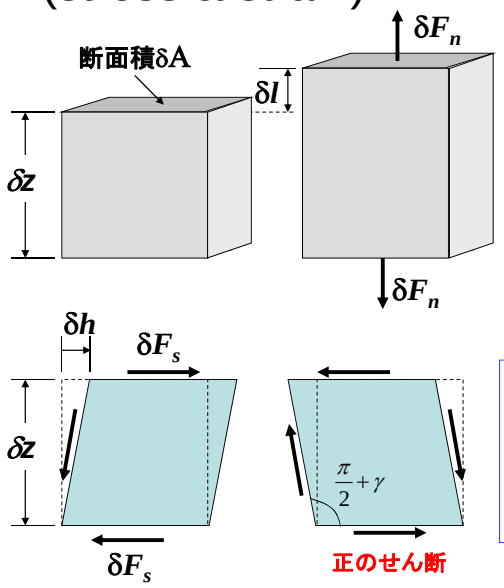
応力とひずみ
(stress & strain)



直応力: $\delta\sigma = -\frac{\delta F_n}{\delta A}$
(normal stress)

直ひずみ: $\delta\varepsilon = -\frac{\delta l}{\delta z}$
(normal stain)

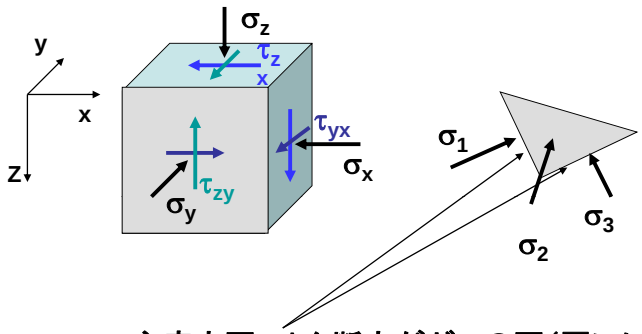
土質力学の符号
- 直応力、ひずみ:
  圧縮を正
- せん断応力、ひずみ:
  反時計周りを正

せん断応力: $\delta\tau = -\frac{\delta F_s}{\delta A}$
(shear stress)

せん断ひずみ: $\delta\gamma = -\frac{\delta h}{\delta z}$
(shear strain)

一般的な微小土要素の応力表示

応力:方向によって変化する。



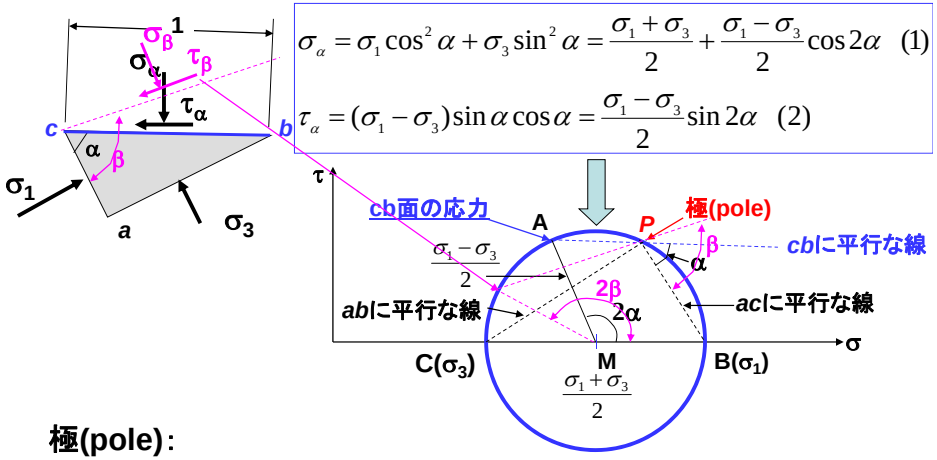
主応力面:せん断力がゼロの面(互いに直交)
(principal plane)
主応力面上の直応力(principal stresses)
最大主応力(σ_1)＞中間主応力(σ_2)＞最小主応力(σ_3)
(major) (intermediate) (minor)

モールの応力円(2次元)
(Mohr's stress circle)

力の釣合い

$$\sigma_\alpha = \sigma_1\cos^2\alpha + \sigma_3\sin^2\alpha = \frac{\sigma_1+\sigma_3}{2} + \frac{\sigma_1-\sigma_3}{2}\cos 2\alpha \quad (1)$$

$$\tau_\alpha = (\sigma_1-\sigma_3)\sin\alpha\cos\alpha = \frac{\sigma_1-\sigma_3}{2}\sin 2\alpha \quad (2)$$

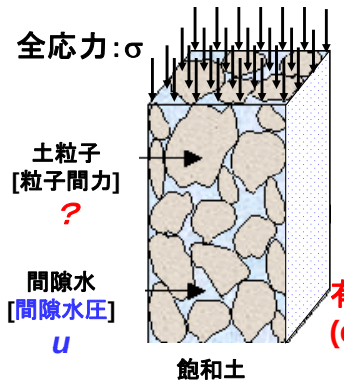


極(pole):
(傾き、応力成分)既知の面があり、モールの応力円上のその点からその面と平行な線を引き、円と交わった点。 ＝＞ 極から任意の傾きの線を引きモール円と交わった点の応力は、その線と平行な面上の応力成分。

地盤中の応力(有効応力、全応力、間隙水圧)

土要素境界、内の応力

境界の直応力:σ ＝＞ 全応力(total stress)



