FOUNDATION ENGINEERING 1

Shallow Foundation

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FOUNDATION ENGINEERING 1

Reference :
- Principle of Foundation Engineering, 8th Edition, Braja M Das
- An Introduction to Geotechnical Engineering (1st Ed), Holtz R.D. and Kovacs W.D.

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Introduction

Shallow foundation must have two main characteristic :

1. The foundations have to be safe against overall shear failure in the soil that support them
2. This foundations can not undergo excessive displacement or settlement

The load unit per area of the foundation at which shear failure in soil will occurs is called **Bearing Load Capacity**

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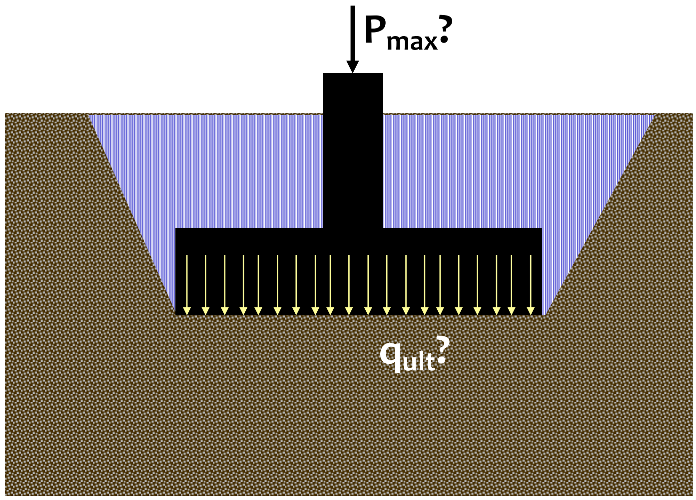

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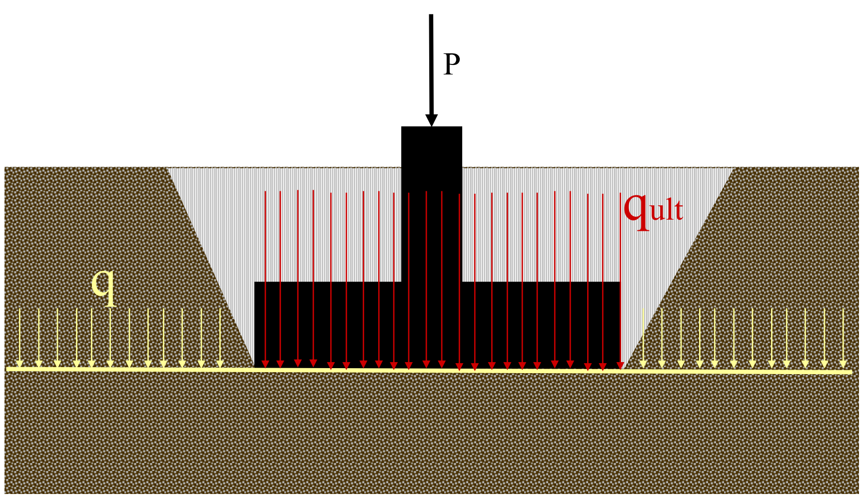

Informasi yang diketahui

Pondasi : dimensinya (B)

Tanahnya : C, ϕ, γ

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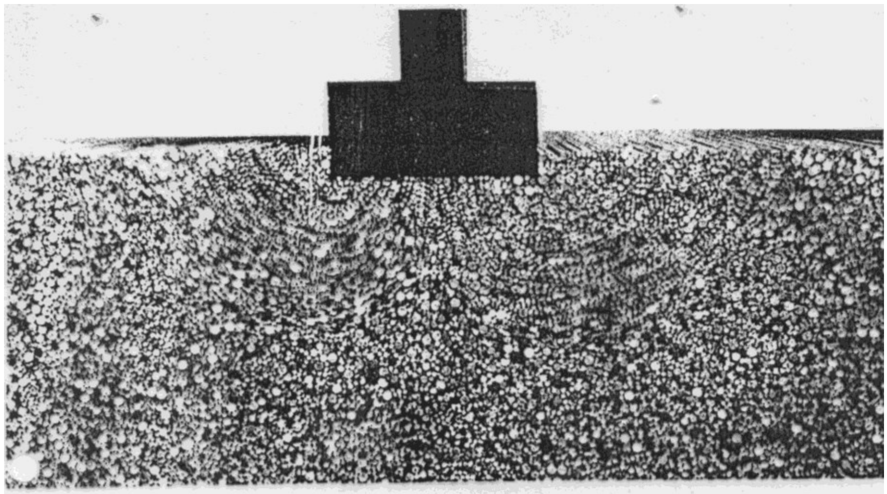
POLA KERUNTUHAN TERZAGHI



Failure zones under footing.

