SOIL MECHANIC 2

Kuat Geser Tanah (2)

Sherly Meiwa , ST., MT

Department of Civil Engineering
Universitas Komputer Indonesia
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Kekuatan Geser Tanah (Shear Strength)

Tujuan Pembelajaran

- Dapat menjelaskan kriteria keruntuhan serta konsep kuat geser tanah
- Dapat menjelaskan prosedur pengujian kuat geser tanah dan interpretasi hasilnya

Pokok Bahasan

- Kriteria keruntuhan tanah
- Kohesi dan sudut geser dalam tanah
- Uji kuat Geser Tanah di Laboratorium dan interpretasinya

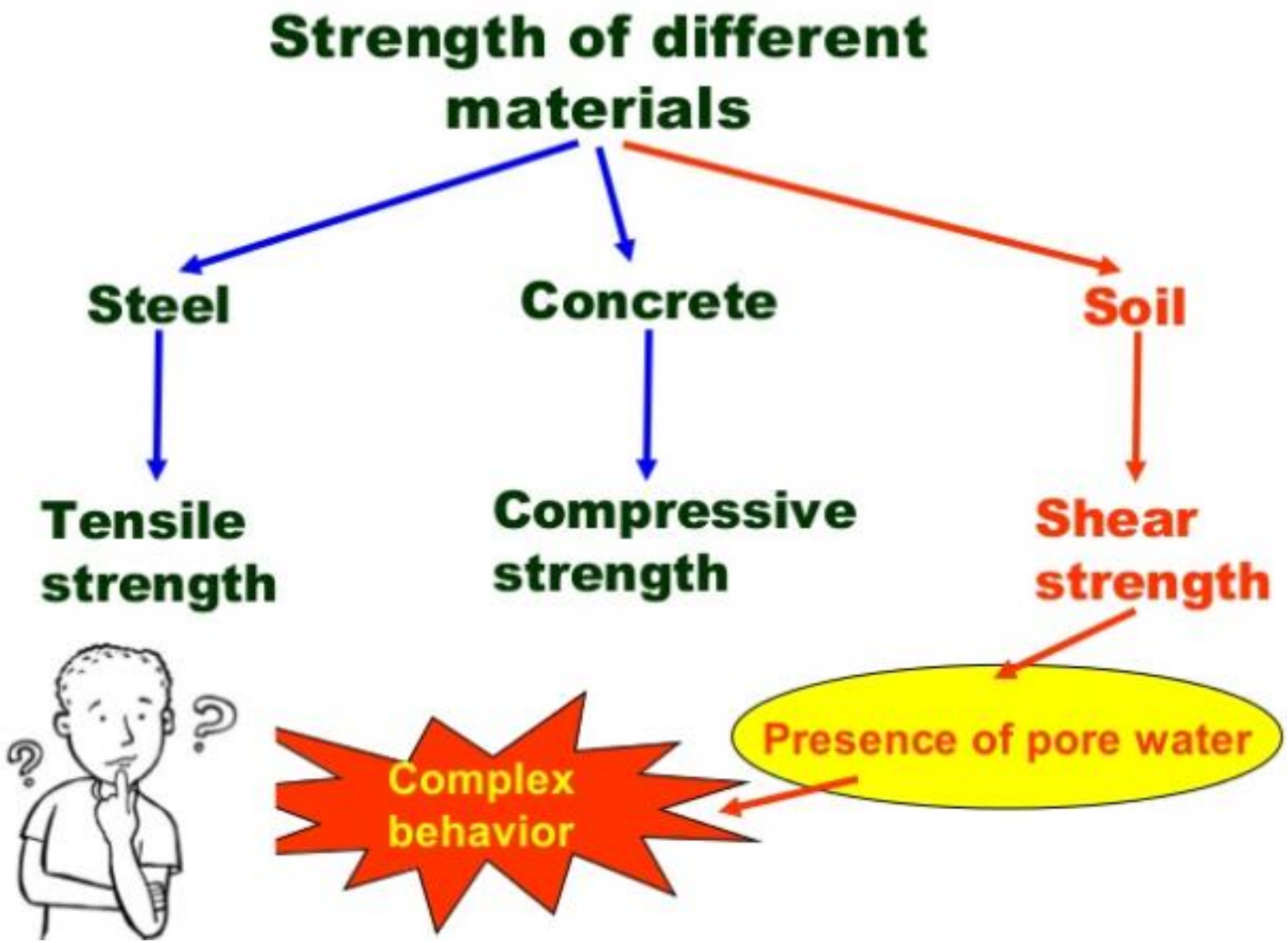
Kekuatan Geser Tanah

Definisi

Perlawanan internal tanah tiap satuan luas terhadap keruntuhan atau pergeseran sepanjang bidang runtuh dalam satu elemen tanah.

Tujuan Studi Kuat Geser Tanah

Untuk analisis masalah kestabilan tanah seperti: daya dukung pondasi; stabilitas lereng (landslide stability); tekanan tanah aktif/pasif pada konstruksi dinding penahan tanah (turap, retaining wall)

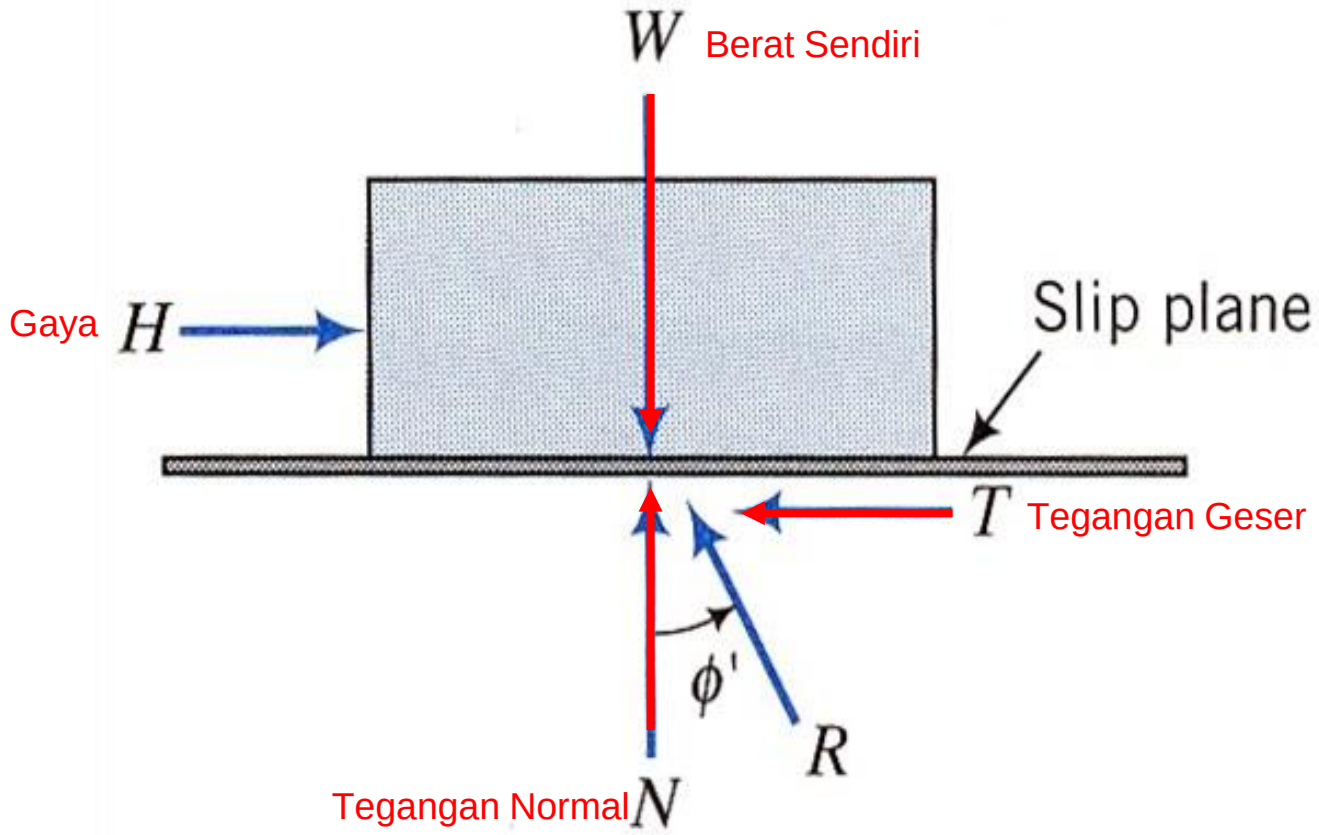

Strength of different materials
Steel
Concrete
Soil
Tensile strength
Compressive strength
Shear strength
Presence of pore water
Complex behavior

Kekuatan geser tanah terbentuk oleh 3 komponen:

1. Komponen gesekan/friksi
2. Kohesi dan Adhesi
3. Interlocking antar partikel tanah

Dasar Teori

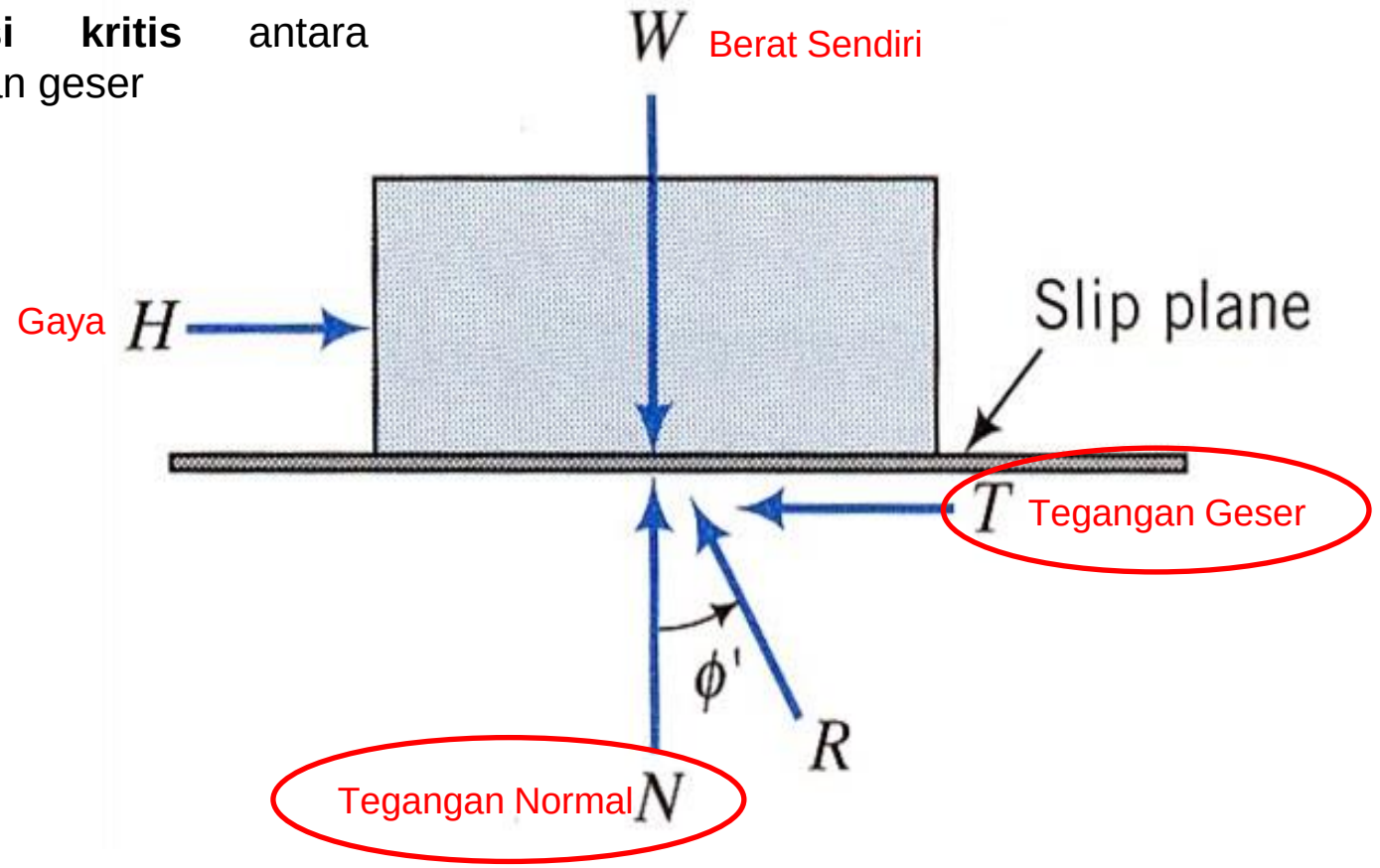
Hukum Gesekan Newton



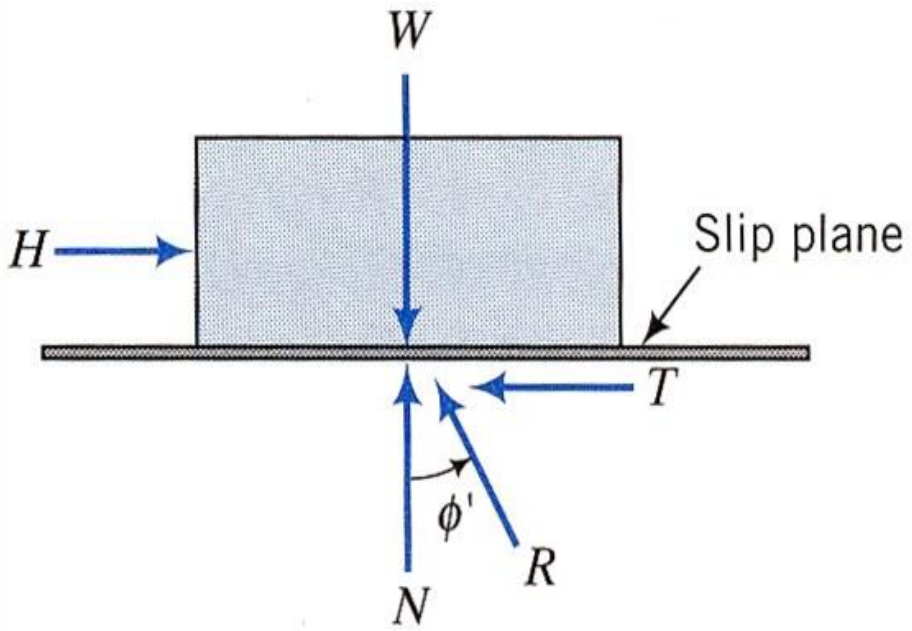
Kriteria Keruntuhan (Mohr-Coulomb)

Mohr (1980)

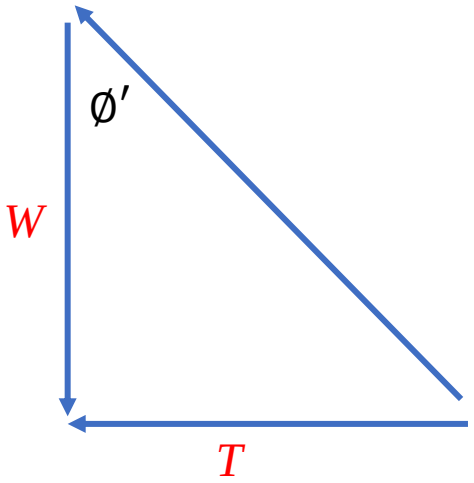
Keruntuhan terjadi pada suatu material akibat **kombinasi kritis** antara tegangan normal dan geser



Kriteria Keruntuhan (Mohr-Coulomb)



$W = N$



$$\tan\emptyset' = \frac{T}{W}$$

Dalam tegangan

$$\tan\emptyset' = \frac{T/A}{W/A}$$

$$\tan\emptyset' = \frac{\tau}{\sigma}$$

$$\tau = \sigma \tan\emptyset'$$

$$\boldsymbol{\tau = c + \sigma \tan\emptyset'}$$

Kriteria Keruntuhan (Mohr-Coulomb)

Kriteria keruntuhan Mohr-Coulomb

Keruntuhan pada Material diakibatkan oleh kombinasi kritis antara teg. normal dan geser serta sifat-sifat mekanis tanah yang dinyatakan dalam bentuk:

