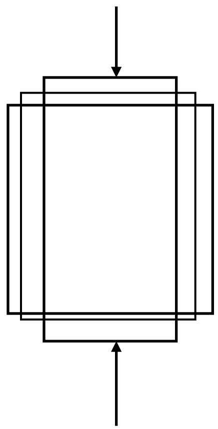
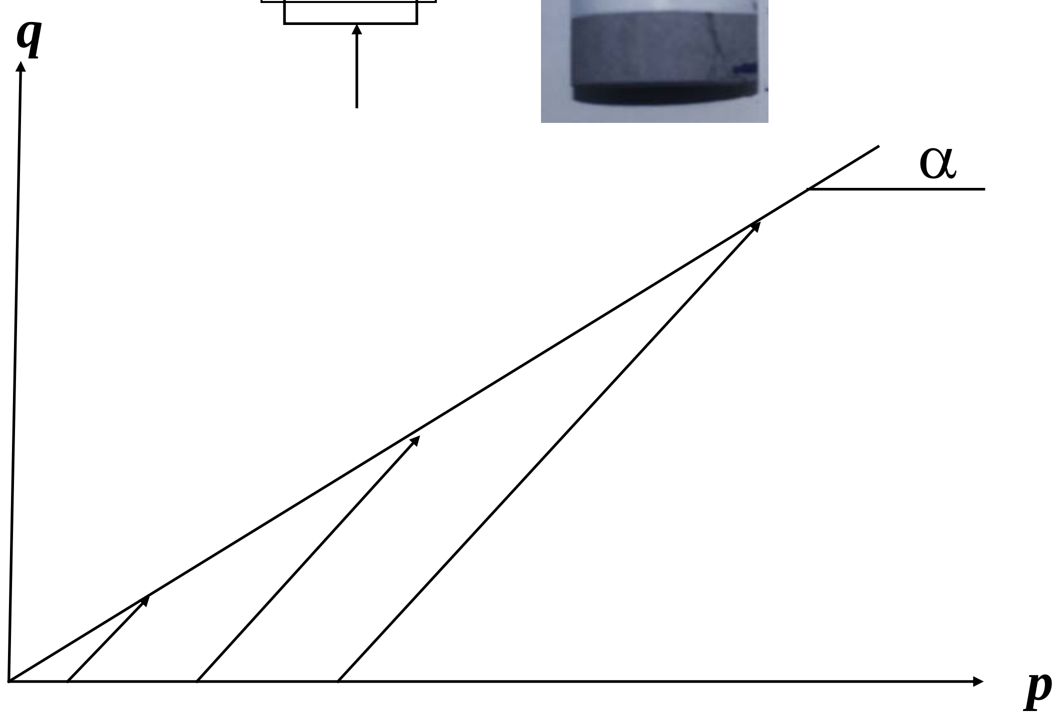
HW5



$\sigma_3 = \ \ 50kPa \quad \sigma_{1,f} = 150kPa$

$\sigma_3 = 150kPa \quad \sigma_{1,f} = 450kPa$

$\sigma_3 = 250kPa \quad \sigma_{1,f} = 750kPa$



Find:
Friction angle and
orientation of failure surface

For linear elastic, isotropic materials

Linear-elastic, isotropic materials

$$E = \frac{\sigma_{11}}{\varepsilon_{11}} \qquad G = \frac{\tau_{12}}{\gamma_{12}}$$

$$\nu = -\frac{\varepsilon_{22}}{\varepsilon_{11}} = -\frac{\varepsilon_{33}}{\varepsilon_{11}}$$

$$\begin{bmatrix} \varepsilon_{11} \\ \varepsilon_{22} \\ \varepsilon_{33} \\ \gamma_{12} \\ \gamma_{13} \\ \gamma_{23} \end{bmatrix} = \begin{bmatrix} \quad \end{bmatrix} \times \begin{bmatrix} \sigma_{11} \\ \sigma_{22} \\ \sigma_{33} \\ \tau_{12} \\ \tau_{13} \\ \tau_{23} \end{bmatrix}$$

$$\varepsilon_{11} = +\frac{1}{E}\cdot\sigma_{11} - \frac{\nu}{E}\cdot\sigma_{22} - \frac{\nu}{E}\cdot\sigma_{33}$$

$$\varepsilon_{22} = -\frac{\nu}{E}\cdot\sigma_{11} + \frac{1}{E}\cdot\sigma_{22} - \frac{\nu}{E}\cdot\sigma_{33}$$

