Critical Hydraulic Gradient, Exit Gradient Safety and Heave

Critical hydraulic gradient for a quick condition, the safety factor against piping at an exit gradient and the factor against heave of a soil plug.

Method: Critical gradient and Terzaghi heave

Input parameters

Unit system: SI

Parameter	Value	Unit
Specific gravity of solids	2.6500	
Void ratio	0.65000	
Exit hydraulic gradient	0.35000	
Embedment depth of the plug (sheet pile)	4.0000	m
Average excess head at the plug base	2.5000	m

Calculated results

Parameter	Value	Unit
Submerged unit weight	9.8066	kN/m³
Critical gradient	1.0000	
Safety factor against piping	2.8571	
Safety factor against heave (Terzaghi plug)	1.6000	

Notes for this case

• i_c = (G_s − 1)/(1 + e) = γ′/γ_w, about 1 for most soils. Factor against piping i_c/i_e (often 3–4 required); Terzaghi's heave check of a soil prism D wide by D deep beside a sheet pile compares its submerged weight with the uplift from the average excess head: FS = γ′D/(γ_wh_a).

Formula and method

The formula is shown on the calculator page: https://calc.firecad.com/civil/geotechnical/critical-gradient-heave

Variables

G_s	Specific gravity of solids	-
e	Void ratio	-
i_e	Exit hydraulic gradient	-
D	Embedment depth of the plug (sheet pile)	m
h_a	Average excess head at the plug base	m
\gamma'	Submerged unit weight	N/m³
i_c	Critical gradient	-
FS_p	Safety factor against piping	-
FS_h	Safety factor against heave (Terzaghi plug)	-

Method and standards

Seepage safety.

Assumptions and limits

- Homogeneous soil; steady seepage.

References

Critical gradient and Terzaghi heave

Report details

Report reference	FCC-D6RZ-5ERC (the same inputs always give the same reference)
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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

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

This calculator online

https://calc.firecad.com/civil/geotechnical/critical-gradient-heave

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.