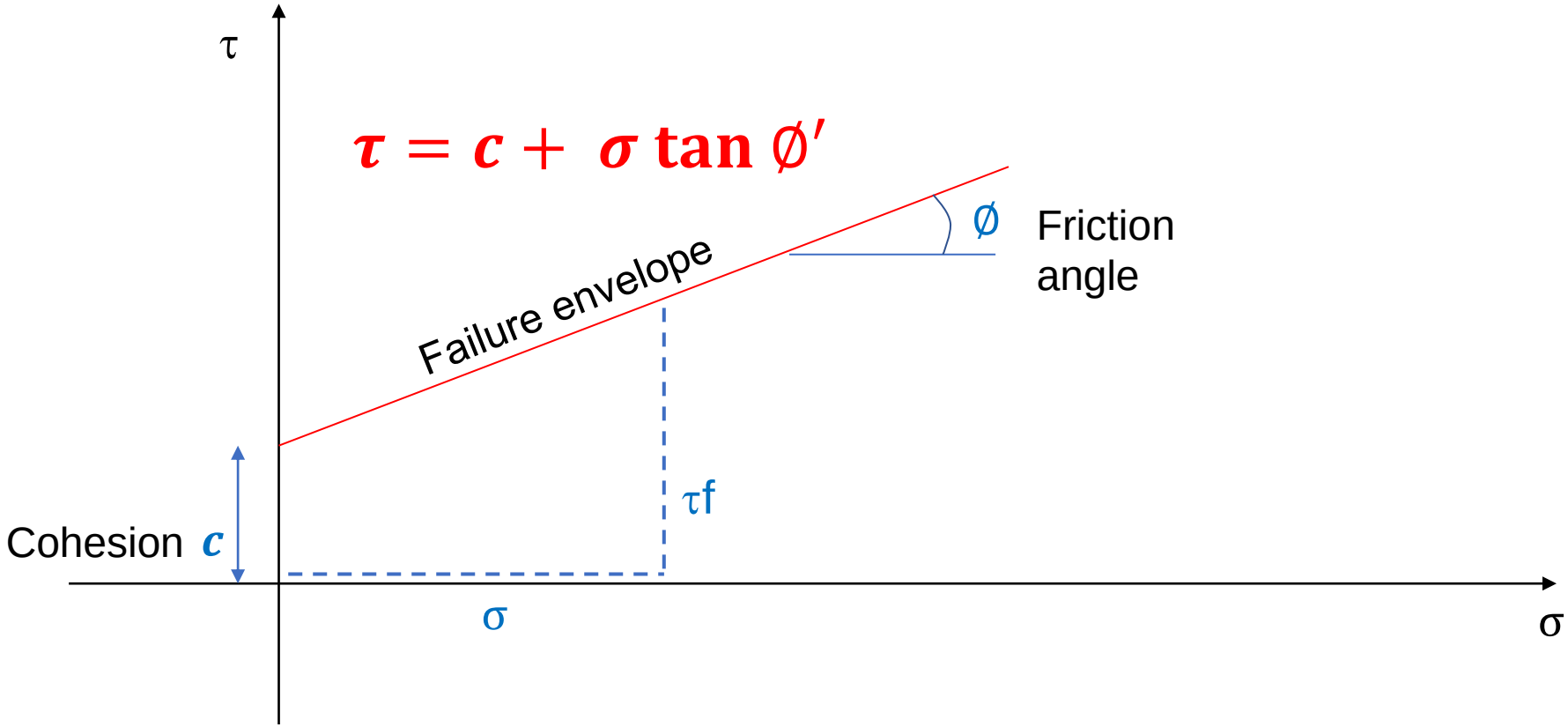
$$\tau_f = c + \sigma \, tan\emptyset$$

τ_f = Teg. Geser pada runtuh (Gaya/luas kN/m^2)
c = Kohesi (Gaya/luas kN/m^2)
$\emptyset$ = Sudut geser dalam (degrees atau ^{o})
σ = Teg. Normal (Gaya/luas kN/m^2)

Kriteria Keruntuhan (Mohr-Coulomb)

(Kondisi tegangan total)

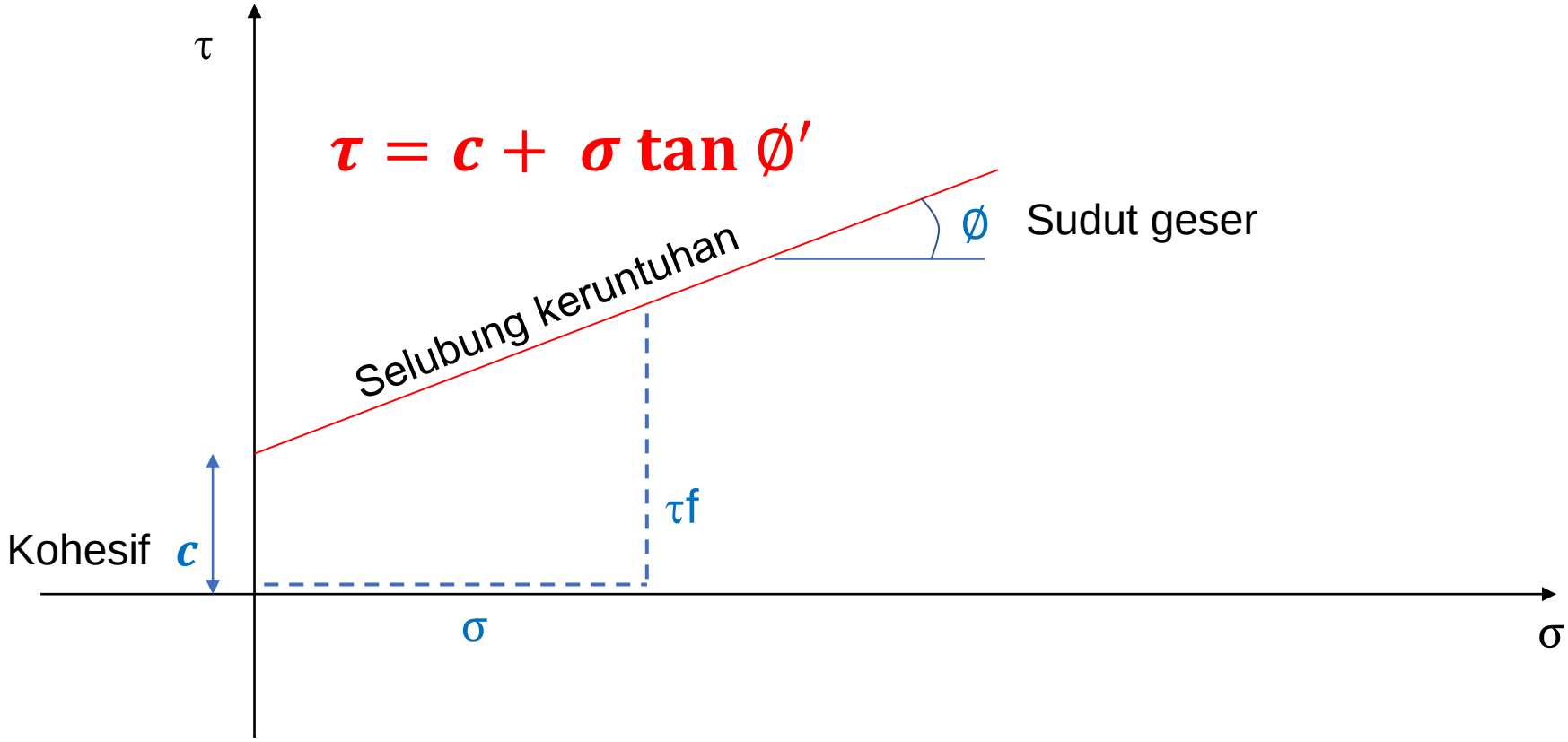
τf adalah tegangan geser maksimum tanah pada tegangan normal σ sebelum terjadi keruntuhan



Kriteria Keruntuhan (Mohr-Coulomb)

(Kondisi tegangan total)

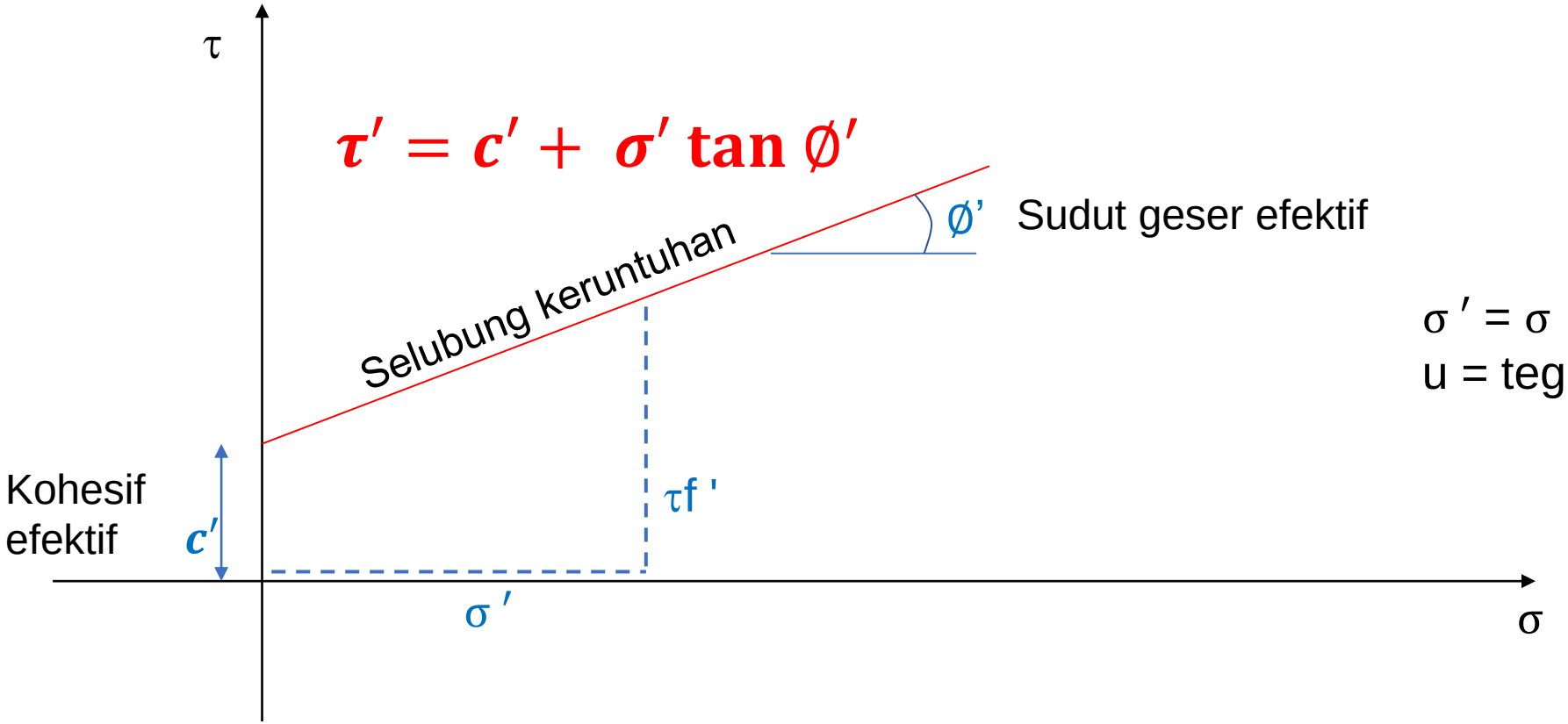
τf adalah tegangan geser maksimum tanah pada tegangan normal σ sebelum terjadi keruntuhan



Kriteria Keruntuhan (Mohr-Coulomb)

(Kondisi tegangan efektif)

τf 'adalah tegangan geser maksium tanah pada tegangan normal efektif σ' sebelum terjadi keruntuhan

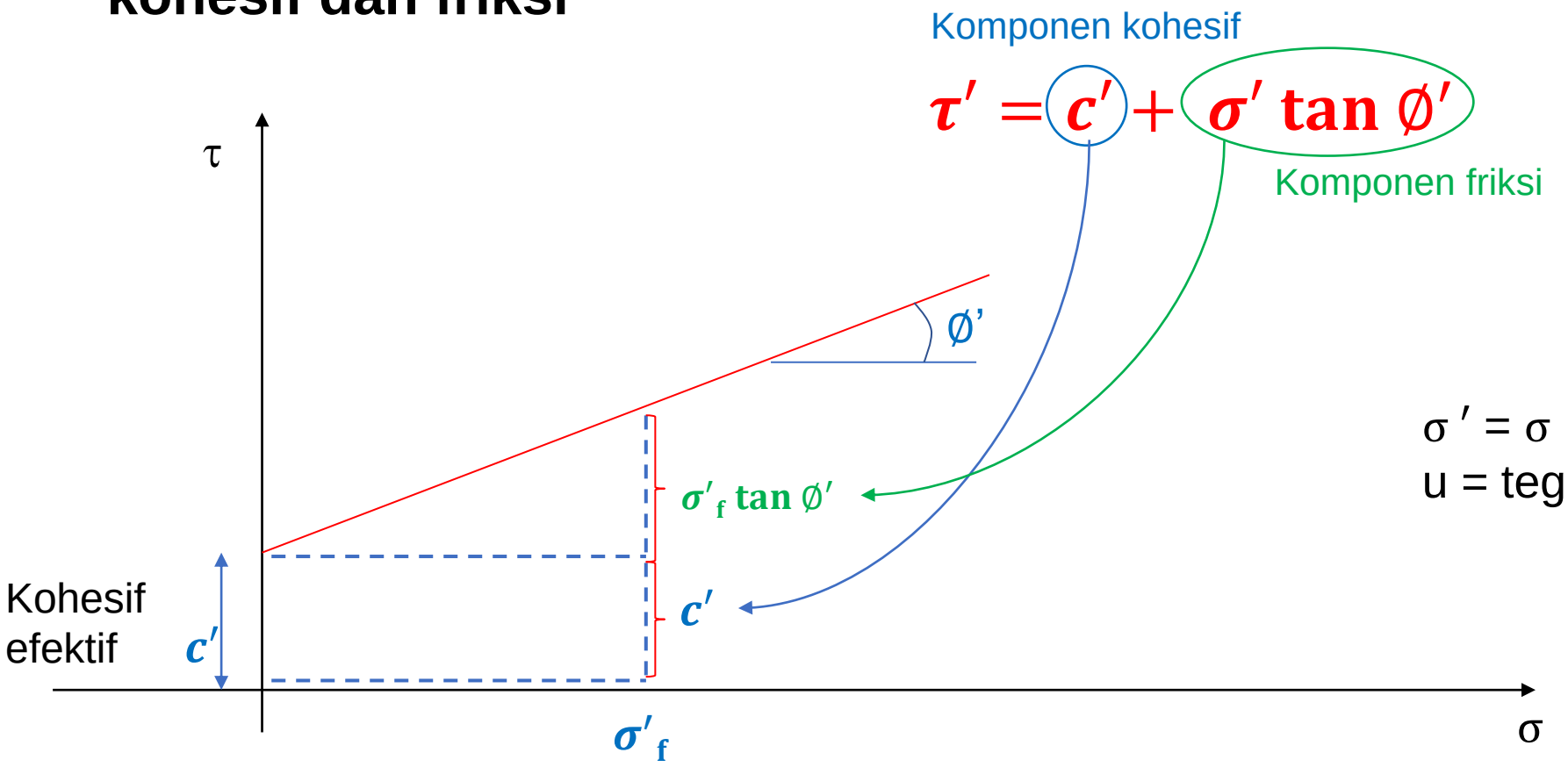


$\sigma' = \sigma - u$

u = tegangan air pori

Kriteria Keruntuhan (Mohr-Coulomb)

Kuat geser terdiri atas dua komponen: kohesif dan friksi



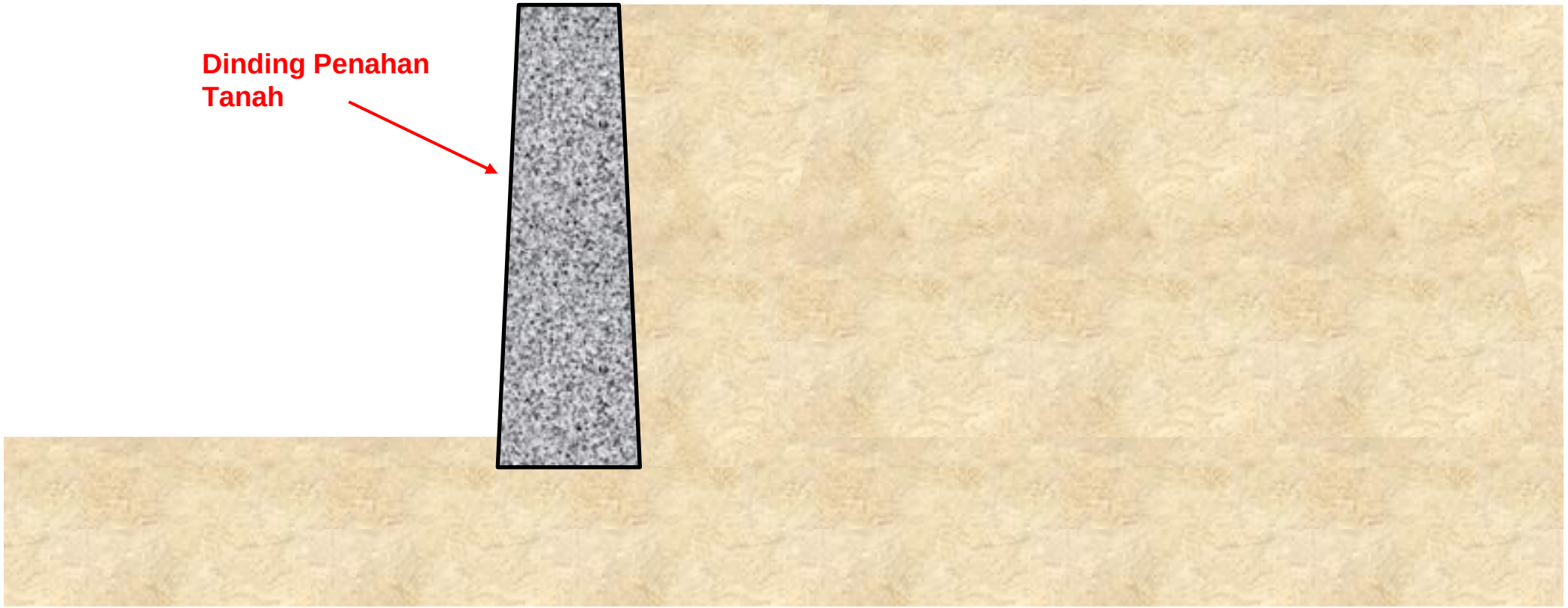
$\sigma' = \sigma - u$

u = tegangan air pori

c dan ϕ adalah parameter dalam kuat geser tanah. semakin tinggi nilainya, semakin besar kuat geser tanah tersebut.

