Lecture 20—Some Loose Ends

Rouse Number

I forgot to mention something last time. It would be nice if we had some sort of quantitative number that talked about what sediment might reasonably be expected to be doing on the bed. We have a number (Shields' criterion) that's supposed to say whether sediment is moving or not, but what about *how* sediment is moving? Specifically, is it rolling, is it hopping, or is it spending most of its time in the flow? Ok, to be fair, this is a continuum, right, so there are no natural divisions, but we'd like to know *something* about how the grains are moving. Things that might be important here:

- The settling velocity of the grain (because the faster it settles, the less it wants to hop or be suspended)
- The velocity *right near* the bed (because the faster the velocity, the more likely the grain is to roll and hop)
- How effectively momentum is distributed in the flow (more effectively means that once the grains get up into the flow proper, the more likely they are to stay up there).

Yes, the answer to this is yet *another* dimensionless number, the Rouse number.

$$P = \frac{w}{\kappa u_*}$$

where w is the settling velocity, κ is Von Karman's constant, and u_* is the shear velocity.

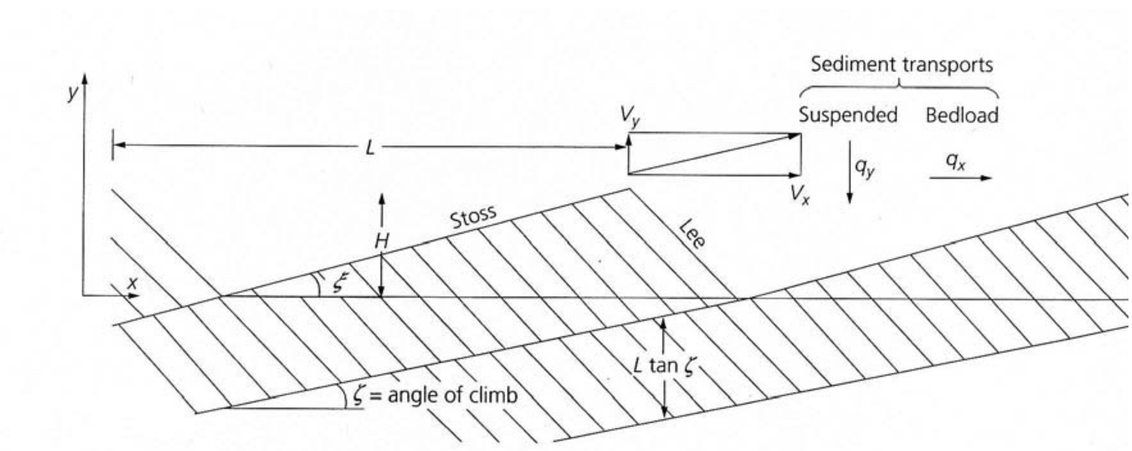
Commonly used ranges for Rouse number are:

P ≥ 7.5	Little movement
7.5 ≥ P ≥ 2.5	Bedload (grains rolling and hopping along bed; bedforms like dunes)
2.5 ≥ P ≥ 0.8	Incipient suspension (grains spending less and less time in contact with bed; bedforms increase in wavelength and decrease in amplitude)
0.8 ≥ P	Suspension (grains spend very little time in contact with bed; plane bed)

Please bear in mind that Rouse number has several different definitions, including simply w/u_*. Obviously, a Rouse number defined in this fashion will not have the same numeric ranges as the one I've defined for you here. There's a third definition that I'll save for later. Oh, and bear in mind that the ranges I gave you are sort of a guide rather than dogma. You'll find other ranges out there. Oh, and a last nastiness—geologists usually use *P* for Rouse number, but engineers will variously use *z* and *α.*

Some transition between bedforms and sediment transport

Here's a little segue between bedforms and the concept of sediment transport. Suppose we had climbing ripples? You remember climbing ripples—they're ripples for which the sedimentation rate is great enough that the bedform "climbs" up in a sedimentary unit.



Sooooo, we could determine an equation for the horizontal motion of the ripple:

$$V_x = \frac{2q_x}{H\rho_B}$$

where q_x is the bedload sediment transport rate for the flow, H is the height of the ripple, and ρ_B is the *bulk* sediment density. This is basically normalizing a mass flux (q_x) by density to make it a volume flux, then dividing by the area of a triangle to get a velocity. By the same token, the velocity *up* is given as:

$$V_y = \frac{q_y}{\rho_B}$$

Where q_y is the rate of suspended load fall-out. So, the *angle* of climb is related to the bedload transport rate and the suspended transport rate:

$$\tan\zeta = \frac{V_y}{V_x} = \frac{q_y H}{2q_x}$$

In short, if we knew something about how sediment was transported in each of these modes, we could use angle of climb alone to tell something about not only the transport rate, but also the flow characteristics of the stream that deposited the ripples.