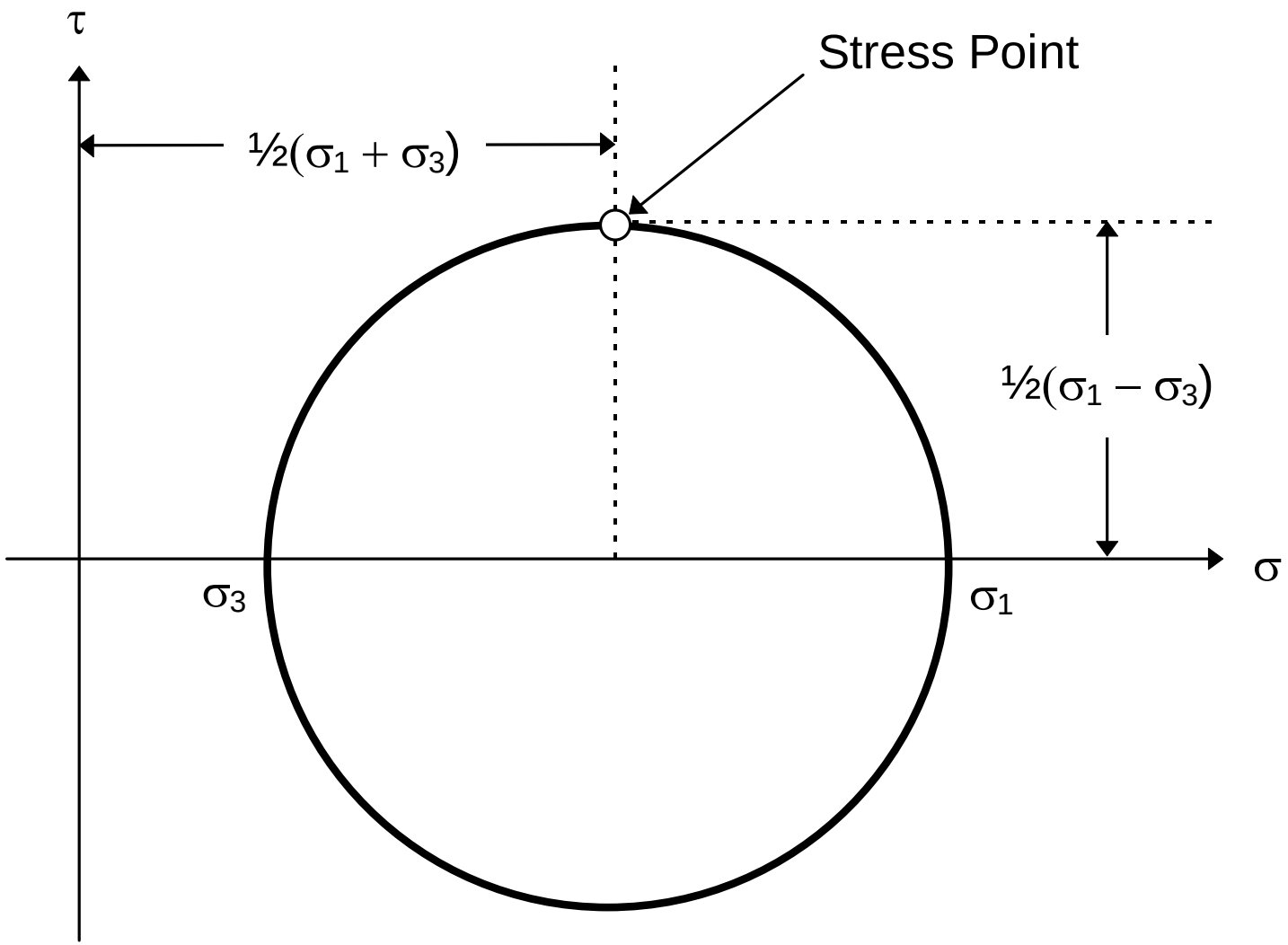
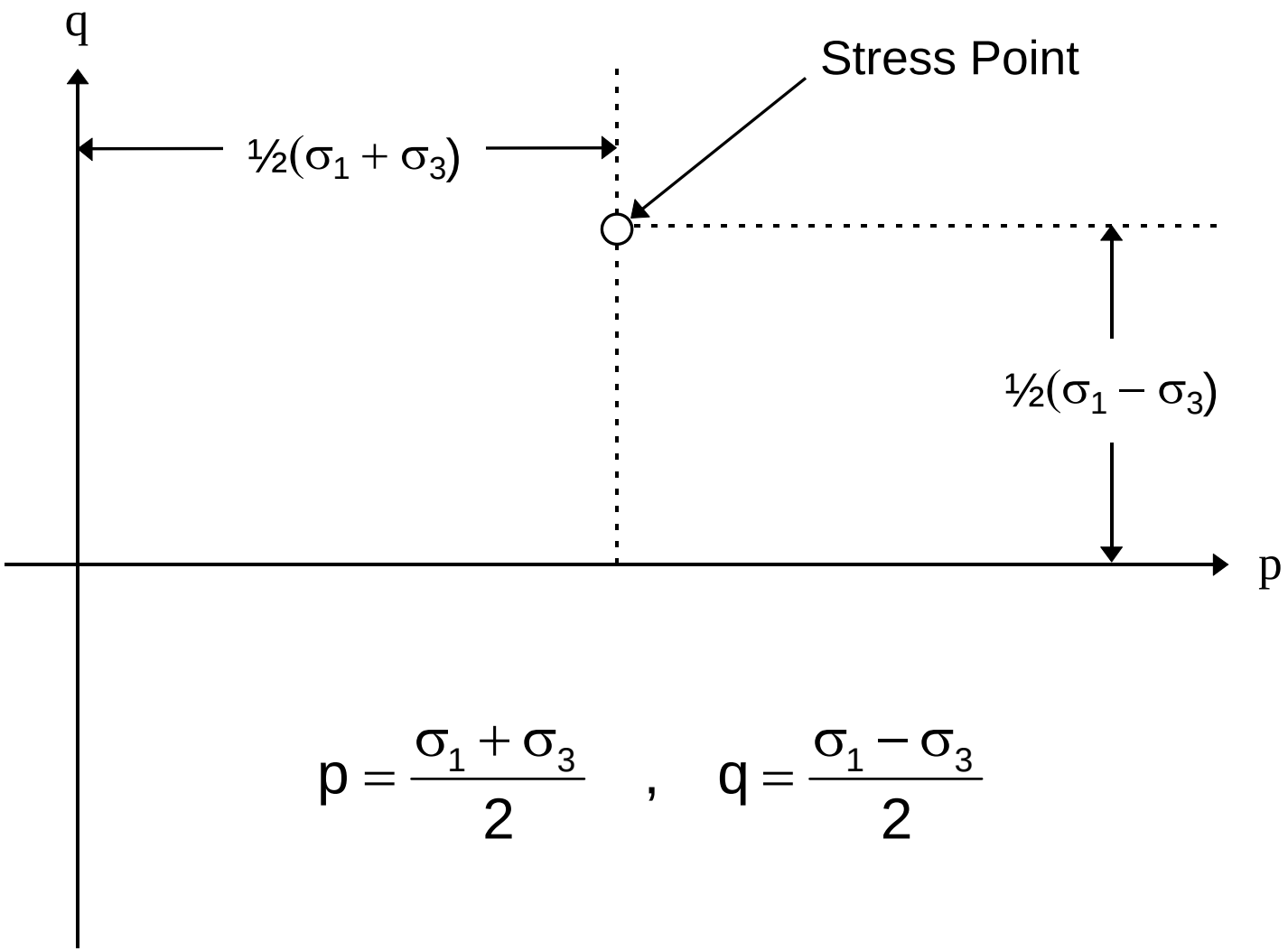
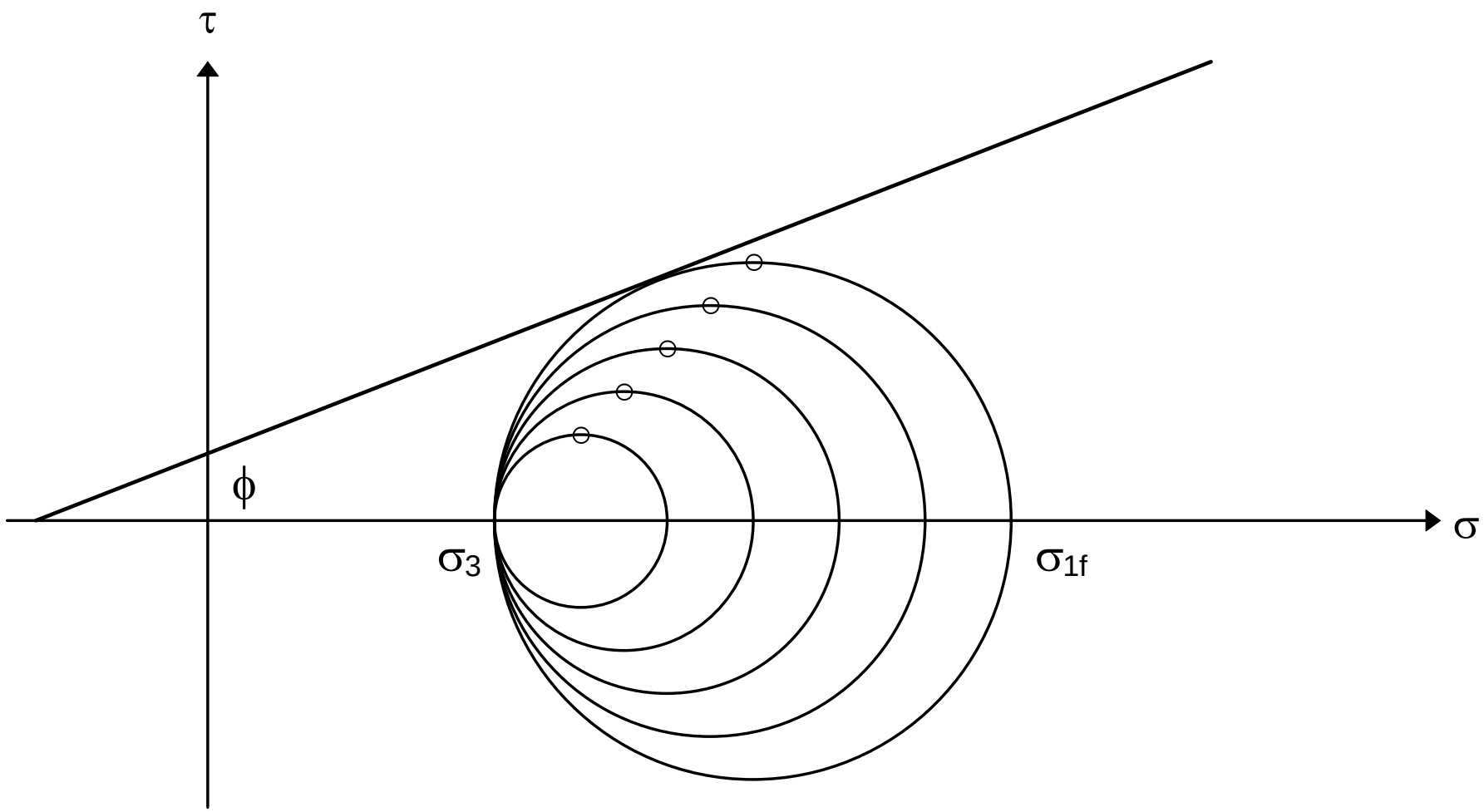
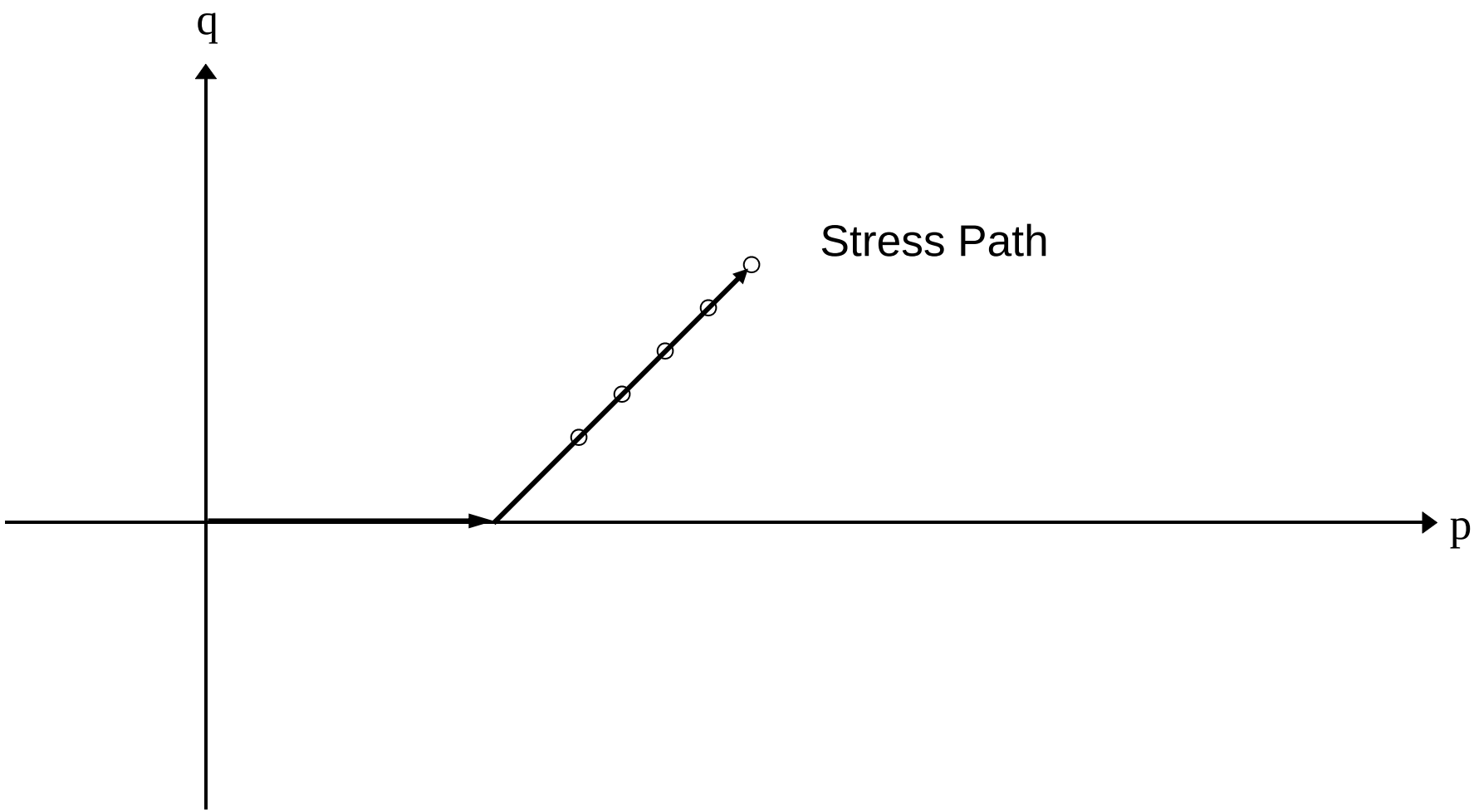
Stress Paths

