FAMU-FSU College of Engineering

Department of Civil and Environmental Engineering

CEG 3011

Soil Mechanics

Fall 2019

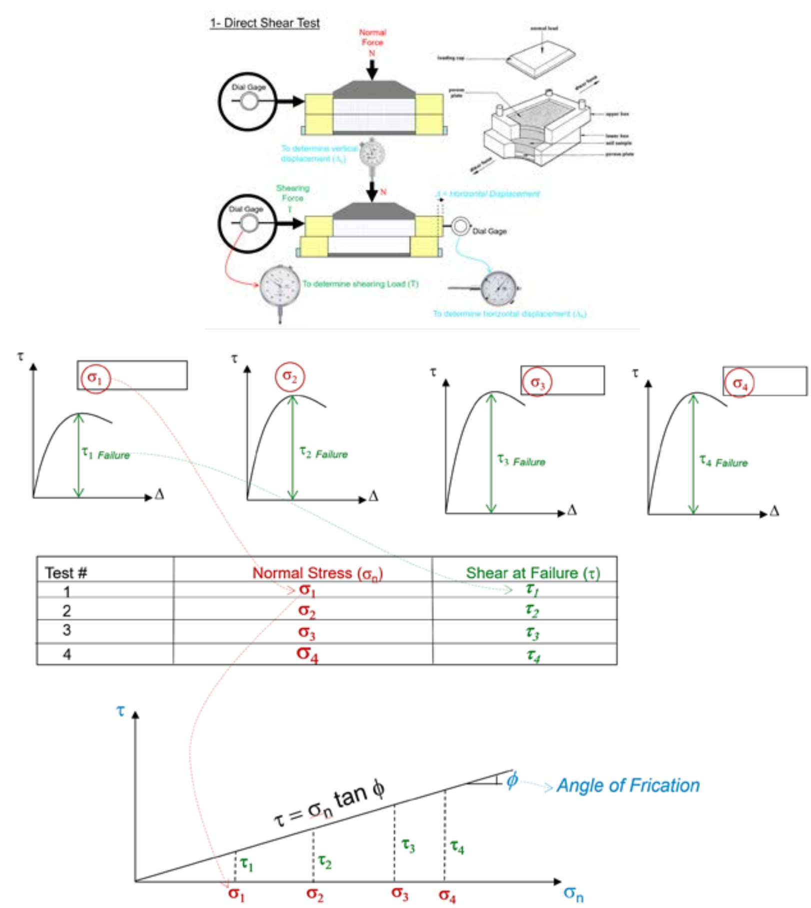
Homework # 8

Soil Strength

Solved the Following Problems

1. The following are the results of four direct shear tests on **sandy soil**. If the size of each specimen is 44 mm x 44 mm, draw a graph for the shear stress at failure against the normal stress, and determine the shear strength parameter of the soil.

Test No.	Normal Force (N)	Shear Force at Failure (N)
1	200	82
2	300	120
3	400	160
4	550	220

