Curvature and Sediment Supply Controls in Gravel Channels

An Investigation into Preliminary Experimental Results

Ryan A. Brown
Peter A. Nelson

February 5th, 2019

ryan.brown@colostate.edu
Sorting in Curved Channels

Well Documented Bed Sorting Pattern

Figures from Clayton and Pitlick (2008)
Sorting in Curved Channels

Well Documented Bed Sorting Pattern

Secondary Flow Circulation versus Gravitational Forces

Figures from Clayton and Pitlick (2008)
Objective

Introduce two flume experiments

Present preliminary results
- Topography
- Bed sorting

Compare results
- More questions than answers

Applications and Future Work
This is perfect!
## Flume Experiments

### Constants

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel Length</td>
<td>15.2 m</td>
</tr>
<tr>
<td>Channel Width</td>
<td>1.35 m</td>
</tr>
<tr>
<td>Wavelength</td>
<td>12.2 m</td>
</tr>
<tr>
<td>Crossing Angle</td>
<td>20 degrees</td>
</tr>
<tr>
<td>Bed Material</td>
<td>sub-angular gravel</td>
</tr>
<tr>
<td>$D_{16}$</td>
<td>1.8 mm</td>
</tr>
<tr>
<td>$D_{50}$</td>
<td>3.3 mm</td>
</tr>
<tr>
<td>$D_{84}$</td>
<td>5.0 mm</td>
</tr>
<tr>
<td>Time to Equilibrium</td>
<td>25 hrs</td>
</tr>
</tbody>
</table>
## Flume Experiments

### Variable parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Low Flow</th>
<th>High Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Bed Slope</td>
<td>0.005</td>
<td>0.007</td>
</tr>
<tr>
<td>Width-to-Depth Ratio</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Discharge</td>
<td>0.04 cms (1.41 cfs)</td>
<td>0.11 cms (3.8 cfs)</td>
</tr>
<tr>
<td>Mean Bed Shear Stress</td>
<td>3.36 Pa</td>
<td>5.45 Pa</td>
</tr>
<tr>
<td>Mean Shields Stress</td>
<td>0.065</td>
<td>0.105</td>
</tr>
<tr>
<td>Excess Shear Ratio</td>
<td>1.6</td>
<td>2.6</td>
</tr>
<tr>
<td>Sediment Supply Rate</td>
<td>59 kg/hr</td>
<td>230 kg/hr (!)</td>
</tr>
</tbody>
</table>
Data Collection

Topographic surveys using Structure-from-Motion photogrammetry
  • ~1 mm spatial resolution!

Bed Grain Size
  • Photo sieving
  • DEM Roughness

Bedload measurements
  • Helley-Smith sampler

Velocity profiles
Topography – Low Flow

Slope increased to 0.006

Notable Morphological Characteristics
• Characteristic meander morphology
• Single bend geometry behaves as three bends with superimposed features
• Propagating local bar forms on top of reach scale features
Equilibrium bed topography after 25 hours.

- Bed slope reduced to ~0.006 m/m
- Same general morphology
Topography - Discussion

Remarkably similar despite:
  • Sediment feed quadrupled!
  • Discharge doubled

Small but notable differences
  • Pool location in High Q
  • Bar height or pool depth

• Channel geometry controls morphology
  • “Forced” bars

• Sediment supply and width-to-depth ratio control:
  • Size and shape of bar-pool morphology
Sorting Patterns – Low Flow

No obvious bed sorting

Unexpected

Automated photosieving using method of Graham et al. (2005)
Sorting Patterns – High Flow
Sorting - Discussion

Hypothesis
There is some threshold value of channel curvature at which expected sorting pattern occurs.

Also function of
- Excess shear
- Sediment supply
- Width-to-depth ratio
Conclusions

- Channel curvature controls reach scale morphology
- Sediment supply and width-to-depth ratio control bar/pool amplitude and bed sorting
- Direct and indirect applications to channel design in restoration
More to Come!

Extensive Velocity Dataset
Couple velocity flow field to bedload transport field

Experiments varying sediment supply under different curvatures

<table>
<thead>
<tr>
<th>φ</th>
<th>L/W</th>
</tr>
</thead>
<tbody>
<tr>
<td>10°</td>
<td>8</td>
</tr>
<tr>
<td>20°</td>
<td>8</td>
</tr>
<tr>
<td>30°</td>
<td>8</td>
</tr>
</tbody>
</table>