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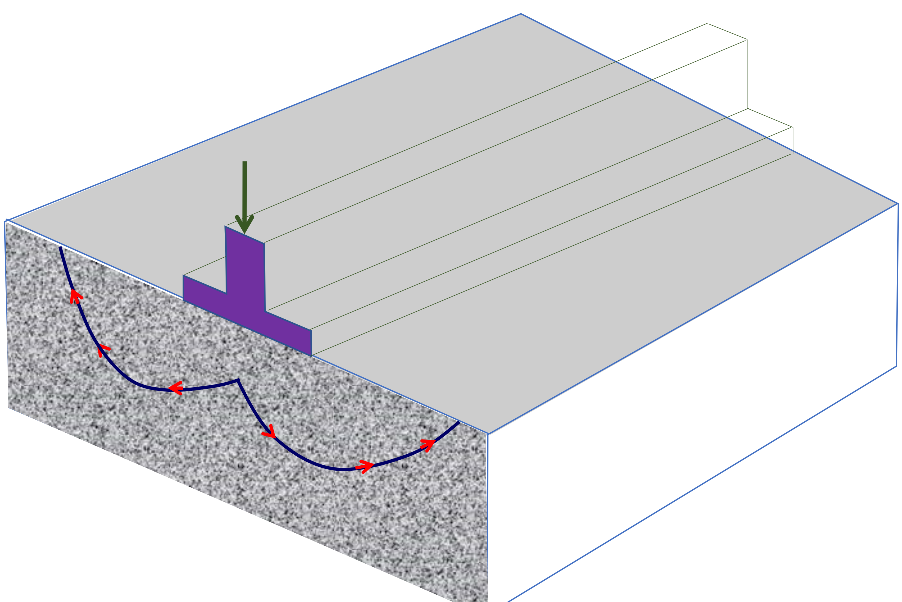

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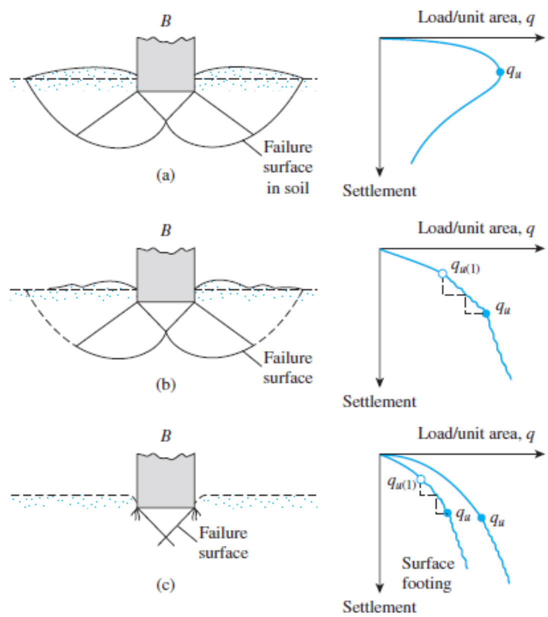

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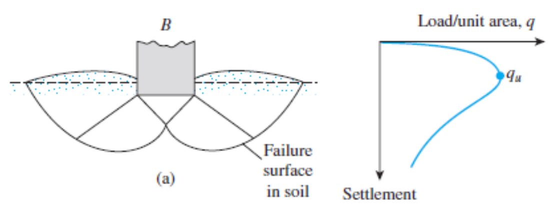

1) A strip foundation with a width of B resting on the surface of a dense sand or stiff cohesive soil. If a load gradually applied to the foundations, settlement will increase. At a certain point – when the load per unit are equals qu – a sudden failure in the soil supporting the foundation will take place, and the failure surface in the surface in the soil will extend to the ground surface. When such sudden failure in soil takes place, it is called general shear failure.

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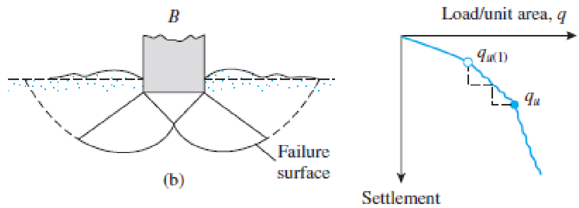
(2) If the foundation under consideration rests on sand or clayey soil of medium compaction, an increase in the load foundation will also be accompanied by an increase in settlement.