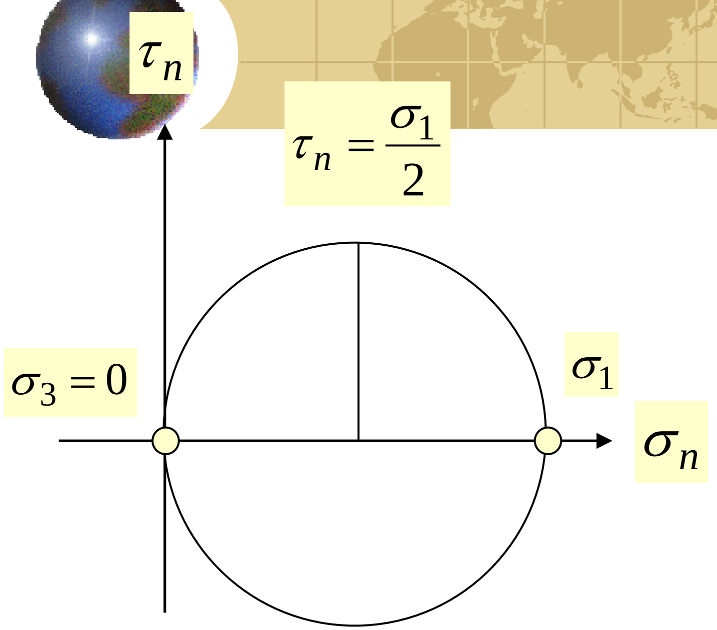
$$\varepsilon_{33} = -\frac{\nu}{E}\cdot\sigma_{11} - \frac{\nu}{E}\cdot\sigma_{22} + \frac{1}{E}\cdot\sigma_{33}$$

$$\gamma_{12} = \frac{1}{G}\cdot\tau_{12}$$

$$\gamma_{13} = \frac{1}{G}\cdot\tau_{13}$$

$$\gamma_{23} = \frac{1}{G}\cdot\tau_{23}$$

How many independent elastic constant ?



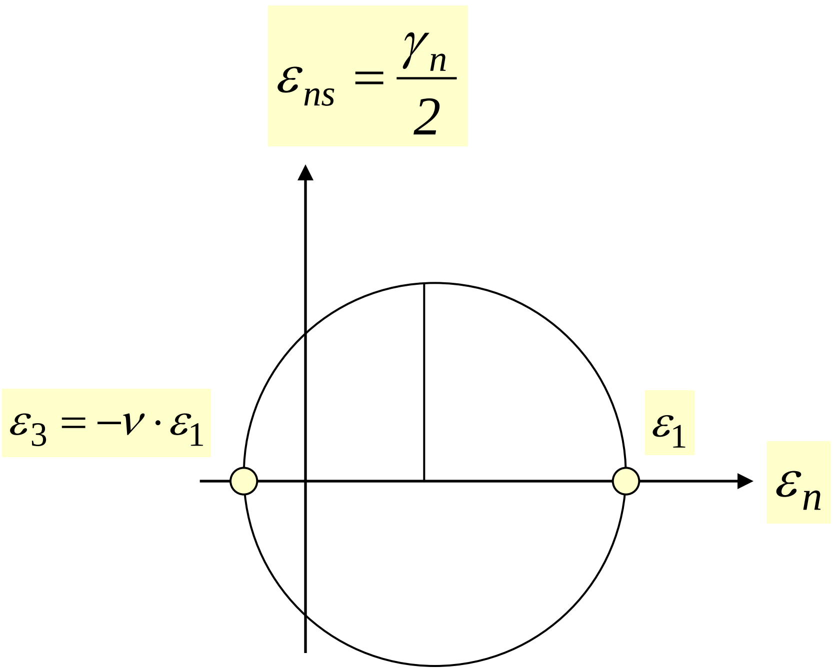
$$\frac{\gamma_n}{2} = \frac{(1+\nu)\cdot\varepsilon_1}{2}$$

