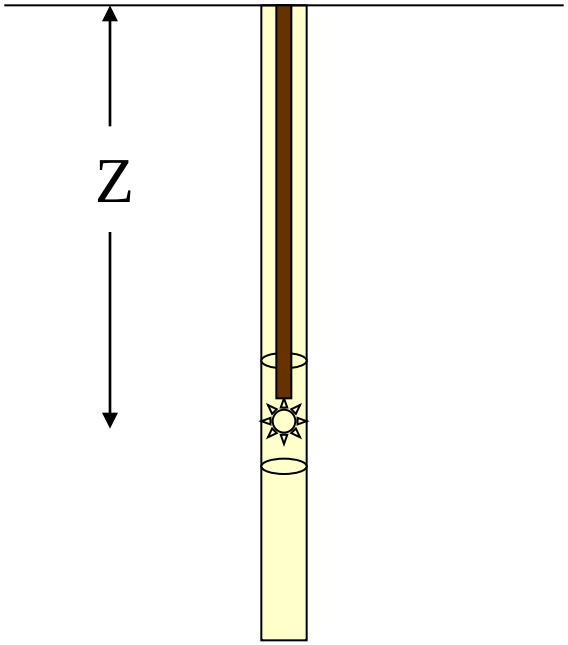
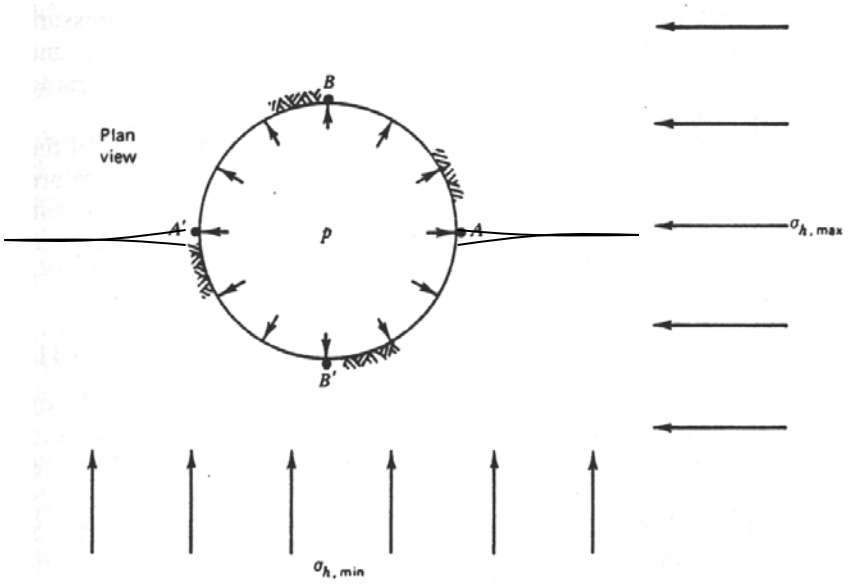
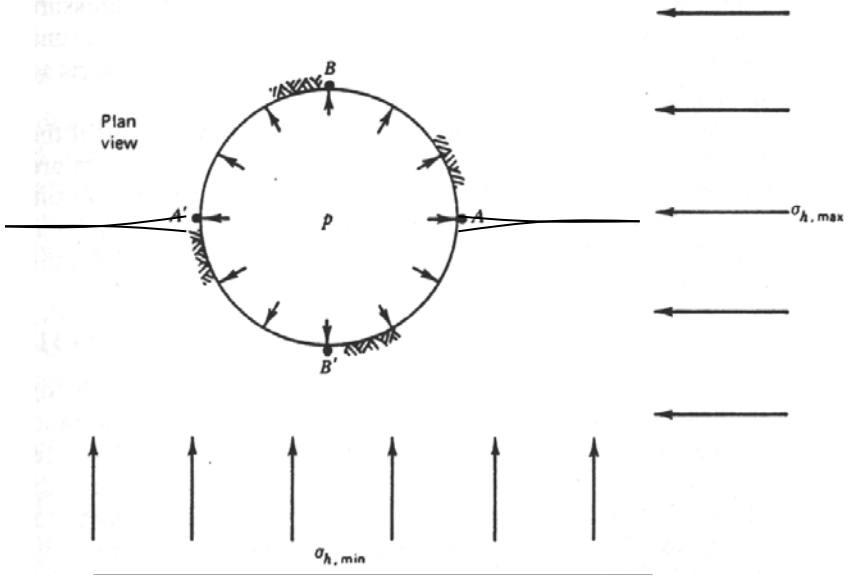
How to measure ?

