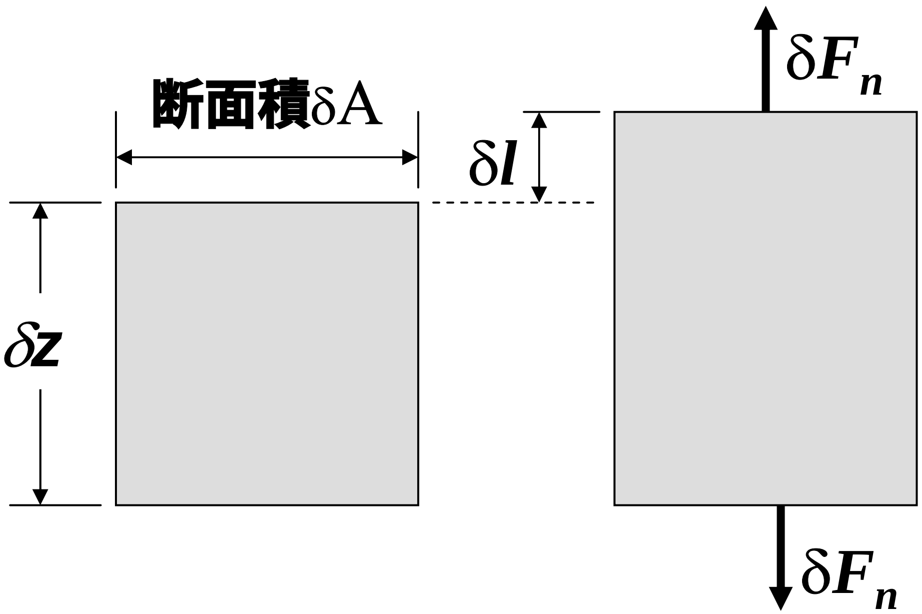
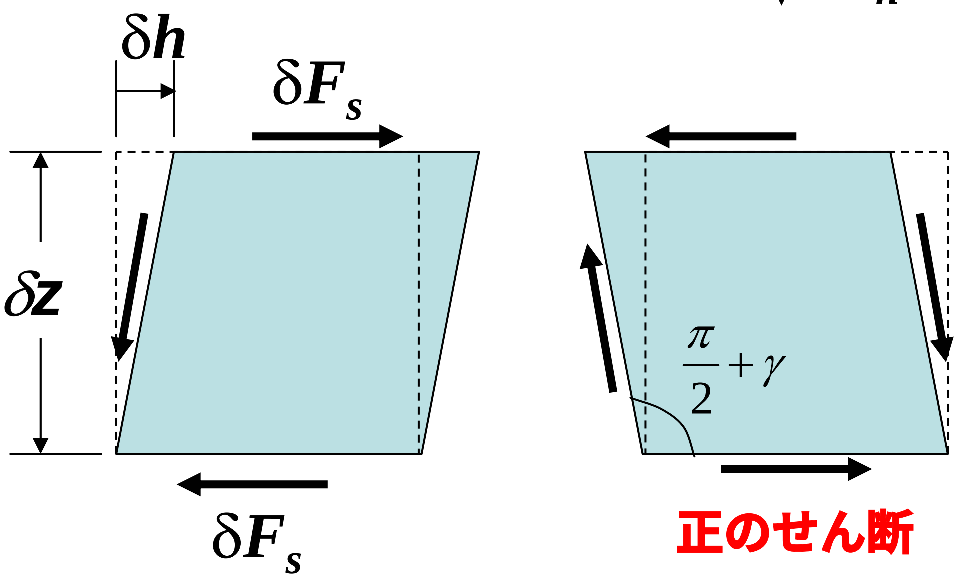
応力とひずみ
(stress & strain)





