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Publication date
2017

Document Version
Final published version

Citation (APA)
Ostanek Jurina, T., & Mosselman, E. (2017). *Closing secondary channels in large sand-bed braided rivers*. 92-93. Abstract from NCR-Days 2017, Wageningen, Netherlands.

Netherlands Centre for River Studies

Nederlands Centrum voor Rivierkunde

Book of abstracts

NCR days 2017
February 1-3, 2017
Wageningen University & Research

NCR is a corporation of the Universities of Delft, Utrecht, Nijmegen, Twente and Wageningen, UNESCO-IHE, RWS-WVL and Deltares

Closing secondary channels in large sand-bed braided rivers

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Introduction

Large braided rivers have many beneficial roles, from provision of water for agriculture and means of transport to various ecosystem services. However, they are geomorphologically active, which results in problems with bank erosion and navigability. Some of the largest rivers may have bank line shifts of hundreds of meters per year (Baki and Gan, 2012). This leads to loss of homes and good agricultural land, destruction of infrastructure and flood protection works.

River training measures are used to combat these problems and reclaim lost land. Conventional structures, mostly developed in smaller watercourses, are problematic in very large and unpredictable braided rivers, due to their required size, cost, inflexibility and environmental disturbance (Nakagawa et al., 2013).

More adaptable, cheaper (local materials) and less disturbing measures are required. One promising possibility is the use of recurrent measures (such as bandals) to close aggressive secondary channels (Mosselman, 2006). Coupled with a prediction model for planform changes and erosion (such as Klaassen et al., 1993), this can be a very flexible and efficient way to protect nearby land against bank erosion, start land reclamation or improve navigability.

Figure 22: Bandals used to close a secondary channel {Mosselman, 2006}

The problem

Channel closure measures provide an option for gradual river training, which is necessary in such complex systems. However, hardly any systematic research has been carried out and no recommendations on their use exist. In the few documented cases measures were only partially successful, as during a flood the river formed a new entrance to the closed channel over the bar or by scouring around the structure.

Pilot measures to close a secondary branch were tested as part of the FAP22 project for the Jamuna river in Bangladesh (Mosselman, 2006). Partial closure for navigation improvement was simulated in a numerical model by Karmaker and Dutta (2016). Effects of a channel closure (and other perturbations) in a self-formed braided river were explored by Schuurman et al. (2016). They all showed problems as mentioned above, but did not examine the problem further.

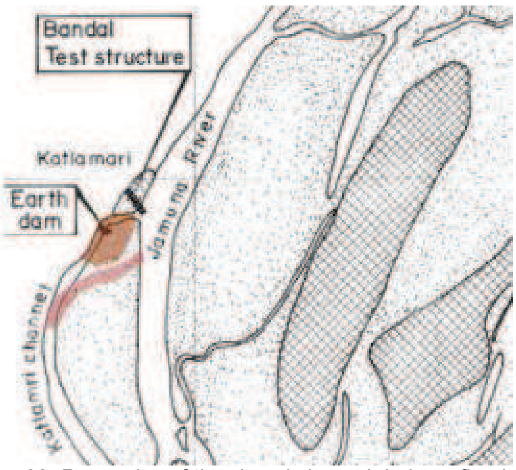

Figure 23: Reopening of the closed channel during a flood.

If such measures are to be successfully applied, understanding is needed about how, why and when they fail and what can be done to prevent it. Optimal arrangements and combinations with other measures need to be defined. This is the focus of the presented research.

Methodology

As large sand-bed braided rivers are very complex and the problem has been mostly unexplored, research will start with a simple case. A two dimensional numerical Delft3D model will be used, with pilot closure site and measures from FAP22 as reference, but with simplified geometry and length of only one bifurcation-confluence reach. A complete closure will be modelled, without taking into account possible openings to induce siltation in the channel.

Applying the reference case will enable calibration of the model to reproduce the problems observed. Processes leading to reopening of the channel will be studied. A sensitivity analysis will be made, testing the effects of roughness predictors, sediment transport formulas, discharge, island height and geometry. Different positions of measures along the channel will be tested.

Various factors possibly contributing to reopening, not (well) taken into account with the numerical model, will be examined and their effect assessed quantitatively or qualitatively. Examples include the effect of groundwater and sediment distribution in the water column during overbar flow.

Based on the knowledge obtained, arrangements of multiple closure works combined with additional measures (artificial roughness, vegetation, increasing island height) will be designed and tested for some representative situations. A model of a larger reach will be made, to see how the proposed measures perform in a more realistic setting. Finally, recommendations for the use of recurrent measures to close secondary channels in large braided rivers will be derived.

Expected results

Main reason behind channel reopening downstream of the closure is expected to be the water level difference between the parallel channels. This already occurs when branches are naturally closed and cross bar channels form due to a transverse hydraulic gradient (Bristow, 1987; Schuurman and Kleinhans, 2015). It is expected that additional measures will be required to perform the closure successfully.

Interesting results are anticipated from the sensitivity analysis of roughness predictors and sediment transport. Molinas and Wu (2001) made the case that common formulas are not applicable in very large and deep rivers. Indeed, in the Jamuna river, a different power of velocity is known to perform better when computing sediment transport.

Seepage probably plays a part in the erosion of the island due to a continuous water level difference from the main channel even during low flow. However the gradients are expected to be too small to make a significant difference. Not including the fact that the water flowing over the island carries only little sediment is likely more relevant.

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Conclusion

We address a mostly unexplored problem, which opens possibilities for useful findings and future research. Effective layouts and combinations of measures will be found and the resulting processes described. This will result in practical recommendations for effective closure of secondary channels in large braided sand-bed rivers.

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