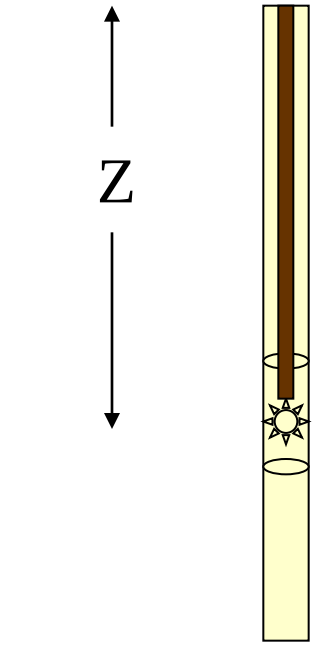
- Hydraulic method **(measure stress at failure)**
  - **Hydraulic fracture**
  - Sleeve fracture
  - Hydraulic test on pre-existing fracture

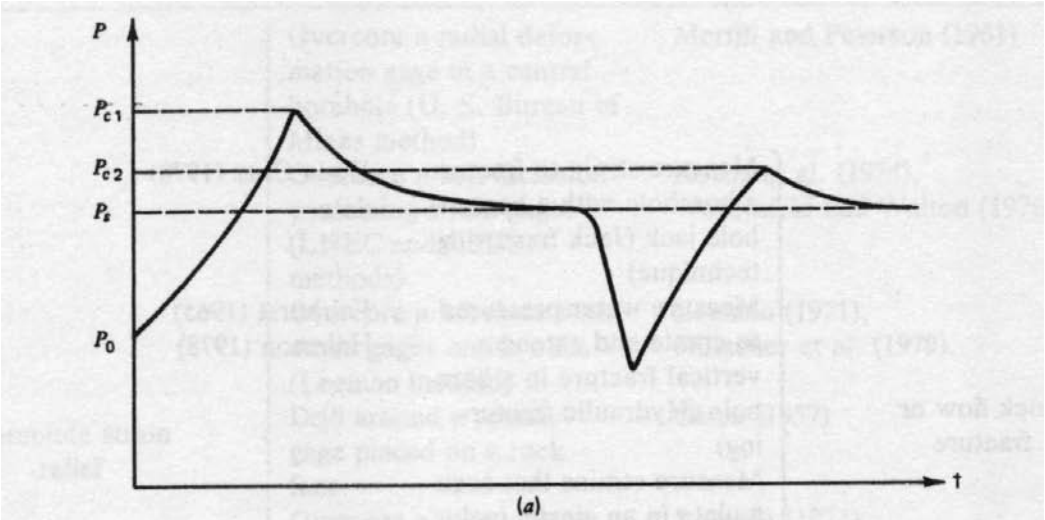




Hydraulic fracture

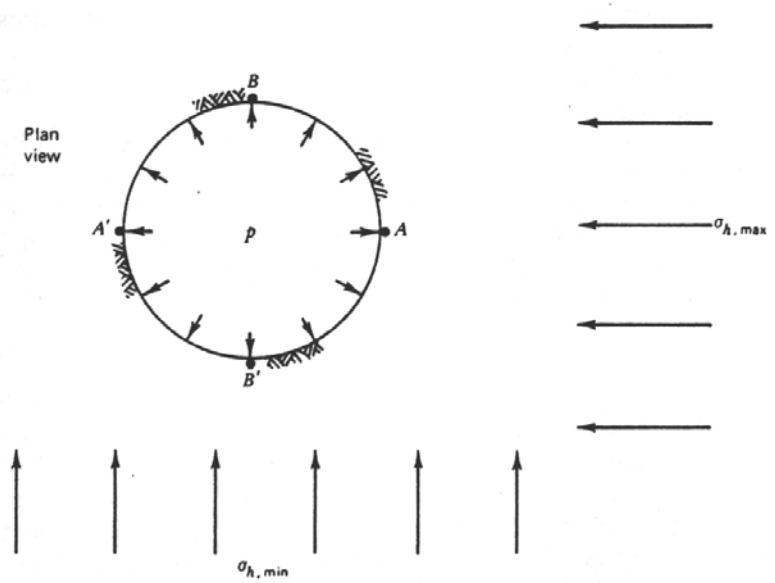


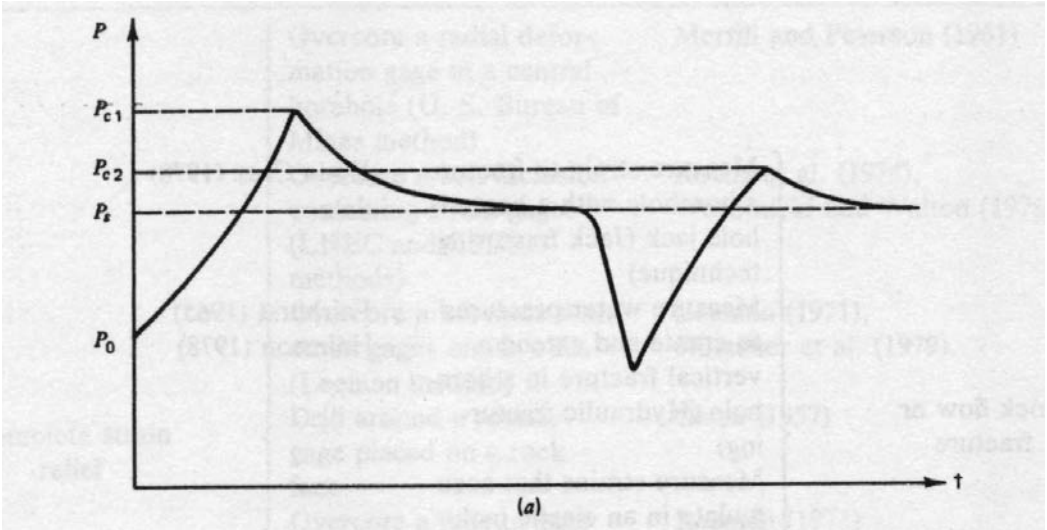




Hydraulic fracture

- P_s : shut-in pressure (steady value)
- P_{c1} : crack forming
- P_{c2} : crack opening





Hydraulic fracture

$$\sigma_\theta = \frac{\sigma_h + \sigma_v}{2}\cdot\left(1+\frac{a^2}{r^2}\right) - \frac{\sigma_h - \sigma_v}{2}\cdot\left(1+\frac{3\cdot a^4}{r^4}\right)\cdot\cos 2\theta$$

P_s : shut-in pressure (steady value)