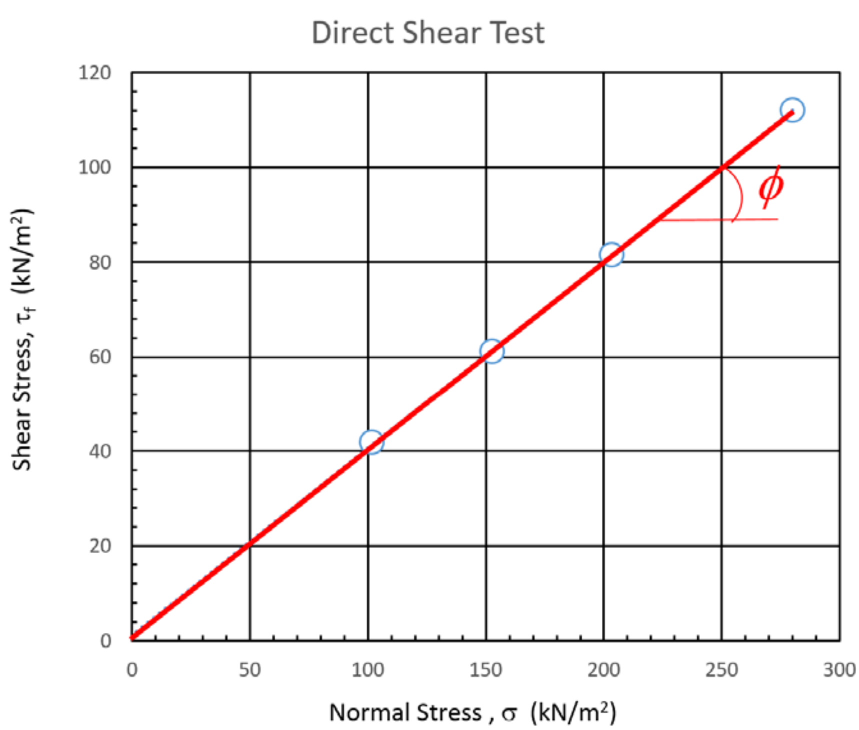


Solution

Area of each specimen = 0.044x0.044 = 0.0019654 m^2

Test No.	Normal Force, N (N)	Shear Force at Failure , S (N)	Normal Stress, σ = N/A (kN/m^2)	Shear Stress, τ_f =S/A (kN/m^2)	$\phi = \tan^{-1}(\tau_f/\sigma)$
1	200	82	101.864	41.72	22.3
2	300	120	152.796	61.06	21.8
3	400	160	203.728	81.41	21.8
4	550	220	280.126	111.94	21.8

A graph of τ_f versus will yield $\phi = 21.9^O$



Example 8.2

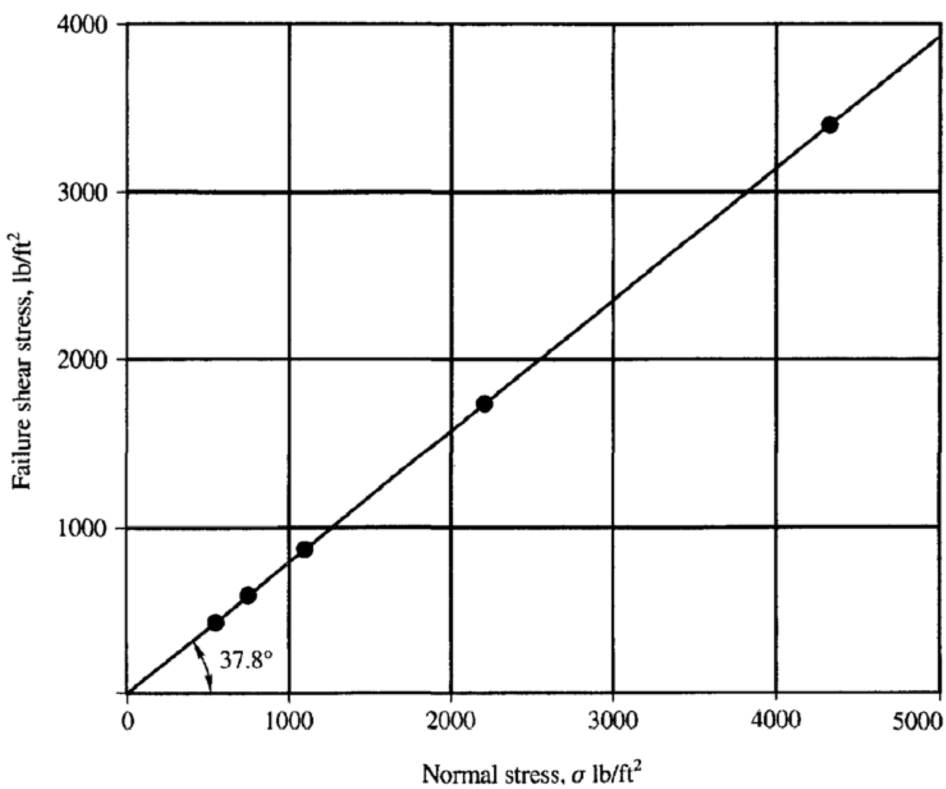
Direct shear tests were conducted on a dry sand. The size of the samples used for the tests was 2 in. × 2 in. × 0.75 in. The test results obtained are given below:

Test No.	Normal load (lb)	Normal stress σ (lb/ft^2)	Shear force at failure (lb)	Shear stress (lb/ft^2)
1	15	540	12	432
2	20	720	18	648
3	30	1080	23	828
4	60	2160	47	1692
5	120	4320	93	3348

Determine the shear strength parameters c and ϕ.

