Given:

Wet Bulk Density = 2.24 g/cm^3
Particle Density = 2.65 g/cm^3
Fluid Density (FD) = 1.0 g/cm^3

What is:

Porosity = ?

BD = (1- ϕ) PD + ϕ (FD)

$$\phi = \frac{SW - DW}{V_T}$$

$$\frac{DW}{V_T} = PD(1-\phi)$$

$$\phi = 1 - \frac{DW}{PD * V_T}$$

BD = (1- ϕ) PD + ϕ (FD)

BD = PD - ϕ PD + ϕ FD

BD = PD + ϕ (FD - PD)

BD – PD = ϕ (FD - PD)

$$\frac{BD - PD}{(FD - PD)} = \phi$$

We have wet bulk density so use fluid density for water

$$\frac{2.24 - 2.65}{1 - 2.65} = \frac{-0.41}{-1.65} \sim 0.25 = \phi$$

Knowing:

Wet Bulk Density = 2.24 g/cm^3
Particle Density = 2.65 g/cm^3
Fluid Density (FD) = 1.0 g/cm^3
Porosity = 0.25

And If:

Total Volume = 25cm^3

What is:

Saturated Weight = ?
Dry Weight = ?

BD = (1- ϕ) PD + ϕ (FD)

$$\phi = \frac{SW - DW}{V_T}$$

$$\frac{DW}{V_T} = PD(1-\phi)$$

$$\phi = 1 - \frac{DW}{PD * V_T}$$

Saturated "Weight" = Vol * WBD = 25cm^3 * 2.24 $\frac{g}{cm^3}$ = 56g (MASS)

Dry Weight = SatWgt – WaterWgt = SatWgt – ϕ TotVol * FD

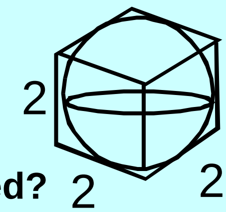
= 56g – (0.25*25cm^3) * 1 $\frac{g}{cm^3}$ = 56g – 6.25g = 49.75g ~ 50g (MASS)

CONSIDERING SPHERES

1 volume of 2x2 units will hold

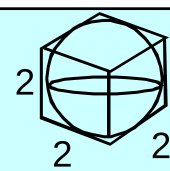
1 sphere	**r=1**
8 spheres	**r=1/2**
64 spheres	**r=1/4**

what space will they leave unoccupied?



$$\phi = \frac{V_V}{V_T} = \frac{2^3 - \left(m\frac{4}{3}\pi r^3\right)}{2^3}$$

m is the # of spheres



$$\phi = \frac{V_V}{V_T} = \frac{2^3 - \left(m\frac{4}{3}\pi r^3\right)}{2^3}$$

m is # spheres r is their radius

m	r	r^3	mr^3
1	1	1	1
8	1/2	1/8	1
64	1/4	1/64	1

$$\phi = \frac{2^3 - \left(\frac{4}{3}\pi\right)(1)}{2^3} = 0.476 \qquad \text{A constant!}$$

HENCE MAX ϕ FOR UNIFORM, CUBIC PACKED SPHERES IS ~ 48%

MIN ϕ WOULD RESULT FROM RHOMBEHEDRAL PACKING ~ 26%

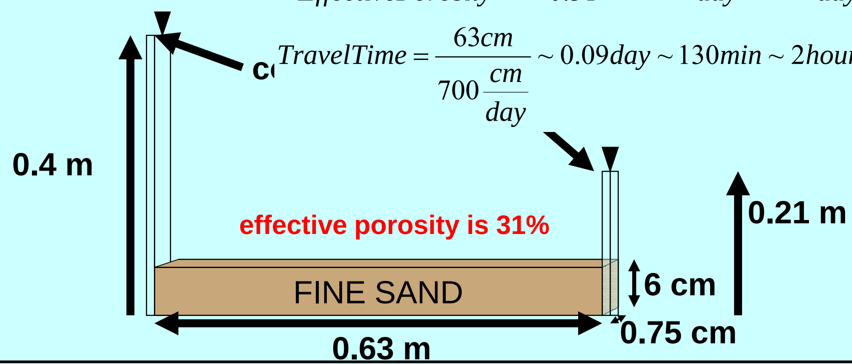
IN GENERAL, IRREGULAR PACKING & ANGULAR PARTICLES YIELD HIGHER ϕ

$$Q = \frac{1\ liter}{day} = \frac{1\ liter}{day}\frac{1000cm^3}{1\ liter} = \frac{1000cm^3}{day}$$