Keruntuhan Geser pada Tanah

Tanah umumnya runtuh akibat geser



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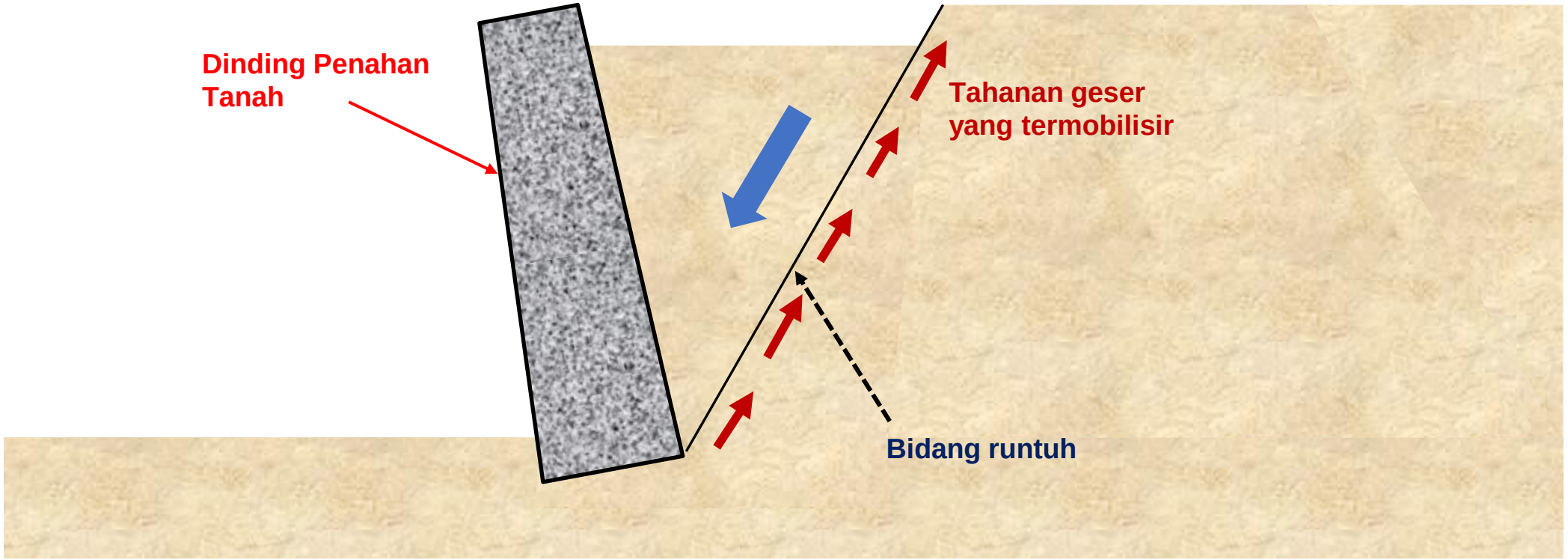
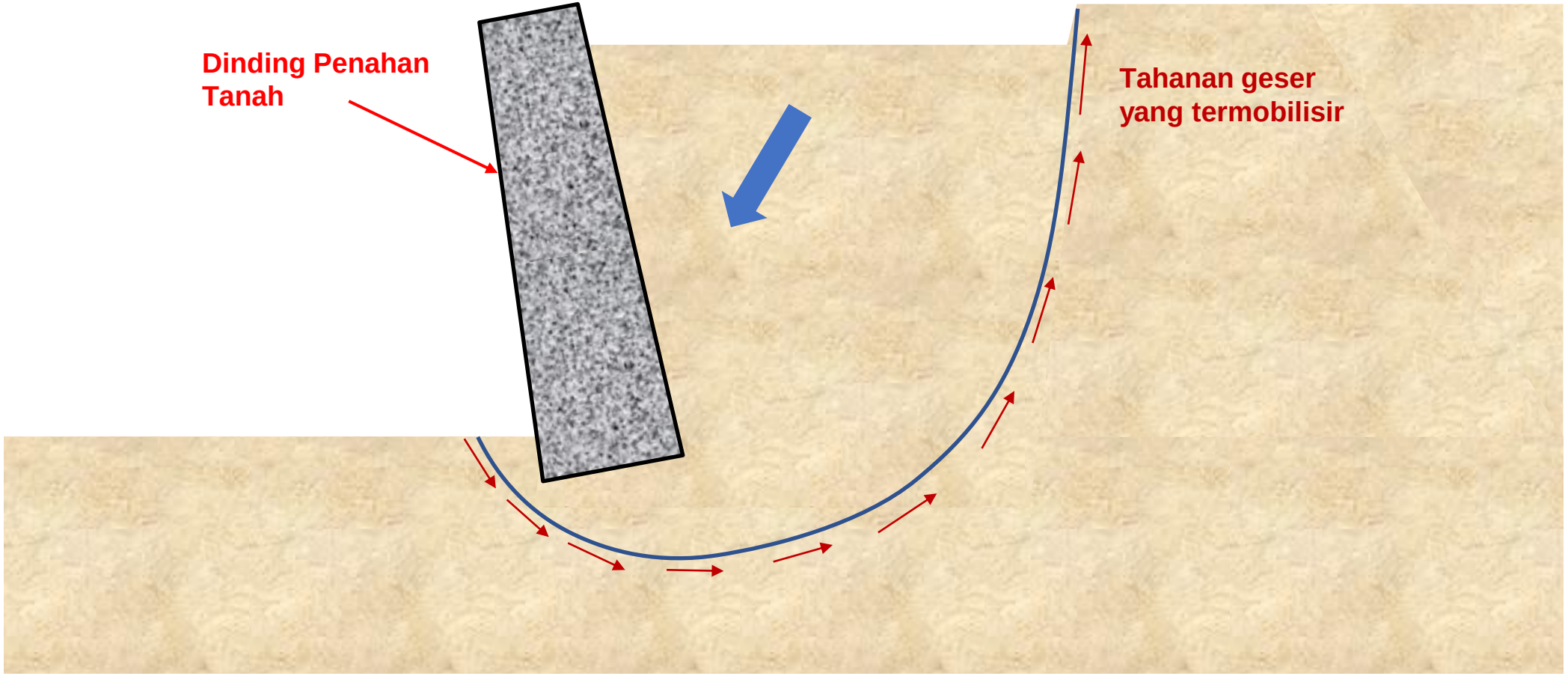


Saat terjadi keruntuhan, tegangan geser di permukaan keruntuhan telah mencapai kekuatan gesernya (tahanan geser yang termobilisir)

Keruntuhan Geser pada Tanah

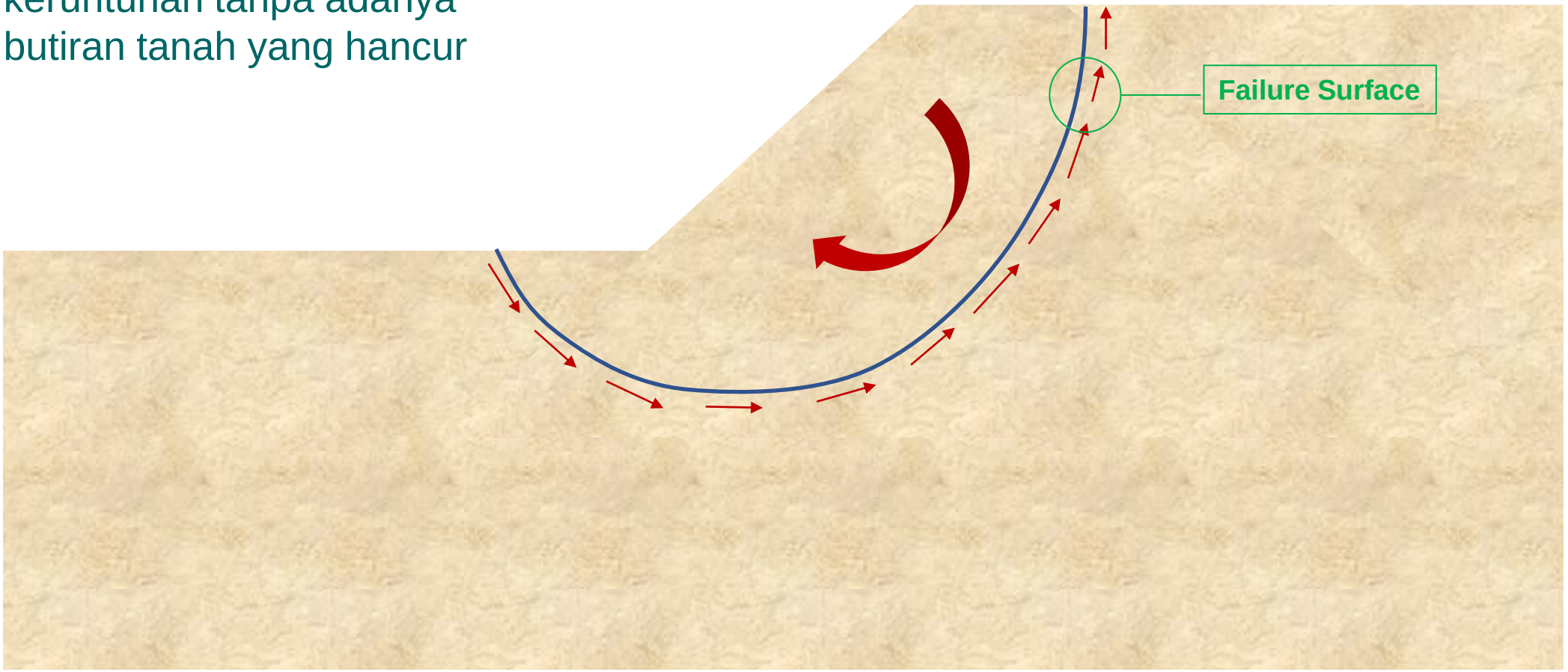
Tanah umumnya runtuh akibat geser

Saat terjadi keruntuhan, tegangan geser di bidang runtuh telah mencapai kekuatan gesernya (tahanan geser yang termobilisir)



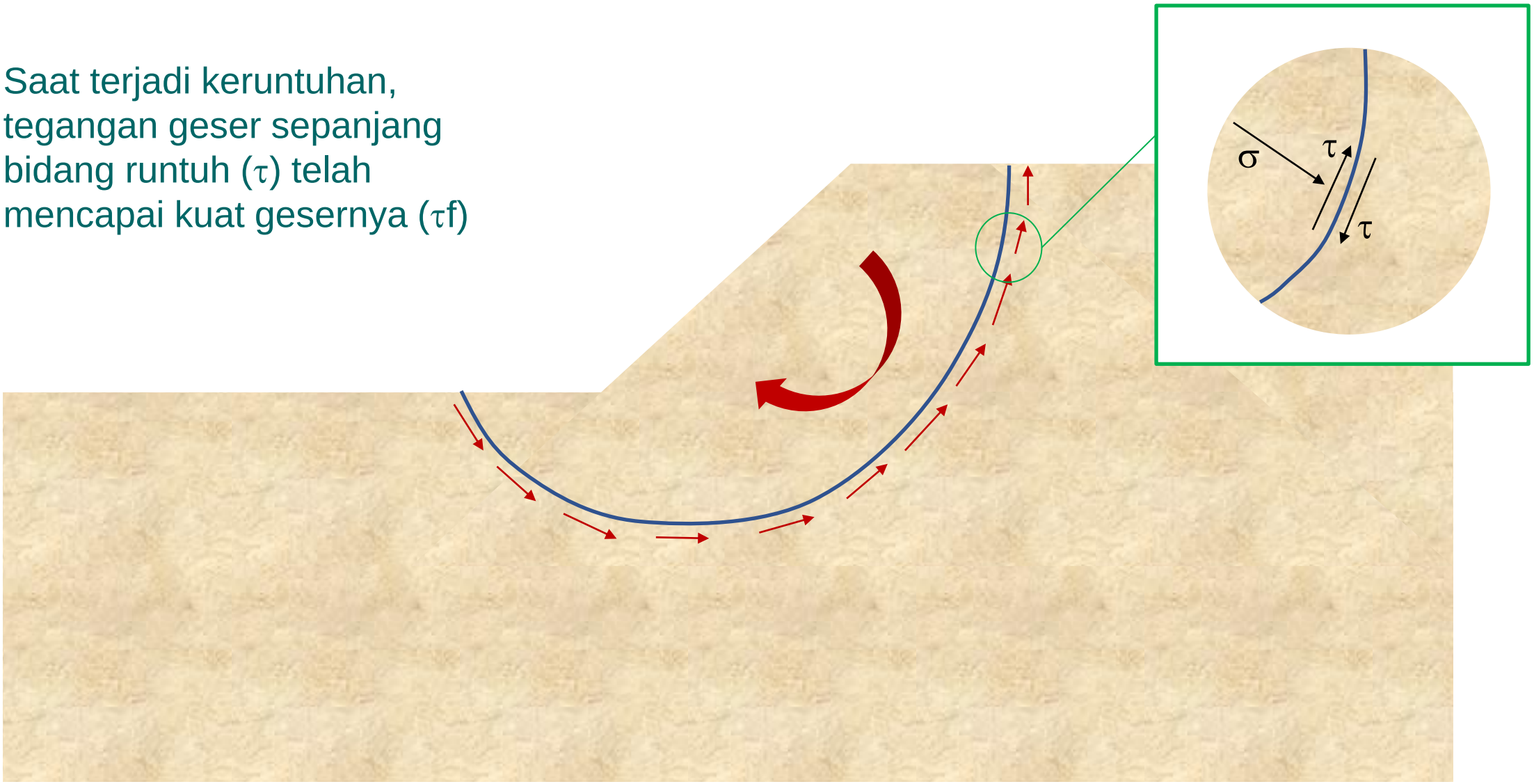
Mekanisme Keruntuhan Geser

Butiran tanah bergeser satu sama lain sepanjang bidang keruntuhan tanpa adanya butiran tanah yang hancur

