Wrocław University of Science and Technology

Soil Mechanics
-Lecture I: Introduction. Physical properties.

HR EXCELLENCE IN RESEARCH

European Funds
Knowledge Education Development

Wrocław University of Science and Technology

European Union
European Social Fund

What is the soil?

Geosciences

Rock mechanics

Soil mechanics

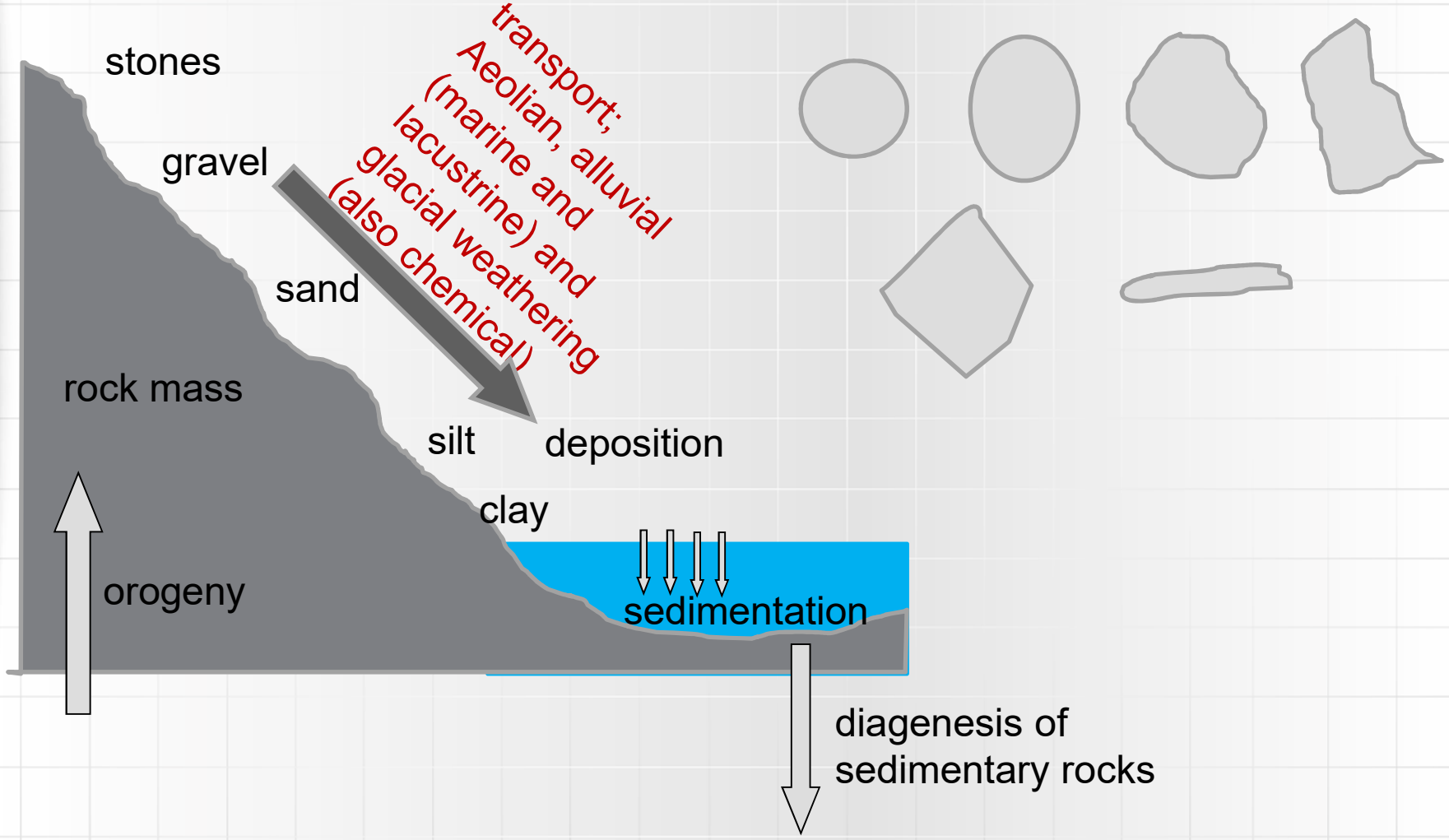
weathering

diagenesis

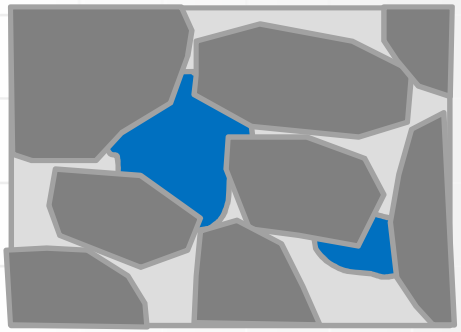
Rock mass

Soil mass

Weathering and deposition of soils



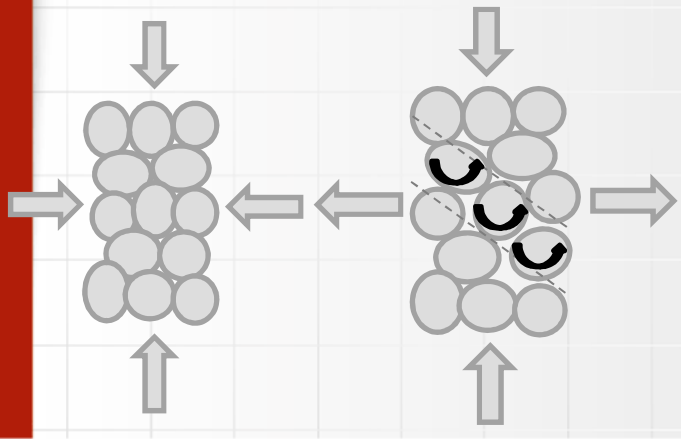
Features of soils



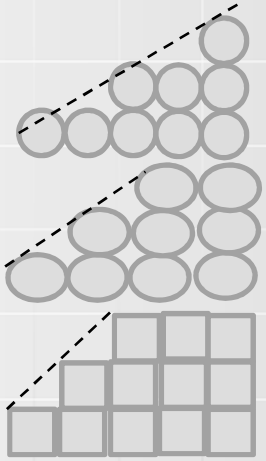
Soils are:

- made of water and air filed pores and particles of solid
- solid for soil (skeleton) is non-continuous and granular
- particles of soil are rather fine and irregular in shape

