Experimental Investigations and Numerical Modelling of Lateral Variations of Hydraulics and Sediment Transport in Braided Rivers

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

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ABSTRACT

Measurement and prediction of cross section averaged bedload transport rates in braided rivers have been long standing problem. Moreover, because bedload transport is non-linear, width averaged calculations of sediment transport will underestimate the true bedload flux where there is marked spatial and temporal variability in hydraulic parameters. However, at present very little is known about this effect or the actual lateral distribution of bedload. This thesis presents results from a series of micro-scale laboratory experiments designed to quantify the role of lateral variation of sediment transport as controls on braided river evolution. The experimental approach follows the “similarity of processes” concept and is therefore not scaled to a real world prototype. In all the five runs, the water discharge was held constant and the sediment feed rate was varied to simulate consecutive aggradation and degradation scenarios.

The qualitative observations of the experiments were supplemented with sediment transport data at the flume outlet and quantitative analysis of high resolution laser profiler attached to the experimental apparatus which measured bed elevations of the experimental channels as they evolved. This allowed the construction of a time series of data on the sediment storage and channel morphology and the changing lateral hydraulic variability on the channel. Aggradation was associated with channel multiplication and an increase in braiding intensity. During degradation, channel pattern was transformed to single thread. Simple averaging of sediment transport computations over the width of the channel is found to underestimate the sediment transport rate. A clear relationship appears to exist between braiding intensity and the width of shear stress distribution shape parameter. Maxima in braiding intensity and minima in shape parameter values occur around the flume outlet. In contrast, minima in braiding intensity and maxima in shape parameter values occur at the flume entrance. The experimental data generated provides a unique opportunity to observe in detail the spatial and temporal changes in the width of shear stress shape parameter that occurred on the channels as they evolved. The digital elevation models collected from the experiments were also used to run a two-dimensional hydraulic model that helped to understand the controls of shear stress on the experimental channels. A relationship was established that relates the width of shear stress distribution shape parameter and channel morphological parameters (channel width to depth ratio and braiding intensity) and the relationship was also compared with observations of the Megech gravel bed braided river in the Northern Ethiopia.

Overall, the investigation has demonstrated the potential for micro scale physical models to investigate aggradation and degradation scenarios and provide rich data concerning the lateral variability of sediment transport in braided channels. These data demonstrate the idea that increasing braiding intensity is a morphological response to high sediment load from upstream. Channel aggradation increases sediment transport by promoting lateral flow variability. This in turn feeds back to further aggradation depending on the response of the channel. This process will continue up to a point where there is no substantial variation in channel width to depth ratio. Beyond this point, there will be a reduction in sediment transport rates as a result of reduction in mean shear stress. This will in turn feed back to promote further aggradation.

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