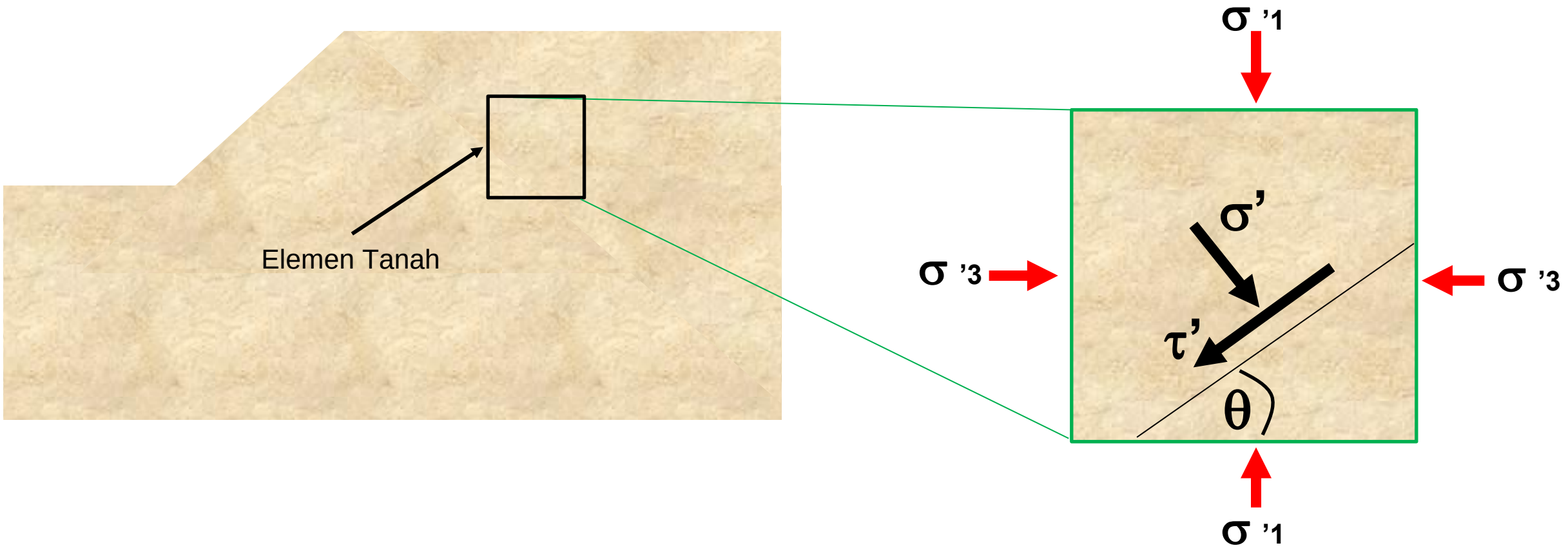


Mekanisme Keruntuhan Geser

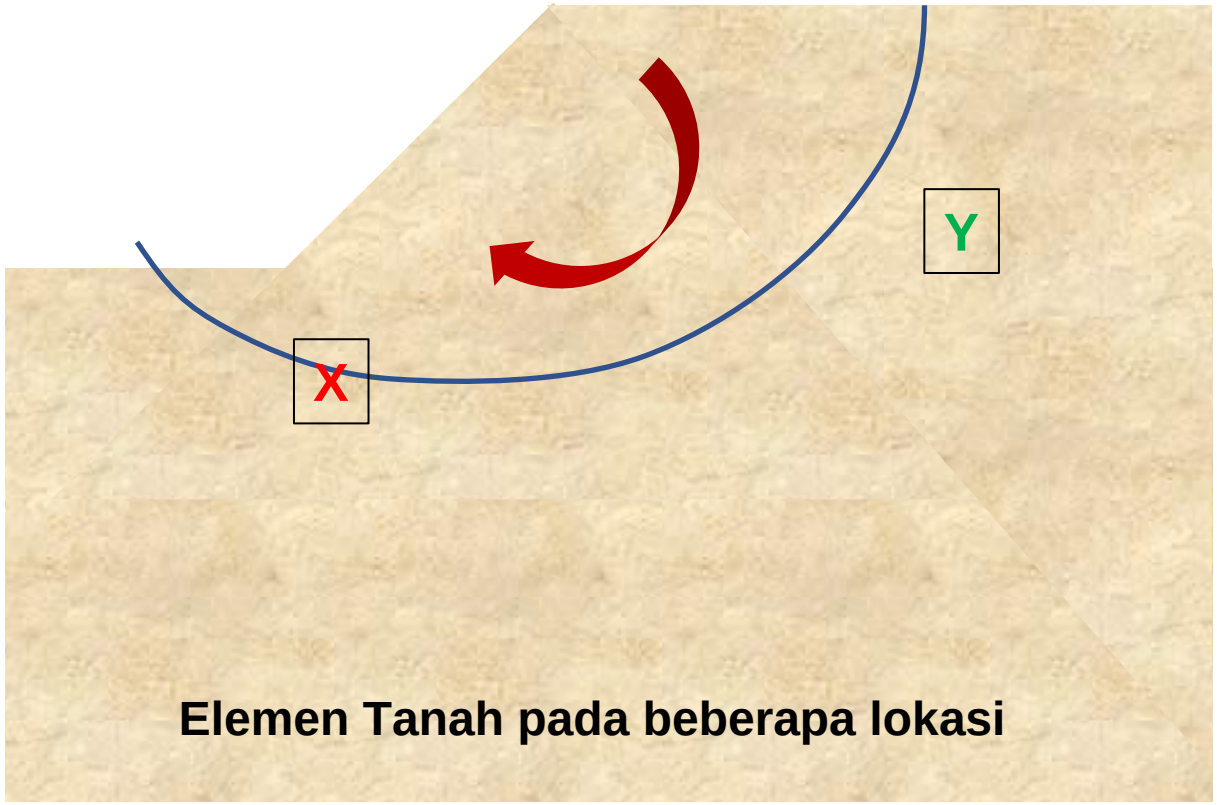
Saat terjadi keruntuhan, tegangan geser sepanjang bidang runtuh (τ) telah mencapai kuat gesernya (τf)



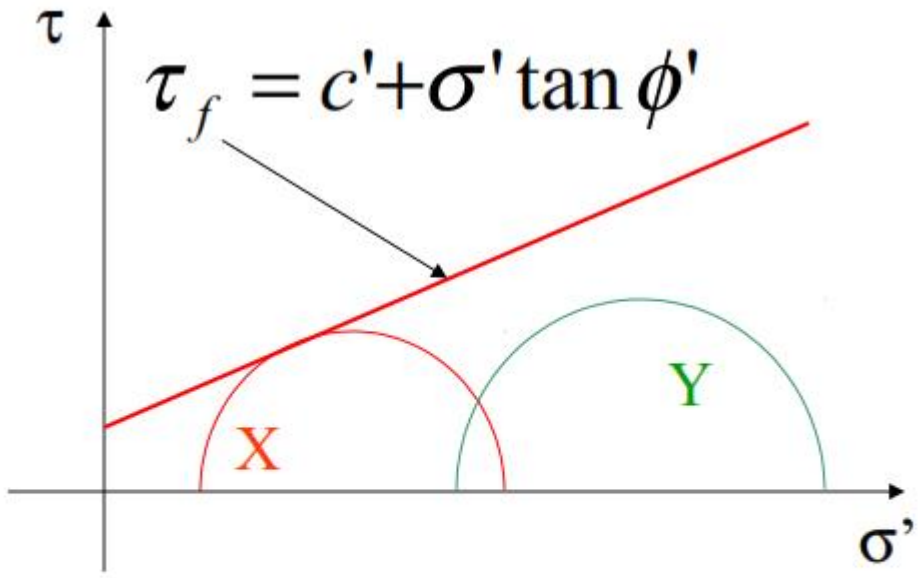
Tegangan pada Lingkaran Mohr



Lingkaran Mohr dan Selubung Keruntuhan



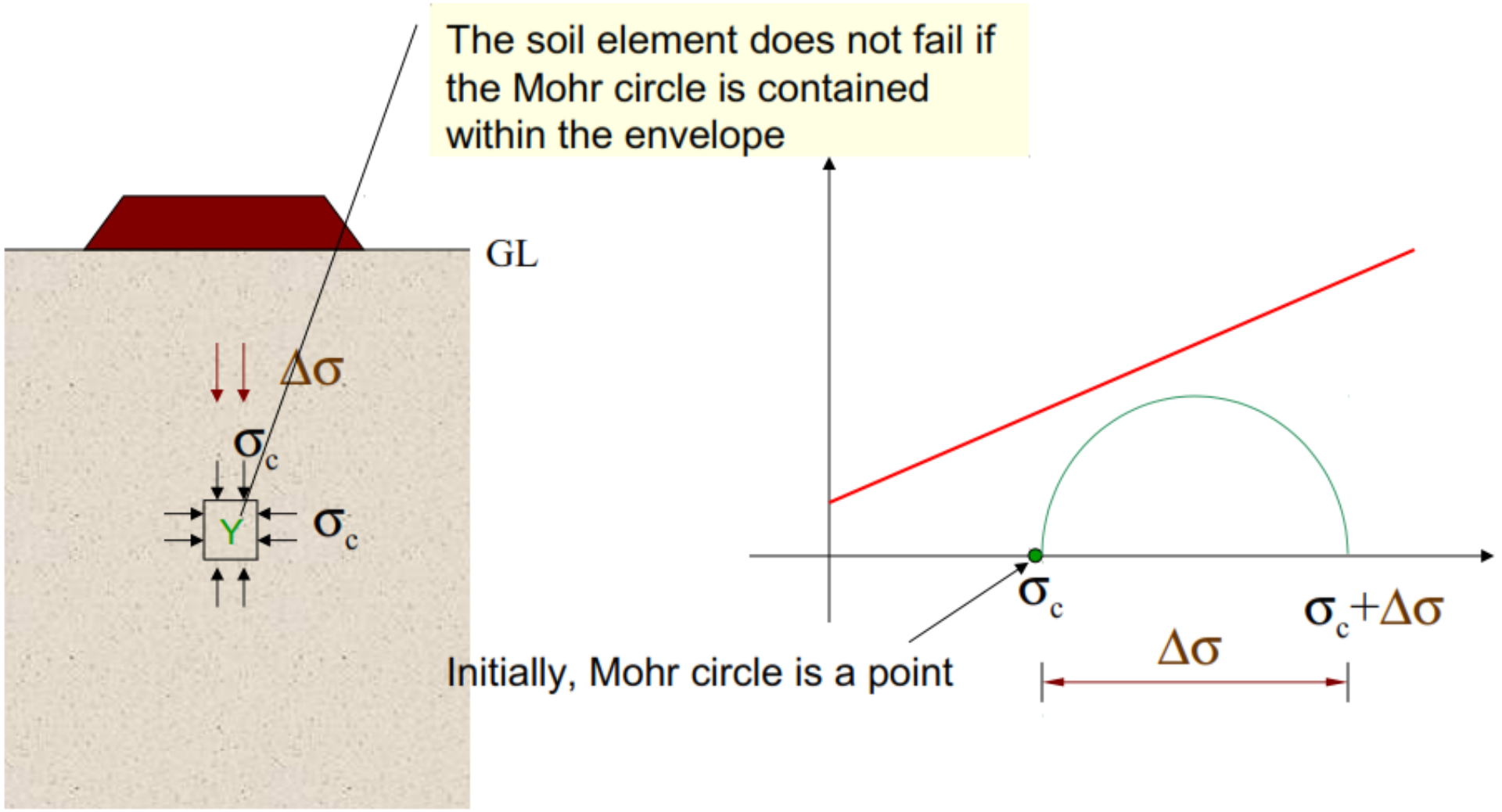
Elemen Tanah pada beberapa lokasi



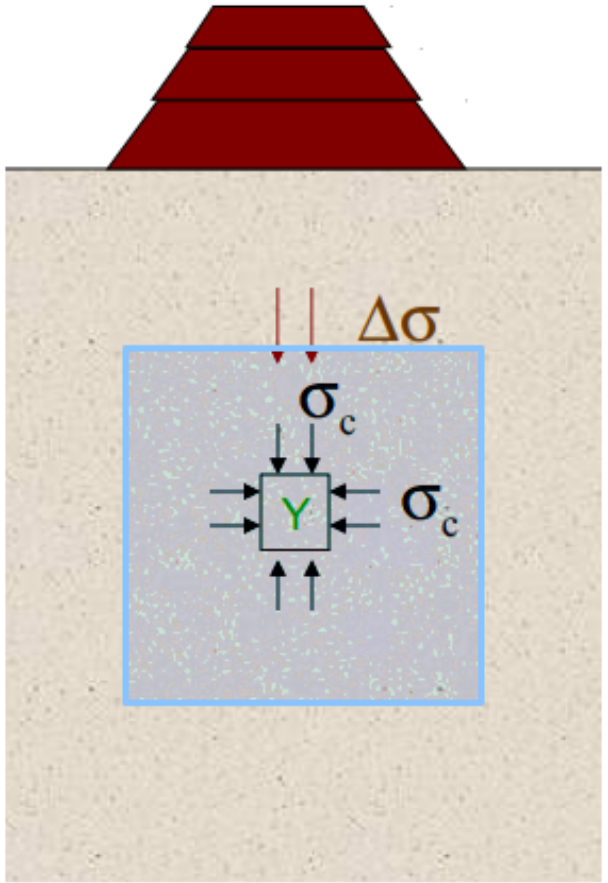
Y ~ stable

X ~ failure

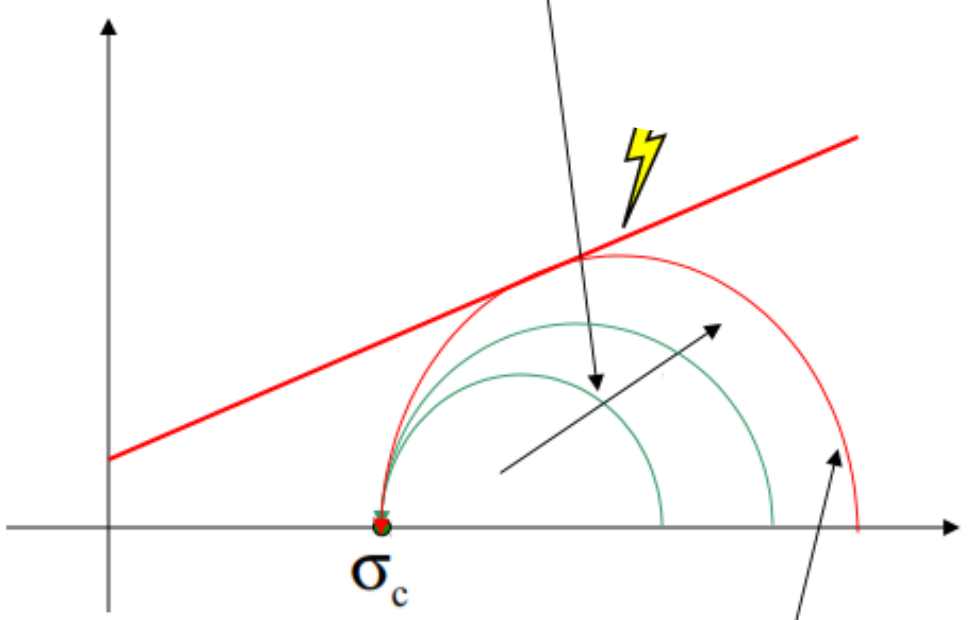
Lingkaran Mohr dan Selubung Keruntuhan



Lingkaran Mohr dan Selubung Keruntuhan

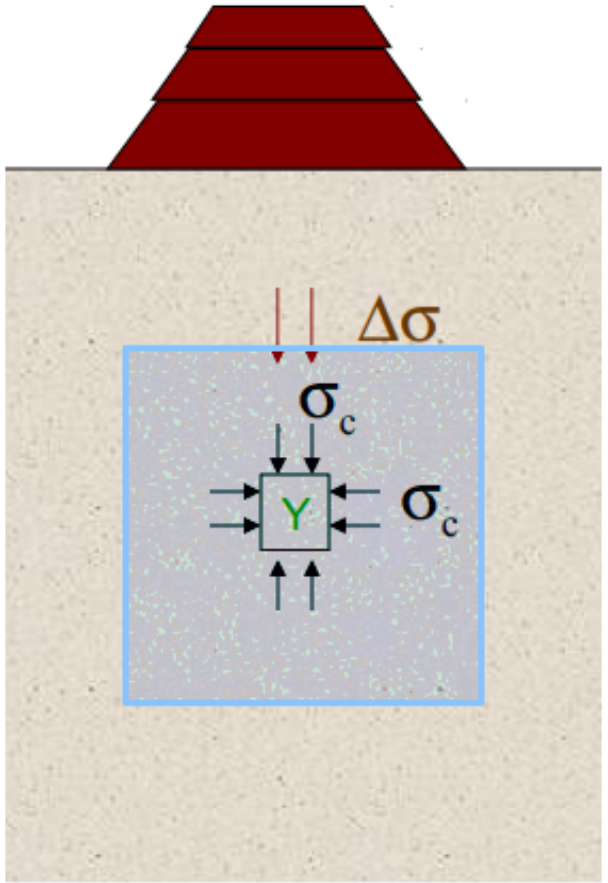


As loading progresses, Mohr circle becomes larger…



.. and finally failure occurs when Mohr circle touches the envelope

Lingkaran Mohr dan Selubung Keruntuhan



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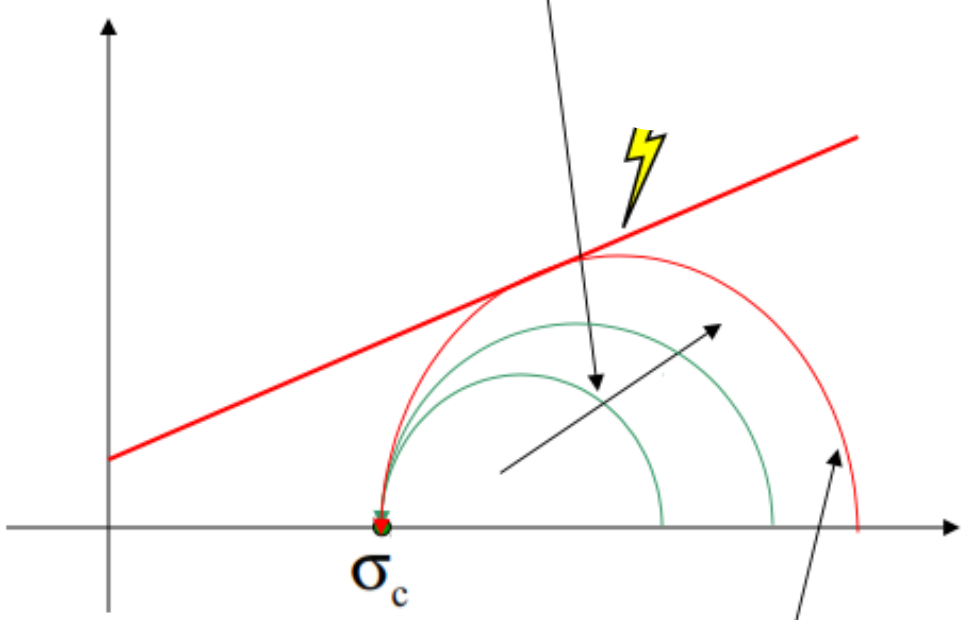