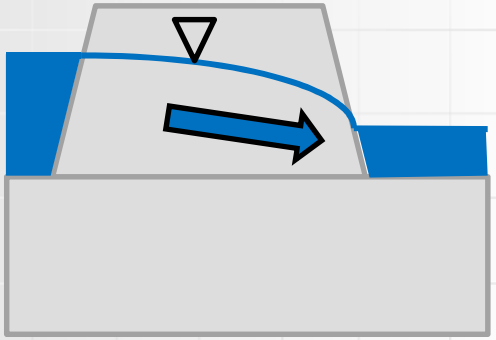
Changes in the packing system



Internal friction

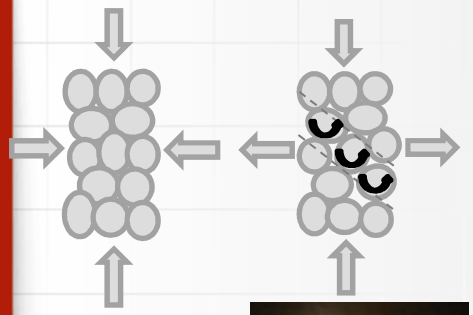


Infuence of gruond water

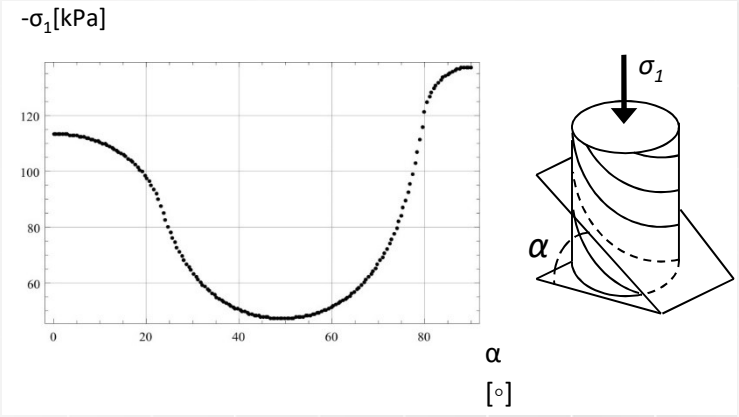


More features of soil

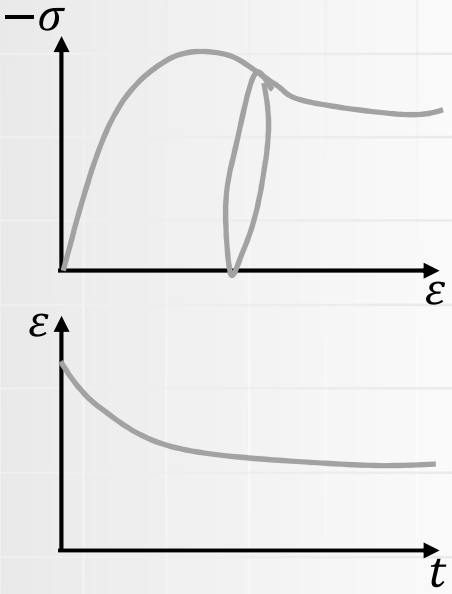
Dilatancy