$$\frac{\tau_n}{2\cdot G} = \frac{(1+\nu)\cdot\sigma_1}{2\cdot E}$$

$$\because \tau_n = \frac{\sigma_1}{2}$$

$$\frac{1}{2\cdot G} = \frac{(1+\nu)}{E}$$

$$G = \frac{E}{2(1+\nu)}$$



Linear-elastic, isotropic materials

$$\begin{bmatrix} \varepsilon_{11} \\ \varepsilon_{22} \\ \varepsilon_{33} \\ \gamma_{12} \\ \gamma_{13} \\ \gamma_{23} \end{bmatrix} = \begin{bmatrix} \frac{1}{E} & -\frac{\nu}{E} & -\frac{\nu}{E} & 0 & 0 & 0 \\ -\frac{\nu}{E} & \frac{1}{E} & -\frac{\nu}{E} & 0 & 0 & 0 \\ -\frac{\nu}{E} & -\frac{\nu}{E} & \frac{1}{E} & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1}{G} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{G} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{1}{G} \end{bmatrix} \times \begin{bmatrix} \sigma_{11} \\ \sigma_{22} \\ \sigma_{33} \\ \tau_{12} \\ \tau_{13} \\ \tau_{23} \end{bmatrix}$$

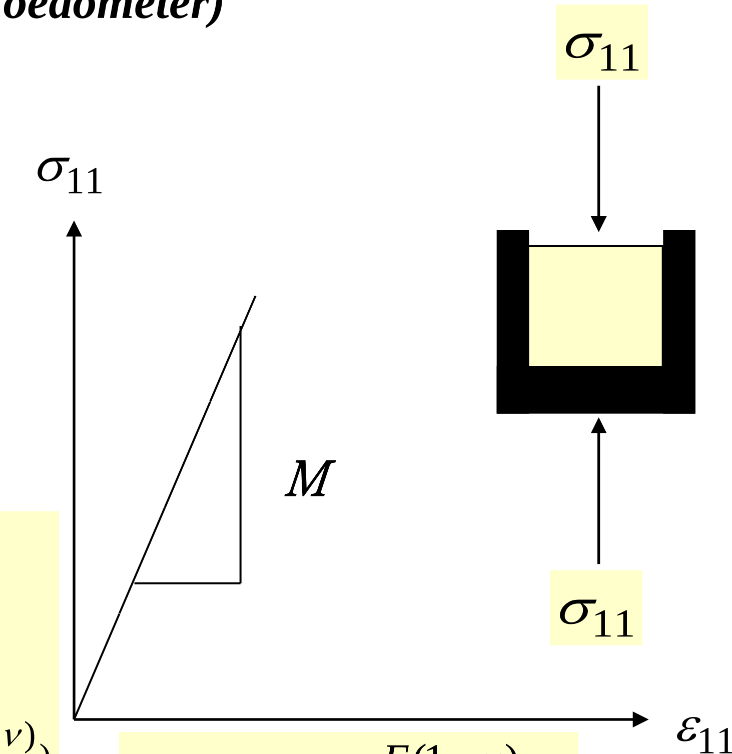
$$\varepsilon_{22} = -\frac{\nu}{E}\sigma_{11} + \frac{1}{E}\sigma_{22} - \frac{\nu}{E}\sigma_{33} = 0$$

$$\sigma_{22} = \sigma_{33} = \frac{\nu}{1-\nu}\sigma_{11}$$

$$\varepsilon_{11} = \frac{1}{E}\sigma_{11} - \frac{\nu}{E}(\sigma_{22}+\sigma_{33}) = \frac{\sigma_{11}}{E}(1-\frac{2\nu^2}{1-\nu}) = \frac{\sigma_{11}}{E}(\frac{(1-2\nu)(1+\nu)}{1-\nu})$$

- IF $\varepsilon_{22} = \varepsilon_{33} = \varepsilon_{12} = \gamma_{13} = \gamma_{23} = 0$

Lateral Confined Loading (oedometer)