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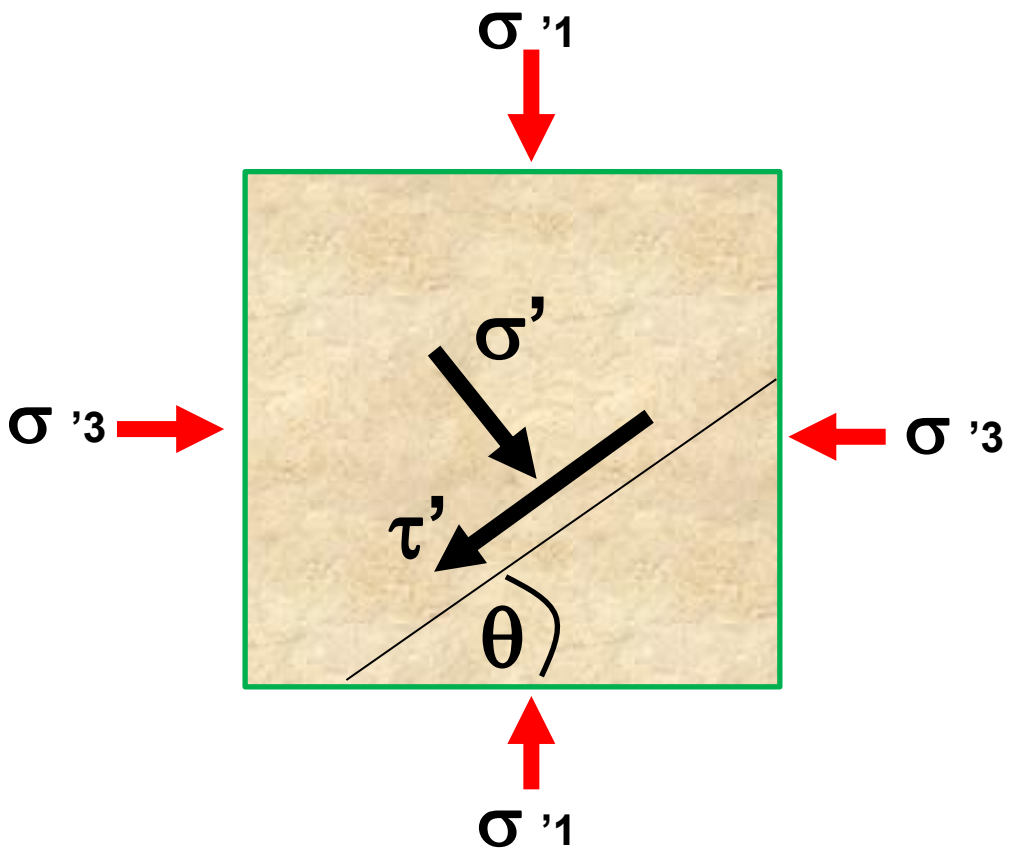
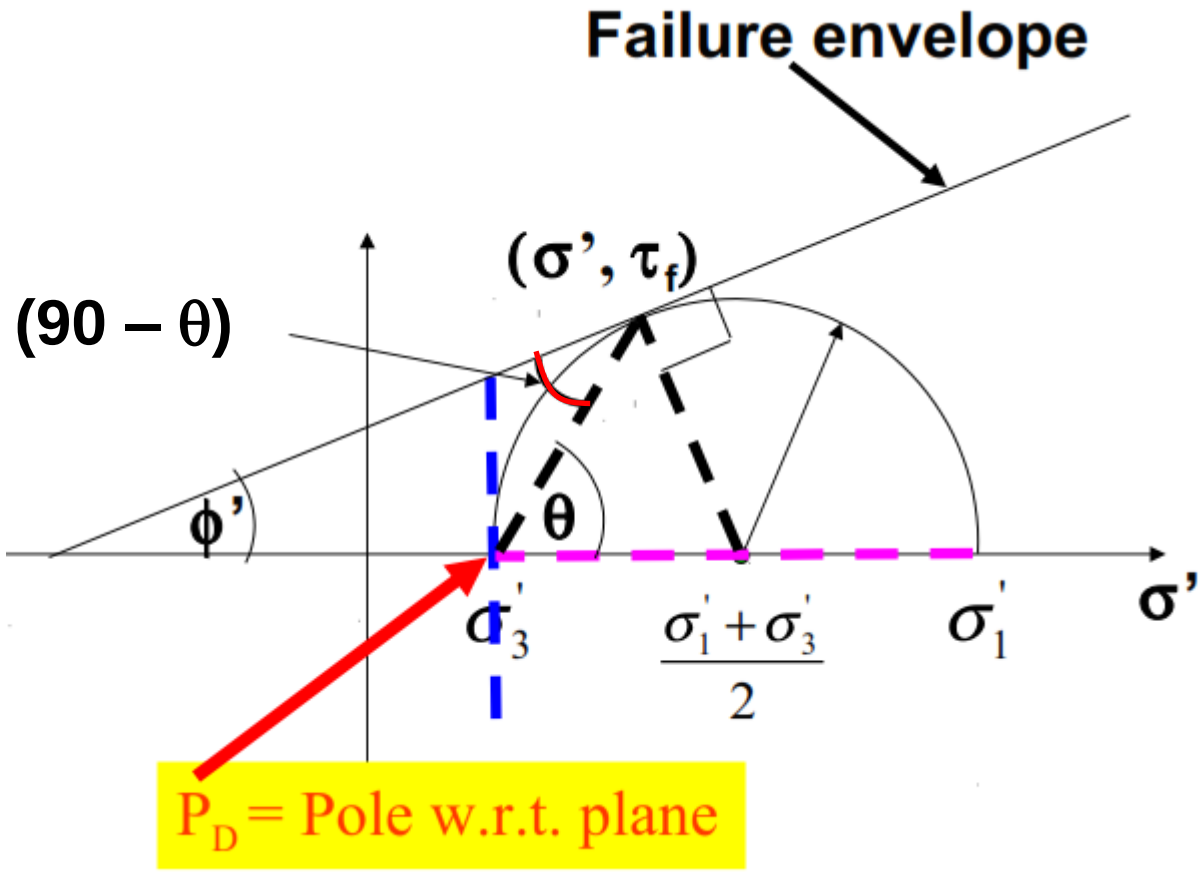
Arah Bidang Runtuh



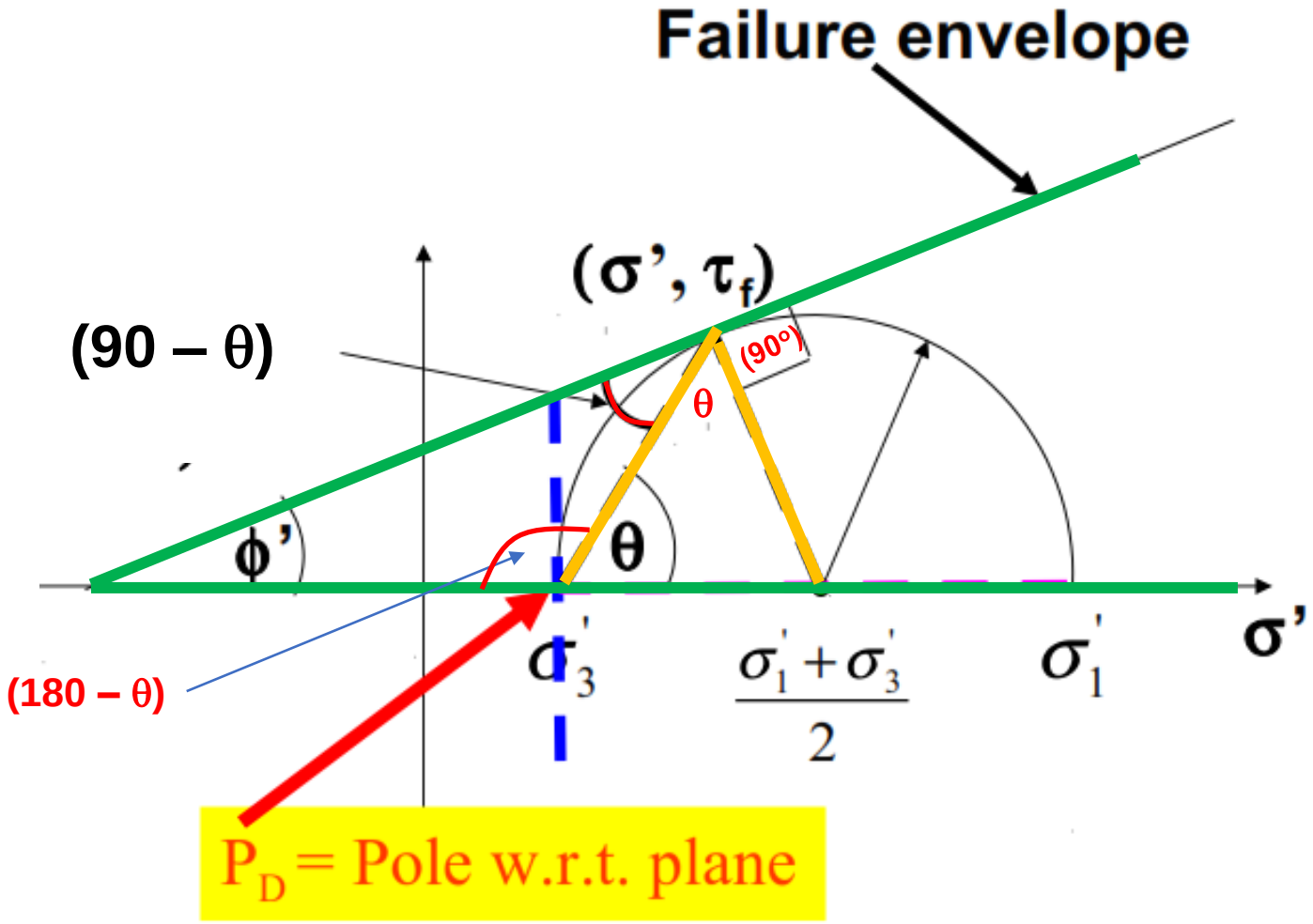


Therefore,

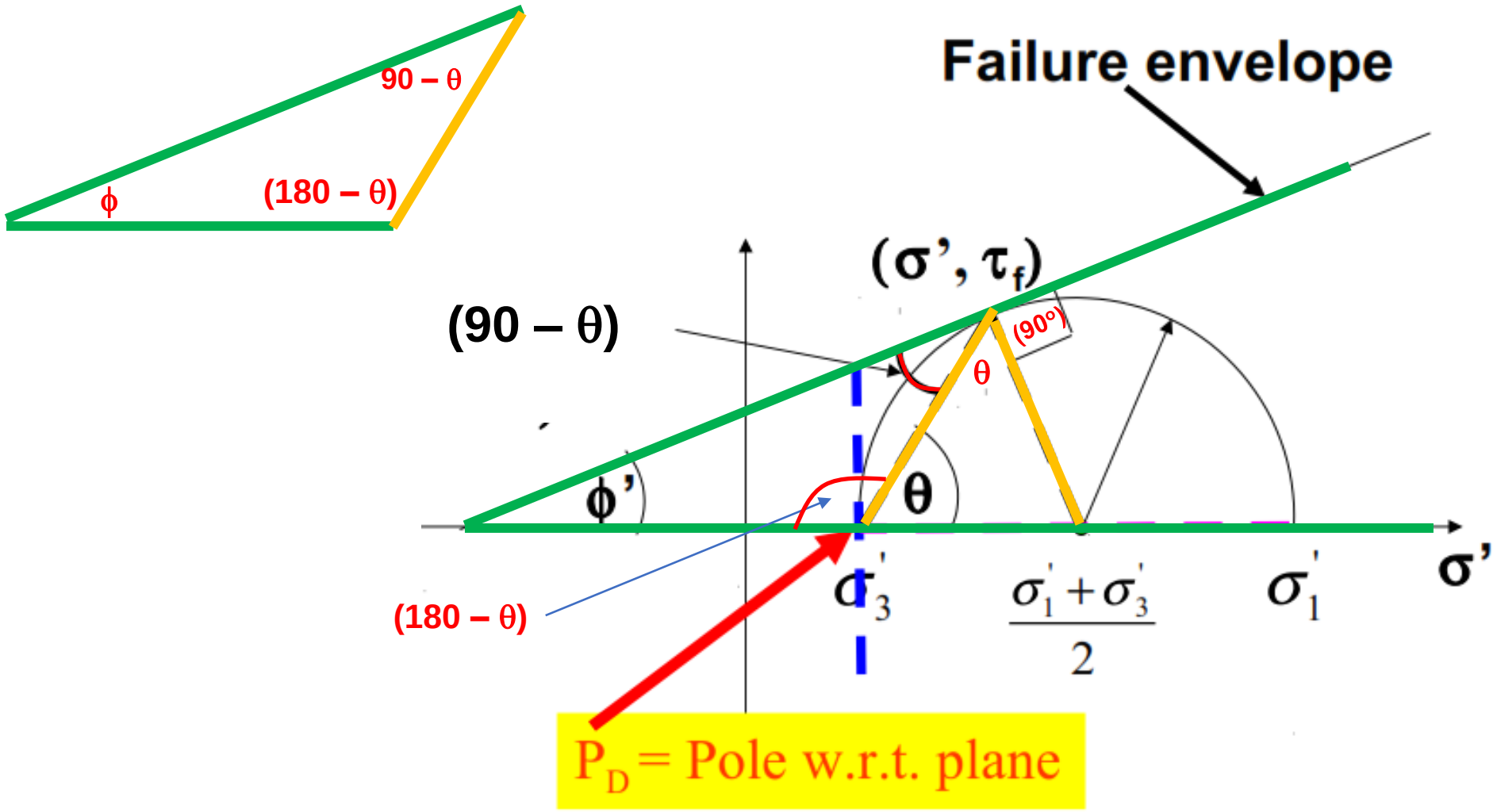
$90 - \theta + \phi' = \theta$

$\theta = 45 + \phi'/2$

Arah Bidang Runtuh



Arah Bidang Runtuh



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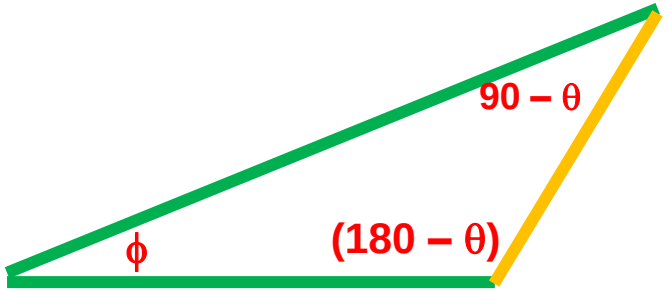
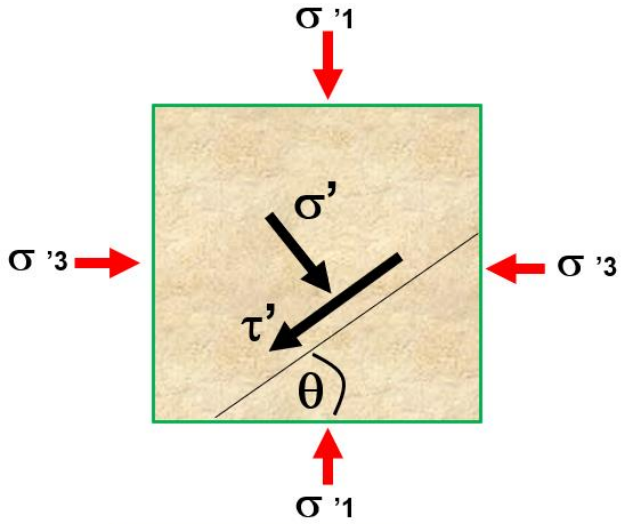