Solution

The failure shear stresses τ_f, as obtained from the tests are plotted against the normal stresses σ, in Figure Ex 8.2. The shear parameters from the graph are: $c = 0$, $\phi = 37.8°$.



Example 6.1.

the top of the sample, and a shear stress is applied by forcing the two halves of the box in opposite directions until failure occurs on the horizontal plane between them. The test is repeated with different normal stresses, and a direct plot is obtained of shear strength against normal stress on the horizontal failure surface.

Example 6.1

The following results were obtained during slow drained tests in a 60 mm shear box on undisturbed samples of a silty clay:

Normal stress	20	40	60	(kN/m^2)
Maximum shear stress	20·6	28·0	38·1	(kN/m^2)

From the diagram (Fig. 6.6),

$$c' = 11\ kN/m^2$$
$$\varphi' = 24°$$

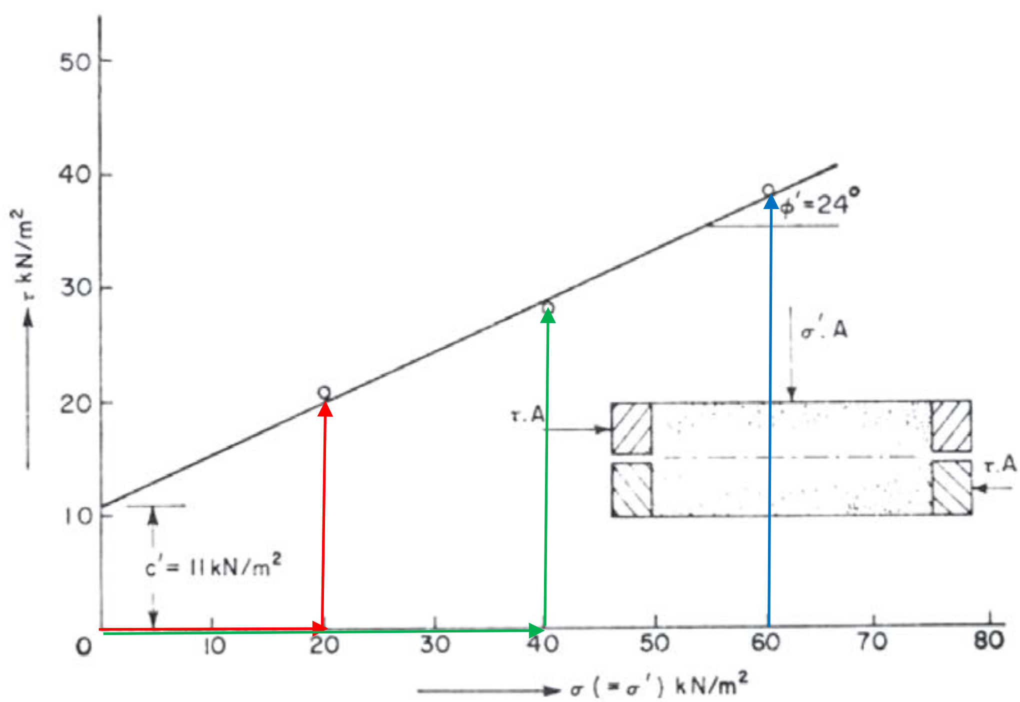


Fig. 6.6 Example 6.1.

EXAMPLE 8-2

Given

A series of direct shear tests was performed on a soil sample with each test carried until the soil specimen experienced shear failure. Test data are listed below.

Specimen Number	*Normal Stress (lb/ft²)*	*Shearing Stress (lb/ft²)*
1	604	1522
2	926	1605
3	1248	1720

Required

The soil's cohesion and angle of internal friction.