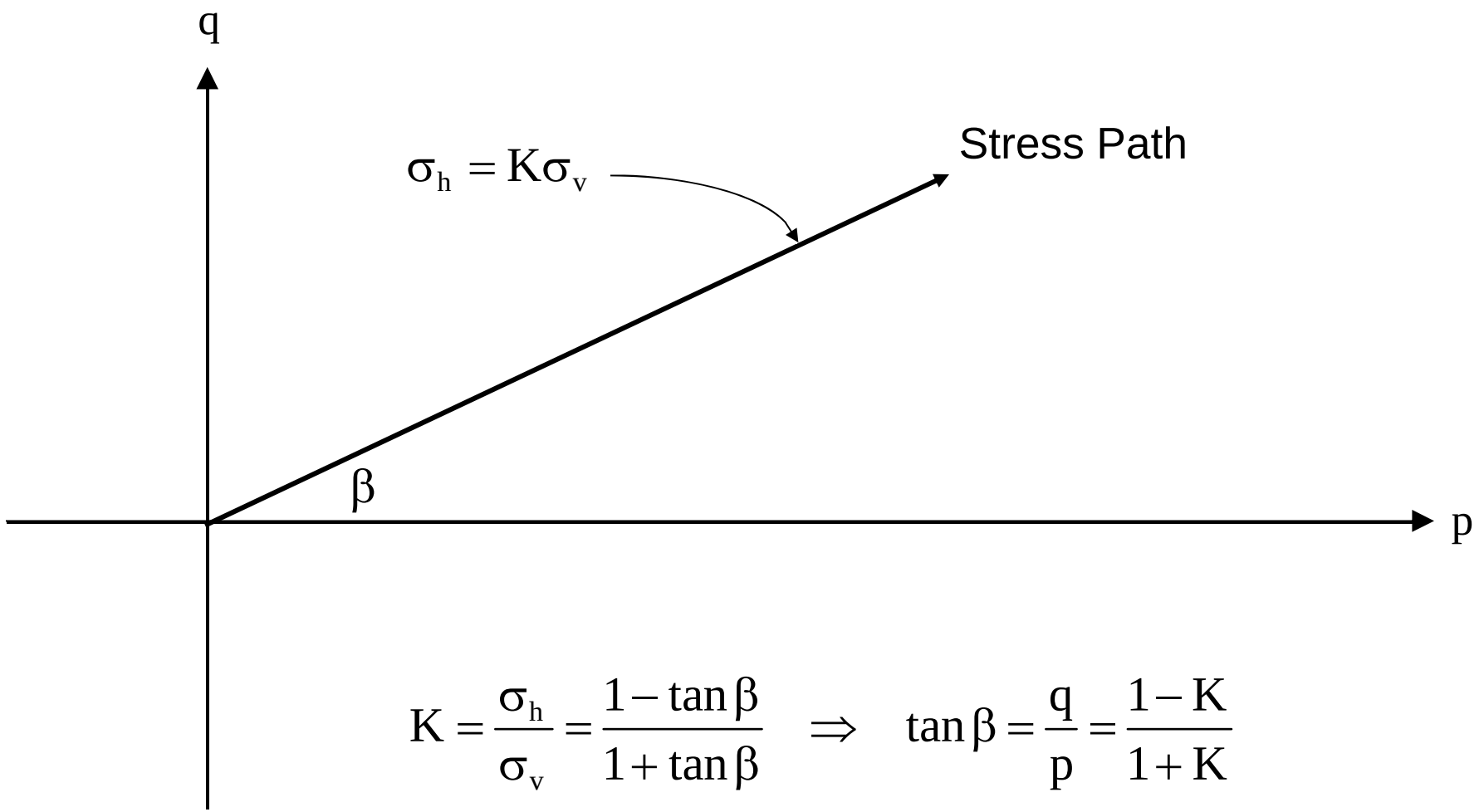

τ
Stress Point
½(σ1 + σ3)
½(σ1 – σ3)
σ3
σ1
σ



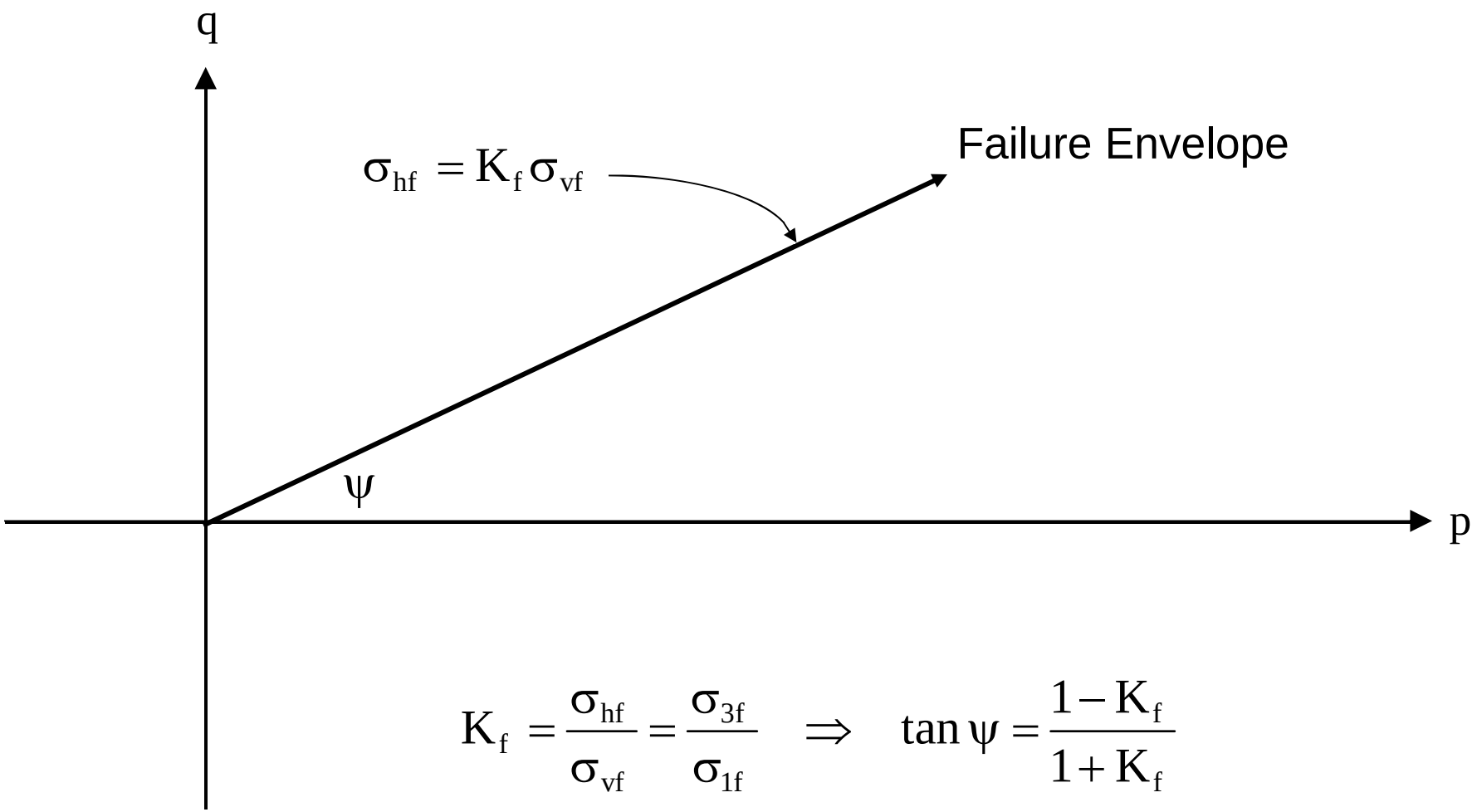
$$p = \frac{\sigma_1 + \sigma_3}{2} \quad , \quad q = \frac{\sigma_1 - \sigma_3}{2}$$


