ENVE 301
2011-2012
PS # 8–Filtration

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EXAMPLE 1

Draw the grain size distribution curve. Determine effective size and uniformity coefficient

US Sieve No	4	10	20	40	100	200	Pan
Sieve Opening (mm)	4.75	2	0.85	0.425	0.15	0.075	
MASS RETAINED (g)	100	150	200	250	200	100	5

EXAMPLES ABOUT CLEAN BED HEADLOSS CALCULATIONS

A) SINGLE MEDIUM FILTERS

Example #1 : Headloss across a bed of uniform size particles

Water at 20^0C is passed through a bed of uniform sand at a filtering velocity of 5 m/hr. The sand grains are 0.4 mm in diameter with a shape factor of 0.85 and a specific gravity of 2.65. The depth of bed is 0.67 m and the porosity 0.4. Determine the headloss through the bed.

at 20^0C; $\mu = 1.002 \times 10^{-3}$ kg/m.sec, $\rho = 998.2$ kg/m^3

Example #2 : Determination of headloss across a bed of nonuniform particles

Water at 20^0C is passed through a filter bed at 4.32 m/hr. The bed is 0.75 m deep and is composed of nonuniform sand (sp. gravity= 2.65) stratified so that the smallest particles are on top, the largest on bottom. The porosity and shape factors are 0.4 and 0.85 throughout the depth of bed. The size distribution of the granules given in the table below. Determine the headloss for clean water flow through bed.

at 20^0C; $\mu = 1.002 \times 10^{-3}$ kg/m.sec, $\rho = 998.2$ kg/m^3

U.S Sieve No.		**Particle Size range, mm**		**Weight fraction retained, x_{ij}**
Passing	Retained	Passing	Retained	
	14		1.41	0.01
14	20	1.41	0.84	0.11
20	25	0.84	0.71	0.20
25	30	0.71	0.60	0.32
30	35	0.60	0.50	0.21
35	40	0.50	0.42	0.13
40		0.42		0.02

B) DUAL MEDIUM FILTERS

Example #3 : Determination of headloss across a dual media (each layer is uniform)

Determine the clear water headloss in a filter bed composed of 0.3 m of uniform anthracite (with an average size of 1.6 mm) placed over 0.3 m layer of uniform sand (with an average size of 0.5 mm) for a filtration rate of 160 L/m^2.min.

Porosity for both anthracite and sand layer = 0.4

Shape factor for both anthracite and sand layer = 1 (spherical)

at 20^0C; $\mu = 1.002 \times 10^{-3}$ kg/m.sec, $\rho = 998.2$ kg/m^3

Example #4 : Determination of headloss across a dual media (each layer is nonuniform)

Calculate the initial headloss in a dual media filter containing anthracite and sand with depth of 0.45 m and 0.30 m respectively. The sphericities of the sand and anthracite are 0.95 and 0.72, respectively. The porosities of anthracite and sand are 0.55 and 0.40, respectively. Filtration velocity is 175 m^3/m^2.d.

at 10^0C; $\mu = 1.307 \times 10^{-3}$ kg/m.sec, $\rho = 999$ kg/m^3

Sieve Analysis Results:

for anthracite layer		
d_1, mm	**d_2, mm**	**Mass fraction retained**
0.72	1	0.2
1	1.18	0.2
1.18	1.27	0.2
1.27	1.53	0.2
1.53	1.81	0.2

for sand layer		
d_1, mm	**d_2, mm**	**Mass fraction retained**
0.51	0.61	0.2
0.61	0.68	0.2
0.68	0.74	0.2
0.74	0.82	0.2
0.82	0.93	0.2

EXAMPLES ABOUT BACKWASH HYDRAULICS

Example: Finding the expanded depth of uniform medium

Filter medium ⟶ sand grains (0.4mm in diameter)

= 0.85

specific gravity= 2.65

depth of the bed=0.67m

porosity=0.4

T=20 C $\mu = 1.002.10^{-3}\ N.s/m^2$

$\rho_w = 998.2\ kg/m^3$

Determine the required backwash velocity to expand the bed to a porosity of 0.7.

Example: Determine the headloss during backwash for a filter bed consisting of 0.6 m sand with a porosity of 0.45.

$\rho_{bed} = 2650\ kg/m^3$, $\rho_{water} = 1000\ kg/m^3$

Example (Finding the expanded depth of a non-uniform bed):

Filter bed ⟶ 0.75m deep, composed of non-uniform sand (sp. gravity 2,65)

porosity:0.4 shape factor: 0.85

at 20^oC ⟶ $\mu = 1.002.10^{-3}\ kg/m.sec$

$\rho_w = 998.2\ kg/m^3$

This bed is to be backwashed at a velocity of 1.5 10^{-2} m/sec. Determine the depth of expanded bed

Sieve Analysis Results:

US Sieve No		Particle size/mm		Mass fraction retained, X_{ij}
	14		1.41	0.01
14	20	1.41	0.84	0.11
20	25	0.84	0.71	0.20
25	30	0.71	0.60	0.32
30	35	0.60	0.50	0.21
35	40	0.50	0.42	0.13
40		0.42		0.02

Example: Calculate the minimum fluidization velocity for an anthracite bed having following characteristics

$d_{90} = 2,9\,mm$ $\rho_{anthracite} = 1600 kg/m^3$

$T = 20\,^{o}C \rightarrow \mu = 1.002 . 10^{-3}\, kg/m\,sec$

$\rho_w = 998\, kg/m^3$

Example: Calculate the minimum fluidization velocity for a non-uniform sand media having following characteristics

$d_{90} = 0.93mm$

$T = 10^{o}C$

$\mu = 1.306.10^{-3}$

$\rho = 999.7 kg/m^3$

$\psi = 0,75$

porosity of unstratified bed = 0.39

porosity of stratified bed = 0.42

$V_{mf} = ?$