Solution

Given data are plotted on a shear diagram (see Fig. 8-5). (Note that both ordinate and abscissa scales are the same.) Connect the plotted points by the best-fitting straight line and note that it makes an angle of 17° with the horizontal and intersects the ordinate at 1340 lb/ft². Therefore, cohesion (c) = 1340 lb/ft² and angle of internal friction (ϕ) = 17°.

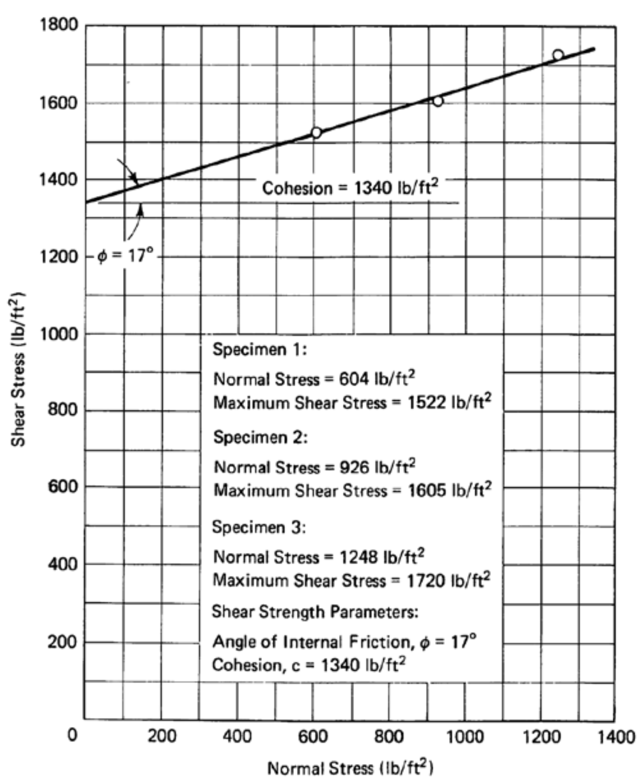


FIGURE 8-5 Maximum shear stress versus normal stress curve for Example 8-2.