$$Darcy\ Velocity = \frac{Q}{Area} = \frac{\frac{1000cm^3}{day}}{6cm0.75cm} = 222\frac{cm}{day}$$

$$Average\ Linear\ Velocity = \frac{DarcyVelocity}{EffectivePorosity} = \frac{222\frac{cm}{day}}{0.31} = 716\frac{cm}{day} \sim 700\frac{cm}{day}$$

$$TravelTime = \frac{63cm}{700\frac{cm}{day}} \sim 0.09day \sim 130min \sim 2hours$$

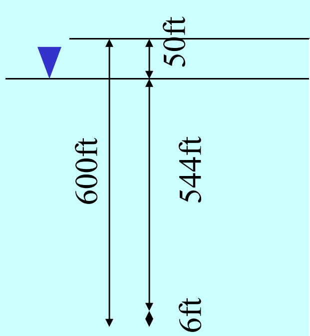


pressure on your head (6ft tall) at the bottom of a well

surface at sea level

bottom at 600 ft

water level 50 ft below the surface



Gage Pressure

$$P = \gamma h = 62.4\frac{lb}{ft^3}544\,ft = 33945.6\frac{lb}{ft^2}$$

$$P = 33945.6\frac{lb}{ft^2}\frac{1}{144}\frac{ft^2}{in^2}$$

$$= 235.7\frac{lb}{in^2} = 235.7\,psi$$

Absolute Pressure ~ 235.7psi + 14.7psi

~ 250.4psi

Estimate the height of capillary rise for water in sand.

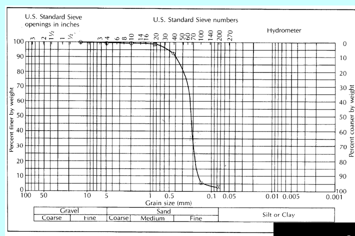
Grain size distributions in Fetter (pg74-75)

Smallest ~ 0.08 mm 10% ~ 0.17mm = 0.017cm

What if the soil is a silty sand?

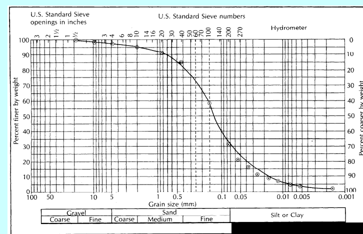
Grain size distributions in Fetter (pg74-75)

Smallest ~ 0.002 mm 10% ~ 0.017mm = 0.0017cm



▲ FIGURE 3.5
Grain-size distribution curve of a fine sand.

sand



▲ FIGURE 3.4
Grain-size distribution curve of a silty fine to medium sand.

silty sand

What if the fluid is gasoline?

Substance Surface Tension (dyne/cm)

Water 72.8 dyne/cm

Gasoline ~33 dyne/cm (note < tension for water)

specific weight? check the web (~0.68 density of water)

Which will dominate, surface tension decrease or specific weight decrease?

Use d_{10} to reflect the typical pore throat size

For fresh water:

$$h_c = \frac{2\sigma(\cos\lambda)}{\gamma r} \quad (\text{for r in cm})$$

$$\sigma = \frac{72.8\text{dyne}}{\text{cm}} \frac{0.00102\text{ g}}{\text{dyne}} \frac{981\text{ cm}}{\text{sec}^2} = \frac{72.8\text{g}}{\text{s}^2}$$

$$\gamma = \rho g = \frac{1\text{g}}{\text{cm}^3} \frac{980\text{cm}}{\text{s}^2} = \frac{980\text{g}}{\text{cm}^2\text{s}^2}$$

For sand

$h_{c\text{-water}}$ = (2*72.8)1/(980*0.017/2) = 17.5cm

$h_{c\text{-gas}}$ = (2*33)1/(0.68*980*0.017/2) = 11.6cm

For silty-sand

$h_{c\text{-water}}$ = (2*72.8)1/(980*0.0017/2) = 174cm

$h_{c\text{-gas}}$ = (2*33)1/(0.68*980*0.0017/2) = 116cm