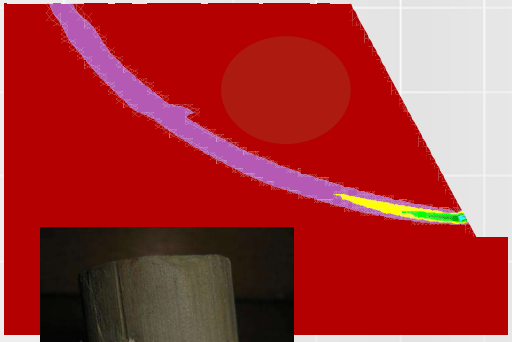
Anisotropy



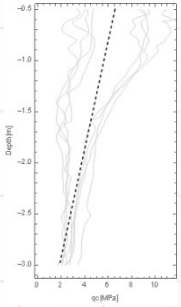
Nonlinear elastic and creep behaviour

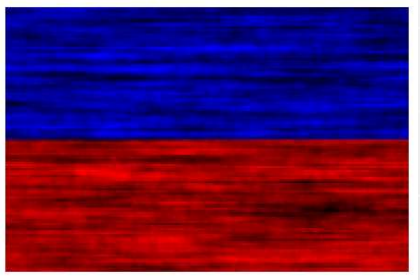


Failure in shearing

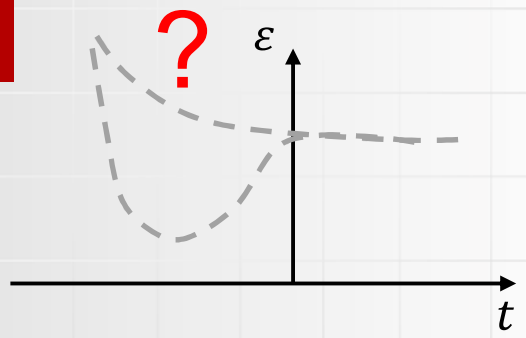


Spatial variability of parameters

