudinal training wall with respect to a steady bar plays an important role on the stability of the bifurcating parallel channels. Starting at a location near the upstream part of the bar leads to side channel silt up. On the contrary, starting at a location near the downstream part of the bar leads to side channel erosion. The most interesting result was that when the longitudinal training wall starts near the bar top, both channels remain open for a long time. However, these results were obtained only for a specific width ratio, ratio between the width of the side and the width of the original channel, B_1/B_0 = 1/6, under a constant discharge. In practice, the width ratio may vary to obtain specific achievements. Wang et al. (1995) showed that the width ratio plays an important role on the stability of bifurcating channels. So, how the system behaves for different width ratios under variable discharge remains unclear and needs further investigation.

Goal of the study

This study analyses the long-term morphological effects of dividing a river channel with a longitudinal wall considering different channel width ratios and variable discharge. The preliminary part of the work presented here, however, analyses only the cases with constant discharge.

Approach

The methodology comprises both numerical simulations and laboratory experiments. The work presented here only deals with numerical simulations, which were carried out by using the Delft3D software.

This study uses the same numerical configuration as Le et al. (2015). To start with, a straight channel with geometrical (width, depth, slope) and morphodynamic (flow and sediment) characteristics is selected to reproduce alternate bars (bar mode m = 1) using Crosato-Mosselman's (2009) formula (Eq. 1).

$$m^2 = 0{,}17\, g \frac{(b-3)}{\sqrt{\Delta D_{50}}} \frac{B^3 i}{CQ} \qquad (1)$$

Where: m is the bar mode, b is the degree of non-linearity of the sediment transport as a function of flow velocity, B is the river width, i is the bed slope, Δ is the sediment relative density, D_{50} is the sediment mean size, C is the Chézy coefficient and Q is the river discharge.

After successfully obtaining alternate bars, the study considers 3 different starting locations of the longitudinal training wall. Location 1 is at the upstream part of a bar, location 2 near the bar top and location 3 is at the downstream part of a bar (near a pool) (Fig. 1). Starting at one of these locations, the longitudinal training wall is continuous till the end of the computational domain. The distance from the right bank to the wall varies. The following width ratios are considers: B_1/B_0 = 1/6, 1/3 and 1/2. The overview of the numerical simulations is given in Table 1.

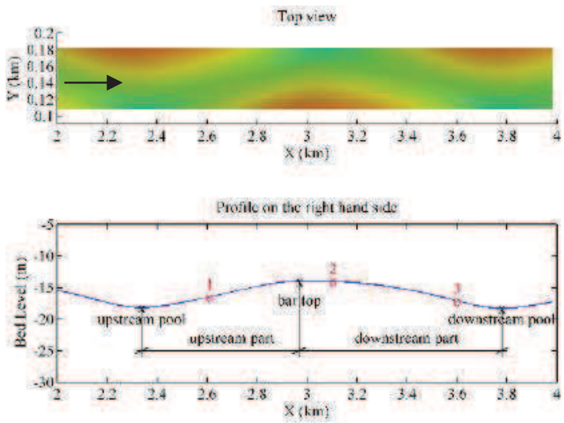

Figure 1. Scenarios studied. Location 1 is at the upstream part of a bar, location 2 near the bar top and location 3 is at the downstream part of a bar (near a pool).

Table 1. *Overview of the simulations. Notation X is number 1, 2 and 3 represent locations of the upstream termination of the longitudinal training wall, depicted in Fig. 1.*

Run	Scenario	Simulation	Description
1	Starting with a flat bed	Run0	Reference case
2, 3, 4	Starting with fully-developed hybrid alternate bars	Run1_X	B_1/B_0 = 1/6
5, 6, 7		Run2_X	B_1/B_0 = 1/3
8, 9, 10		Run3_X	B_1/B_0 = 1/2

Preliminary results

Regardless of width ratio, the starting location of the training wall plays an important role in the morphodynamic evolution of the parallel channels. Fig. 2 shows the evolution of the discharge ratio between side channel and original channel with time. In this figure, Q_1/Q_0=0 means that the side channel silts up, while Q_1/Q_0=1 means that the side channel conveys all water and the main channel silts up. Three situations can be distinguished: if the training wall starts at upstream part of a bar, all lines representing the discharge ratio finally go to zero (blue lines). When the training wall starts at the downstream part of a bar, all lines eventually approach the value of 1 (red lines). When the training wall starts near the bar top, all lines become horizontal at a value of discharge ratio between 0.5 and 0.2.

This means that if the training wall starts at the upstream part of a bar, the side channel eventually silts up completely, and this happens for all width ratios (Q_1/Q_0=0, blue lines). For the largest width ratio (B_1/B_0=1/2), in which the channels have the same width, the silting up process takes a longer time to finish (continuous blue line).

Instead, if the training wall starts at the downstream part of a bar, the side channel eventually conveys more than 90% of the discharge, and this happens for all width ratios (red lines). For B_1/B_0=1/6, the process becomes extreme, because the side channel is found to eventually convey all water (Q_1/Q_0=1, dash red line). This means that the main channel silts up. For larger width ratios, a conveyance of more than 95% still means that both channels remain open, although with different bed levels.

When the training wall starts near the bar top, both channels remain open (black lines). If the two channels have the same width, one of the two conveys much more water than the other one, but the difference between the two channels is less marked.

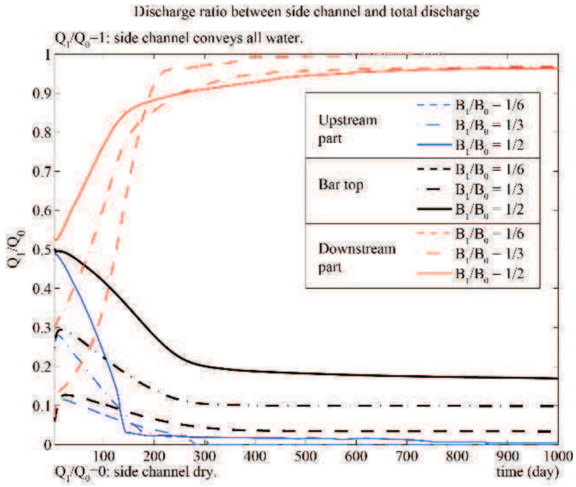

Figure 2. Discharge ratio between side channel and original channel. Blue lines are training wall starting at upstream part, red lines are at downstream part, and black lines are near the bar top.

Preliminary conclusions

In this study, the subdivision of river channels with alternate bars in two parallel channels by means of a longitudinal training wall always results in a deeper and a shallower channel. However, the evolution depends on the starting location of the longitudinal training wall with respect to a bar. Moreover, when the width of the side channel increases, the two channels are likely to remain both open. On other words, a larger side channel seems to produce a more stable system than a relatively narrow one.

Future works

These preliminary simulations will be followed by simulations studying the effects of a variable discharge regime and by experiments in the laboratory of Fluid Mechanics of TU Delft.

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