

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

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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.

TABLE OF CONTENTS

ABSTRACT

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENT

1. INTRODUCTION

- 1.1. INTRODUCTION
- 1.2. THESIS STRUCTURE

2. BRAIDED RIVER RESEARCH: STATE OF THE ART

- 2.1. INTRODUCTION
- 2.2. IMPORTANCE OF STUDYING BRAIDED RIVERS
- 2.3. CAUSES OF BRAIDING
- 2.4. AGGRADATION AND DEGRADATION IN BRAIDED RIVERS
- 2.5. ESTIMATING SEDIMENT TRANSPORT IN BRAIDED RIVERS
 - 2.5.1. Conventional Bedload Functions (equations)
 - 2.5.2. Morphological Approach
 - 2.5.3. Stochastic Approaches to Bedload Prediction
- 2.6. ESTIMATION OF SHEAR STRESS
- 2.7. OUTLINE OF CURRENT RESEARCH PROJECT
 - 2.7.1. Aims and objectives

3. METHODS FOR UNDERSTANDING BRAIDING RIVER PROCESSES AND FORM: BENEFITS, DIFFICULTIES & LIMITATIONS

- 3.1. INTRODUCTION
- 3.2. FIELD STUDIES OF BRAIDED RIVERS
 - 3.2.1. Field measurements used in braided river studies
- 3.3. PHYSICAL MODELLING FOR BRAIDED RIVER STUDIES
 - 3.3.1. Classes of Physical Models
 - 3.3.2. Froude Scale Modelling
 - 3.3.3. Micro-Scale Modelling
- 3.4. NUMERICAL MODELLING
 - 3.4.1. Description of Fluvial Models
 - 3.4.2. Numerical Modelling in Braided River studies
- 3.5. APPROACH TO BE USED IN THIS PROJECT
- 3.6. SUMMARY

4. PHYSICAL MODEL EXPERIMENTAL DESIGN AND DATA COLLECTION

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- 4.1. OVERVIEW
- 4.2. EXPERIMENTAL APPARATUS
- 4.3. Experimental Design
 - 4.3.1. Length and time scale calculations

- 4.3.2. Basis for water and sediment discharge calculations
- 4.3.3. Summary of model parameters
- 4.4. EXPERIMENTAL SCENARIOS
- 4.5. REALISING THE EXPERIMENTAL DESIGN: EXPERIMENTAL PROCEDURE AND DATA COLLECTION
 - 4.5.1. Initial conditions
 - 4.5.2. Channel morphology and geometry
 - 4.5.3. Sediment Transport
 - 4.5.4. Additional Observations
 - 4.5.5. Data Post-Processing
- 4.6. SUMMARY

5. CHANGES IN SEDIMENT STORAGE AND CHANNEL MORPHOLOGY IN A MICRO-SCALE EXPERIMENTAL BRAIDED RIVER

- 5.1. INTRODUCTION
- 5.2. DATASETS
 - 5.2.1. Channel cross sections and Digital Elevation models
 - 5.2.2. Sediment transport data
- 5.3. RESULTS
 - 5.3.1. Variability and Changes in sediment output and Channel storage
 - 5.3.2. Changes in channel pattern and morphology
 - 5.3.3. Variation in water surface slope between aggradation and degradation runs
 - 5.3.4. Development of longitudinal profile and channel bed slope
- 5.4. SUMMARY

6. HYDRAULIC AND SEDIMENT TRANSPORT CHARACTERISTICS OF EXPERIMENTAL BRAIDED CHANNELS

- 6.1. INTRODUCTION
- 6.2. METHODS OF ANALYSIS
- 6.3. MEAN SEDIMENT TRANSPORT RATE AND EFFECT OF FLOW VARIABILITY
- 6.4. DOWNSTREAM VARIATIONS IN SEDIMENT TRANSPORT
- 6.5. HYDRAULIC CHARACTERISTICS OF THE EXPERIMENTAL CHANNELS
 - 6.5.1. Frequency distributions of hydraulic variables
- 6.6. STABLE GAMMA PARAMETERS IN AGGRADING AND DEGRADING CHANNELS
- 6.7. RELATIONSHIP BETWEEN SEDIMENT TRANSPORT AND BRAIDING INTENSITY
- 6.8. RELATIONSHIP BETWEEN BRAIDING INTENSITY AND SHAPE PARAMETER α
- 6.9. RELATIONSHIP BETWEEN CHANNEL WIDTH TO DEPTH RATIO AND SHAPE PARAMETER α
- 6.10. SUMMARY

7. APPLICATION OF TWO DIMENSIONAL HYDRAULIC MODEL TO THE EXPERIMENTAL CHANNELS

- 7.1. INTRODUCTION
- 7.2. DESCRIPTION OF THE TWO-DIMENSIONAL HYDRAULIC MODEL
- 7.3. MODEL CALIBRATION AND SENSITIVITY ANALYSIS
- 7.4. SPATIAL REPRESENTATION OF MODELLING RESULTS
- 7.5. SHEAR STRESS DISTRIBUTION

7.6. FREQUENCY DISTRIBUTION OF MODELLED FLOW VARIABLES

7.7. SUMMARY

8. CONCLUSION

8.1. INTRODUCTION

8.2. PROJECT SUMMARY

8.3. RESEARCH AIMS REVISITED

8.4. FUTURE WORK

8.4.1. Field Site

8.4.2. Field Data Collection

8.4.3. Velocity & Depth Measurement

8.4.4. Model Application

8.4.5. Model Depth Predictions

8.4.6. Model Velocity Predictions

8.4.7. Simulated Hydraulics at Higher Discharges

8.5. FINAL CONCLUSION

REFERENCES