The failure surface in the soil will gradually extend outward from the foundation. When the load per unit area on the foundation equal qu(1), movement of the foundation will be accompanied by sudden jerks. A considerable movement of the foundation is then required for the failure surface in soil to extend to the ground surface. The load per unit area at which this happens is the ultimate bearing capacity, qu.

Beyond that point, an increase in load will accompanied by a large increase in foundation settlement. The load per unit area of the foundation, qu(1), is referred to as the first failure load. A peak value of q is not realized in this type of failure, which is called the local shear failure in soil.

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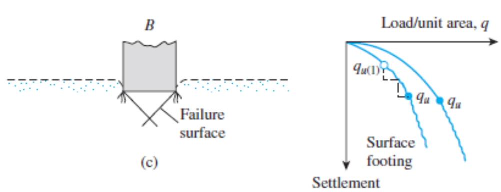
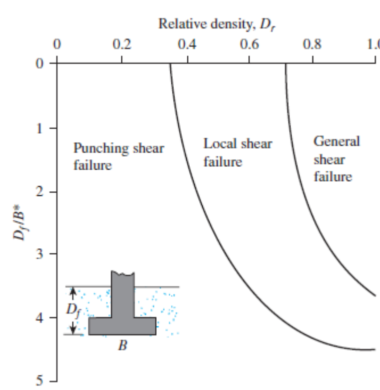
If the foundation supported by a fairly loose soil, the failure surface in soil will not extend to the ground surface. Beyond the ultimate failure load, qu, the load-settlement plot will be steep and practically linear. This type of failure in soil is called the punching shear failure.





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Terzaghi's Bearing Capacity Theory

Local Shear Failure

$$q_u = c'N_c + qN_q + \frac{1}{2}\gamma B N_\gamma$$ (Strip foundation)

$$q_u = 1.3c'N_c + qN_q + 0.4\gamma B N_\gamma \quad \text{(square foundation)}$$

$$q_u = 1.3c'N_c + qN_q + 0.3\gamma B N_\gamma \quad \text{(circular foundation)}$$

c' = cohesion of soil (kN/m^2)

γ = unit wight of soil (kN/m^3)

q = γ Df

where N_c, N_q, and N_γ = bearing capacity factors.

$$q_{all} = \frac{q_u}{FS}$$

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Terzaghi's Bearing Capacity Theory

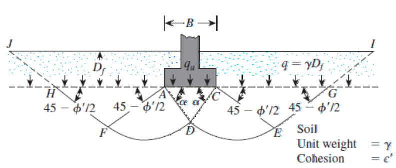

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Table 4.1 Terzaghi's Bearing Capacity Factors—Eqs. (4.15), (4.13), and (4.11).[a]

ϕ'	N_c	N_q	N_γ[a]	ϕ'	N_c	N_q	N_γ[a]
0	5.70	1.00	0.00	26	27.09	14.21	9.84
1	6.00	1.10	0.01	27	29.24	15.90	11.60
2	6.30	1.22	0.04	28	31.61	17.81	13.70
3	6.62	1.35	0.06	29	34.24	19.98	16.18
4	6.97	1.49	0.10	30	37.16	22.46	19.13
5	7.34	1.64	0.14	31	40.41	25.28	22.65
6	7.73	1.81	0.20	32	44.04	28.52	26.87
7	8.15	2.00	0.27	33	48.09	32.23	31.94
8	8.60	2.21	0.35	34	52.64	36.50	38.04
9	9.09	2.44	0.44	35	57.75	41.44	45.41
10	9.61	2.69	0.56	36	63.53	47.16	54.36
11	10.16	2.98	0.69	37	70.01	53.80	65.27
12	10.76	3.29	0.85	38	77.50	61.55	78.61
13	11.41	3.63	1.04	39	85.97	70.61	95.03
14	12.11	4.02	1.26	40	95.66	81.27	115.31
15	12.86	4.45	1.52	41	106.81	93.85	140.51
16	13.68	4.92	1.82	42	119.67	108.75	171.99
17	14.60	5.45	2.18	43	134.58	126.50	211.56
18	15.12	6.04	2.59	44	151.95	147.74	261.60
19	16.56	6.70	3.07	45	172.28	173.28	325.34
20	17.69	7.44	3.64	46	196.22	204.19	407.11
21	18.92	8.26	4.31	47	224.55	241.80	512.84
22	20.27	9.19	5.09	48	258.28	287.85	650.67
23	21.75	10.23	6.00	49	298.71	344.63	831.99
24	23.36	11.40	7.08	50	347.50	415.14	1072.80
25	25.13	12.72	8.34				

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Example

A square foundation is 2 m × 2 m in plan. The soil supporting the foundation has a friction angle of $\phi' = 25°$ and $c' = 20$ kN/m². The unit weight of soil, γ, is 16.5 kN/m³. Determine the allowable gross load on the foundation with a factor of safety (FS) of 3. Assume that the depth of the foundation (D_f) is 1.5 m and that general shear failure occurs in the soil.