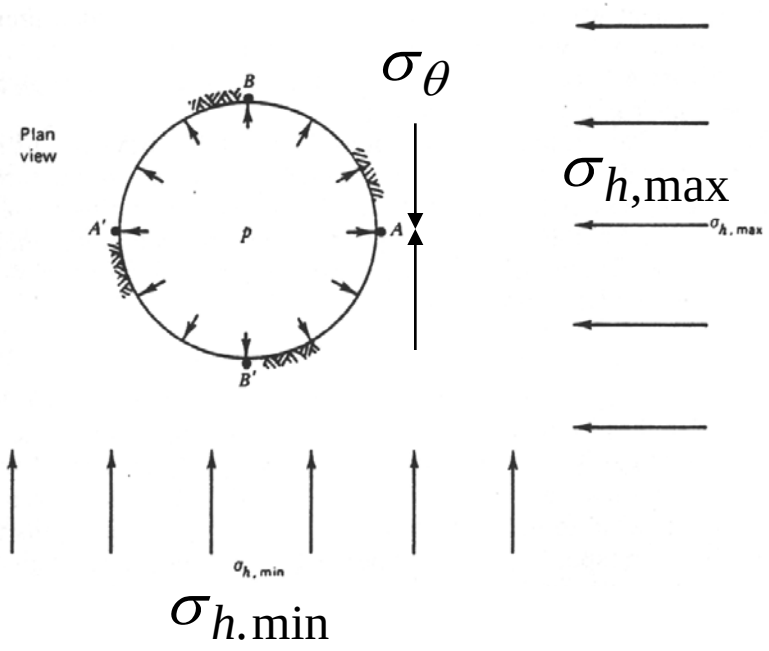
P_{c1} : crack forming

P_{c2} : crack opening

From Kirsch's solution

At point A and A' (q=0,180)

$$\sigma_\theta = 3\cdot\sigma_{h.\min} - \sigma_{h,\max}$$



1. Cracks occurs when pressure $p = P_{c1}$

$$P_{c1} - \sigma_\theta = T_o$$

$$P_{c1} - 3\cdot\sigma_{h.\min} + \sigma_{h,\max} = T_o$$

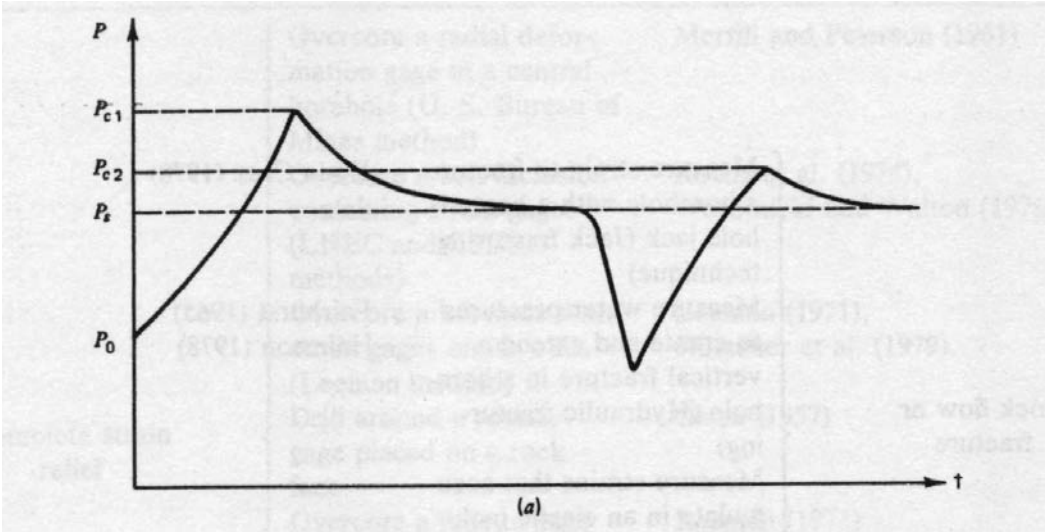
$$\sigma_{h,\max} = 3\cdot\sigma_{h.\min} - P_{c1} + T_o$$