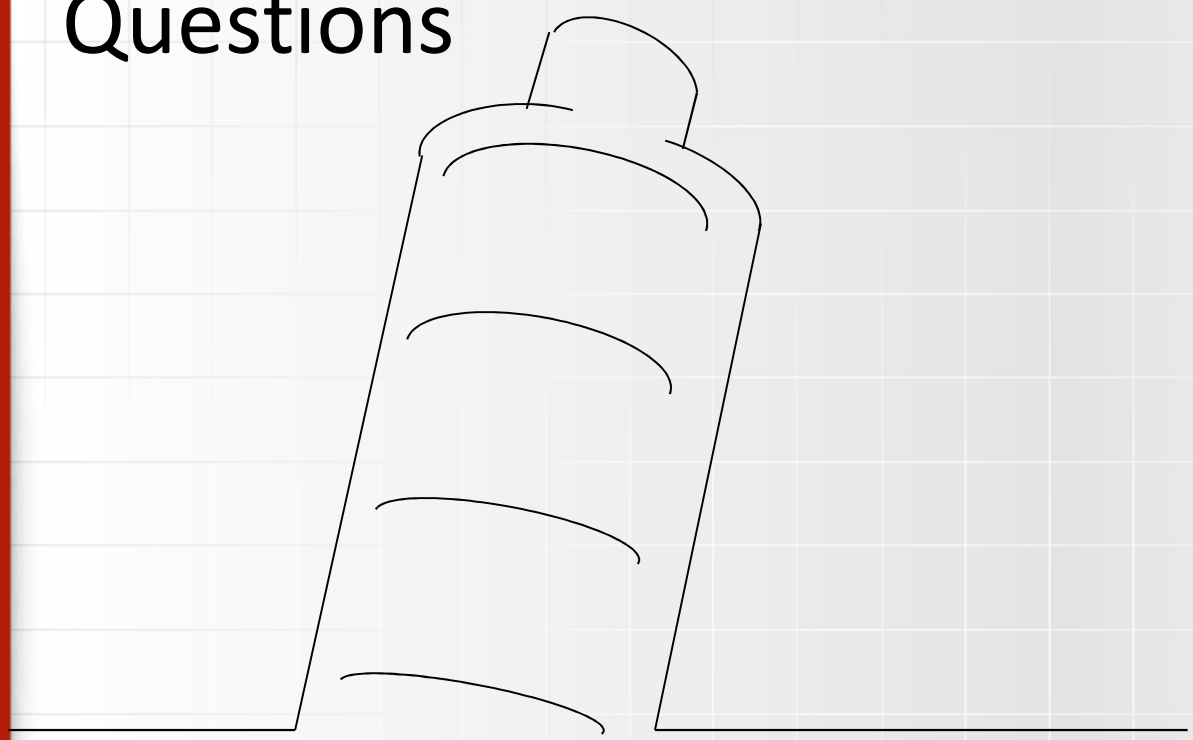




Unknown influence of history



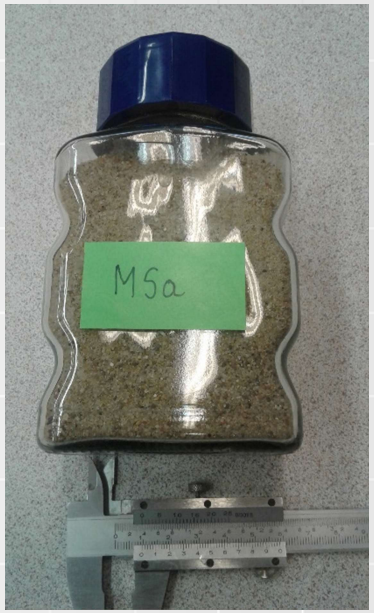
Questions

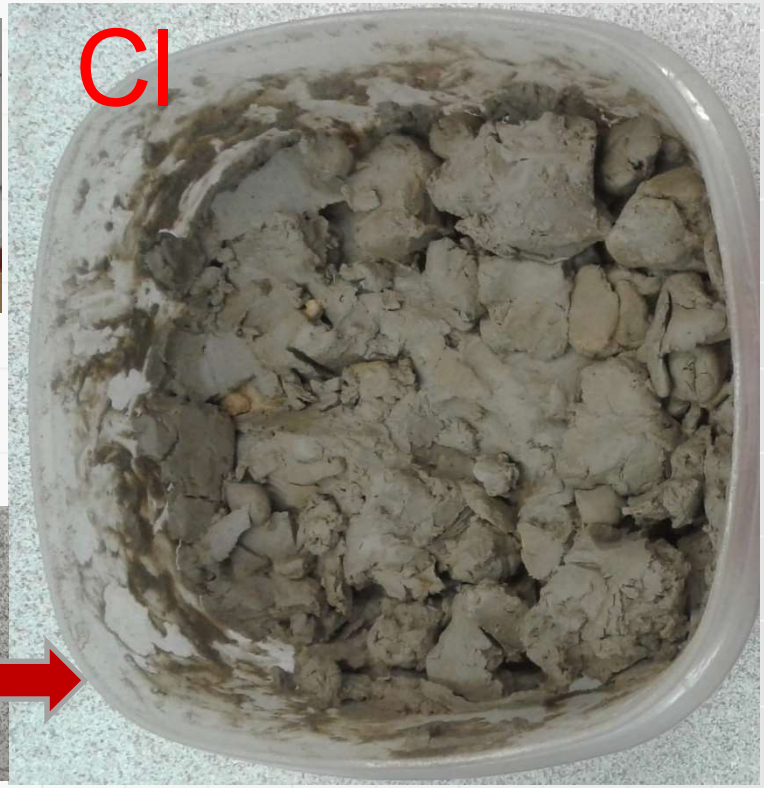


- On which side compressible clay is thicker?
- On which side ancient building has been located?
- How to repair the tower building?