Solution

From Eq. (4.17)

$$q_u = 1.3c'N_c + qN_q + 0.4\gamma BN_\gamma$$

From Table 4.1, for $\phi' = 25°$,

$$N_c = 25.13$$
$$N_q = 12.72$$
$$N_\gamma = 8.34$$

Thus,

$$q_u = (1.3)(20)(25.13) + (1.5 \times 16.5)(12.72) + (0.4)(16.5)(2)(8.34)$$
$$= 653.38 + 314.82 + 110.09 = 1078.29 \text{ kN/m}^2$$

So, the allowable load per unit area of the foundation is

$$q_{all} = \frac{q_u}{FS} = \frac{1078.29}{3} \approx 359.5 \text{ kN/m}^2$$

Thus, the total allowable gross load is

$$Q = (359.5)\,B^2 = (359.5)\,(2 \times 2) = \mathbf{1438\ kN}$$

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Example

Refer to Example before Assume that the shear-strength parameters of the soil are the same. A square foundation measuring $B \times B$ will be subjected to an allowable gross load of 1000 kN with FS = 3 and D_f = 1 m. Determine the size B of the foundation.

Solution

Allowable gross load Q = 1000 kN with FS = 3. Hence, the ultimate gross load Q_u = (Q)(FS) = (1000)(3) = 3000 kN. So,

$$q_u = \frac{Q_u}{B^2} = \frac{3000}{B^2} \qquad \text{(a)}$$

From Eq. (4.17),

$$q_u = 1.3c'N_c + qN_q + 0.4\gamma BN_\gamma$$

For $\phi' = 25°$, $N_c = 25.13$, $N_q = 12.72$, and $N_\gamma = 8.34$.
Also,

$$q = \gamma D_f = (16.5)(1) = 16.5 \text{ kN/m}^2$$

Now,

$$q_u = (1.3)(20)(25.13) + (16.5)(12.72) + (0.4)(16.5)(B)(8.34)$$
$$= 863.26 + 55.04B \qquad \text{(b)}$$

Combining Eqs. (a) and (b),

$$\frac{3000}{B^2} = 863.26 + 55.04B \qquad \text{(c)}$$

By trial and error, we have

$$B = 1.77 \text{ m} \approx \mathbf{1.8\ m}$$

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Problems

A square column foundation has to carry a gross allowable load of 1805 kN (FS = 3). Given: $D_f = 1.5$ m, $\gamma = 15.9\ \text{kN/m}^3$, $\phi' = 34°$, and $c' = 0$. Use Terzaghi's equation to determine the size of the foundation (B). Assume general shear failure.

$$q_u = c'N_c + qN_q + \frac{1}{2}\gamma B N_\gamma \quad \text{(Strip foundation)}$$

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Assignment

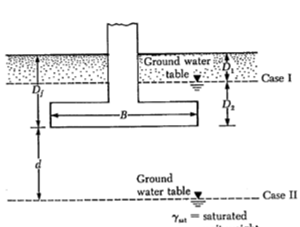
TASK #1
Rekayasa Pondasi I

Shallow Foundation
(duration of task : 3 weeks)
Lecture : Sherly Meiwa ST., MT

Problem No 1

Please explain about *Terzaghi's Bearing Capacity Equation*
Please explain about *Meyerhoff's Bearing Capacity Equation*

Problem No 2



A square foundation is B x B m in plan. The soil supporting the foundation has a friction angle of ϕ and c. The unit weight of soil γ and saturated unit weight of soil γ_{sat}. Assume that the depth of foundation is D_f and that general shear failure occurs in the soil.
B = 1.5, 1.75, 2.0 m,
ϕ = 20°, 22°, 24°,
c = 14, 15, 16 kN/m².
γ = 17.2, 17.4, 17.6 kN/m³
and γ_{sat} = 19 kN/m³.
D_f = 1, 1.25, 1.5 m

Determine the allowable gross load on the foundation with a factor of safety (FS) of 4 using Terzaghi's Bearing Capacity Equation, if:
a) The ground water table is located in Case II with d = 10m.
b) The ground water table is located in Case II with d = 1m
c) The ground water table is located in Case I with D_1 = 0.5m

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