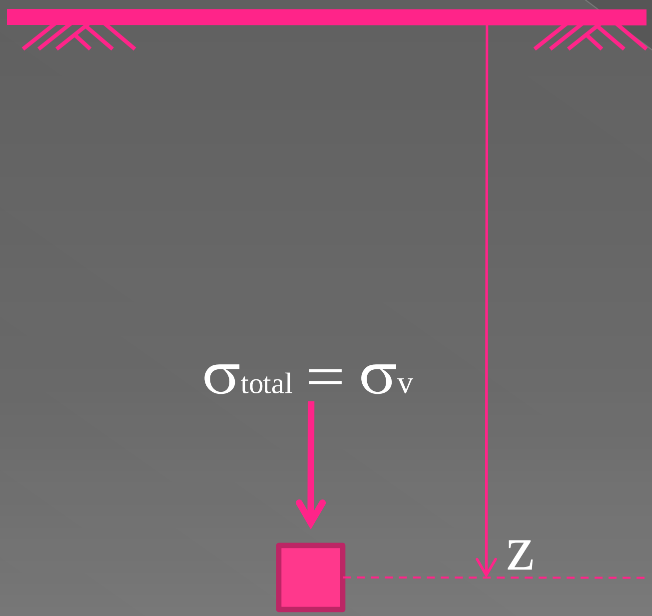
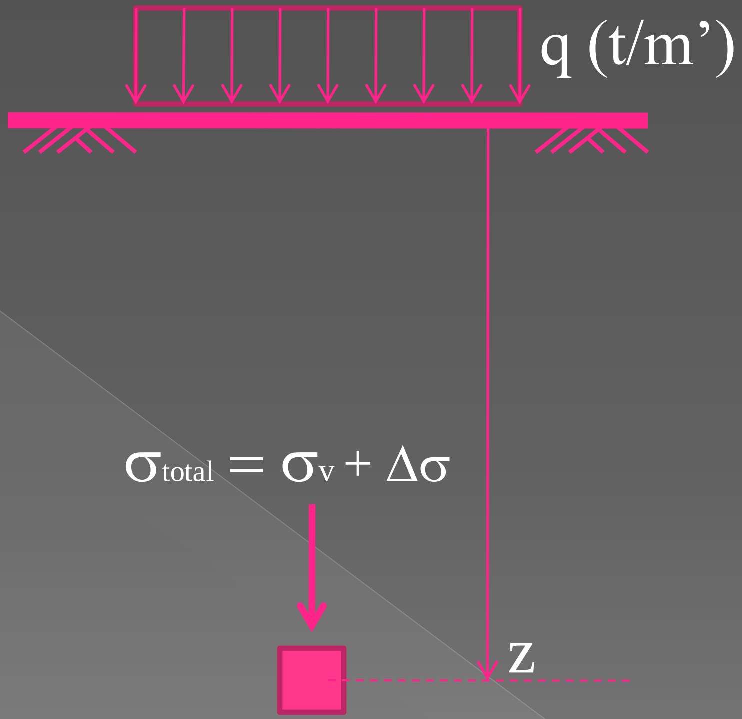
TEGANGAN PADA TANAH DAN DISTRIBUSI TEGANGAN

TEGANGAN TANAH

- Tujuan akhir : Untuk menghitung penurunan

EFEK BEBAN KE TANAH





METODE PERHITUNGAN

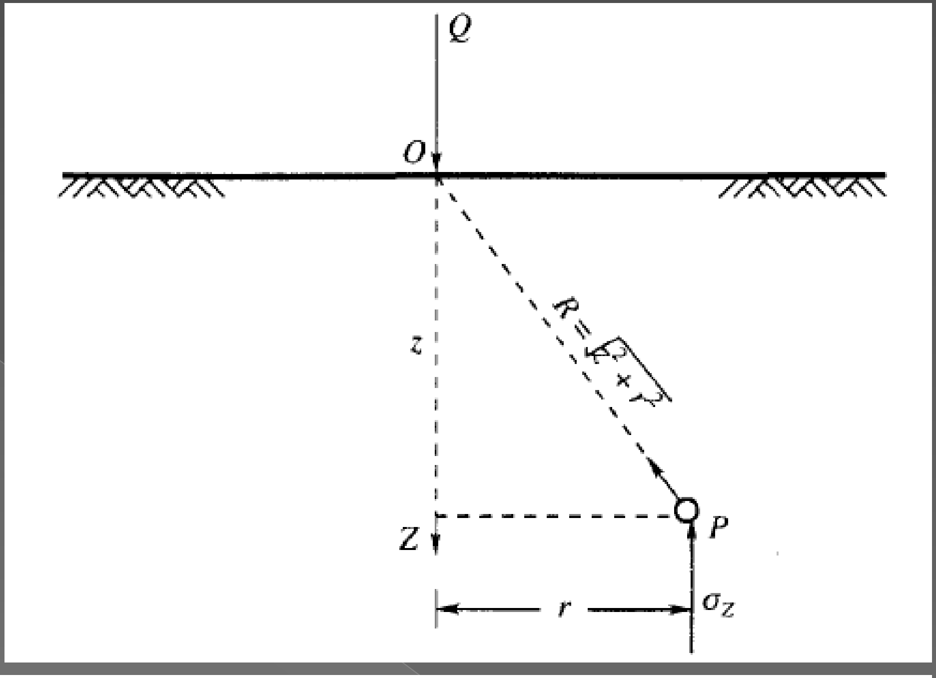
Metode menghitung distribusi tegangan :