Soils classification

Soil type	min. [mm]	max. [mm]
clay		0.002
silt	0.002	0.063
sand	0.063	2
gravel	2	63





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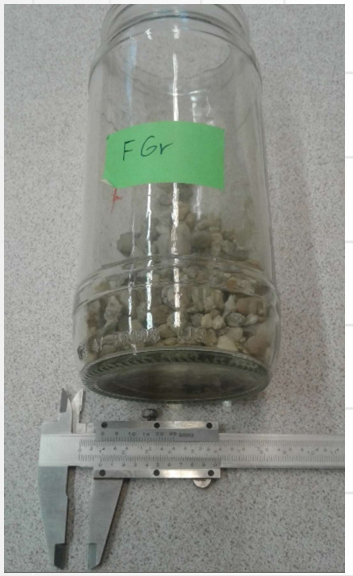
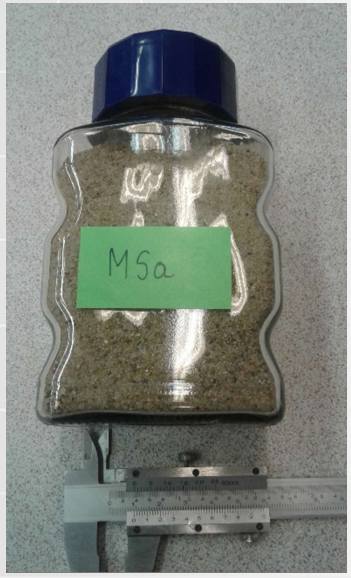
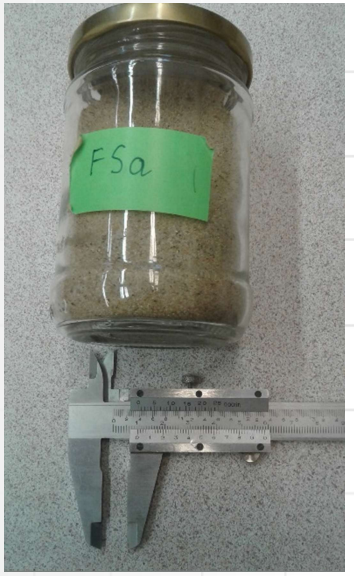
Name				Size range (mm)
Very coarse soil		Large boulder	LBo	>630
		Boulder	Bo	200-630
		Cobble	Co	63-200
Coarse soil	Gravel	Coarse gravel	CGr	20-63
		Medium gravel	MGr	6.3-20
		Fine gravel	FGr	2.0-6.3
	Sand	Coarse sand	CSa	0.63-2.0
		Medium sand	MSa	0.2-0.63
		Fine sand	FSa	0.063-0.2
Fine soil	Silt	Coarse silt	CSi	0.02-0.063
		Medium silt	MSi	0.0063-0.02
		Fine silt	FSi	0.002-0.0063
	Clay		Cl	≤0.002