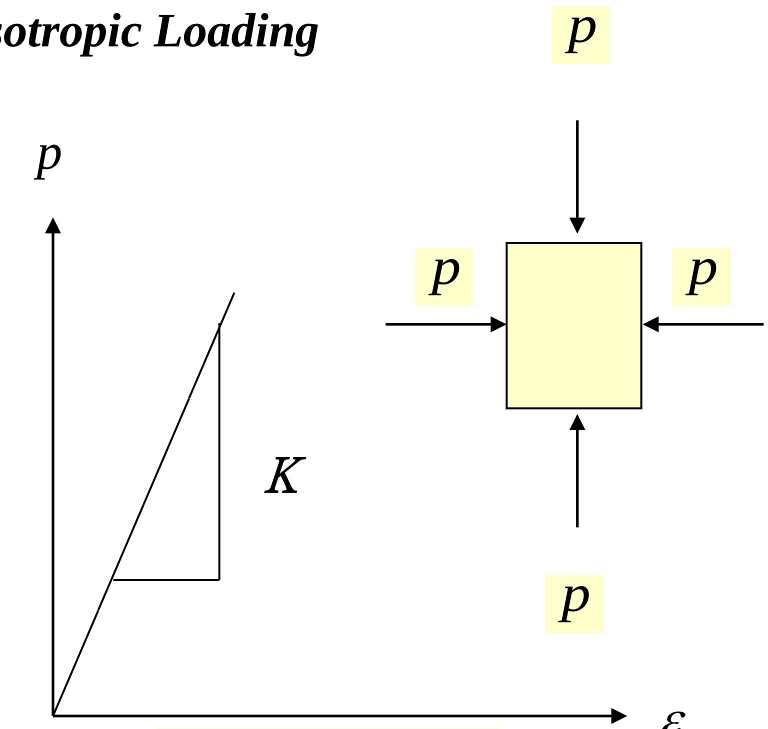
$$M = \frac{\sigma_{11}}{\varepsilon_{11}} = \frac{E(1-\nu)}{(1-2\nu)(1+\nu)}$$

Linear-elastic, isotropic materials

$$
\begin{bmatrix} \varepsilon_{11} \\ \varepsilon_{22} \\ \varepsilon_{33} \\ \gamma_{12} \\ \gamma_{13} \\ \gamma_{23} \end{bmatrix}
=
\begin{bmatrix}
\frac{1}{E} & -\frac{\nu}{E} & -\frac{\nu}{E} & 0 & 0 & 0 \\
-\frac{\nu}{E} & \frac{1}{E} & -\frac{\nu}{E} & 0 & 0 & 0 \\
-\frac{\nu}{E} & -\frac{\nu}{E} & \frac{1}{E} & 0 & 0 & 0 \\
0 & 0 & 0 & \frac{1}{G} & 0 & 0 \\
0 & 0 & 0 & 0 & \frac{1}{G} & 0 \\
0 & 0 & 0 & 0 & 0 & \frac{1}{G}
\end{bmatrix}
\times
\begin{bmatrix} \sigma_{11} \\ \sigma_{22} \\ \sigma_{33} \\ \tau_{12} \\ \tau_{13} \\ \tau_{23} \end{bmatrix}
$$

- IF $\sigma_{11} = \sigma_{22} = \sigma_{33} = p; \tau_{12} = \tau_{13} = \tau_{23} = 0$

Isotropic Loading



$$\varepsilon_v = \varepsilon_{11} + \varepsilon_{22} + \varepsilon_{33} = \frac{3}{E}p - \frac{6\nu}{E}p = \frac{3p}{E}(1-2\nu)$$

$$K = \frac{p}{\varepsilon_v} = \frac{E}{3(1-2\nu)}$$

Linear-elastic, Orthotropic materials

$$\varepsilon_{11} = +\frac{1}{E_{11}} \cdot \sigma_{11} - \frac{\nu_{12}}{E_{22}} \cdot \sigma_{22} - \frac{\nu_{13}}{E_{33}} \cdot \sigma_{33}$$

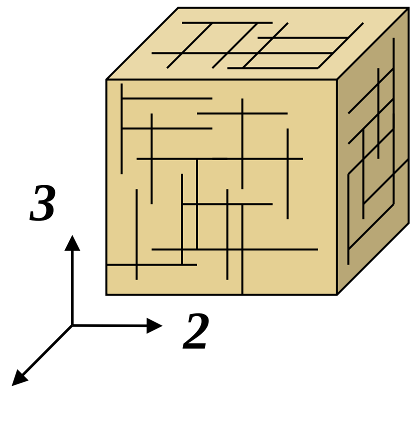
$$\varepsilon_{22} = -\frac{\nu_{21}}{E_{11}} \cdot \sigma_{11} + \frac{1}{E_{22}} \cdot \sigma_{22} - \frac{\nu_{23}}{E_{33}} \cdot \sigma_{33}$$

