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Artificially generating sediment incipient motion in natural conditions

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Incipient motion thresholds for gravel bed rivers are studied in flumes and natural rivers. Flume studies allow variables such as channel slope, water velocity, water depth, sediment size and sediment composition to be controlled. Meanwhile, in the field, the incipient motion of particles is studied in natural conditions allowing the structure of the bed and the flood characteristics to be considered. Though much less developed, an intermediate possibility also exists. By artificially accelerating near bottom velocity of the water flow in a small portion of the bed, it is possible to initiate sediment transport. This allows sediment incipient motion to be observed in natural conditions while controlling the water velocities.

The Cemagref (HHLY) has developed a device which confines water flow in a small tunnel on the bottom of the riverbed. It was developed in order to create a boundary layer similar to the one generated by natural flow. Water is injected into a filter which smoothes the flow before it enters a Plexiglas tunnel where sediment motion is observed. The flow is accelerated by two large pumps that allow flow velocities of up to 2.5 m/s in a small area 40 cm long, 20 cm wide and 12 cm high. As the water flow is confined, large scale turbulence similar to that occurring in natural rivers cannot be reproduced using the device. The velocity profile in the tunnel is stable and in equilibrium with the riverbed.

Sediment motion was observed using this device on three Belgian gravel bed rivers (3.5 cm $<D50<$8 cm). The incipient critical velocities measured were coherent in the three rivers sampled, ranging between 1.3 m/s and 1.7 m/s. A progressive increase in velocity in the tunnel permitted size selective entrainment to be observed. Analysis of the particle entrainment schemes and associated velocities allowed the role played by the armoured layer and the Di/D50 ratio to be more fully understood.

Critical velocities measured using the device were also compared to critical velocities observed in natural conditions, determined during several pebble tracing campaigns. This revealed that incipient motion velocities of the largest particles recorded in artificial conditions were systematically larger than those observed in natural conditions. This demonstrates the roles played by large scale turbulence and the vertical component of the flow velocity in single particle entrainment. Due to its inherent characteristics, both of these flow components are weak in the artificial conditions generated by the device.

In conclusion, our study demonstrates that this type of device is a useful tool in observing and studying incipient motion processes and, in particular, the role played by the bed structure (armouring, protrusion, etc.). However, some improvements are still required in order to more accurately measure critical velocities, allowing critical discharges to be determined.