Sediment Threshold of Motion (Shields) in Channel Flow

Critical Shields parameter, critical bed shear stress and shear velocity for a sediment grain, compared with the bed shear of the flow to judge if the bed moves.

Method: Shields criterion with the Soulsby–Whitehouse formula

Input parameters

Unit system: SI

Parameter	Value	Unit
Grain diameter (d_{50})	0.50000	mm
Grain density	2,650.0	kg/m³
Water density	1,000.0	kg/m³
Kinematic viscosity	1.0000	mm²/s
Hydraulic radius (≈ depth for wide channels)	1.2000	m
Energy slope	2.0000e-04	

Calculated results

Parameter	Value	Unit
Dimensionless grain size	12.647	
Critical Shields parameter	0.030837	
Critical bed shear stress	0.24949	Pa
Critical shear velocity	0.015795	m/s
Bed shear stress ρgR_hS	2.3536	Pa
Mobility ratio (above 1: the bed moves)	9.4336	

Notes for this case

- Soulsby–Whitehouse fit of the Shields curve, for non-cohesive grains on a flat bed in steady flow. Bed forms, armouring, cohesion and bank slopes change the real threshold.

Formula and method

$$D_* = d\left[\frac{(s-1)g}{\nu^2}\right]^{1/3}, \quad \theta_{cr} = \frac{0.30}{1+1.2D_*} + 0.055\left(1-e^{-0.020D_*}\right)$$

$$\tau_{cr} = \theta_{cr}(\rho_s - \rho)gd, \quad \tau_b = \rho g R_h S$$

Variables

d	Grain diameter (d_{50})	m
ρ_s	Grain density	kg/m³
ρ	Water density	kg/m³
ν	Kinematic viscosity	m²/s
R_h	Hydraulic radius (≈ depth for wide channels)	m
S	Energy slope	-
D_*	Dimensionless grain size	-
θ_{cr}	Critical Shields parameter	-
τ_{cr}	Critical bed shear stress	Pa
u_{*cr}	Critical shear velocity	m/s
τ_b	Bed shear stress ρgR_hS	Pa

τ_b/τ_{cr}	Mobility ratio (above 1: the bed moves)	-

Method and standards

Threshold of sediment motion.

Assumptions and limits

- Non-cohesive grains, flat bed, steady uniform flow.

References

Shields criterion with the Soulsby–Whitehouse formula

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/civil/hydraulics/shields-sediment-threshold

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.