Triaxial Shear Test

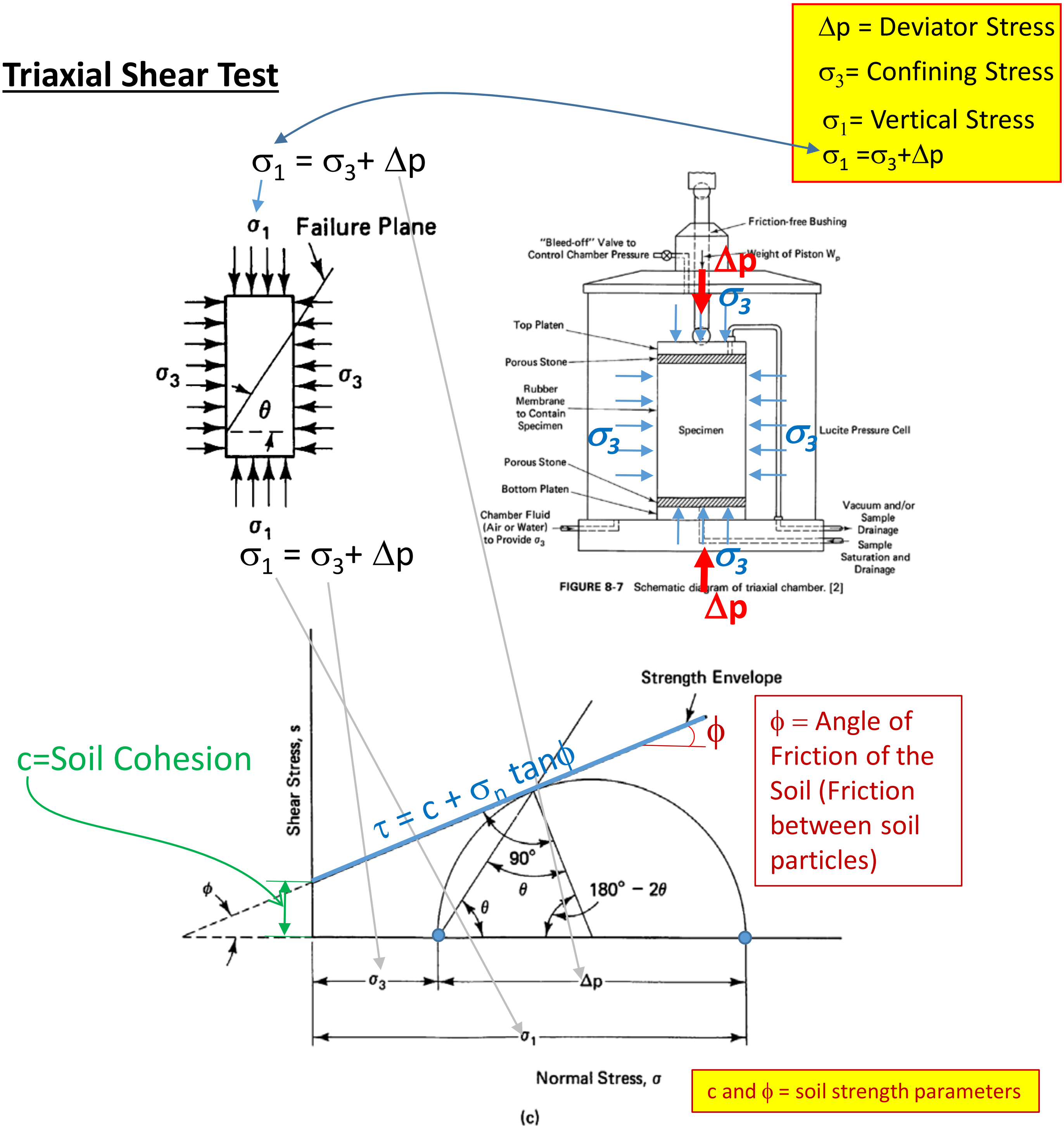


FIGURE 8-7 Schematic diagram of triaxial chamber. [2]

FIGURE 8-12 Relationship between angle of internal friction (ϕ) and orientation of failure plane (θ): (a) failure plane; (b) stresses acting on the failure plane; (c) Mohr's circle.

where
- s = shear stress on the failure plane
- σ_n = normal stress on the failure plane
- σ_1 = major principal stress
- σ_3 = minor principal stress
- θ = angle between failure plane and horizontal plane (see Fig. 8-13)

EXAMPLE 8-4

Given

Triaxial compression tests on three specimens of a soil sample were performed with each test carried until the specimen experienced shear failure. Test data are tabulated below.

Specimen Number	*Minor Principal Stress, σ_3 (Confining Pressure) (kips/ft²)*	*Deviator Stress at Failure, Δp (kips/ft²)*
1	1.44	5.76
2	2.88	6.85
3	4.32	7.50

Required

The soil's cohesion and angle of internal friction.

Solution

As shown in Fig. 8-9, draw three Mohr's circles. Each one starts at a minor principal stress (σ_3) and has a diameter equal to the deviator stress at failure (Δp). Then draw the strength envelope tangent as nearly as possible to all three circles. The soil's cohesion is indicated by the intersection of the strength envelope and the ordinate where a value of 1.8 kips/ft² is read. The soil's angle of internal friction, which is the angle between the strength envelope and the horizontal, is 17°.