τ
ϕ
σ
σ3
σ1f


q
Stress Path
p



$$K = \frac{\sigma_h}{\sigma_v} = \frac{1 - \tan\beta}{1 + \tan\beta} \quad \Rightarrow \quad \tan\beta = \frac{q}{p} = \frac{1 - K}{1 + K}$$



$$K_f = \frac{\sigma_{hf}}{\sigma_{vf}} = \frac{\sigma_{3f}}{\sigma_{1f}} \quad \Rightarrow \quad \tan\psi = \frac{1 - K_f}{1 + K_f}$$

Not tangent!

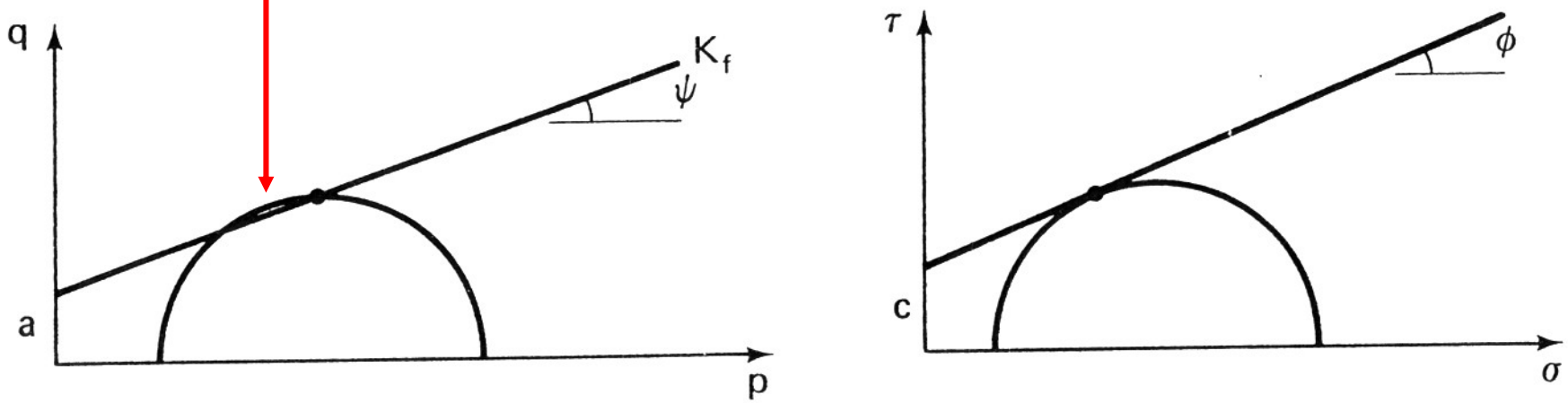
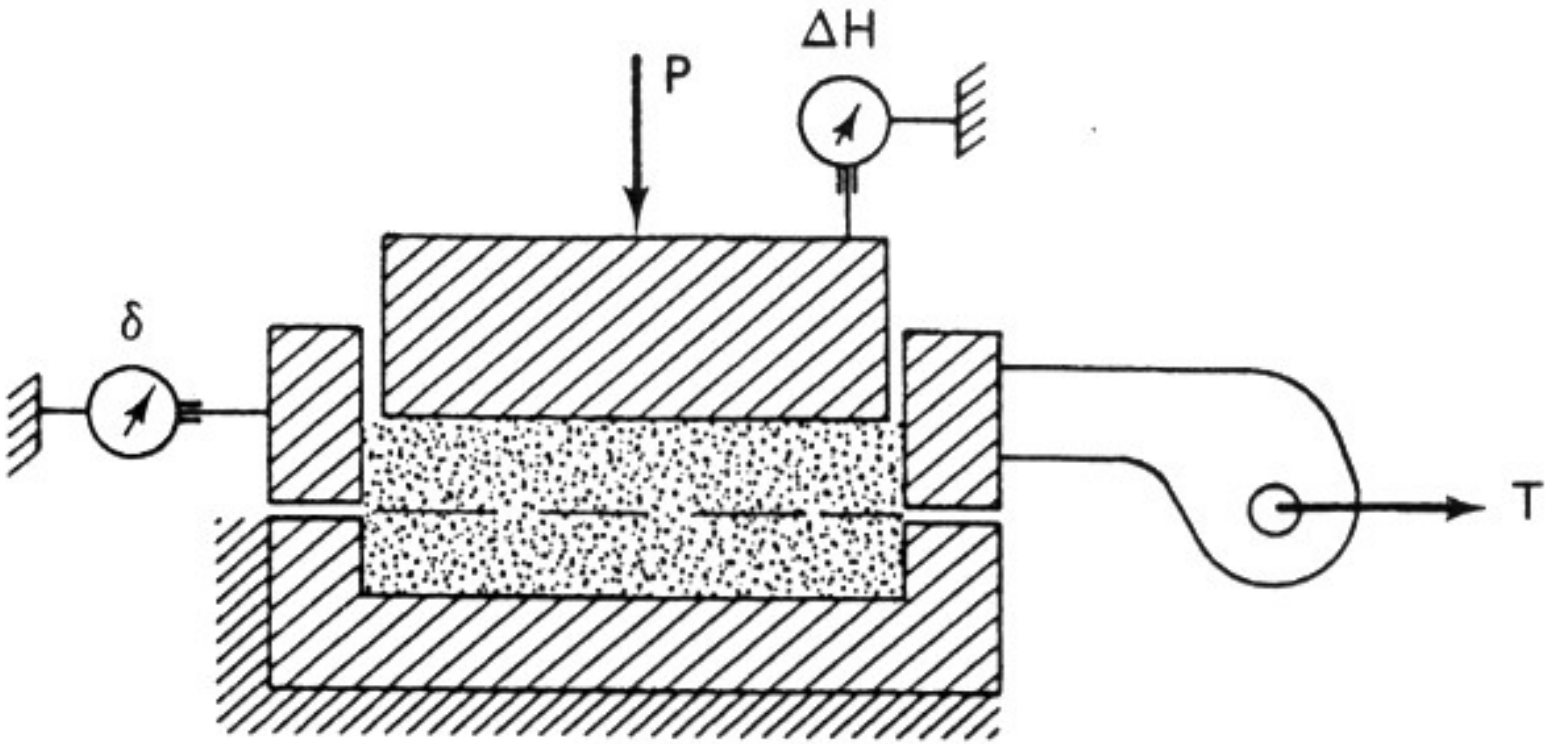
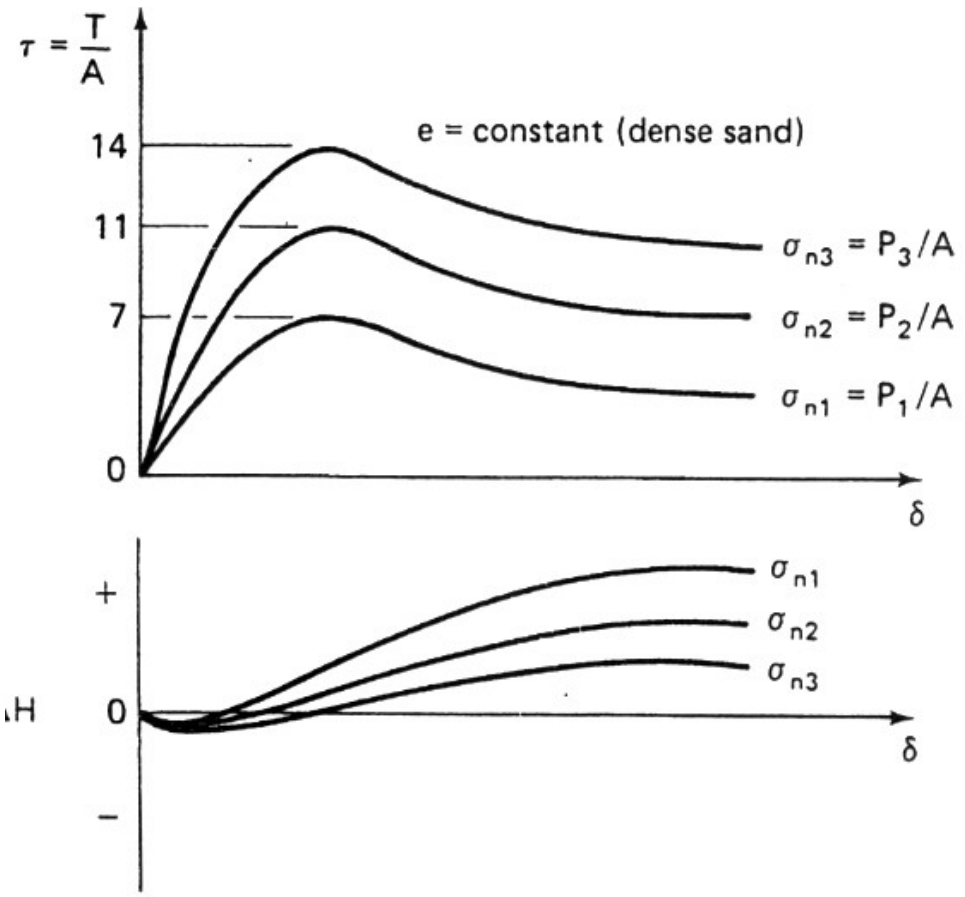


Fig. 10.23 Relationship between the K_f line and the Mohr-Coulomb failure envelope.