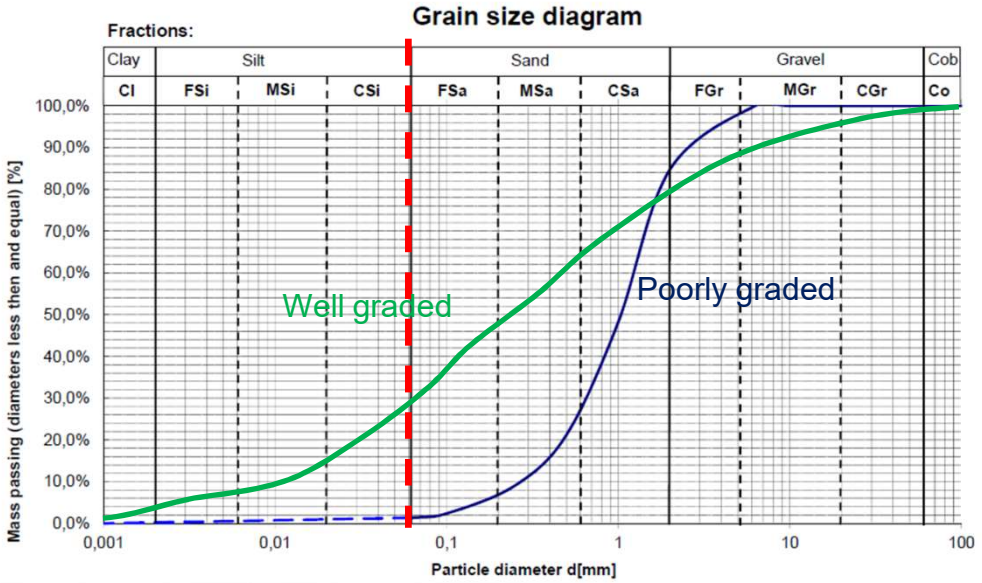




Grain size analysis

Sieve analisys
(gradation test)

Hydrometer analisys

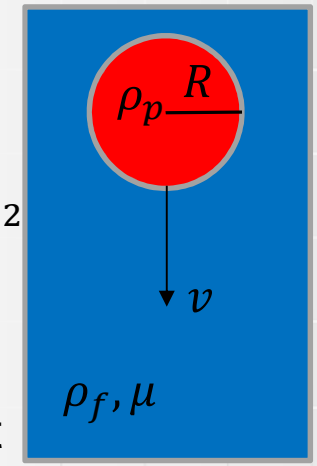


Uniformity Coefficient

$$c_u = \frac{d_{60}}{d_{10}}$$

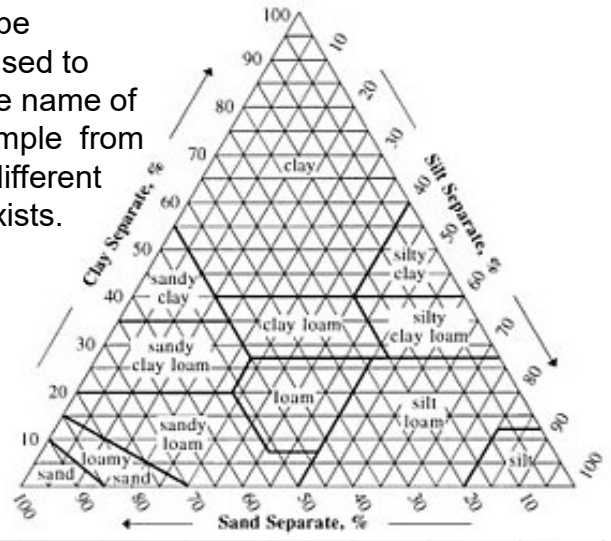
Stock's Law

$$v = \frac{2}{9}\frac{(\rho_p - \rho_f)}{\mu} g\, R^2$$

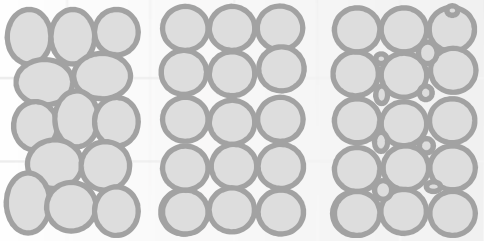


μ-viscosity
g – gravity constant

Knowing grain size diagram classification triangle can be sometimes used to recognize the name of the soil (example from US). Some different ideas also exists.



