River morphodynamics

Part 3.1: Bedload

Institute of Geophysics
Polish Academy of Sciences

Michael Nones
mnones@igf.edu.pl

Introduction

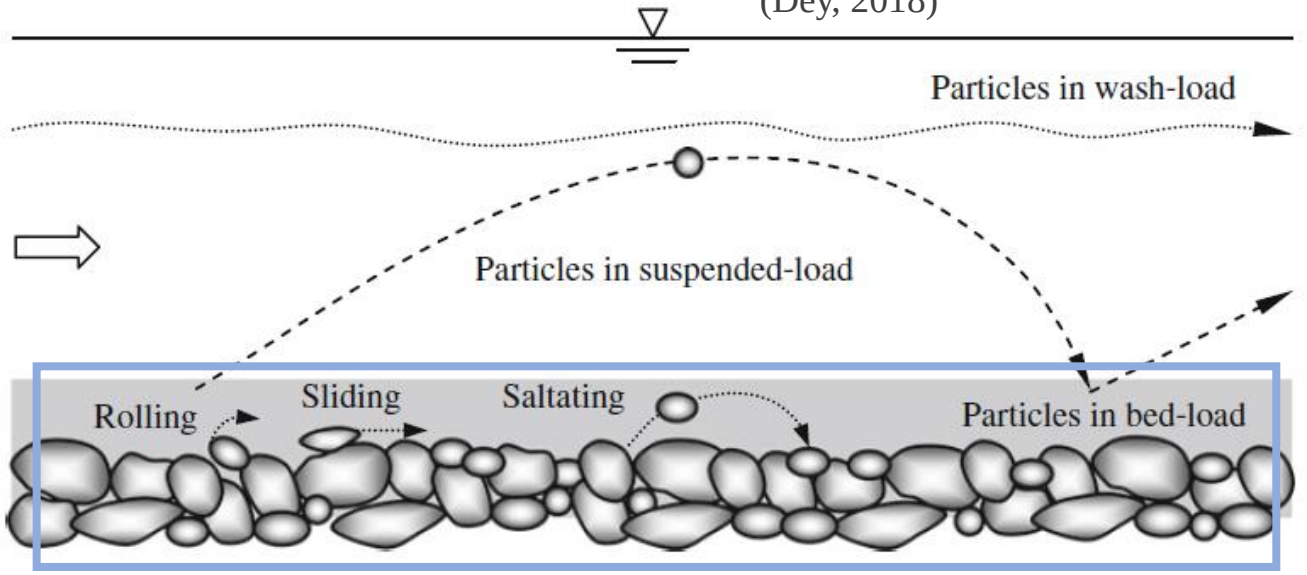
Transport of sediments by *rolling*, *sliding*, and *saltation* in a layer close to the bed. It is governed by the balance of hydrodynamic forces (drag and lift) versus particle weight.

It is composed mainly by sand and gravel, kept in motion (rolling and sliding) by the shear stress acting at the boundary. Unlike the suspended load, the bed-load component is almost always capacity limited (that is, a function of hydraulics rather than supply).

Bed sediments: the bed material is the source of this bedload. Its grainsize distribution is generally coarser than the load transported in suspension as it forms when the flow allows for deposition of some material (for natural homogeneous material this depends solely on the diameter).

Bed load: refers to a mode of transport and not to a source; strictly defined, it is just that component of the moving sediment that is supported by the bed.

Bedload modes of movement (Dey, 2018)

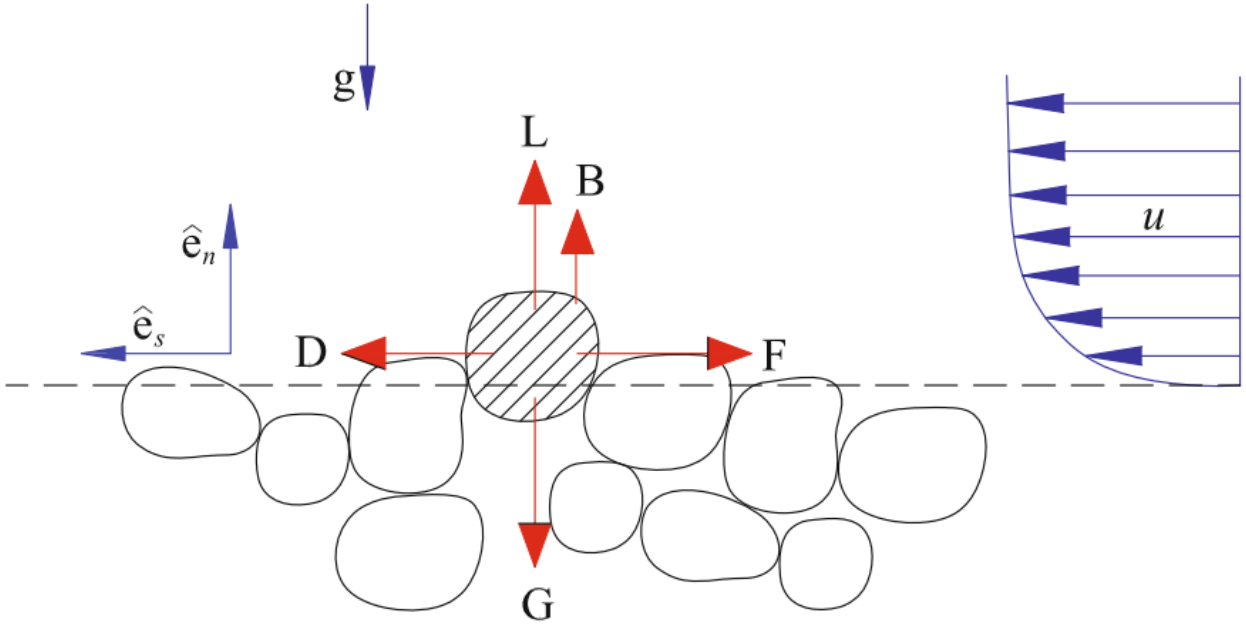


Mobilisation

Incipient motion conditions occur when the balance of forces acting on the single sediment breaks

- drag $D = f_1(\rho, \rho_s, d, u)$
- lift $L = f_2(\rho, \rho_s, d, u)$
- gravity $G = f_3(\rho_s, d)$
- friction $F = f_4(d, u)$
- buoyancy $B = f_5(\rho, d)$

Forces acting on a single grain (Armanini, 2018)



Bedload formulas

Meyer-Peter Müller formula (1948)

- one of the earliest equations, but one of the most widely used
- developed from flume experiments of sand and gravel under plane bed conditions
- simple excess shear relationship
- applicable to gravel system (underestimation in the case of fine material)
- corrected by Wong and Parker (2006) accounting for a form drag coefficient

Van Rijn formula (1984)

- developed from flume experiments of sand and gravel under plane bed conditions
- based on threshold conditions