2. Cracks propagate when pressure $p = P_s$

$$P_s = \sigma_{h,\min}$$

$T_o = ?$

$$T_o = P_{c1} - P_{c2}$$



Hydraulic fracture

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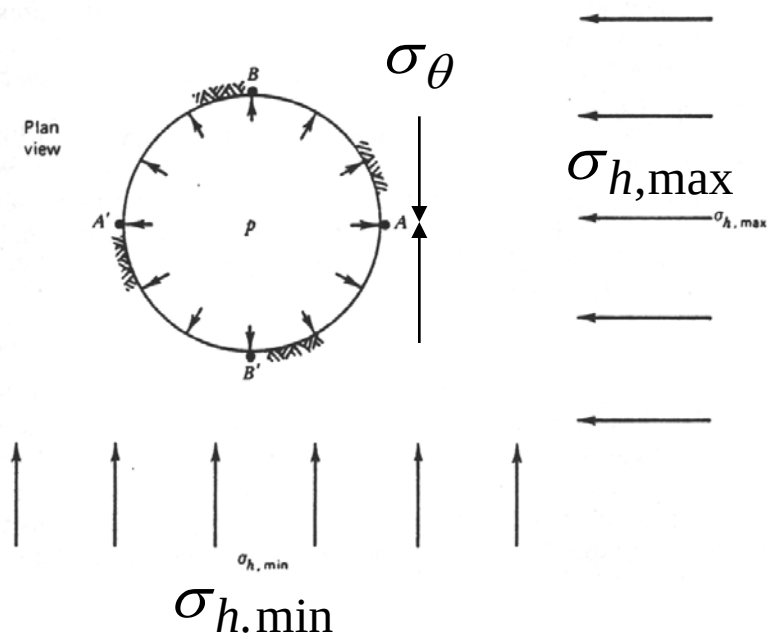


1. Cracks occurs when pressure $p = P_{c1}$

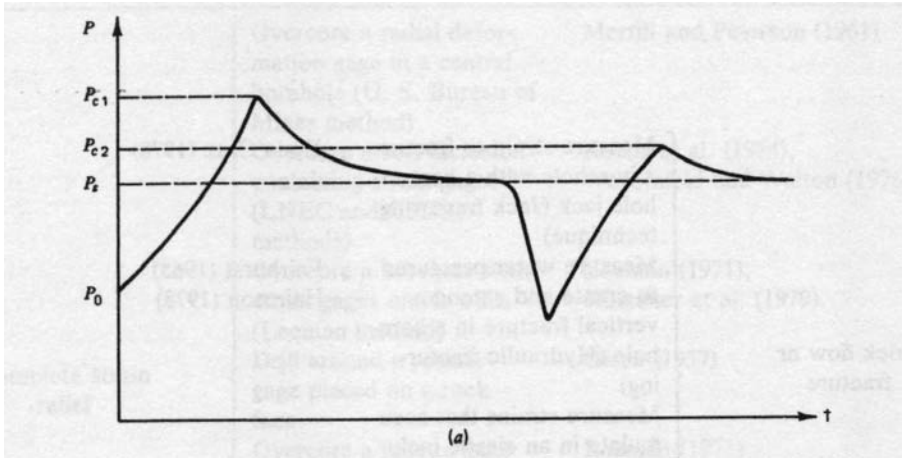
$$P_{c1} - \sigma_\theta = T_o$$

If vertical stress is too small, i.e. depth is too shallow

$$P_{c1} - \sigma_v = T_o$$

Horizontal fracture will occur, You cannot find horizontal stress

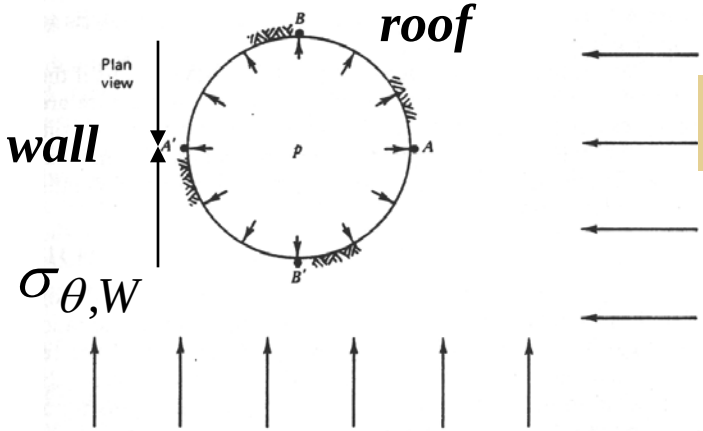
$$\sigma_v > (3 \cdot \frac{\sigma_{\mathrm{h,min}}}{\sigma_{\mathrm{h,max}}} - 1) \cdot \sigma_{\mathrm{h,max}} \quad (\sigma_v > \sigma_\theta)$$