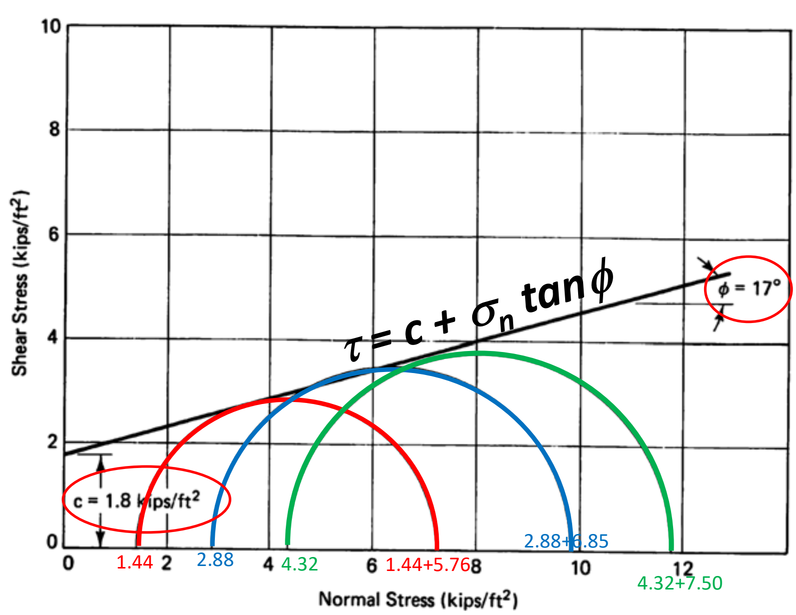


FIGURE 8-9 Mohr's circles for Example 8-4.

EXAMPLE 8-5

Given

A sample of dry, cohesionless soil subjected to a triaxial compression test was carried until the specimen failed at a deviator stress of 105.4 kN/m². A confining pressure of 48.0 kN/m² was used for the test.

Required

This soil's angle of internal friction.

Solution

Given data are plotted on a shear diagram (Fig. 8-10). (Note that both ordinate and abscissa scales are the same.) Point *A* is located along the abscissa at 48.0 kN/m² (the confining pressure—σ_3) and point *B* at 48.0 kN/m² + 105.4 kN/m², or 153.4 kN/m² (confining pressure plus deviator stress at failure—$\sigma_3 + \Delta p$). The Mohr's circle is drawn with a center along the abscissa at 100.7 kN/m² $\left(\text{i.e., } 48.0 \text{ kN/m}^2 + \dfrac{105.4 \text{ kN/m}^2}{2}\right)$ and a radius of 52.7 kN/m². Since cohesion is virtually zero for dry, cohesionless soil, a line is drawn through the origin and tangent to the Mohr's circle. The angle between this line and the horizontal is measured to be 32°. Therefore, the soil's angle of internal friction (ϕ) is 32°.

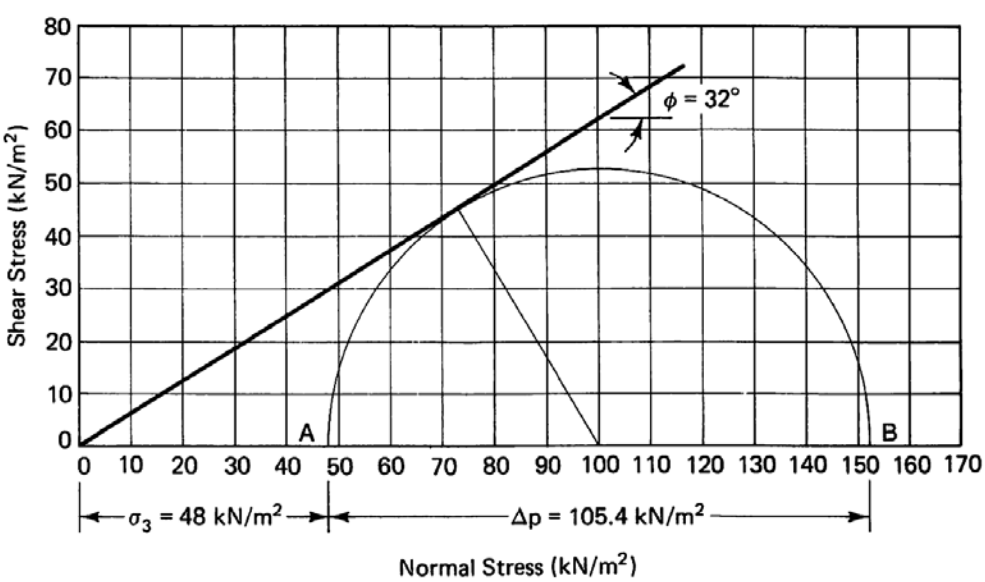


FIGURE 8-10 Mohr's circle for Example 8-5.