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

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

土質力学の符号

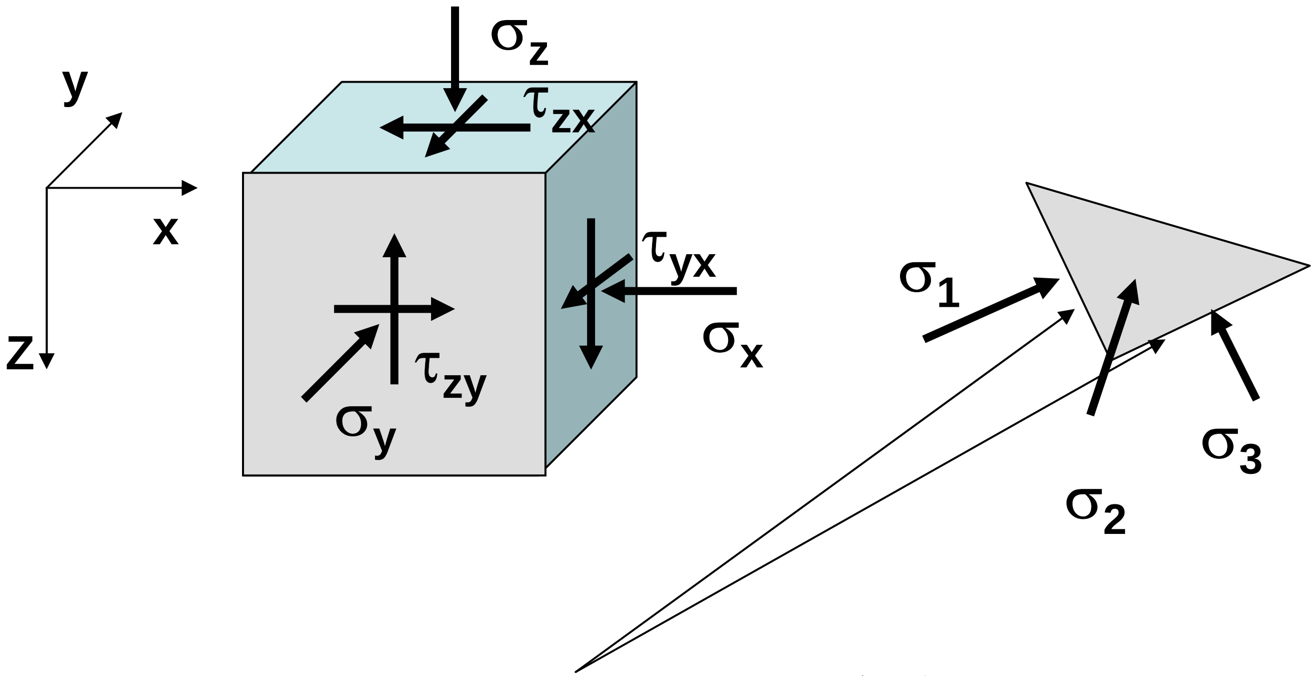
- **直応力、ひずみ:**
  圧縮を正
- **せん断応力、ひずみ:**
  反時計周りを正