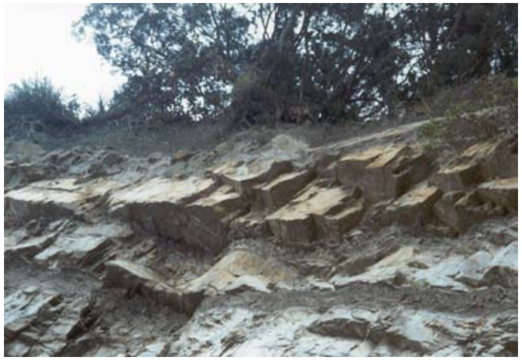
$$\varepsilon_{33} = -\frac{\nu_{31}}{E_{11}} \cdot \sigma_{11} - \frac{\nu_{32}}{E_{22}} \cdot \sigma_{22} + \frac{1}{E_{33}} \cdot \sigma_{33}$$

$$\gamma_{12} = \frac{1}{G_{12}} \cdot \tau_{12}$$

$$\gamma_{13} = \frac{1}{G_{13}} \cdot \tau_{13}$$

$$\gamma_{23} = \frac{1}{G_{23}} \cdot \tau_{23}$$





$$\begin{bmatrix} \varepsilon_{11} \\ \varepsilon_{22} \\ \varepsilon_{33} \\ \gamma_{12} \\ \gamma_{13} \\ \gamma_{23} \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} & C_{13} & 0 & 0 & 0 \\ C_{21} & C_{22} & C_{23} & 0 & 0 & 0 \\ C_{31} & C_{32} & C_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & C_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & C_{55} & 0 \\ 0 & 0 & 0 & 0 & 0 & C_{66} \end{bmatrix} \times \begin{bmatrix} \sigma_{11} \\ \sigma_{22} \\ \sigma_{33} \\ \tau_{12} \\ \tau_{13} \\ \tau_{23} \end{bmatrix}$$

How many independent elastic constant ?

Linear-elastic, Transversely isotropic materials

$$\varepsilon_{11} = +\frac{1}{E_s}\cdot\sigma_{11} - \frac{\nu_{st}}{E_s}\cdot\sigma_{22} - \frac{\nu_{ns}}{E_n}\cdot\sigma_{33}$$

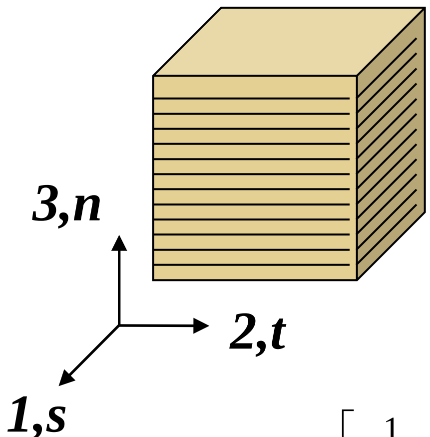
$$\varepsilon_{22} = -\frac{\nu_{st}}{E_s}\cdot\sigma_{11} + \frac{1}{E_s}\cdot\sigma_{22} - \frac{\nu_{ns}}{E_n}\cdot\sigma_{33}$$

$$\varepsilon_{33} = -\frac{\nu_{ns}}{E_s}\cdot\sigma_{11} - \frac{\nu_{ns}}{E_s}\cdot\sigma_{22} + \frac{1}{E_n}\cdot\sigma_{33}$$