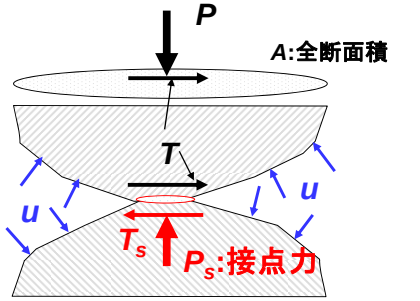
Terzaghi (1923)

$$\sigma' = \sigma - u \quad (1)$$

有効応力
(effective stress)

間隙水圧
pore water pressure

土要素内の力釣合い



全断面

直応力: $\sigma = \frac{P}{A}$, せん断(応)力: $\tau = \frac{T}{A}$

粒子接触面

直応力: $\sigma_s = \frac{P_s}{A_s}$, せん断(応)力: $\tau_s = \frac{T_s}{A_s}$

土要素内の力釣合い

面と垂直な方向の力の釣合い

Aで割る $a = \frac{A_s}{A}$

$P = P_s + (A - A_s)u$

$\sigma = a\sigma_s + (1-a)u$

$a = \frac{\sigma - u}{\sigma_s - u}$

これらを計ることは困難

inter-granular stress (粒子間力／全断面) $\sigma_g = \frac{P_s}{A}$

$\sigma_g = \frac{P - (A - A_s)u}{A}$

$= \sigma - (1-a)u$

$a \sim 0$ (接点面積0)

$\sigma_g = \sigma - u = \sigma'$

面と平行な方向の力の釣合い

水は強度ゼロ → $T = T_s \rightarrow \tau = a\tau_s$ ⇒ 粒子接点力 => 有効応力

せん断応力: 全応力＝有効応力

粒子間接点摩擦力がせん断力を伝える

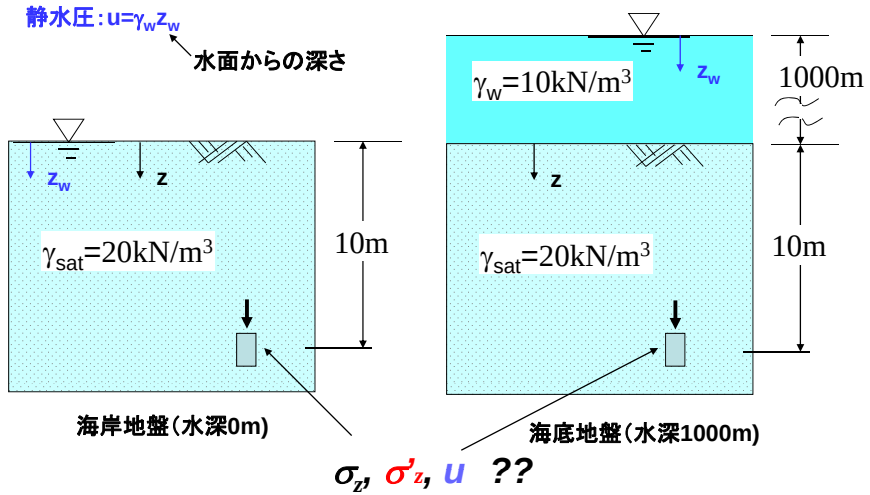
有効応力の原理 by **Karl Terzaghi** (1937)

(The principle of effective stress)

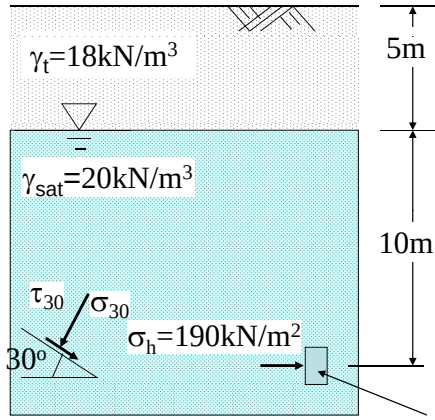
The stresses in any point of a section through a mass of soil can be computed from the total principal stress, σ_1, σ_2, σ_3, which act at this point. If the voids of the soil are filled with water under a stress *u*, the total stresses consist of two parts. One part u acts in the water and in the solid in every direction with equal intensity. It is the neutral stress (or pore pressure). The balance $\sigma'_1=\sigma_1-u$, $\sigma'_2=\sigma_2-u$ and $\sigma'_3=\sigma_3-u$ represents an excess over the neutral stress *u* and it has its seat exclusively in the solid phase of the soil. This fraction of the total principal stress will be called the effective stress.

All measurable effects of a change of stress, such as compression, distortion and a change of shearing resistance, are due exclusively to changes of effective stress. The effective stress σ' is related to the total stress and pore pressure by $\sigma'=\sigma-u$. （宿題:この翻訳:期限11/4）

地盤中の応力



地盤中の応力



σ_z, σ'_z, u ??

モールの応力円、極

(σ'_{30}, τ_{30})と(σ'_{30}, τ_{30})??

本日のTechnical terms

応力:stress; ひずみ:strain
直応力:normal stress; 直ひずみ:normal strain
せん断応力:shear stress; せん断ひずみ:shear strain
全応力:total stress;
有効応力:effective stress;
間隙水圧:pore water pressure;
有効応力原理:The principle of effective stress;
主応力:principal stresses; 主応力面:principal plane
最大主応力:major principal stress
中間主応力:intermediate principal stress
最小主応力:minor principal stress
モールの応力円:Mohr's stress circle
(モール円の)極:pole