- Boussinesq
- Westergaard
- Sederhana
- 2 : 1

BEBAN TERPUSAT

BEBAN TERPUSAT / BEBAN TITIK

- BOUSSINESQ



$$\sigma_z = \frac{3Q}{2\pi z^2}\frac{1}{[1+(r/z)^2]^{5/2}} = \frac{Q}{z^2} I_B \qquad (6.1)$$

where, r = the horizontal distance between an arbitrary point P below the surface and the vertical axis through the point load Q.

z = the vertical depth of the point P from the surface.

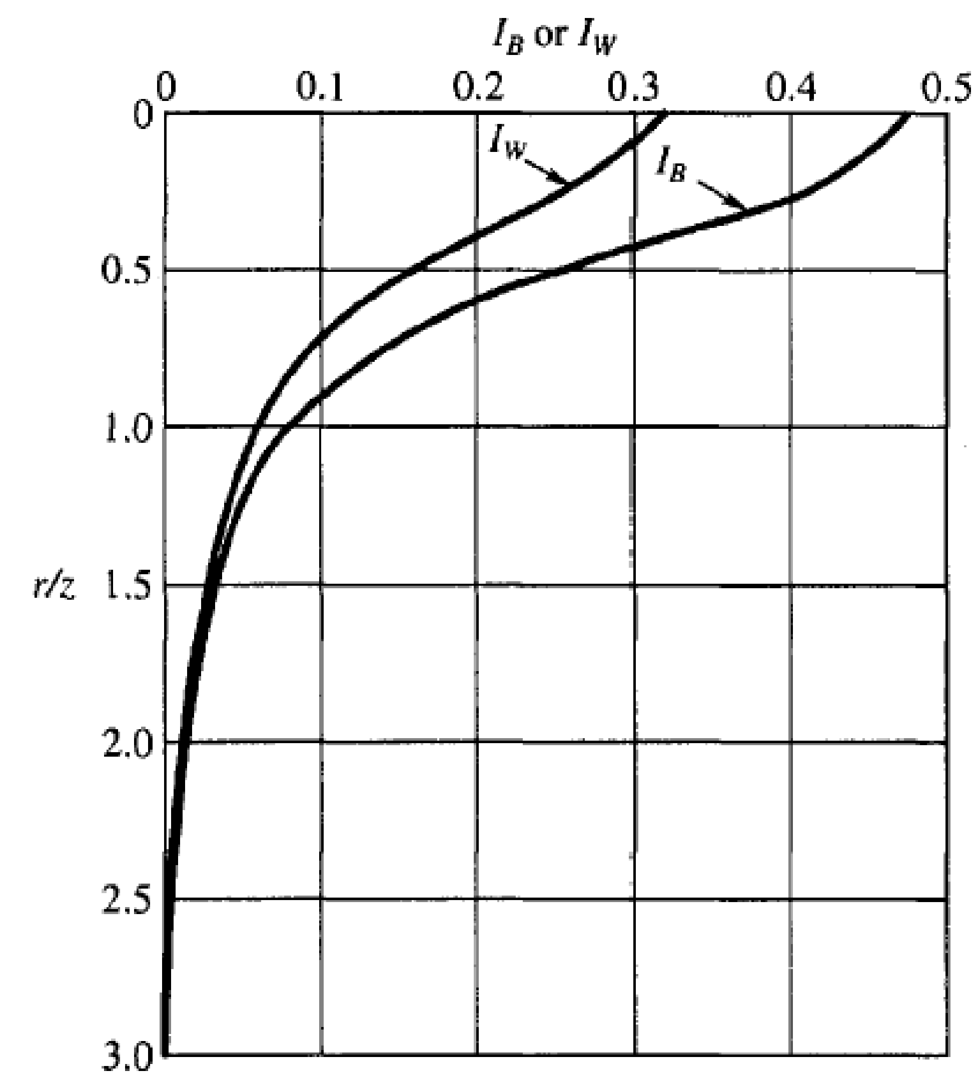
$$I_B = \text{Boussinesq stress coefficient} = \frac{3}{2\pi}\frac{1}{[1+(r/z)^2]^{5/2}} \qquad (6.1a)$$