$\cancel{180^o} = \phi + (90^o - \theta) + (\cancel{180^o} - \theta)$

$0^o = \phi + 90^o - 2\theta$

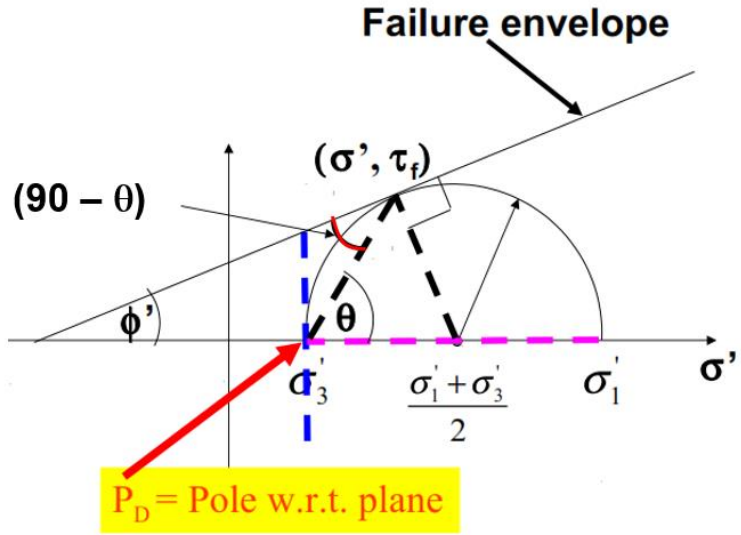
$2\theta = \phi + 90^o$

$\theta = \phi/2 + 45^o$

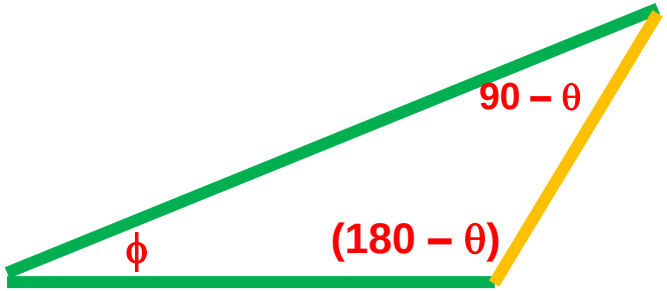


Therefore,

$90 - \theta + \phi' = \theta$ → **$\theta = 45 + \phi'/2$**



Arah Bidang Runtuh

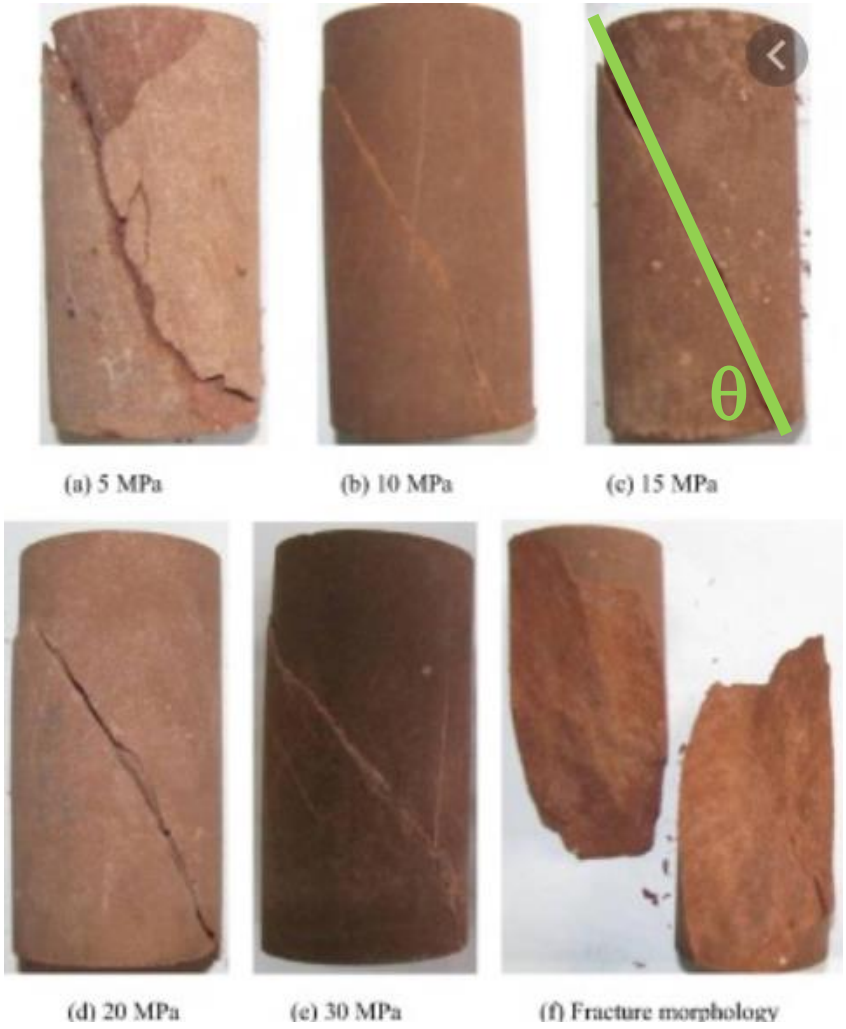


$$\cancel{180^o} = \phi + (90^o - \theta) + (\cancel{180^o} - \theta)$$

$$0^o = \phi + 90^o - 2\theta$$

$$2\theta = \phi + 90^o$$

$$\theta = \phi/2 + 45^o$$



Pengujian parameter kuat geser tanah

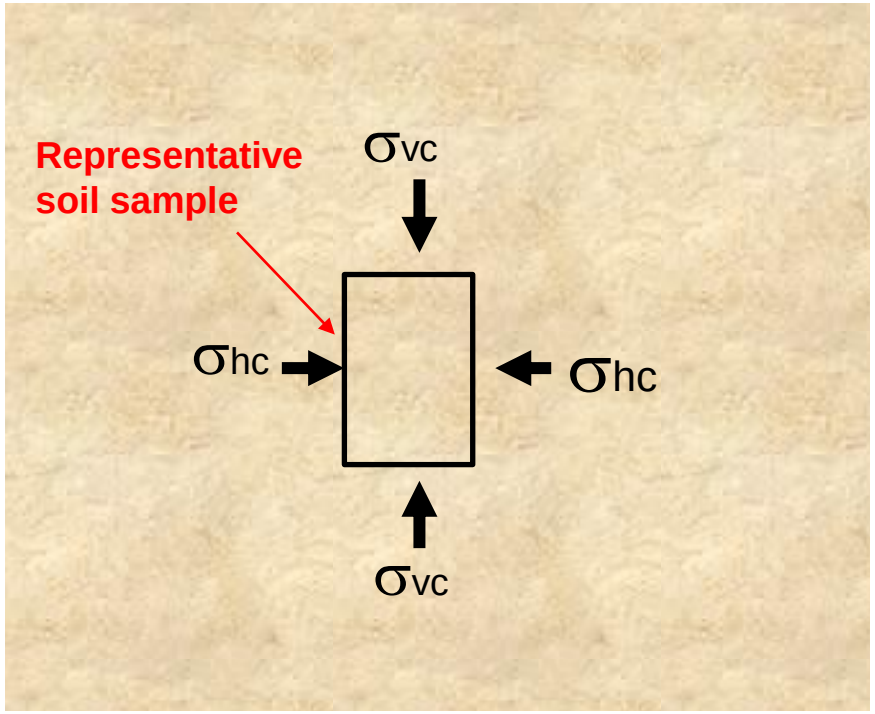
Pengujian Laboratorium

1. Uji Geser Langsung (Direct Shear Test)
2. Uji Triaxial (Triaxial Test)
3. Uji Kuat Tekan Bebas (Unconfined Compressive Strength Test)

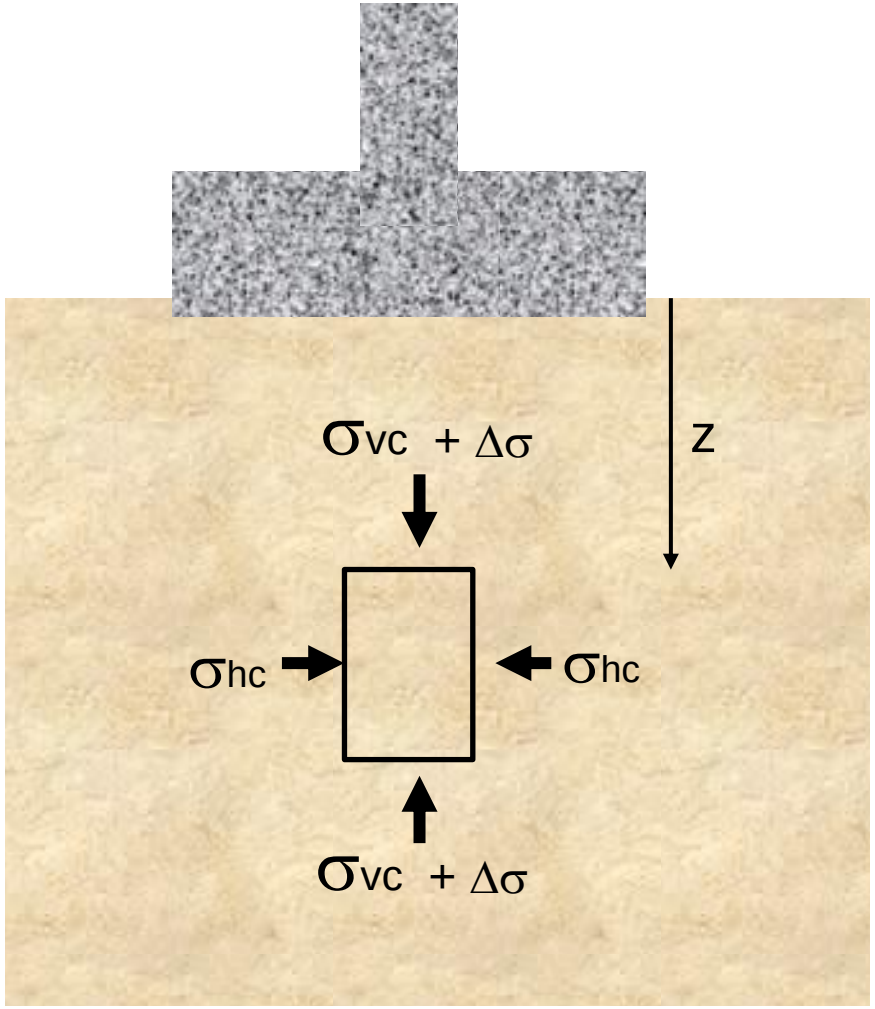
Pengujian Lapangan

1. Uji Vane shear
2. Pressure Meter

Laboratory Test



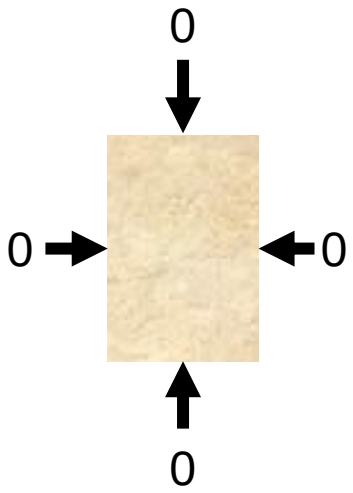
Before Construction



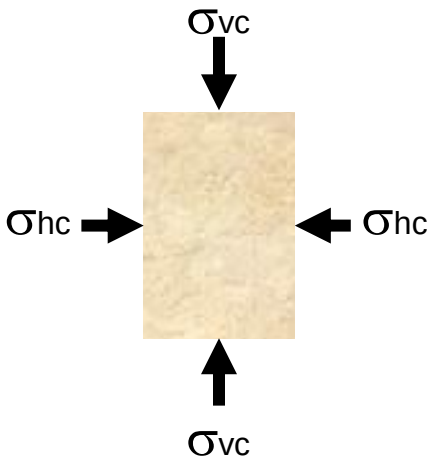
After and during Construction

Laboratory Test

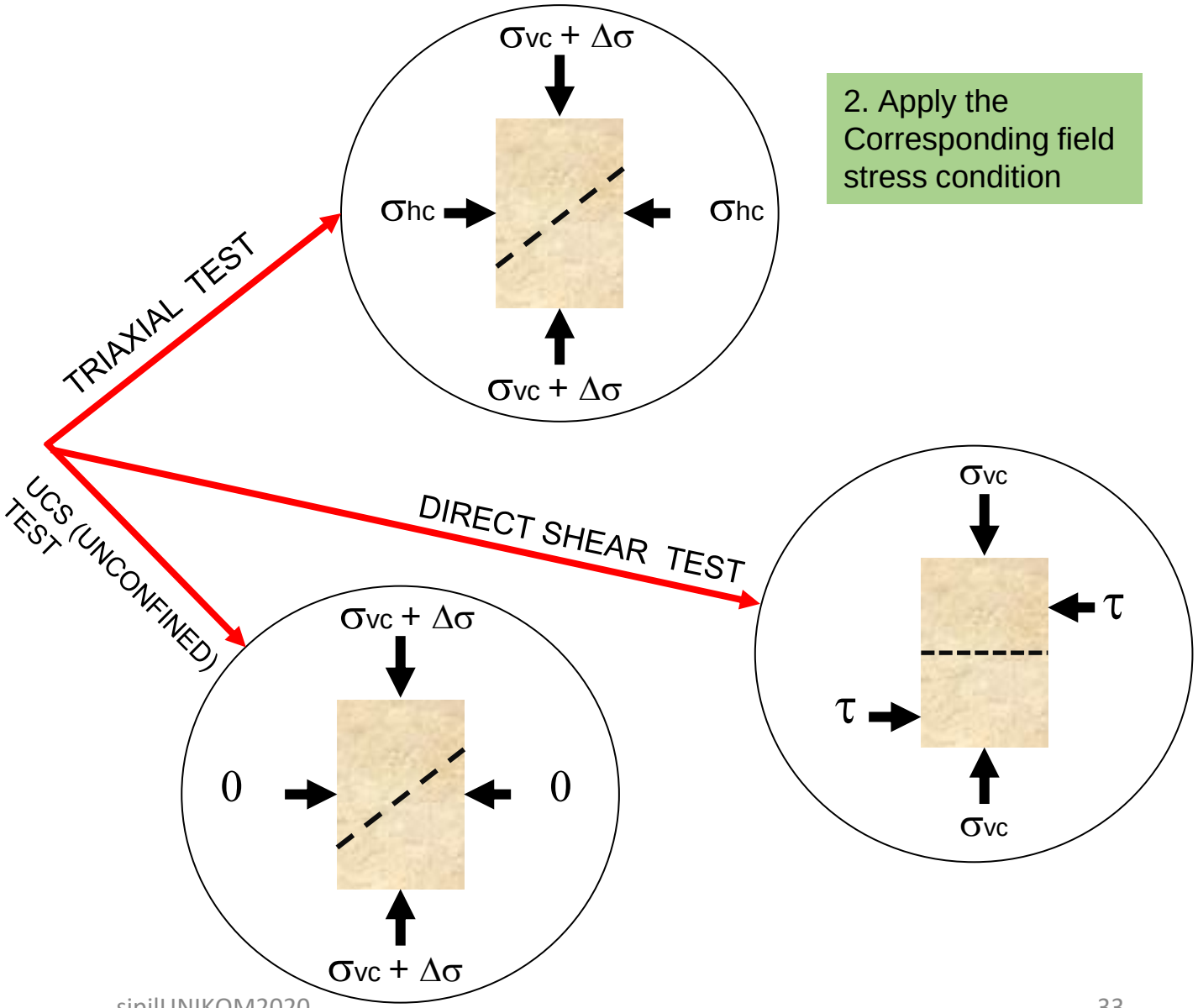
Simulating Field Condition in the Laboratory