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

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

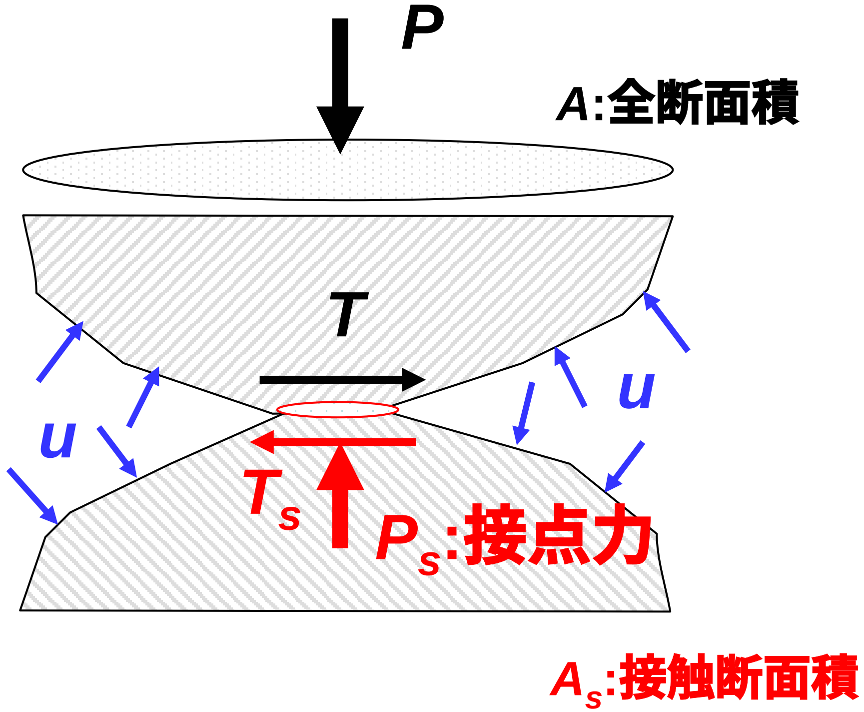
一般的な微小土要素の応力表示

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)

土要素内の力釣合い



全断面

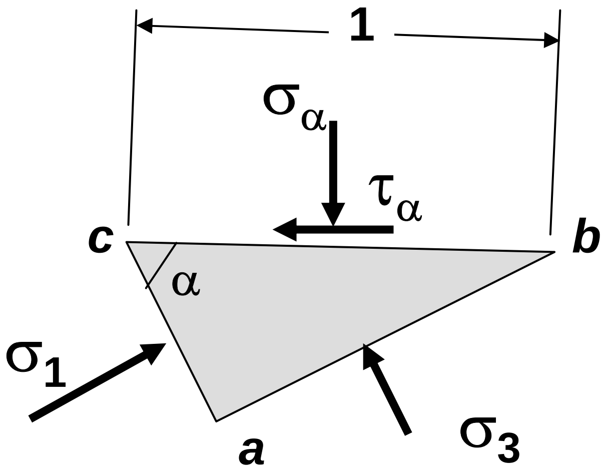
直応力: $\sigma = \dfrac{P}{A}$, せん断(応)力: $\tau = \dfrac{T}{A}$

粒子積極面

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

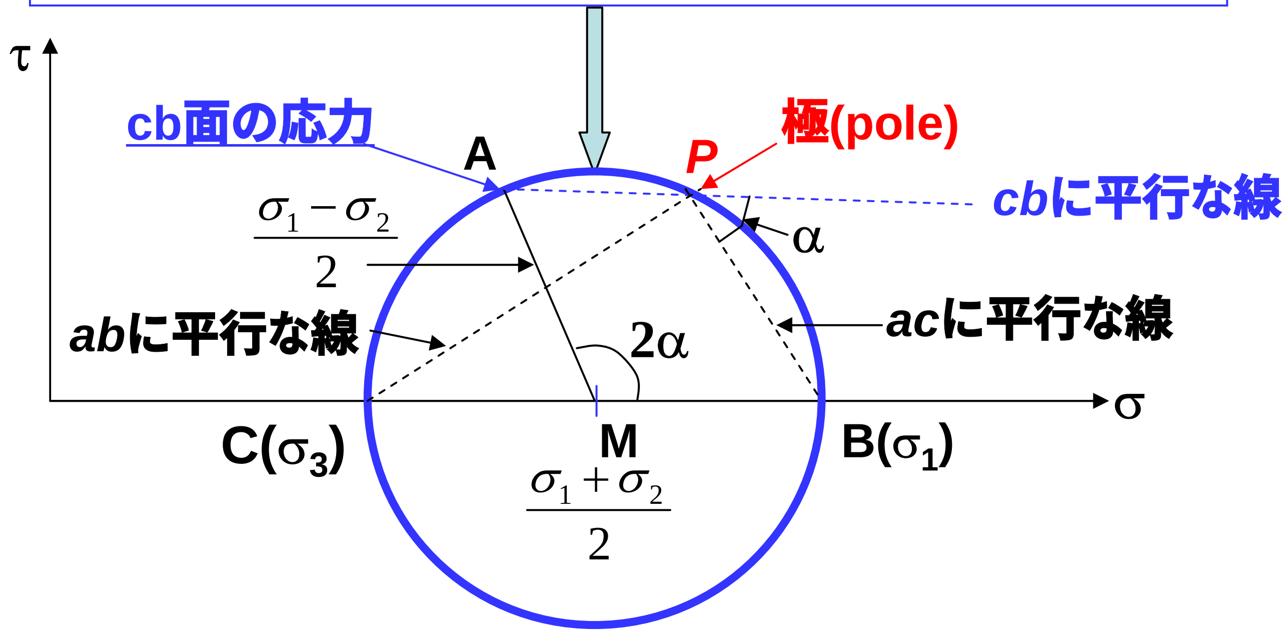
モールの応力円 (2次元)
(Mohr's stress circle)