$$\gamma_{12} = \frac{1}{G_{st}}\cdot\tau_{12}$$

$$\gamma_{13} = \frac{1}{G_{ns}}\cdot\tau_{13}$$

$$\gamma_{23} = \frac{1}{G_{ns}}\cdot\tau_{23}$$



s = t

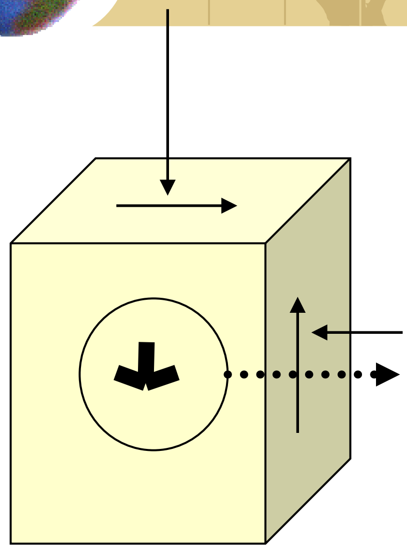
In s-t plane

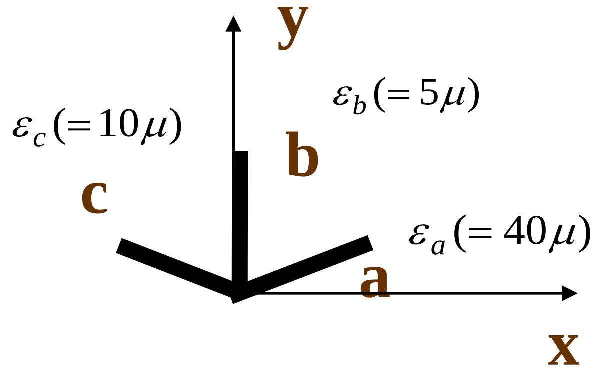
$$G_{st} = \frac{E_s}{2\cdot(1+\nu_{st})}$$

$$\begin{bmatrix}\varepsilon_{11}\\ \varepsilon_{22}\\ \varepsilon_{33}\\ \gamma_{12}\\ \gamma_{13}\\ \gamma_{23}\end{bmatrix} = \begin{bmatrix} \frac{1}{E_s} & -\frac{\nu_{st}}{E_s} & -\frac{\nu_{ns}}{E_n} & 0 & 0 & 0 \\ -\frac{\nu_{st}}{E_s} & \frac{1}{E_s} & -\frac{\nu_{ns}}{E_n} & 0 & 0 & 0 \\ -\frac{\nu_{ns}}{E_n} & -\frac{\nu_{ns}}{E_n} & \frac{1}{E_n} & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1}{G_{st}} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{G_{ns}} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{1}{G_{ns}} \end{bmatrix} \times \begin{bmatrix}\sigma_{11}\\ \sigma_{22}\\ \sigma_{33}\\ \tau_{12}\\ \tau_{13}\\ \tau_{23}\end{bmatrix}$$

How many independent elastic constant ?

HW8





Strain gage a,b,c
分別與水平夾

$\theta_a, \theta_b, \theta_c (= 30^o, 90^o, 150^o)$

- *If the elastic constant E=10GPa , ν=0.25, determine the principal stress and principal direction*
- *Compare with the principal direction of strain derived from HW7*

考慮二維問題,z方向不計
思考:若為平面應變條件如何解?若為平面應力條件如何解?

