EXPERIMENTAL STUDY ON THE IMPACT OF KEYSTONES ON GRAVEL BED MORPHOLOGY

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A laboratory experiment was undertaken to evaluate how the addition of large particles, or keystones, into a gravel-bed system impacts sediment transport and bed morphology. Keystones are common elements in gravel-bed rivers. They can be naturally occurring or introduced due to anthropogenic activities such as river engineering infrastructure protection or erosion control.

The study was undertaken in a 0.5 m wide flume, consisting of trials with five different keystone densities on the channel bed and a sixth being a control with no keystones. Prior to the addition of keystones, the channel bed was made up of a poorly sorted gravel mixture with a bi-modal distribution of sand and gravel. Keystones were sized in a similar manner to material that would be specified for erosion works and channel rehabilitation projects, such that average keystones were stable at peak flows with a factor of safety of 2 applied and then scaled to the experimental setup. Flow history for each configuration was established by using a low flow without sediment input until equilibrium was reached and sediment transport had ceased. After this flow history was established, a single hydrograph was imposed with sediment input to simulate upstream bedload. The bed material, not including the keystones, was designed such that the D84 particle size had a mobility ratio of 1 at peak discharge.

During the experiments, data were collected pertaining to sediment transport, bed topography and bed texture. Sediment transport measurements were taken using a sediment trap located at the downstream end of the flume. The bed topography and texture data were collected immediately before and after the hydrograph, as well as after the second flow history. The topography data were obtained using a mini echo-sounder, and the texture data was collected using topographic photos. Additionally, real-time photos were taken from the top and side of the flume during the hydrograph to supplement the sediment transport data with a visual component.

Changes in sediment transport for each keystone density run were compared based upon transport rates and transported material textures. Surface textures were compared both as a bulk change within the study reach, but also on 2-D reach meshes to evaluate sediment clustering around keystones. Finally, the bed topography data were used to determine erosional and depositional trends both on bulk scales and 2-D mesh reach scales by evaluating changes in elevations between runs. The topography data were also used to evaluate the changes in bed roughness over the hydrograph.

The results show that while the rate of sediment transport decreases with increased keystone density, there is little evidence that the shear stress acting on the mobile channel bed is decreasing within the studied range of densities. While the density of keystone particles is increasing, the transport rate may be decreasing, the transported and bed material are much coarser at low densities, and nearly equivalent to the base case at the highest tested density. Coupling this with the changes to the bed elevation, bed profile, spatial coarse material distribution and fractional transport analysis suggests that the shear stress active on the mobile bed sediment is not reduced due to the presence of larger material on the surface, but may in fact be greater due to their presence, just affecting a smaller surface area.

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Description of Presentation

The presentation will be focused on interpreting the results of the flume study, describing the processes found within the study, and using the findings to suggest possible applications to channel design, and to relate the processes to findings in the field.

Biography

Chris works as a water resources specialist at GeoProcess Research Associates where he focuses on natural channel design and fluvial geomorphology. He has been working in the field of water resources for the past 5 years, and is completing a masters of applied science in Environmental Engineering at the University of Waterloo focusing on sediment transport in urban streams.