Representative soil sample taken from the site

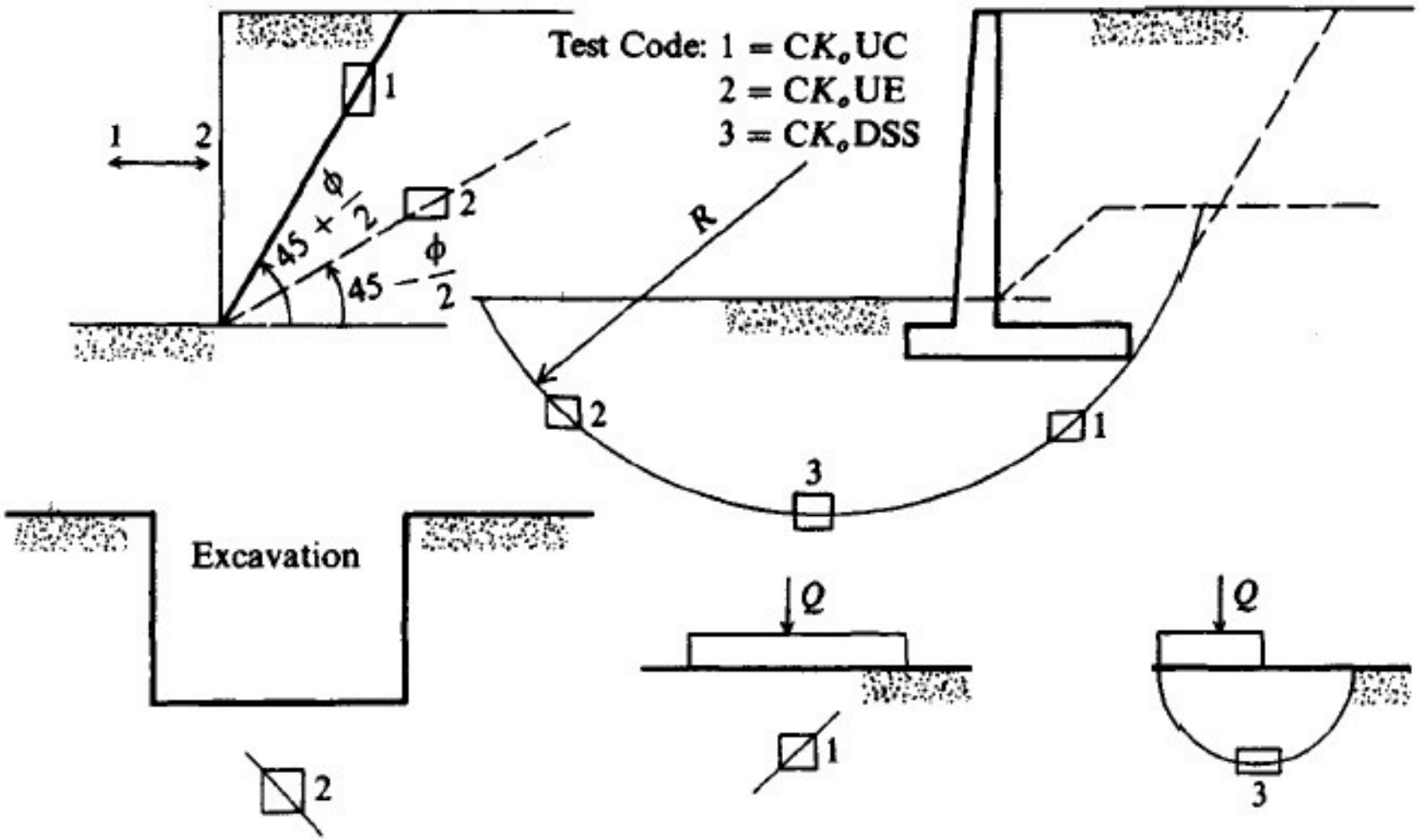


1. Set the specimen In the apparatus and apply the initial Stress condition

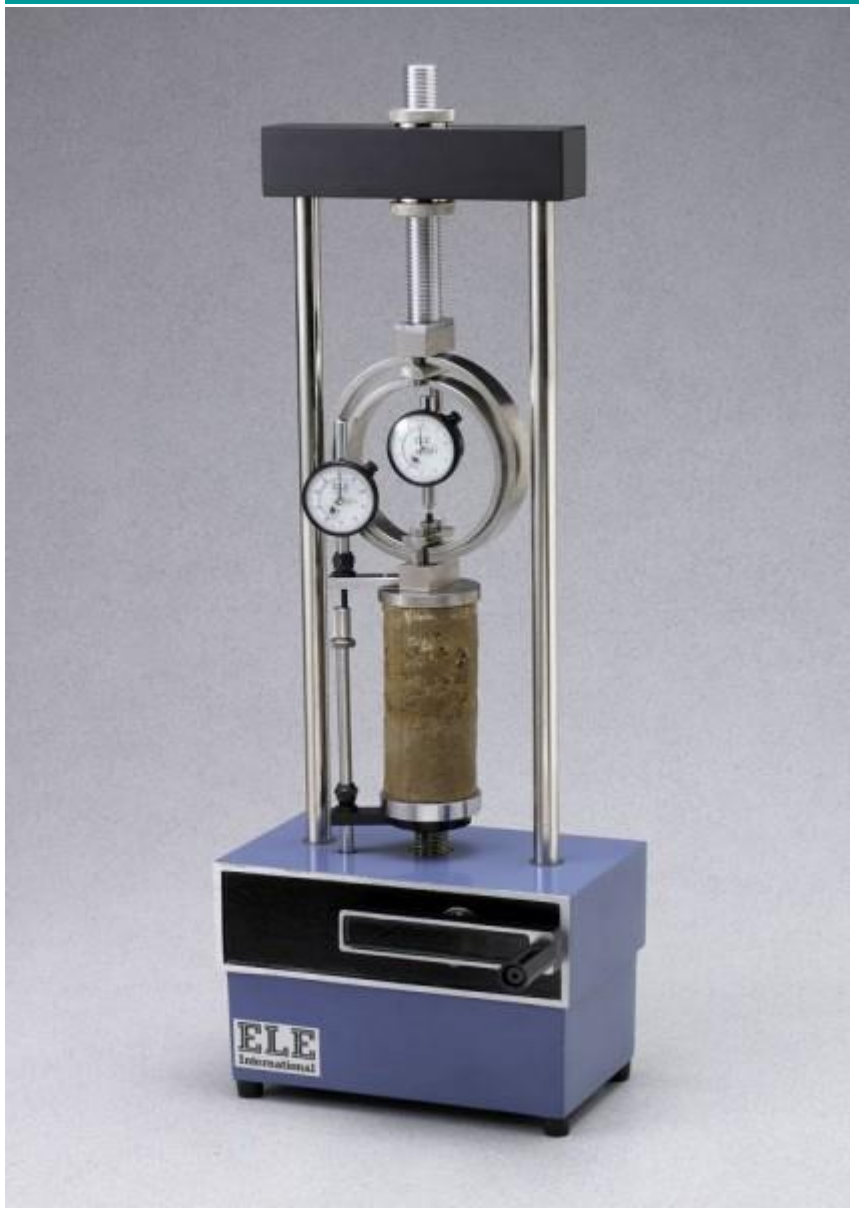


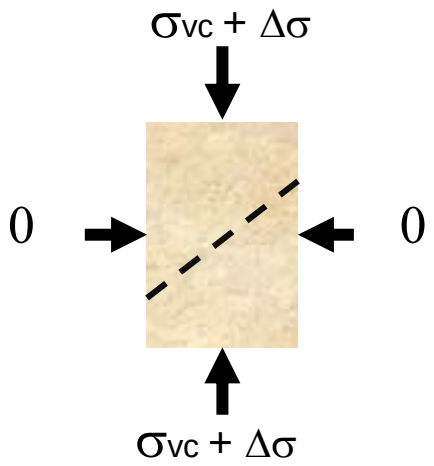
2. Apply the Corresponding field stress condition

Aplikasi

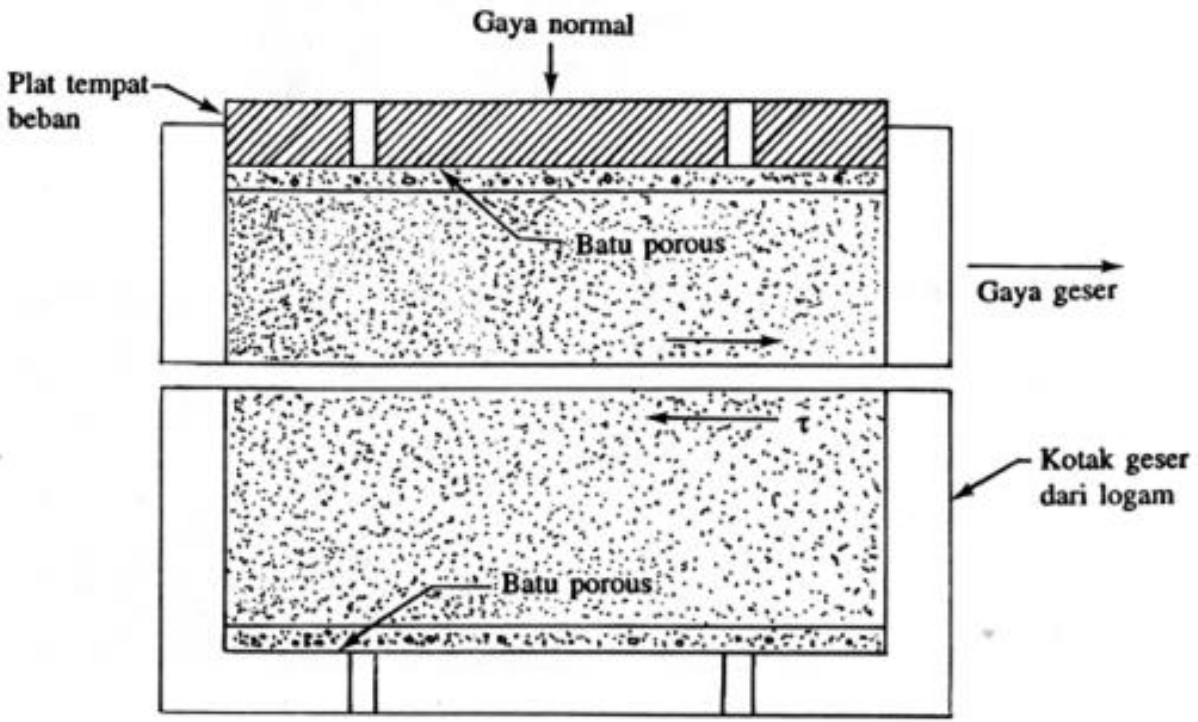

Test Code: 1 = CK$_o$UC
2 = CK$_o$UE
3 = CK$_o$DSS
1
2
45 + ϕ/2
45 − ϕ/2
R
Excavation
Q
Q

Unconfined Compression Test



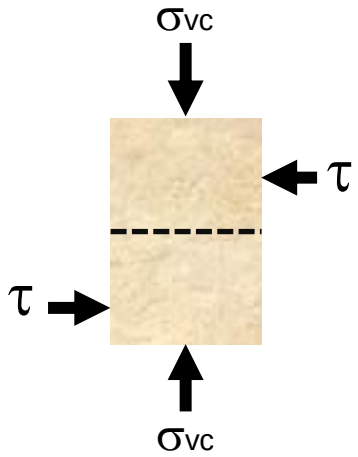


Uji Geser Langsung (Direct Shear Test)



Gambar 9-4 Diagram susunan alat uji geser langsung.

Ni : Beban Vertikal (normal)
Ti. : Gaya horisontal yang diperlukan untuk menggeser ring (tanah)
A : luas penampang tanah
Si : lintasan yang diperlukan sampai tanah tergeser



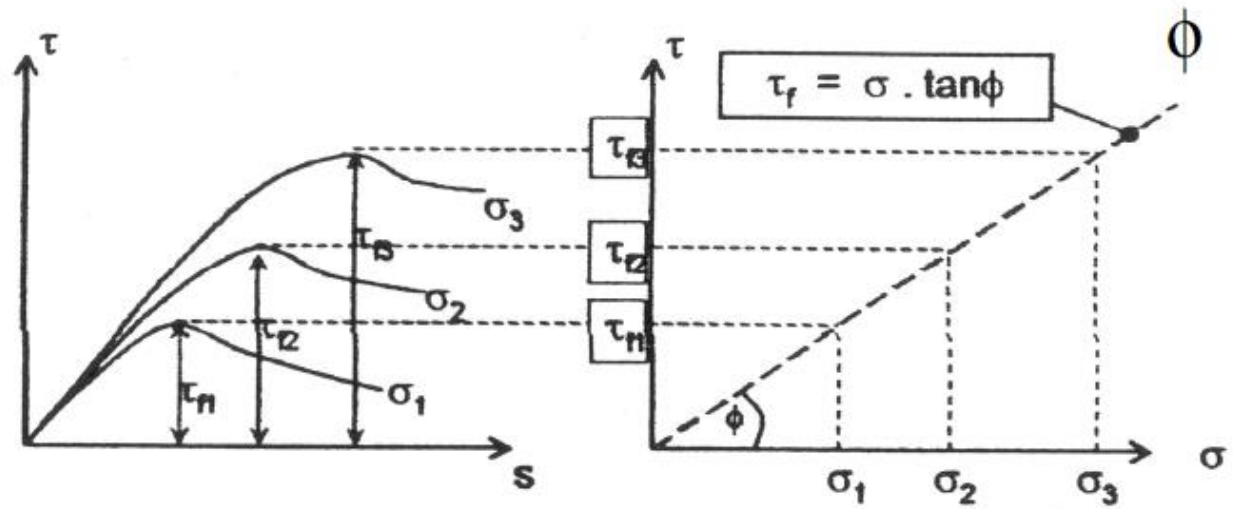
Direct Shear Test pada Tanah Pasir

Uji 1 : $\sigma_1 = \frac{N_1}{A} : \tau_1 = \frac{T_1}{A} : S_1$

Uji 1 : $\sigma_2 = \frac{N_2}{A} : \tau_2 = \frac{T_2}{A} : S_2$

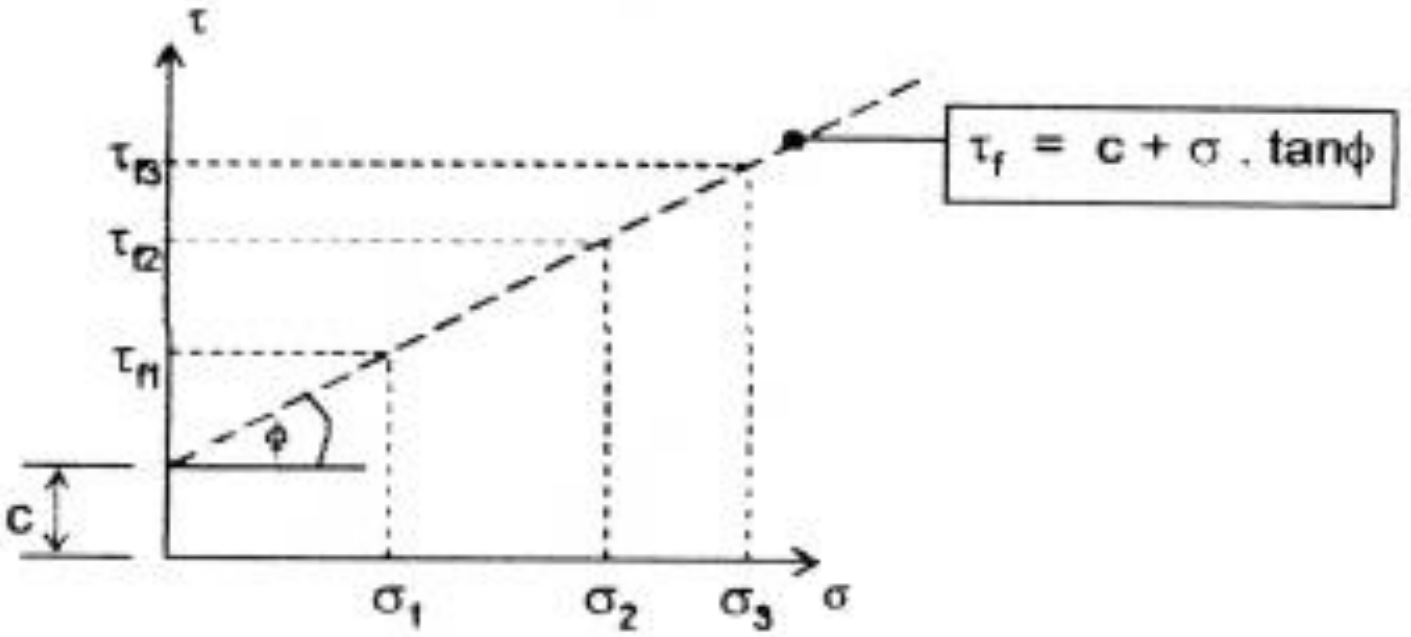
Uji 1 : $\sigma_3 = \frac{N_3}{A} : \tau_3 = \frac{T_3}{A} : S_3$

Hasil Uji



ϕ = sudut geser dalam

Direct Shear Test pada Tanah Lempung



ϕ : sudut geser dalam

c : kohesi [kN/m^2]

