Sediment grading and braiding of gravel-bed rivers

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1. Introduction

Recent studies have shown that the river bed topography is very sensitive to the composition of bed sediment. So, human interventions and natural processes leading to changes in sediment size grading might result in morphological adjustments of river reaches. This study deals with the effects of changing sediment size grading on the braiding intensity and bar characteristics of gravel-bed rivers. Previous studies have shown that bars decrease in height (Lanzoni, 2000, Lanzoni and Tubino, 1999) and braiding intensity increases (Teramoto and Tsujimoto, 2006) as sediment become less sorted but these conclusions were based on short-term laboratory experiments and simplified linear analyses. This study focuses on the long-term developments to establish whether these conclusions hold also for real rivers.

2. Methodology

To discriminate the effects of sediment grading from other effects, we studied the phenomenon of bar formation and merging using a fully non-linear morphological model based on the Delft3D code (www.deltares.nl). In order to represent a real river in the best possible way, the model was set up with the slope, discharge and sediment characteristics of the Waimakariri River in New Zealand (Figure 1).

Figure 1: Waimakariri River at Cross-Bank (after Griffiths, 1979) near Christchurch, New Zealand.

Bed load transport was simulated using the Meyer-Peter-Muller formula with Parker and Klingeman's (1982) hiding-exposure formulation. The vertical flux of sediment fractions was based on Hirano's (1971) model. Several computational tests simulated the channel bed development with different sediment mixtures (Table 1) under either partial or full mobility conditions (reduced threshold for sediment movement in the MPM formula).

3. Results and Conclusions

The simulated bed development agrees with the results of previous studies. The braiding intensity increases and the bar height decreases if sediment become less well sorted. With partial mobility, however, the initial trend is the opposite (Figure 2). Finally, initially the bar length decreases if sediment heterogeneity increases, but the relation is not consistent as the bed development progresses. In general, smaller bars merge to form larger multiple bars which redefine the dynamics of the system.

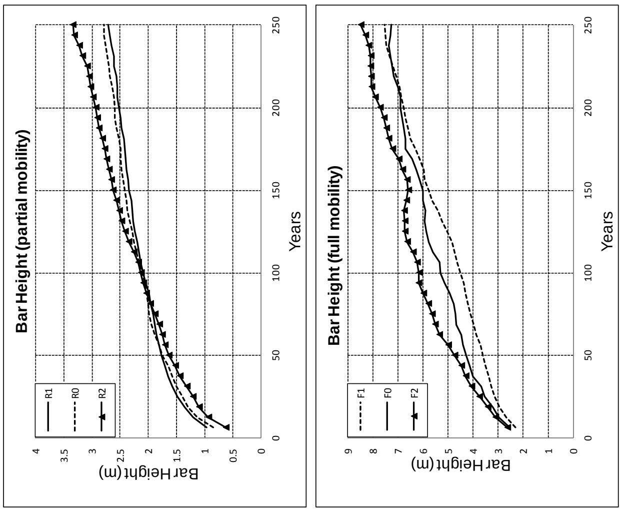

Figure 2: Temporal development of bar height (MATLAB scripts by Schuurman and Kleinhans, 2011)

Scenario	Range of sediment sizes in mm			
	Dmin	D_{50}	Dm	Dmax
R0/F0	0.0625	27	17	152
R1/F1	0.0625	27	17	250
R2/F2	2	27	21	80

Table 1: Grain size ranges for partial (R) and full (F) mobility conditions. R0 and F0 = Waimakariri River (reference) conditions. Dmin and Dmax = minimum and maximum sediment diameters.

References

Griffiths G.A. (1979). J. of Hydrology, 18 (I), 6-28.
Hirano M. (1971). T. Japan. Soc. Civil Eng., 3, 194-195.
Lanzoni, S. (2000). Water Resour. Res., 36, 3351-3363.
Lanzoni, S. and Tubino, M. (1999). J. of Fluid Mech., 393, 149-174.
Parker G. and Klingeman P.C. (1982). Water Resour. Res., 18, 1409-1423.
Schuurman F. and Kleinhans M.G. (2011) In proc. RCEM 2011, 1647-1657.
Teramoto A. and Tsujimoto T. (2006) In proc. RCEM 2005, 433-444.