BEBAN TERPUSAT / BEBAN TITIK

- WESTERGAARD

$$\sigma_z = \frac{Q}{\pi z^2}\frac{1}{[1+2(r/z)^2]^{3/2}} = \frac{Q}{z^2} I_w$$

$$I_w = \frac{(1/\pi)}{[1+2(r/z)^2]^{3/2}}$$



BEBAN TERPUSAT / BEBAN TITIK

- CONTOH

A concentrated load of 1000 kN is applied at the ground surface. Compute the vertical pressure (i) at a depth of 4 m below the load, (ii) at a distance of 3 m at the same depth. Use Boussinesq's equation.

Solution

The equation is

$$\sigma_z = \frac{Q}{z^2} I_B, \text{ where } I_B = \frac{3/2\pi}{\left[1+(r/z)^2\right]^{5/2}}$$

(i) When $r/z = 0$, $I_B = 3/2\,\pi = 0.48$, $\sigma_z = 0.48\frac{Q}{z^2} = 0.48 \times \frac{1000}{4 \times 4} = 30 \text{ kN/m}^2$

(ii) When $r/z = 3/4 = 0.75$

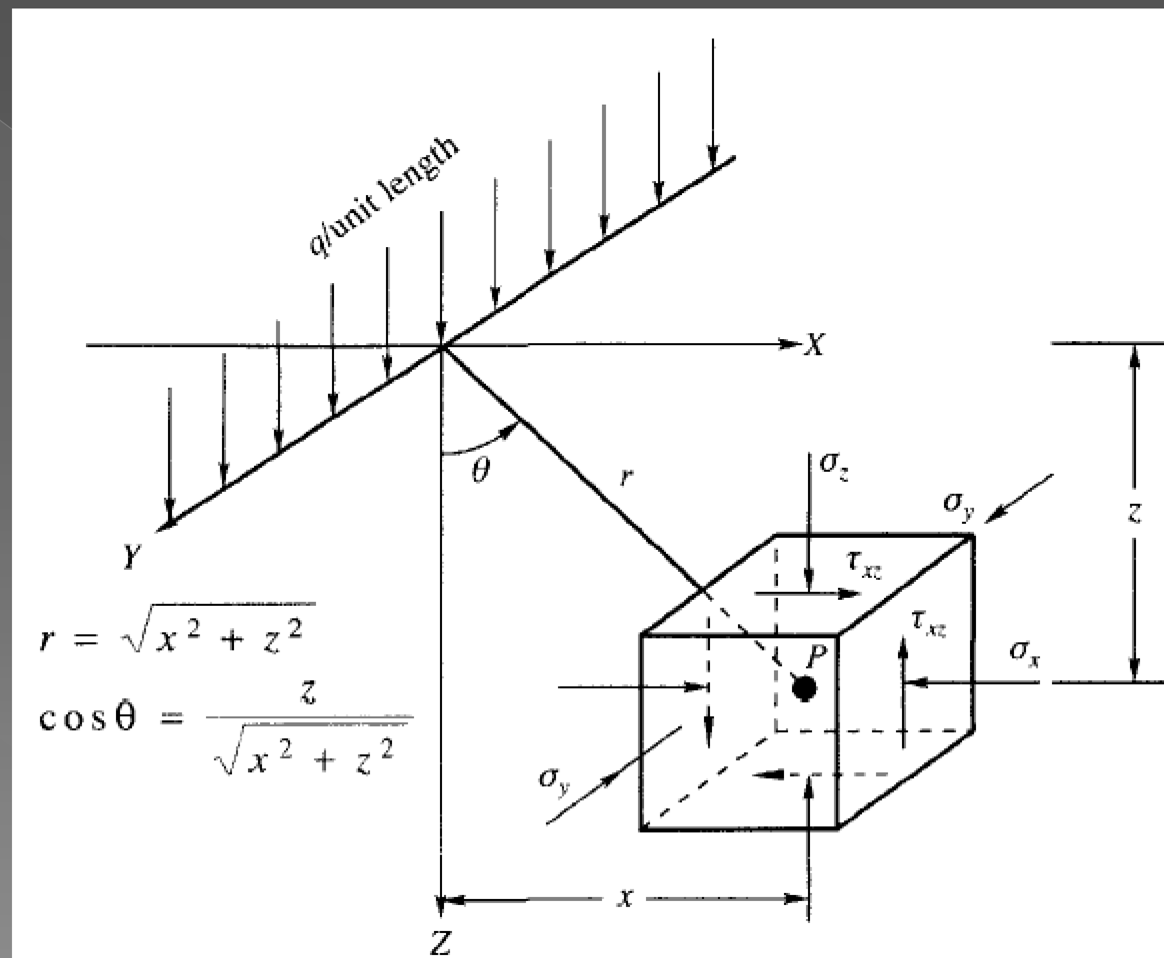
$$I_B = \frac{3/2\pi}{\left[1+(0.75)^2\right]^{5/2}} = 0.156, \quad \sigma_z = \frac{0.156 \times 1000}{4 \times 4} = 9.8 \text{ kN/m}^2$$