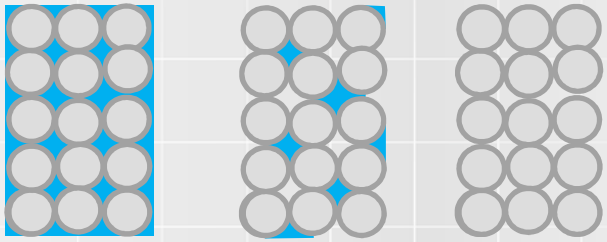
Physical properties



Porosity $n = \frac{V_p}{V_{tot}}$

V_p – volume of pores

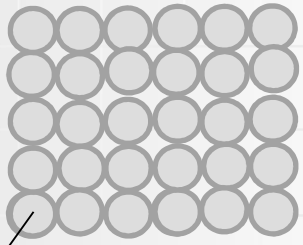
V_{tot}– total volume



Saturation degree $S_r = \frac{V_w}{V_p}$

V_w – volume of water

V_p - volume of pores



Particles density $\rho_p = \frac{M_s}{V_s}$

M_s – mass of particles

V_s – volume of particles

Other physical properties

Porosity ratio $e = Vp/Vs$

$e = n/(1-n)$

Vp – pores volume

Vs - solid volume

Density (bulk density)

$\rho = Sr\, n\, \rho_w + (1-n)\, \rho_p$

ρ_w – water density

g – gravity constant

Water (moisture) content $w = Mw/Ms$

M_w – mass of water

M_s – mass of solid (dry soil)

$w = Sr\, e\, \rho_w / \rho_p$

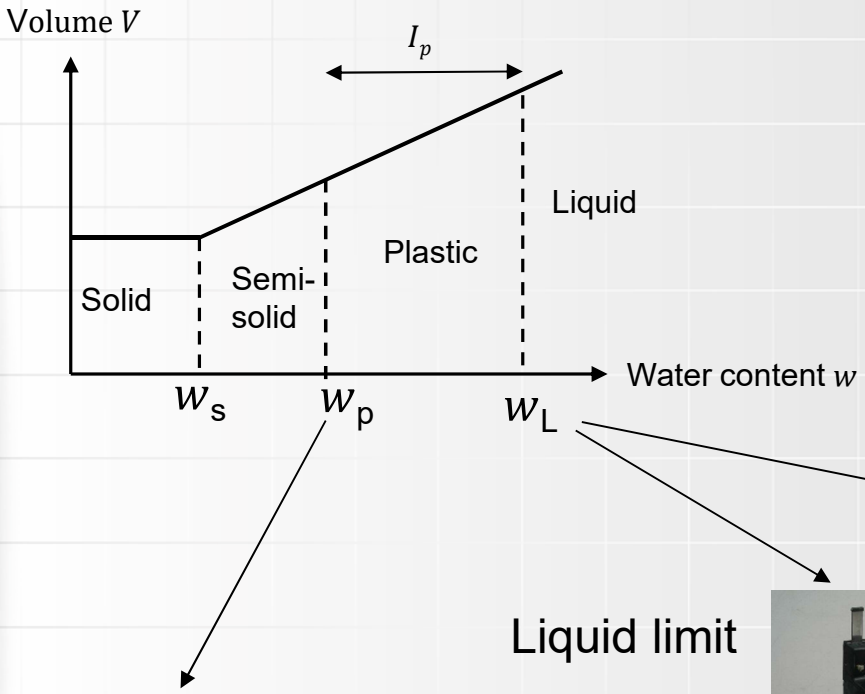
Unit (volumetric) weight

$\gamma = [S_r\, n\, \rho_w + (1-n)\rho_p]g$

$\rho_{sat} = n\, \rho_w + (1-n)\, \rho_p$

$\rho_d = (1-n)\, \rho_p = \rho/(1+w)$

Atterberg (consistency) limits



Plasticity index

$$I_P = wL - wP$$

Plastic limit

roll to thread of 3 mm

Liquid limit

Cone penetrometer

20 mm penetration

Casagrande test

After 25 drops of hollow container V-shaped groove cut closes at length of 10mm and thickness of 1mm

State of soil

Liquidity Index

$$I_L = \frac{w - w_P}{(w_L - w_P)}$$

1 Liquid Plastic Solid 0

0 Consistency Index 1

$$I_C = \frac{w_L - w}{(w_L - w_P)}$$

Relative density

0 Very loose Loose Medium Dense Very dense 1

$$I_D = \frac{e_{max} - e}{(e_{max} - e_{min})}$$

Questions

- Macroscopic identification of name of soil
- Macroscopic identification of state of fine soil (is it possible for sands?)
- Which physical properties can be measured?
- Evaluate some dependent properties

Bibliography

Verruijt, A., & Van Baars, S. (2007). *Soil mechanics* (pp. 19-25). Delft, the Netherlands: VSSD.

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