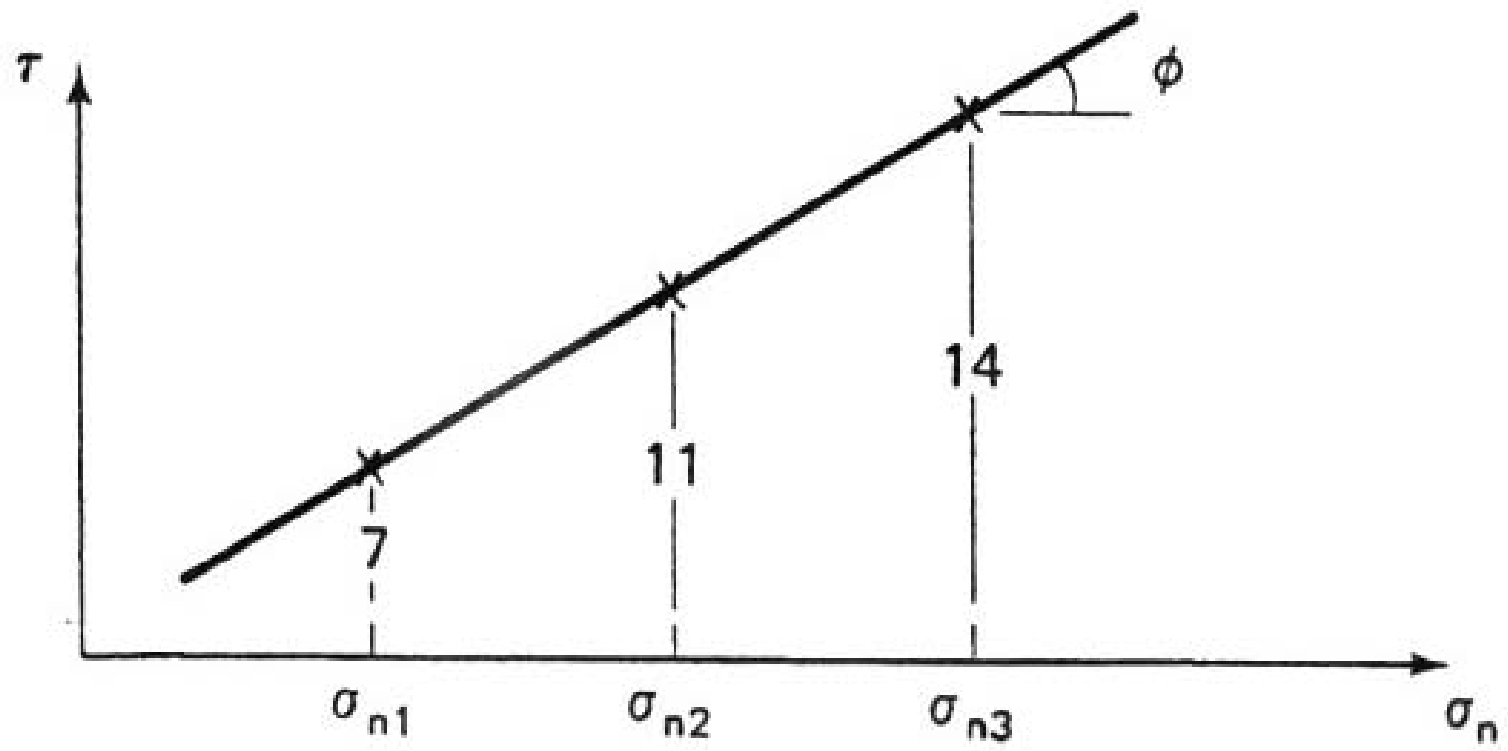
Direct Shear Test



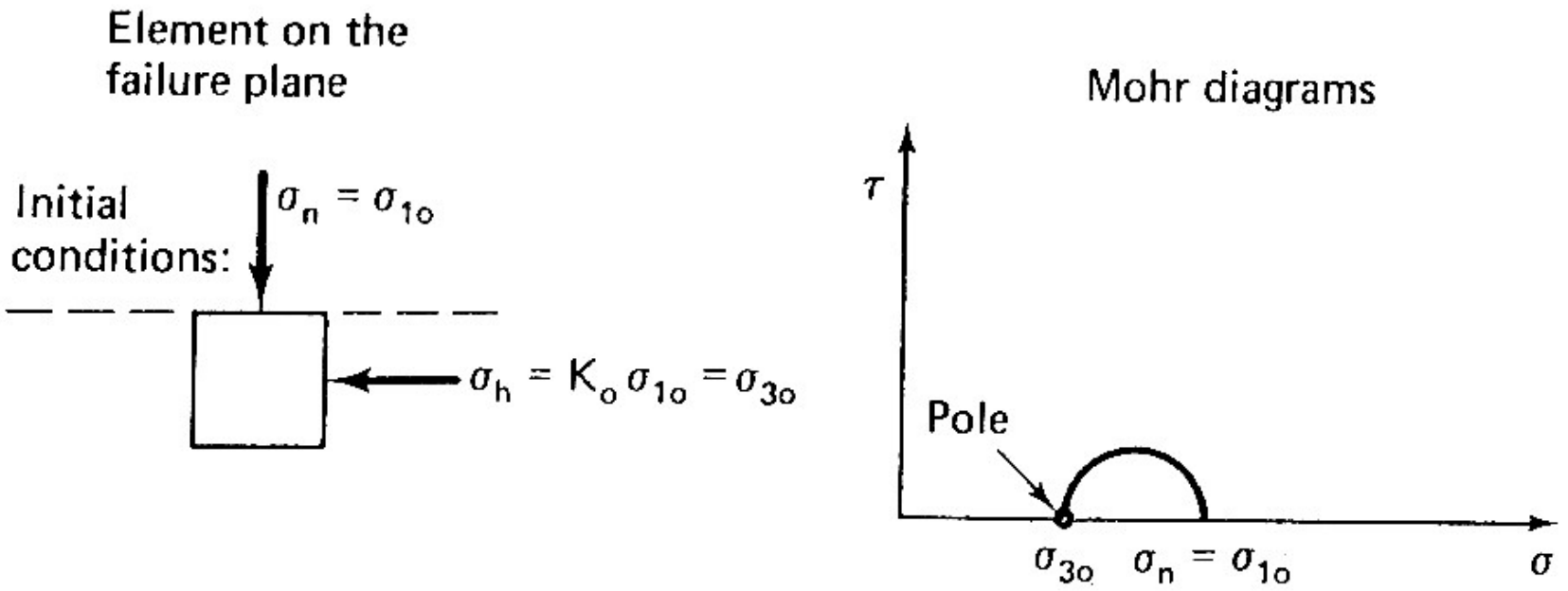
(a) Apparatus

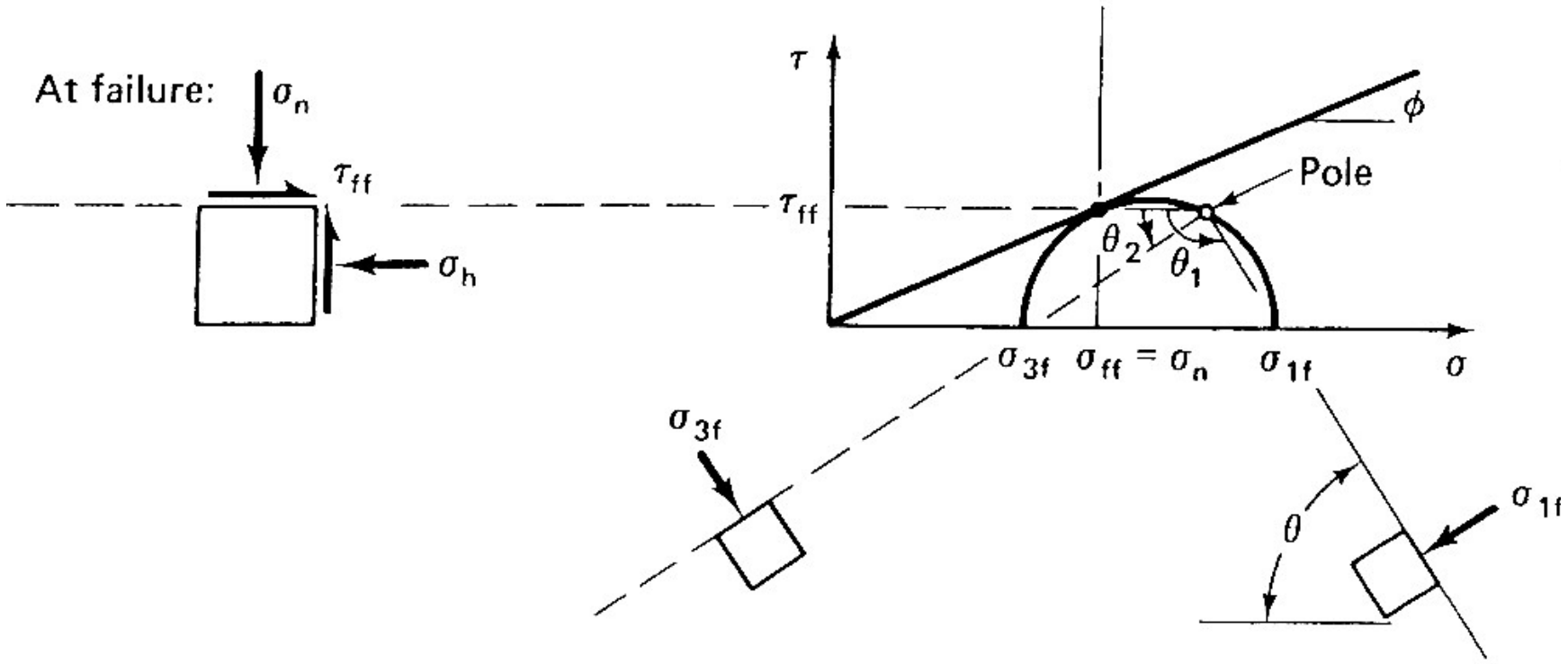


(b) Test results



(c) Mohr diagram

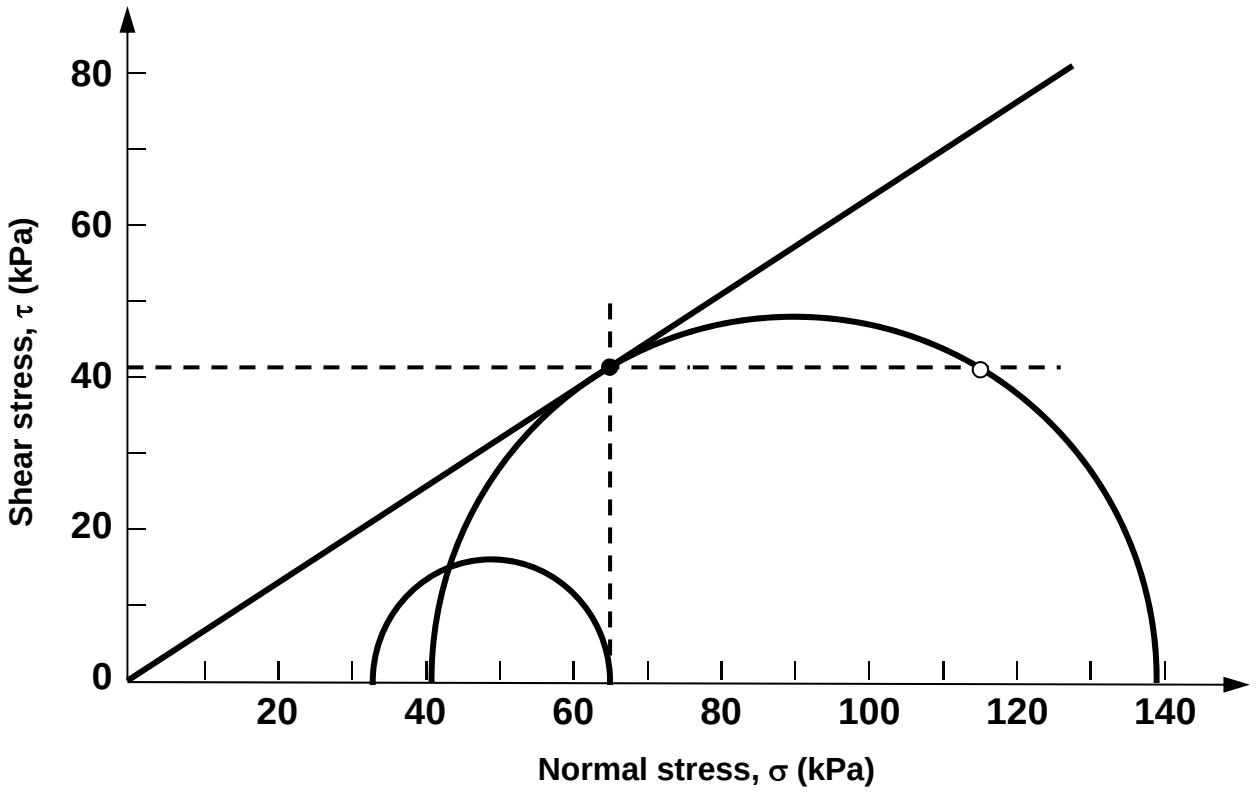

Element on the failure plane
Initial conditions:
$\sigma_n = \sigma_{1o}$
$\sigma_h = K_o \sigma_{1o} = \sigma_{3o}$
Mohr diagrams
τ
Pole
σ_{3o}
$\sigma_n = \sigma_{1o}$
σ


At failure:
σ_n
τ_{ff}
σ_h
τ
τ_{ff}
ϕ
Pole
θ_2
θ_1
σ_{3f}
$\sigma_{ff} = \sigma_n$
σ_{1f}
σ
σ_{3f}
θ
σ_{1f}

Example

- A direct shear test is run on a medium dense sandy silt with σ_n = 65 kPa. At failure the shear stress is 41 kPa.