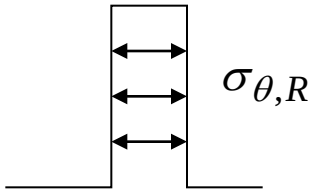


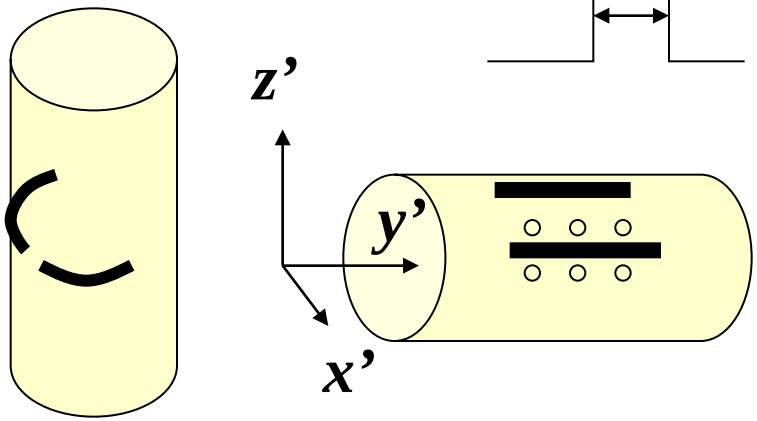
Flat jack method (measure compensate stress)

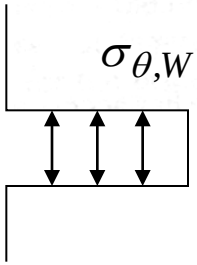
$$\sigma_{\theta,R} = 3 \cdot P_h - P_v$$

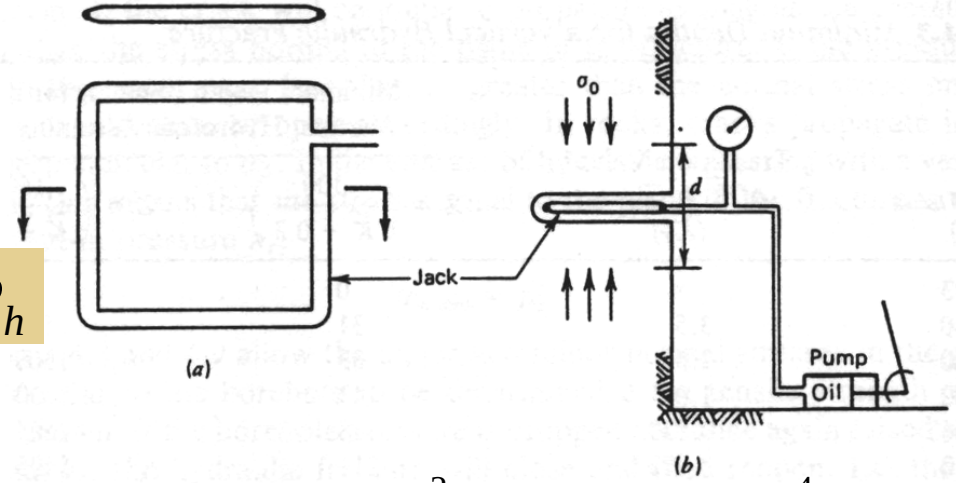
$$\sigma_{\theta,W} = 3 \cdot P_v - P_h$$











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