Granular Filter Backwash: Expanded Bed Depth

Expanded depth of a stratified sand or anthracite bed at a backwash rate, from the size fractions, settling velocities and the expanded porosity (v/vs)^0.22.

Input parameters

Unit system: SI

Parameter	Value	Unit
Backwash rate	0.75000	m/min
Bed depth	0.90000	m
Bed porosity (fixed)	40.000	%
Media specific gravity	2.6500	
Water temperature	5.0000	°C
Size of fraction 1	2.1800	mm
Mass fraction 1	1.0000	%
Size of fraction 2	1.8300	mm
Mass fraction 2	3.0000	%
Size of fraction 3	1.3000	mm
Mass fraction 3	16.000	%
Size of fraction 4	0.92000	mm
Mass fraction 4	16.000	%
Size of fraction 5	0.71000	mm
Mass fraction 5	30.000	%
Size of fraction 6	0.50000	mm
Mass fraction 6	22.000	%
Size of fraction 7	0.35000	mm
Mass fraction 7	12.000	%

Calculated results

Parameter	Value	Unit
Expanded bed depth	1.4858	m
Bed expansion	65.090	%
Expanded porosity of the coarsest fraction	0.49906	
Settling velocity of the coarsest fraction	0.29439	m/s
Settling velocity of the finest fraction	0.046469	m/s

Notes for this case

- Fractions are normalised to their total.
- The coarsest fraction is fluidised: the whole bed expands.

Formula and method

$$\frac{L_e}{L} = (1-\alpha)\sum \frac{p_i}{1-\alpha_{e,i}}, \quad \alpha_{e,i} = \left(\frac{v}{v_{s,i}}\right)^{0.22}, \quad C_d = \frac{24}{Re} + \frac{3}{\sqrt{Re}} + 0.34$$

Variables

v	Backwash rate	m/s
L	Bed depth	m
α	Bed porosity (fixed)	-
s	Media specific gravity	-
T	Water temperature	K
d_1	Size of fraction 1	m
p_1	Mass fraction 1	-
d_2	Size of fraction 2	m
p_2	Mass fraction 2	-
d_3	Size of fraction 3	m
p_3	Mass fraction 3	-
d_4	Size of fraction 4	m
p_4	Mass fraction 4	-
d_5	Size of fraction 5	m
p_5	Mass fraction 5	-
d_6	Size of fraction 6	m
p_6	Mass fraction 6	-
d_7	Size of fraction 7	m
p_7	Mass fraction 7	-
L_e	Expanded bed depth	m
$(L_e - L)/L$	Bed expansion	-
$\alpha_{e,1}$	Expanded porosity of the coarsest fraction	-
$v_{s,1}$	Settling velocity of the coarsest fraction	m/s
$v_{s,7}$	Settling velocity of the finest fraction	m/s

Method and standards

Fair and Geyer expansion with the Richardson-Zaki type porosity relation.

Assumptions and limits

- Spherical-particle drag law; sieve geometric mean sizes.

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/environmental/wastewater/filter-backwash-bed-expansion

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.