- Draw the Mohr circles for the initial and failure conditions and determine:
  - The principal stresses at failure
  - The orientation of the failure plane
  - The orientation of the plane of maximum normal stress at failure
  - The orientation of the plane of maximum shear stress at failure


80
60
40
20
0
Shear stress, τ (kPa)
20
40
60
80
100
120
140
Normal stress, σ (kPa)

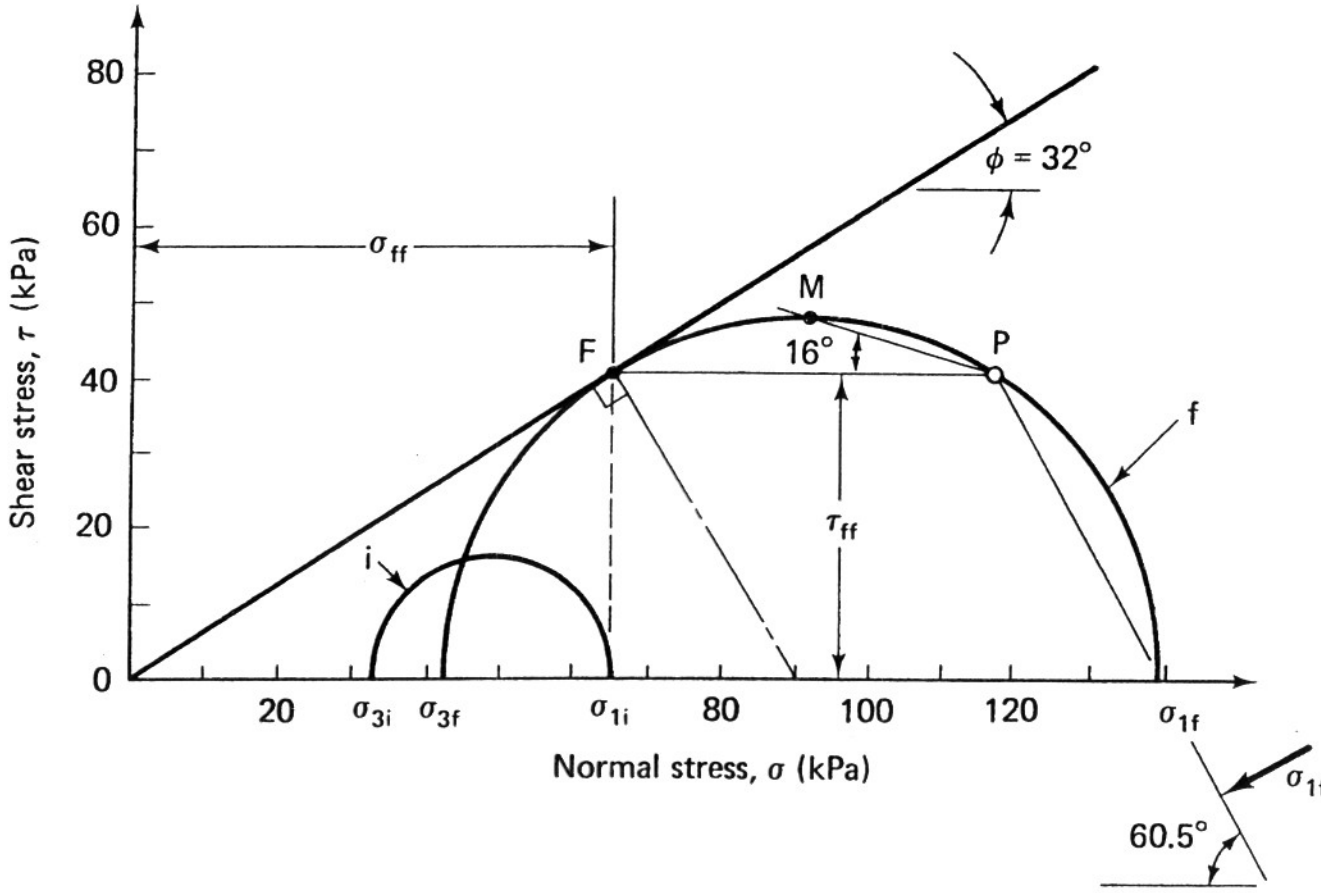
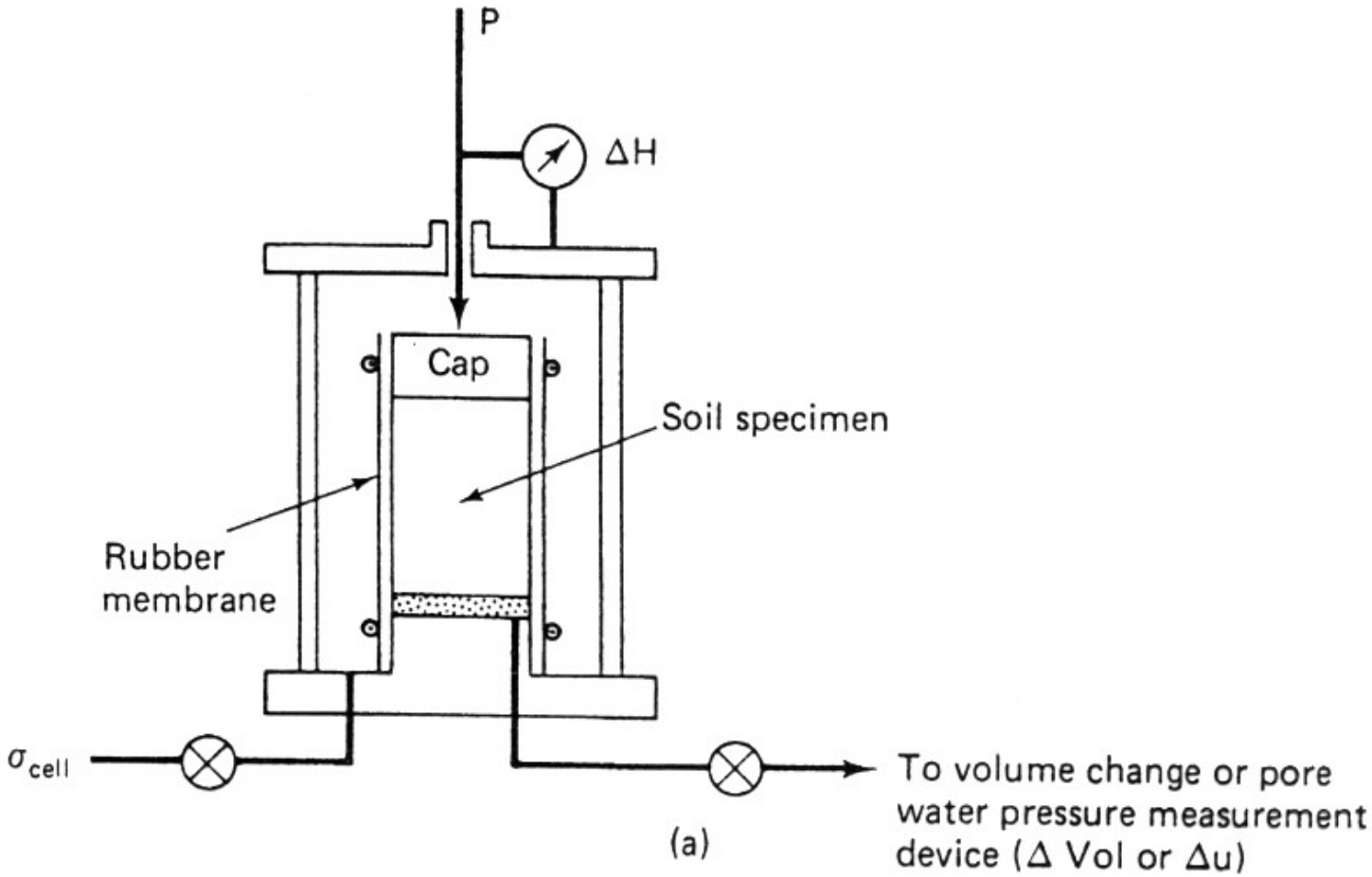
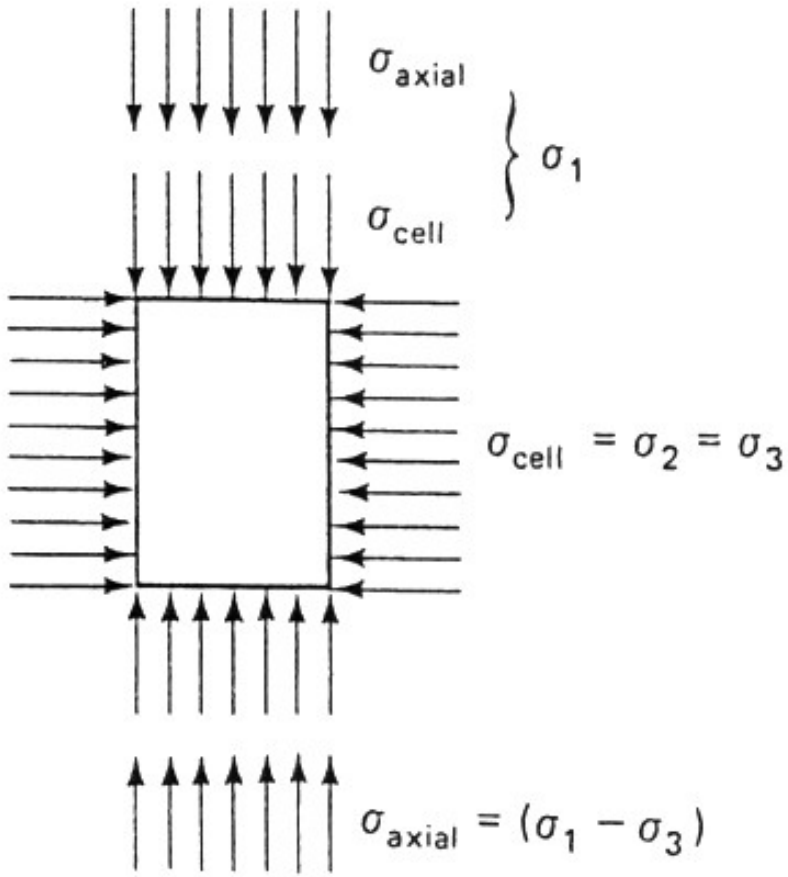
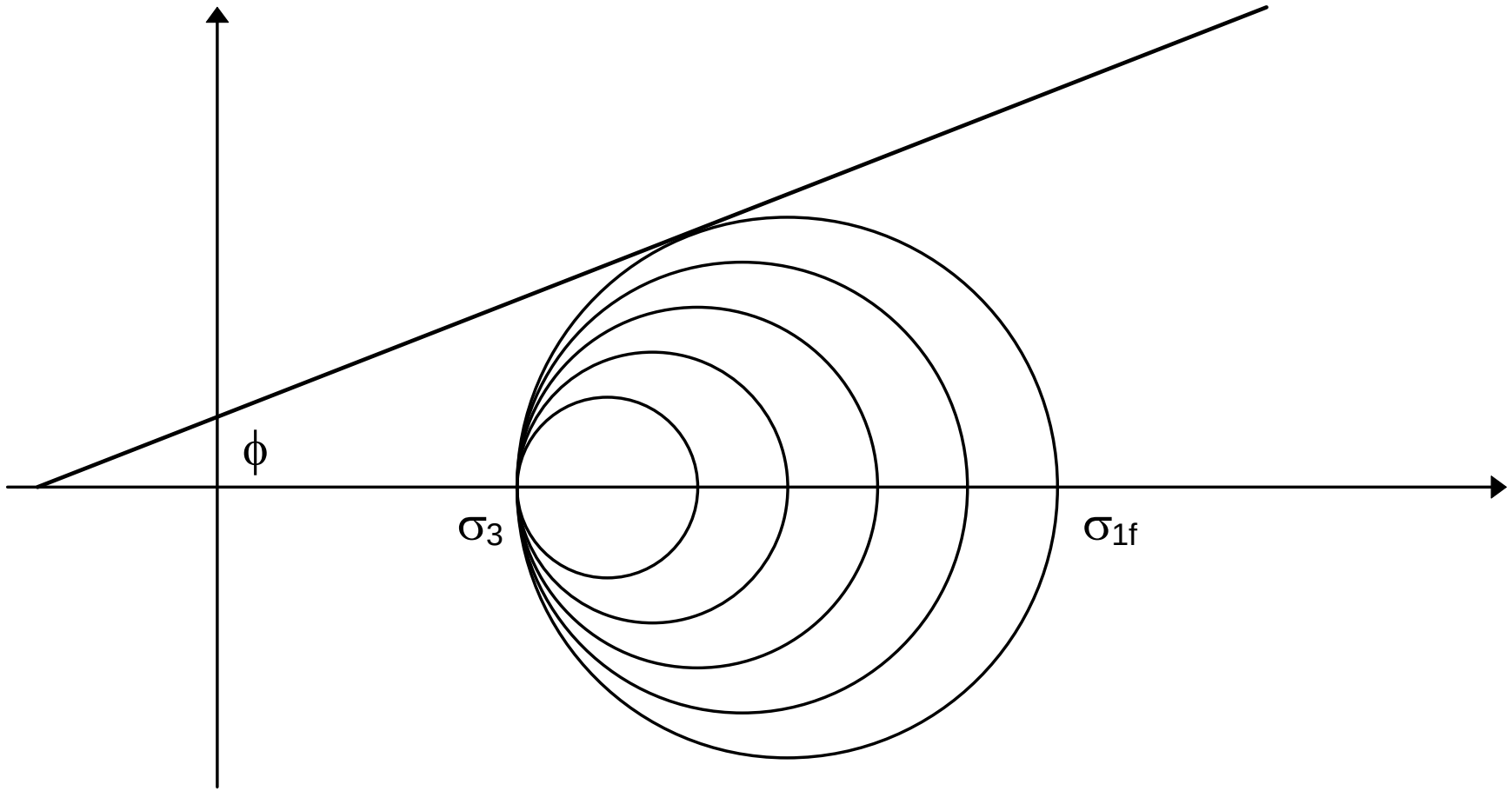