力の釣合い



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

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



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)

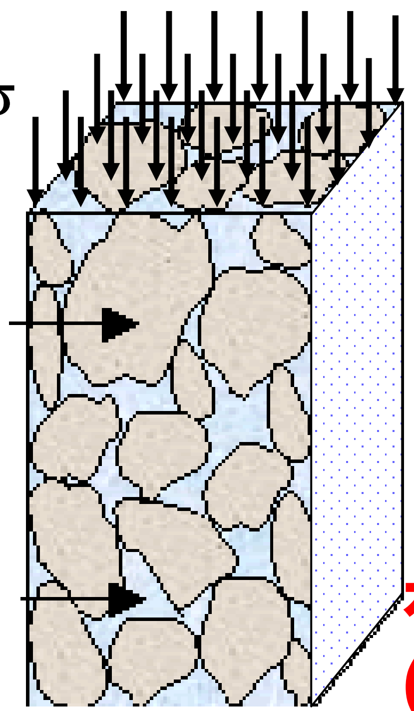
土要素境界、内の応力

境界の直応力：σ　=>　<u>全応力 (total stress)</u>

全応力：σ

土粒子
[粒子間力]
?

間隙水
[間隙水圧]
u



飽和土

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

面と垂直な方向の力の釣合い

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

Aで割る

$$a = \frac{A_s}{A}$$

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

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

inter-granular stress
(粒子間力／全断面)

$$\sigma_g = \frac{P_s}{A}$$

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

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

$$\sigma_g = \sigma'$$

a~0
(接点面積0)