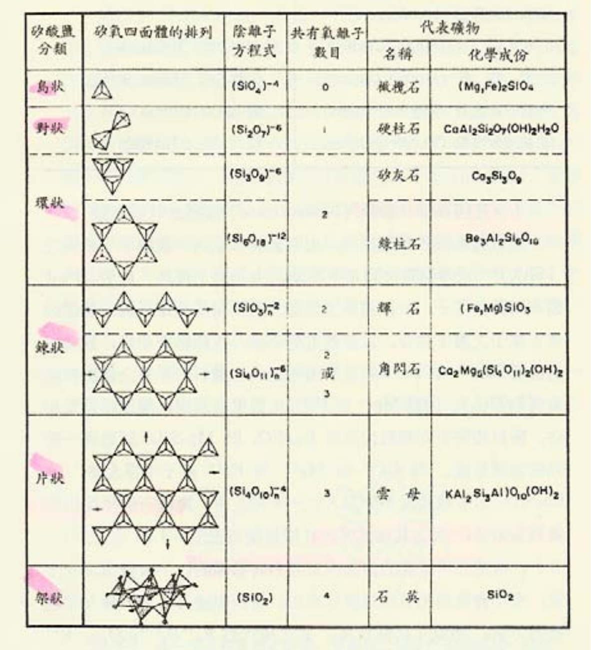
2 Discontinuities of rock mass

主要造岩礦物

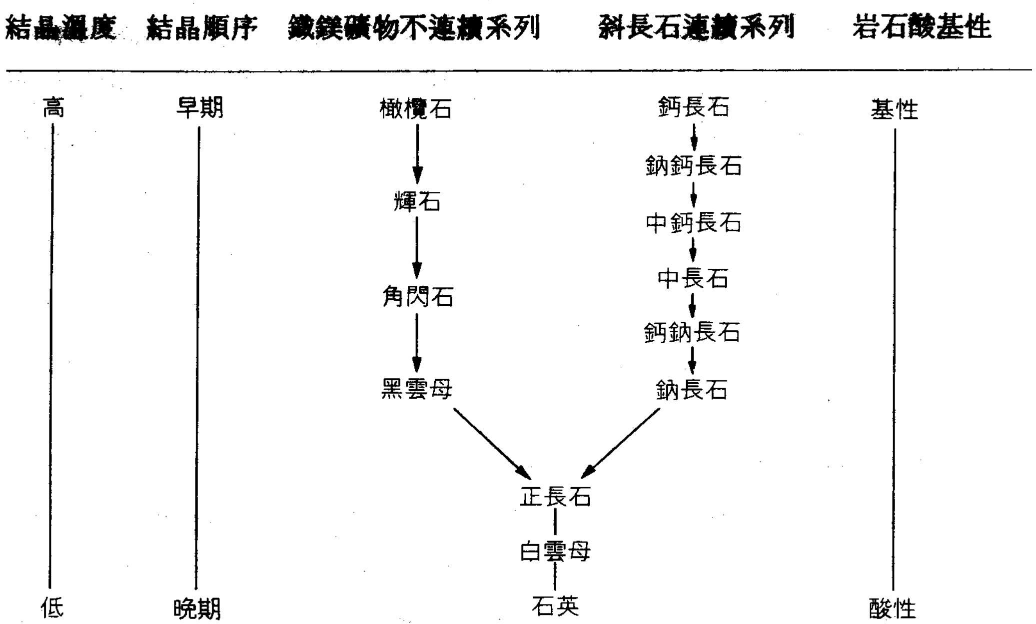
造岩礦物約200種
岩石約1000種

土木工程關心的造岩礦物約16種,岩石約40種

- 矽酸鹽類造岩礦物
  - 依離子鍵結方式，矽酸鹽類礦物可分為六大類
  - 依顏色區分，則可分為深色（鐵礦）矽酸鹽類及淺色矽酸鹽類礦物
  - 依礦物結晶作用，可分為連續的斜長石類及不連續的鐵鎂矽酸鹽類礦物二種
- 非矽酸鹽類造岩礦物：碳酸鹽類礦物(方解石、石膏)、氧化物、硫化物(**Pyrite**黃鐵礦) 、金屬礦物