80
60
40
20
0
Shear stress, τ (kPa)
σ_{ff}
$\phi = 32°$
M
F
16°
P
f
τ_{ff}
i
20
σ_{3i}
σ_{3f}
σ_{1i}
80
100
120
σ_{1f}
Normal stress, σ (kPa)
σ_{1}
60.5°

Fig. Ex. 10.7

Triaxial Shear Test

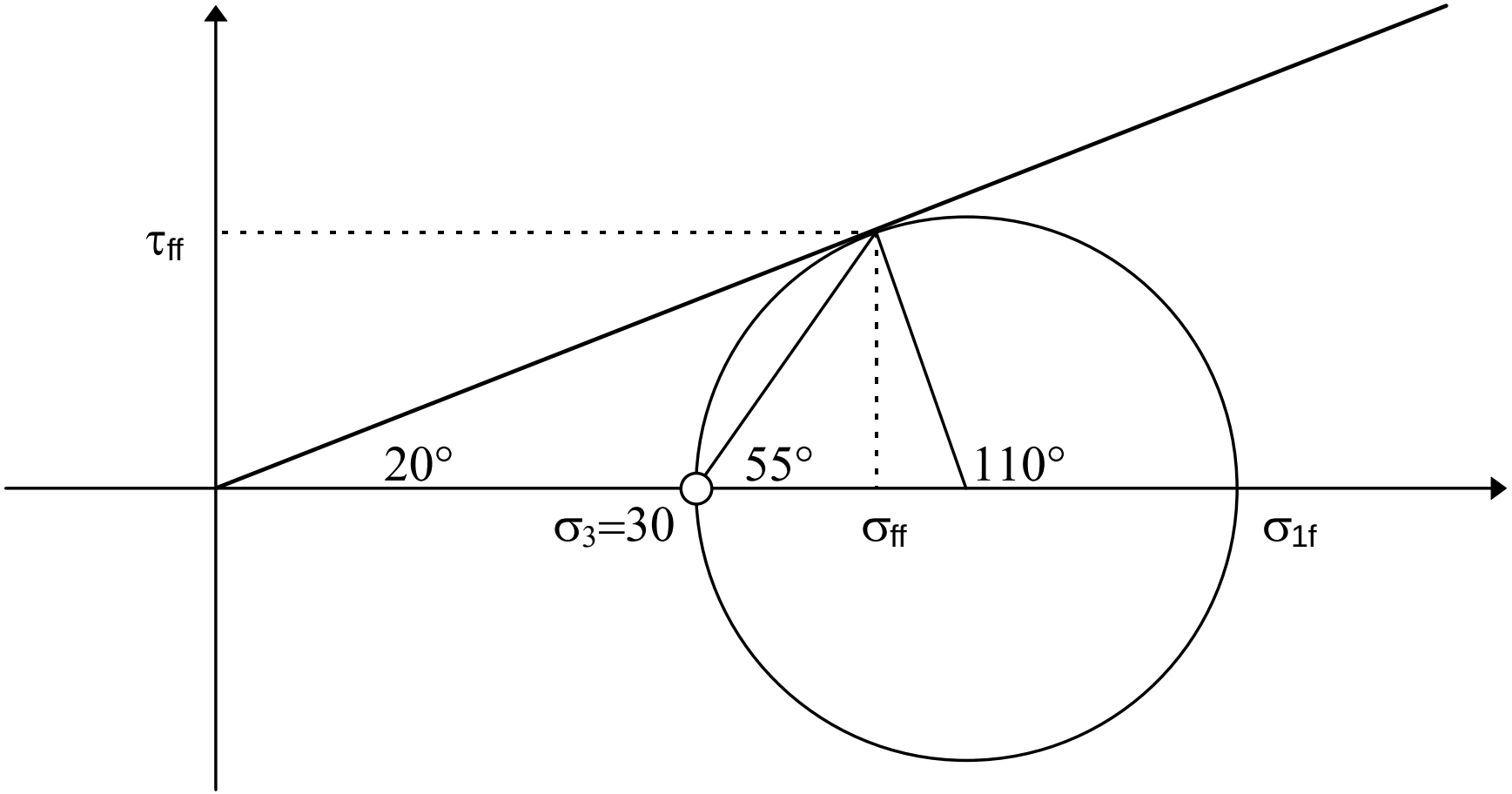

P
ΔH
Cap
Soil specimen
Rubber
membrane
σ_{cell}
To volume change or pore
water pressure measurement
device (Δ Vol or Δu)
(a)