面と平行な方向の力の釣合い

水強度ゼロ →

$$T = T_s \rightarrow \tau = a\tau_s$$

有効応力 <= 粒子接点力

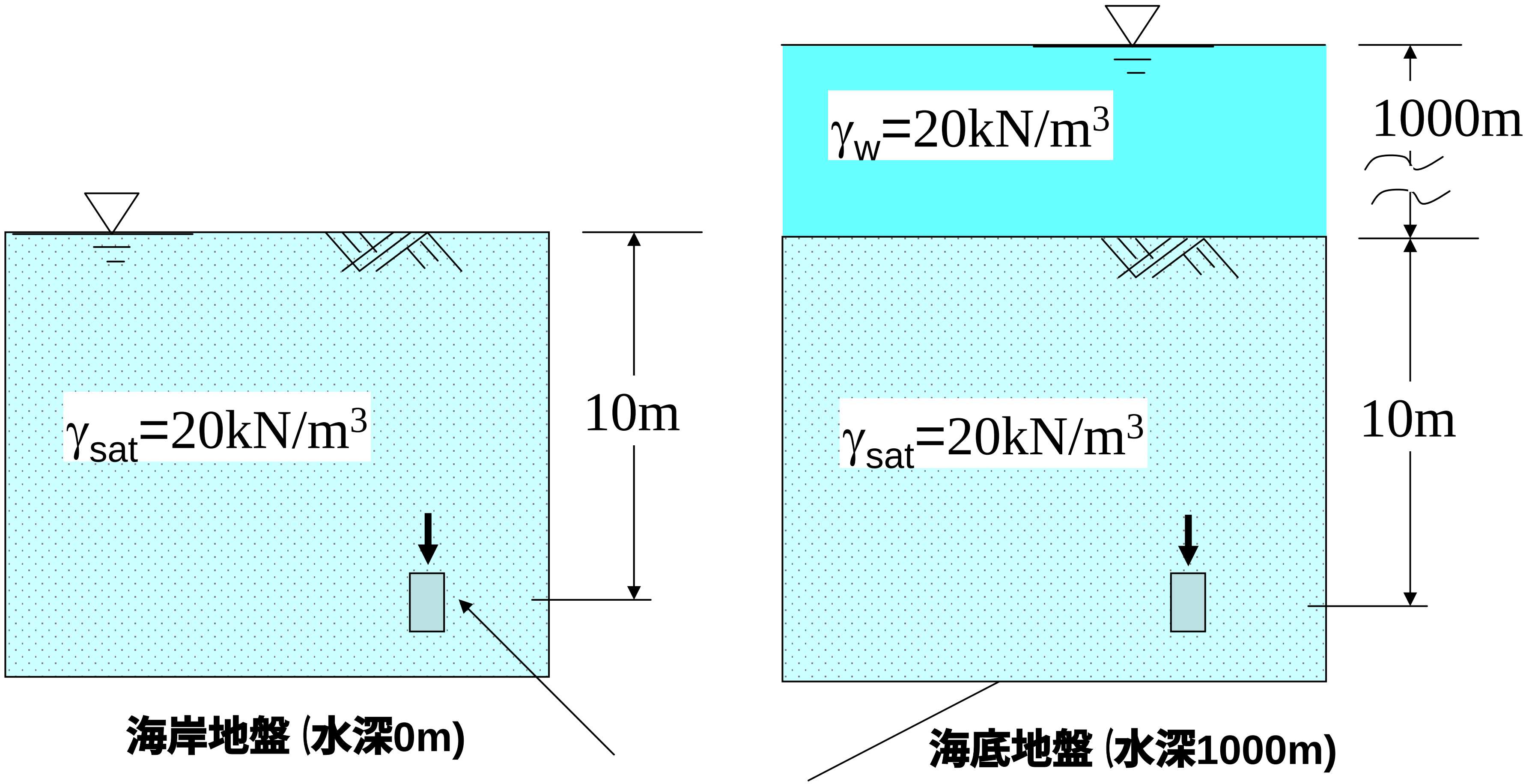
せん断応力： 全応力＝有効応力

有効応力の原理 by K. 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.

