

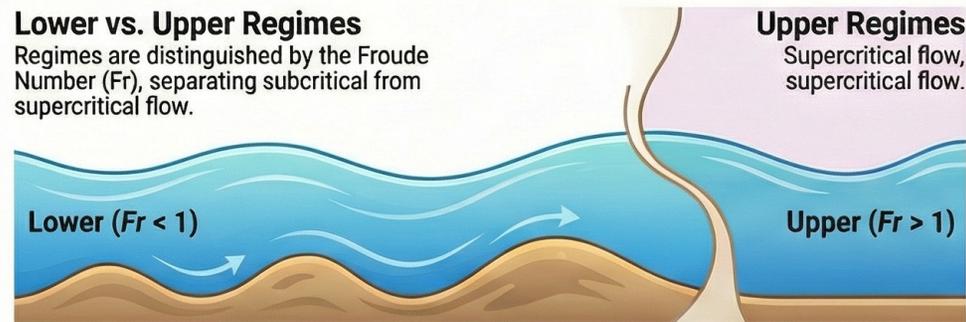
# Riverbed Morphodynamics: Bed Forms & Flow Resistance

Bed forms are self-organized sediment structures (like dunes) created by water flow. They are critical to hydraulics because they change a river's flow resistance, affecting both the water level (stage) and the amount of sediment transported.

## Bed Form Regime Classification

### Lower vs. Upper Regimes

Regimes are distinguished by the Froude Number ( $Fr$ ), separating subcritical from supercritical flow.



### Bed and Water Phase Relations

Surfaces are out-of-phase in lower regimes (dunes) but in-phase in upper regimes.



### Rating Curve Dependency

River water levels shift based on bed configuration, even if discharge remains constant.

Bed Form	Ripples	Dunes	Antidunes
Flow Regime			
Phase Relation	Lower ( $Fr < 1$ ) Out-of-phase	Lower ( $Fr < 1$ ) Out-of-phase	Upper ( $Fr > 1$ ) In-phase
Scaling Factor	Small-scale (Grain-dominated)	Flow Depth ( $H$ )	Surface Waves

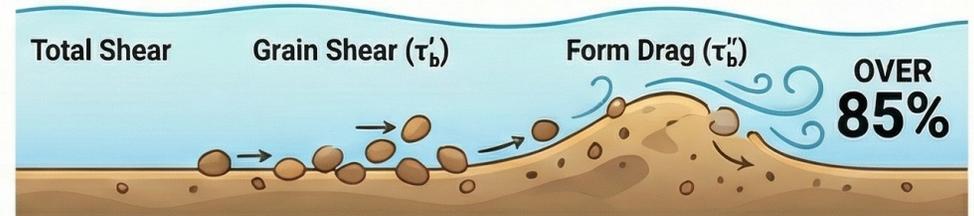
## Shear Stress Partitioning

### Effective Shear vs. Total Shear

Only grain shear ( $\tau'_b$ ) moves sediment; form drag ( $\tau''_b$ ) is lost to turbulence.

### Form Drag Dominance

In dune-bed rivers, form drag can account for over 85% of total resistance.



## Three Classical Partition Methods