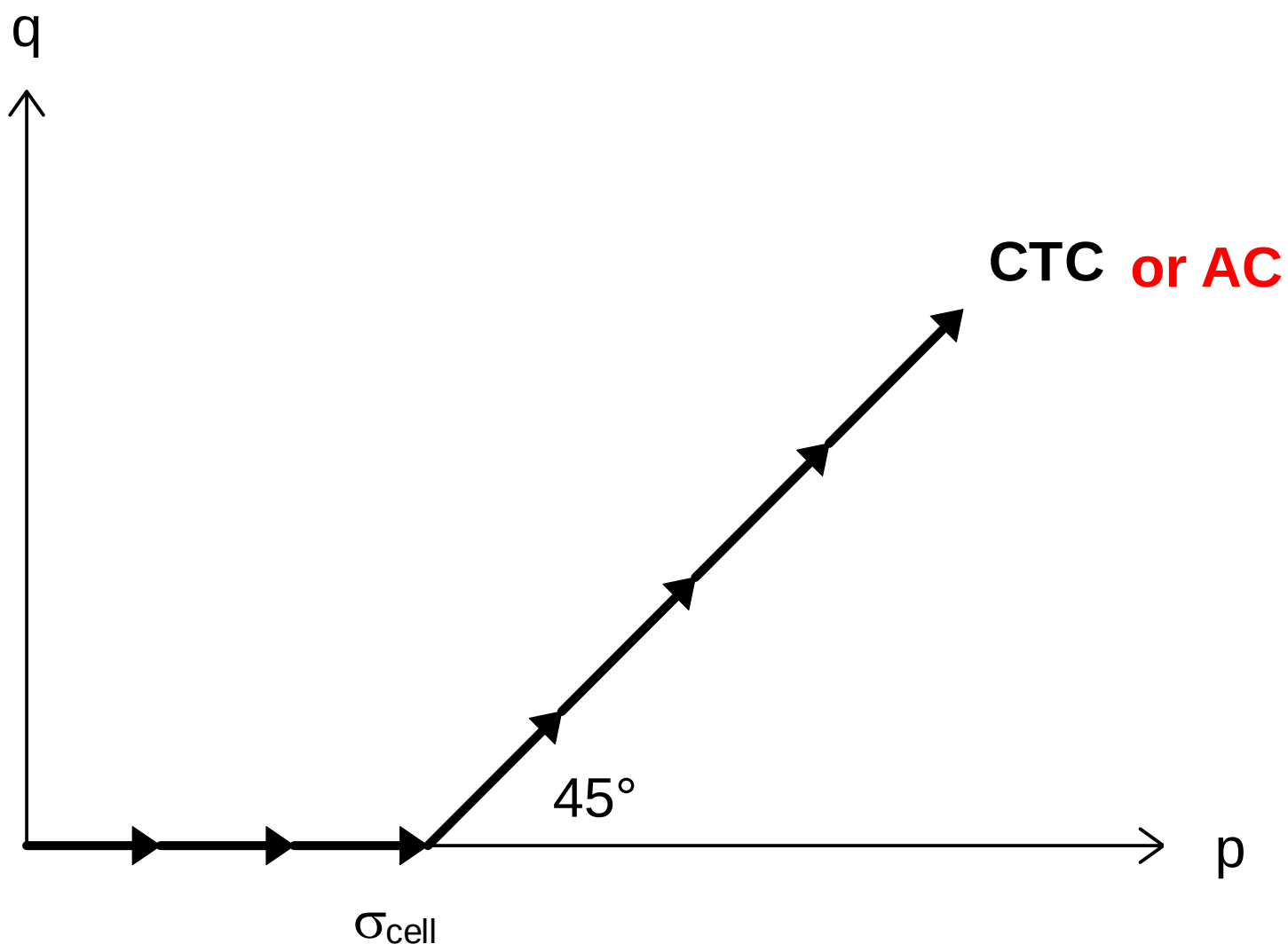

σ_{axial}
σ_1
σ_{cell}
$\sigma_{cell} = \sigma_2 = \sigma_3$
$\sigma_{axial} = (\sigma_1 - \sigma_3)$