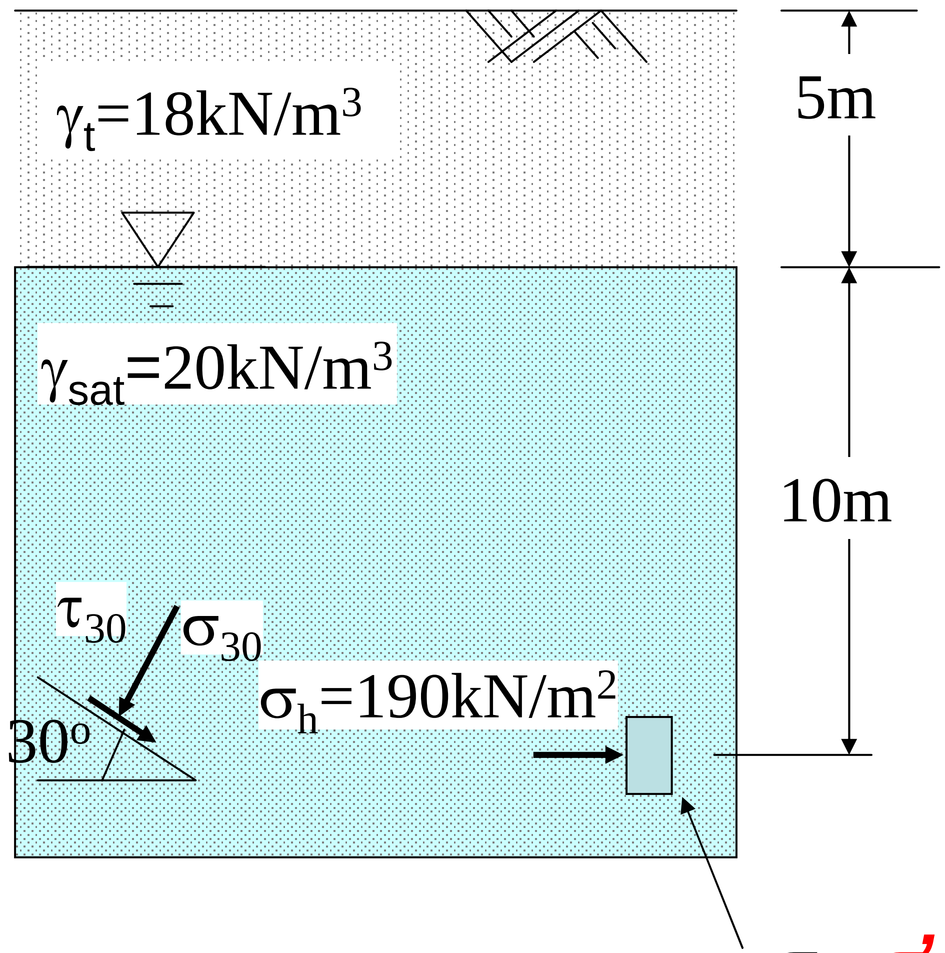
All measurable effects of a change of stress, such as compression, distortion and a change of shearing resistance, are due exclusively to changes of effective stress. The effective stress σ' is related to the total stress and pore pressure by $\sigma'=\sigma-u$. （宿題：この翻訳）

地盤中の応力



σ_z, σ'_z, u ??

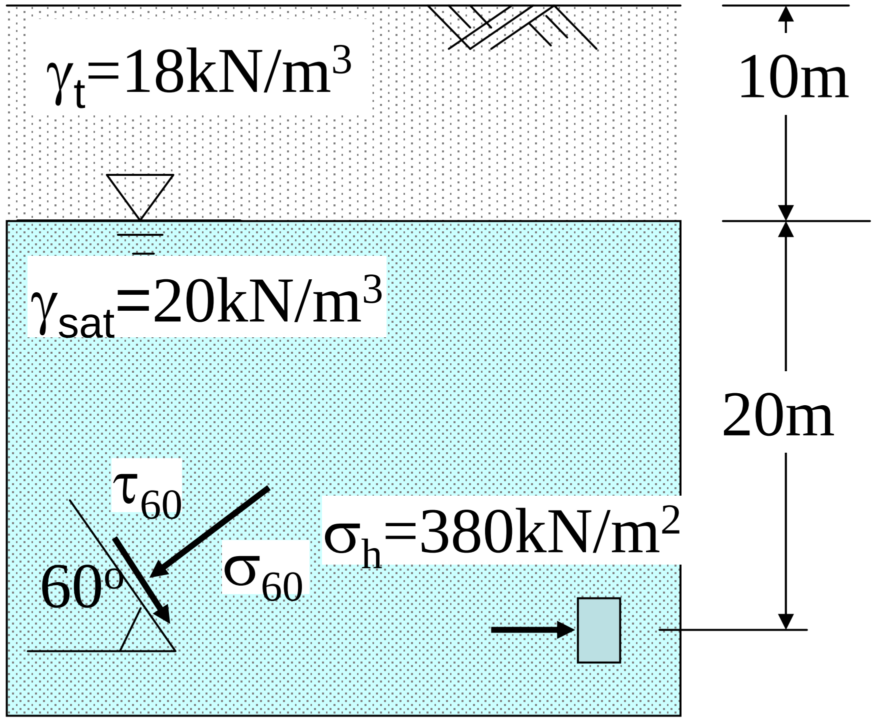
地盤中の応力



σ_z, σ'_z, u ??

モールの応力円、極

小テスト



σ_z, σ'_z, u ??

全応力、有効応力のモール円、極の位置

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
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