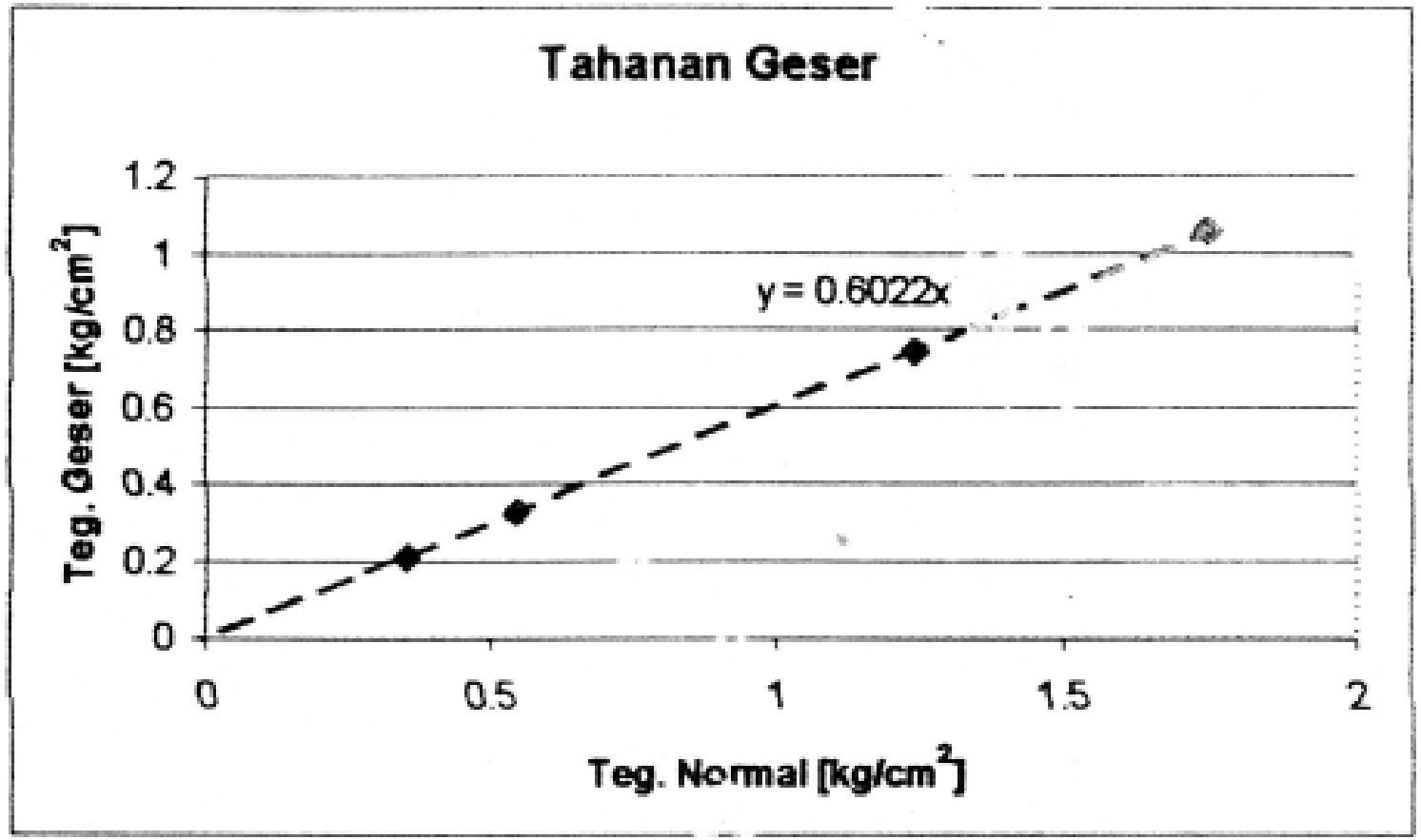
Uji Geser Langsung (Direct Shear Test)

Contoh Tanah Pasir

Luas Sample: A = (5.08*5.08) cm^2

No. Uji	Arah Normal		Arah Geser	
	Gaya	Tegangan	Gaya	Tegangan
	kg	kg/cm^2	kg	kg/cm^2
1	9	0.348751	5.44	0.210924
2	14	0.542501	8.30	0.32166
3	32	1.240002	19.10	0.739993
4	45	1.743753	27.26	1.056638

Uji Geser Langsung (Direct Shear Test)



$\Phi = a \tan(0{,}6022) = 31^{o}$

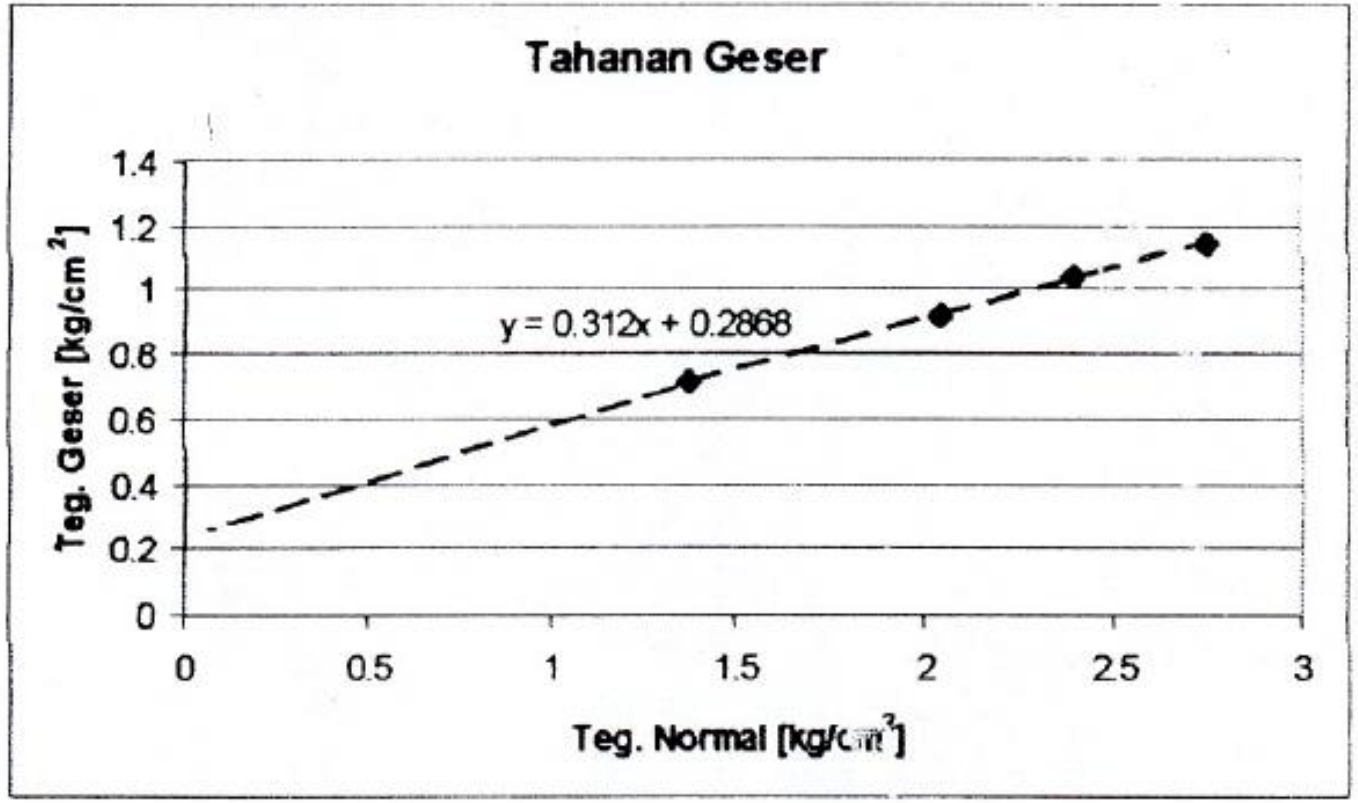
$c = 0$

Uji Geser Langsung (Direct Shear Test)

Contoh Tanah Pasir

Diameter Sample: D = 5.08 cm

No. Uji	Arah Normal		Arah Geser	
	Gaya	Tegangan	Gaya	Tegangan
	kg	kg/cm^2	kg	kg/cm^2
1	27	1.374545	14.06	0.715782
2	40	2.036363	18.06	0.919418
3	47	2.392727	20.41	1.039054
4	54	2.749091	22.43	1.141891



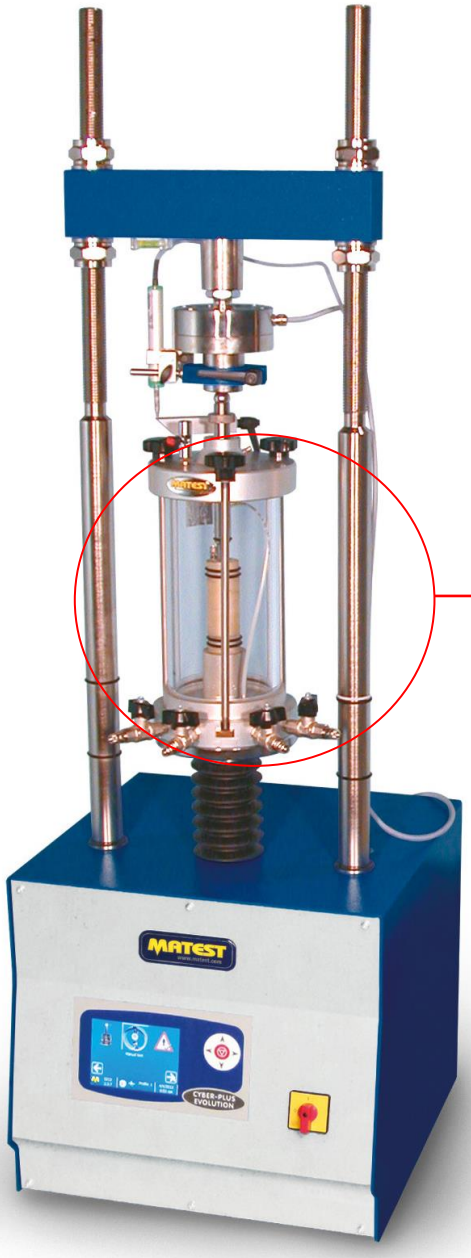
ϕ = atan(0.312) = 17.32^0
c = 0.2868 kg/cm^2

Uji Triaxial (Triaxial Test)

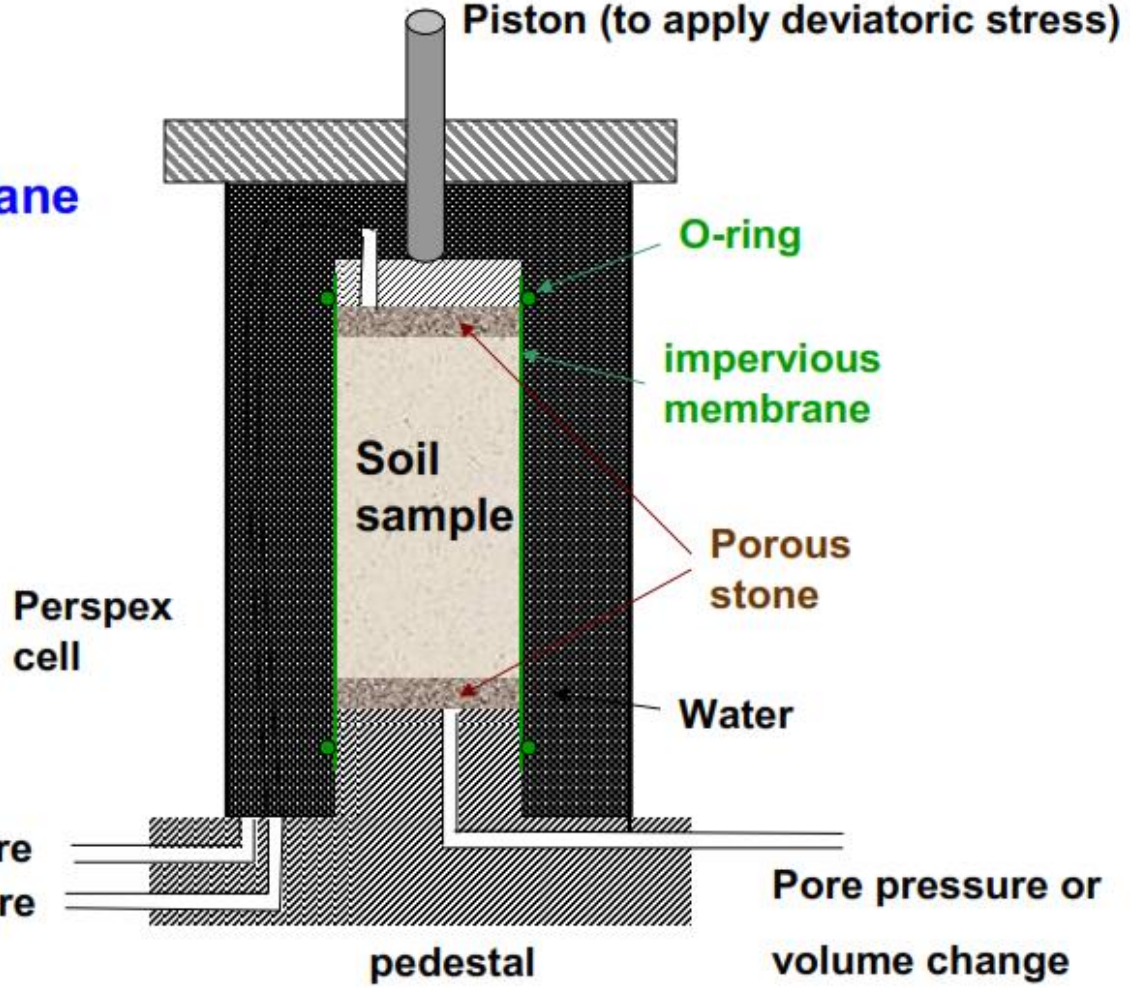
Tiga tipe standard dari uji triaxial yang biasanya dilakukan

1. Consolidated-drained test atau drained test (CD test)
2. Consolidated-undrained test (CU test)
3. Unconsolidated-undrained test atau undrained test (UU test)

Uji Triaxial (Triaxial Test)



Soil sample at failure



Uji Triaxial (Triaxial Test)

Specimen preparation (undisturbed sample)

Edges of the sample are carefully trimmed

Setting up the sample in the triaxial cell

Uji Triaxial (Triaxial Test)

Specimen preparation (undisturbed sample)

Sample is covered with a rubber membrane and sealed

Cell is completely filled with water

Uji Triaxial (Triaxial Test)

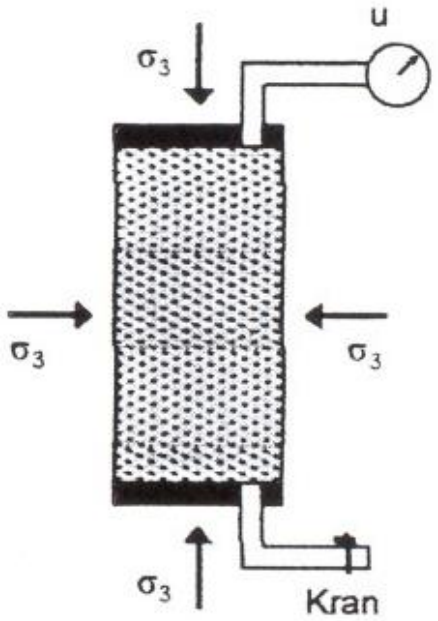
Specimen preparation (undisturbed sample)

Proving ring to measure the deviator load

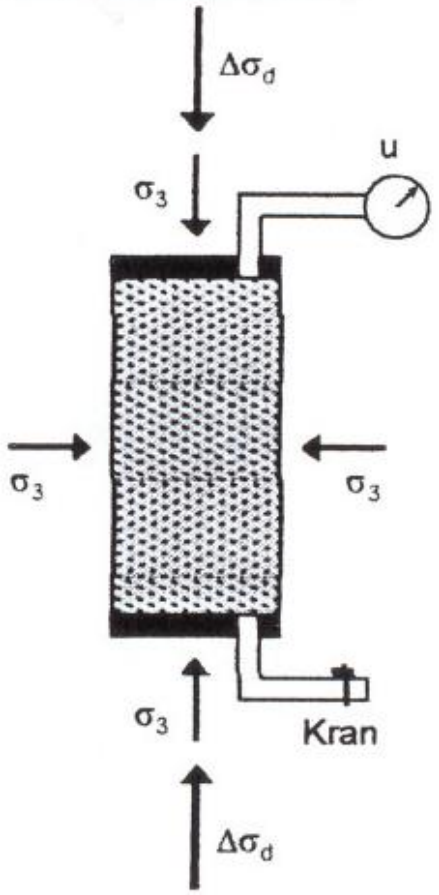
Dial gauge to measure vertical displacement

Prinsip Uji Triaxial

Tahap 1:
Confining Pressure



Tahap 2:
Shear Pressure



Pemberian Beban:

σ_3 : konstan

$\Delta\sigma_d$: bertahap sampai runtuh $(\Delta\sigma_d)_f$

Perbedaan Tipe Standard Pengujian Triaxial

Jenis Uji	Confining Pressure		Shear Pressure	
	Kran	Teg. Air Pori (u)	Kran	Teg. Air Pori (u)
CD	Buka	$u = u_c = 0$	Buka	$u = u_c + \Delta u_d = 0$
CU	Buka	$u = u_c = 0$	Tutup	$u = u_c + \Delta u_d = 0$
UU	Tutup	$u = u_c$	Tutup	$u = u_c + \Delta u_d$