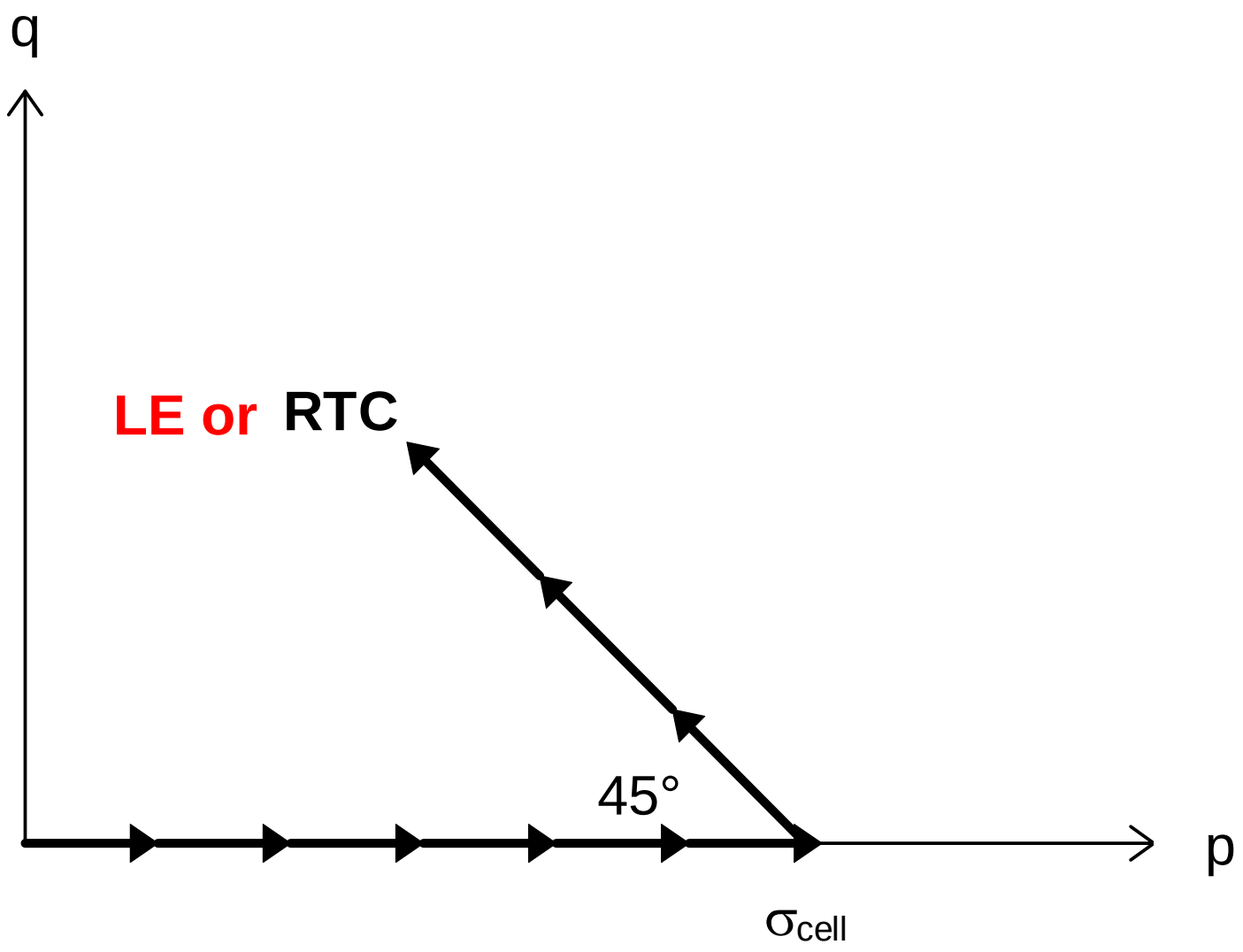

ϕ
σ3
σ1f

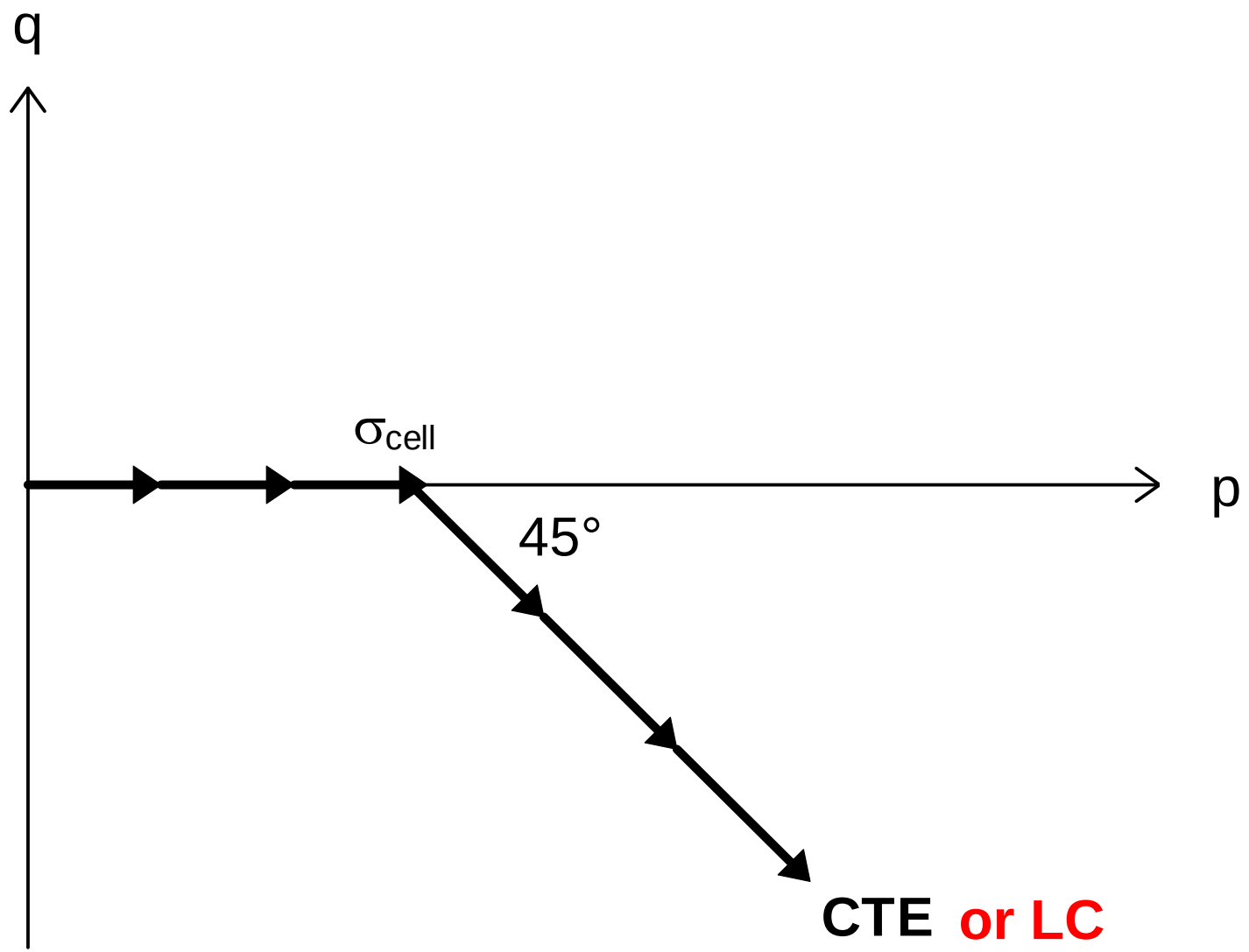
Example

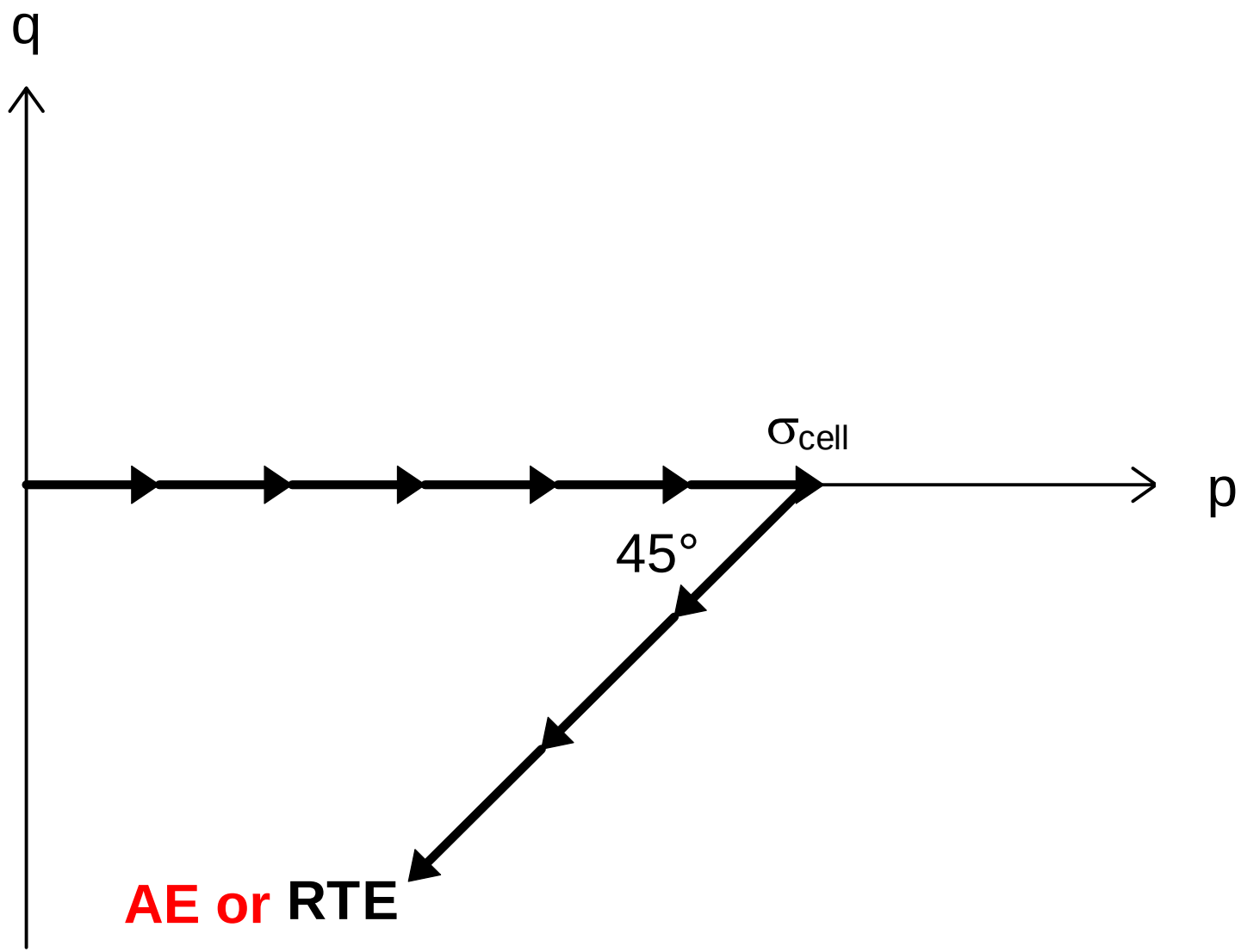
- A conventional triaxial compression (CTC) test is run on a loose sand with a friction angle of 20. The cell pressure is 30 psi. Determine the following:
  - The orientation of the failure plane
  - The stresses acting on the failure plane at failure
  - The axial stress at failure
  - The stress path corresponding to this test

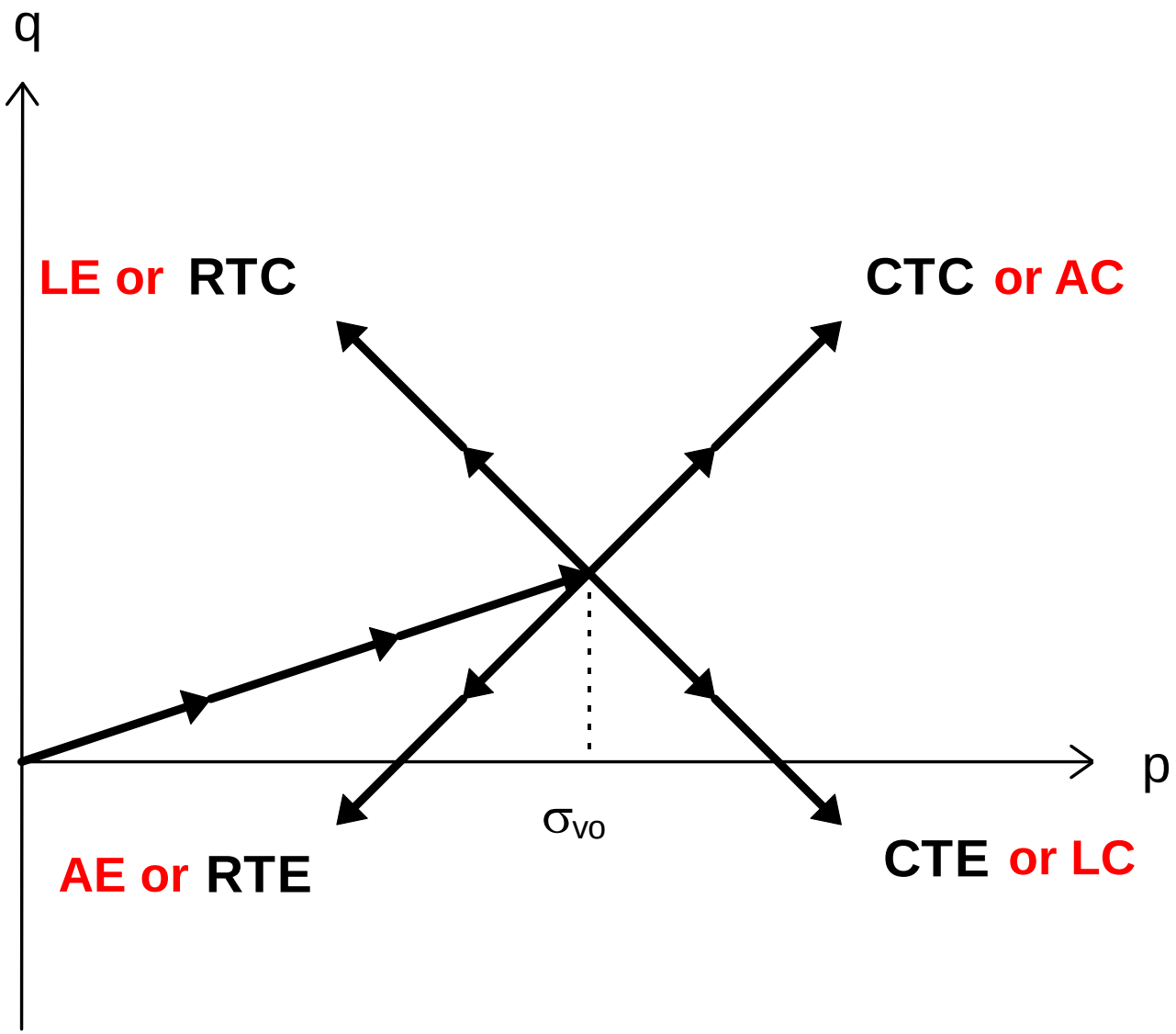

τff
20°
55°
110°
σ3=30
σff
σ1f

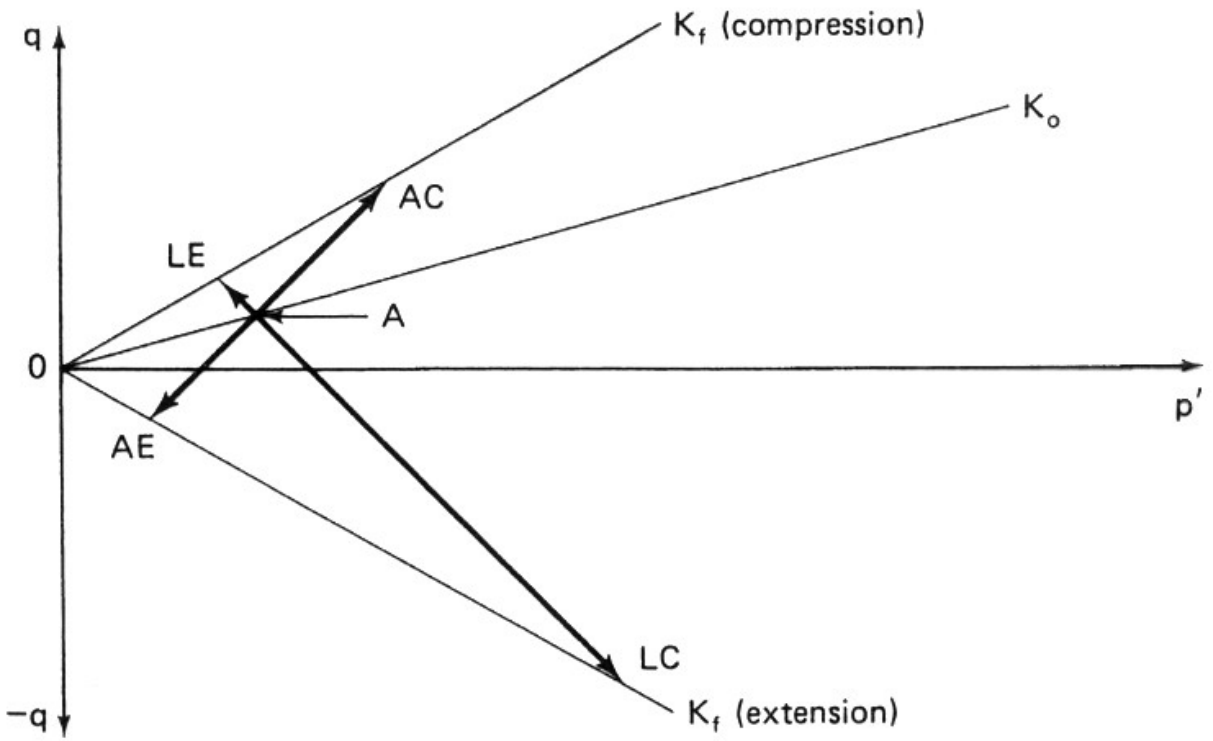

q
CTC or AC
45°
p
σcell


q
LE or RTC
45°
p
σcell


q
σcell
p
45°
CTE or LC


q
σcell
p
45°
AE or RTE


q
LE or RTC
CTC or AC
p
σvo
AE or RTE
CTE or LC



	Symbol	Geotechnical Engineering example
AC:	Axial Compression	Foundation loading – increase σ_v, σ_h constant
LE:	Lateral Extension	Active earth pressure – decrease σ_h, σ_v constant
AE:	Axial Extension	Unloading (excavation) – decrease σ_v, σ_h constant
LC:	Lateral Compression	Passive earth pressure – increase σ_h, σ_v constant