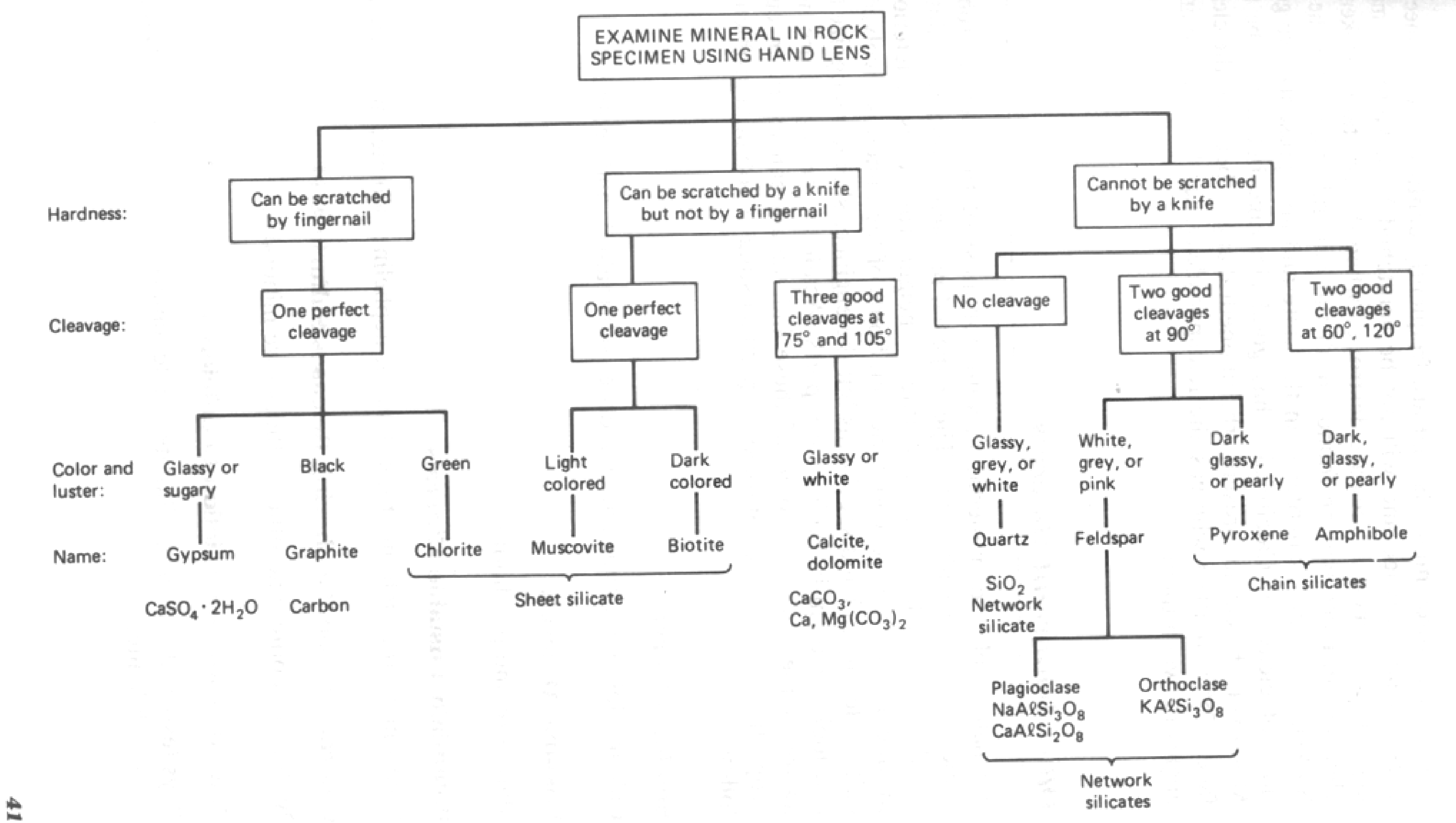
矽酸鹽分類	矽氧四面體的排列	陰離子方程式	共有氧離子數目	代表礦物	
				名稱	化學成份
島狀		$(SiO_4)^{-4}$	0	橄欖石	$(Mg,Fe)_2SiO_4$
對狀		$(Si_2O_7)^{-6}$	1	硬柱石	$CaAl_2Si_2O_7(OH)_2H_2O$
環狀		$(Si_3O_9)^{-6}$	2	矽灰石	$Ca_3Si_3O_9$
		$(Si_6O_{18})^{-12}$		綠柱石	$Be_3Al_2Si_6O_{18}$
鍊狀		$(SiO_3)_n^{-2}$	2	輝　石	$(Fe,Mg)SiO_3$
		$(Si_4O_{11})_n^{-6}$	2 或 3	角閃石	$Ca_2Mg_5(Si_4O_{11})_2(OH)_2$
片狀		$(Si_4O_{10})_n^{-4}$	3	雲　母	$KAl_2Si_3Al)O_{10}(OH)_2$
架狀		(SiO_2)	4	石　英	SiO_2



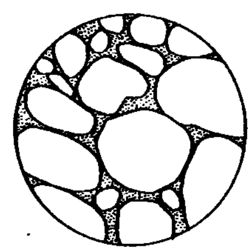
摘自廖志中“應用工程地質”講義

造岩礦物鑑定流程

Simplified Mineral Identification Flowchart: Common Rock-forming Minerals



岩石的特徵

	火　成　岩	沈　積　岩	變　質　岩
岩石構造	缺少層理，成塊狀，不規則的火成岩體。 一次次的熔岩流也可成層狀構造。 當熔岩流流動時，已經結晶出的礦物平行排列成流紋構造。	多具層理，及含交錯層、波痕、底痕、泥裂痕等沈積構造。	原岩爲沈積岩，經低度變質作用，尙可殘留有層理。經高度變質，層理受破壞，由礦物平行排列而有葉理構造。
岩石組織	礦物顆粒彼此緊密鑲嵌。 如圖: 	磨圓的顆粒，空隙處由膠結物充塡。 如圖: 	長形或片狀，礦物顆粒平行排列。 如圖: 
化石	深成岩多不含化石，熔岩流、火山灰中偶含化石。	常含化石。	原岩中若含有化石，可能經變質作用變形，甚至破壞。

摘自廖志中“應用工程地質”講義