BEBAN GARIS

BEBAN GARIS/LINE LOAD

- BOUSSINESQ

$$\sigma_z = \frac{q}{z} \frac{2/\pi}{[1+(x/z)^2]^2} = \frac{q}{z} I_z$$

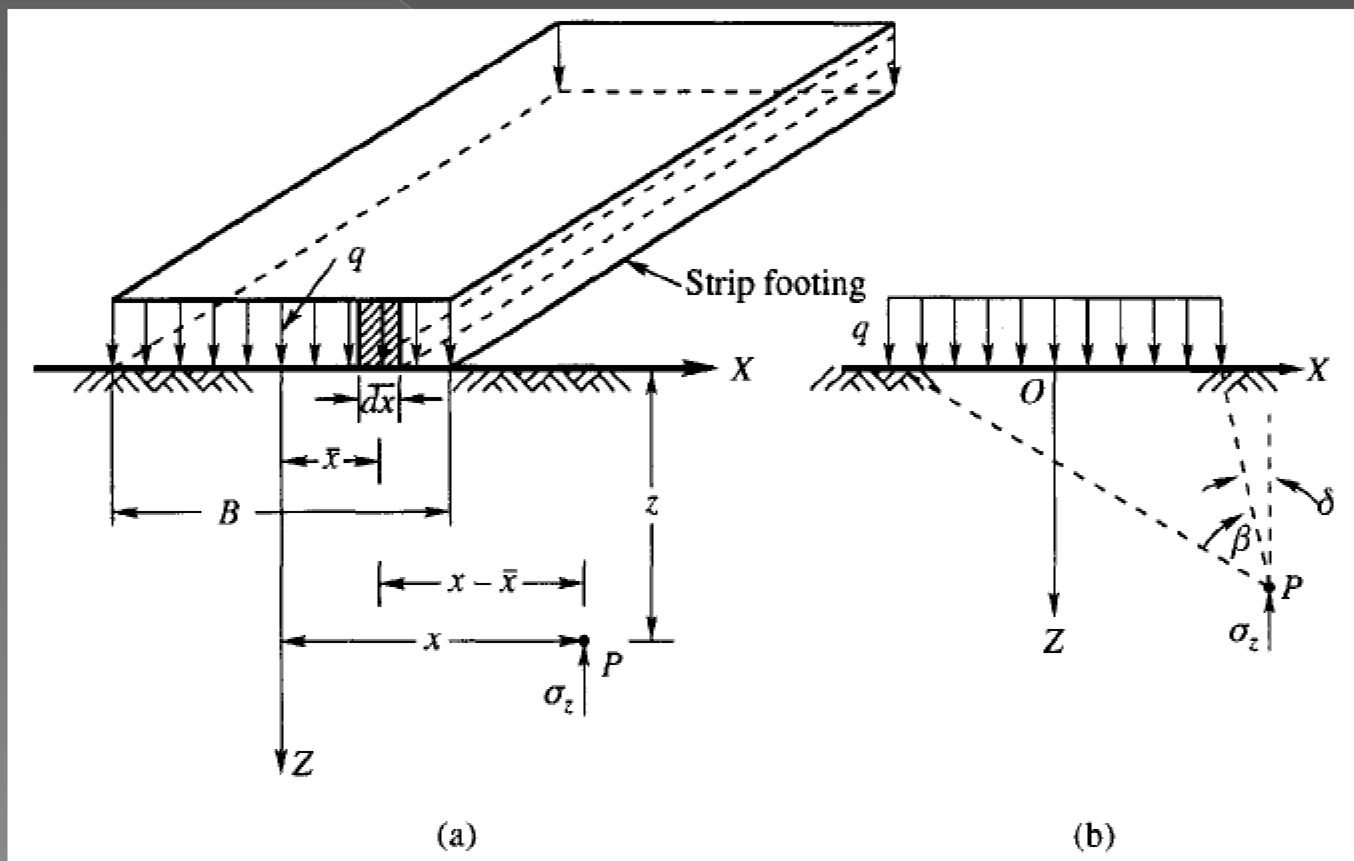


BEBAN MERATA MENERUS

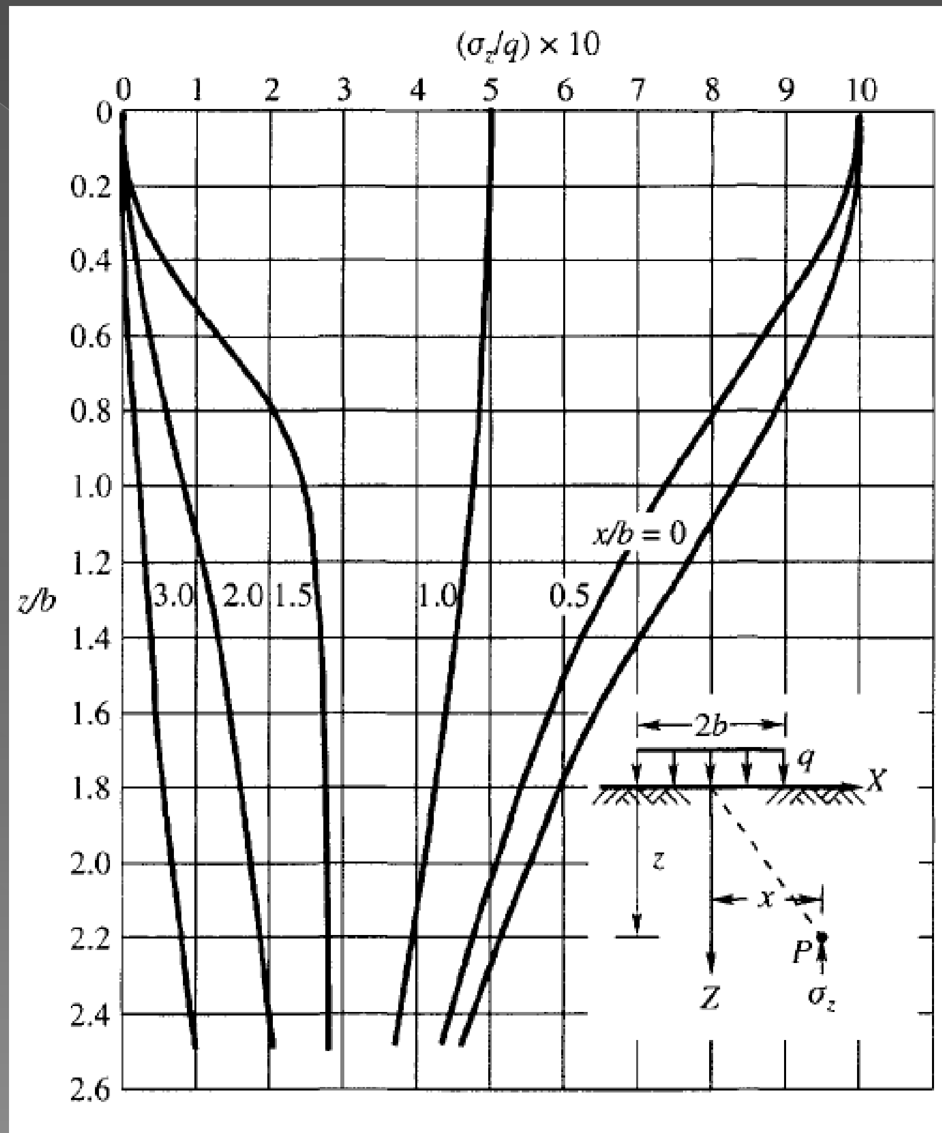
BEBAN MERATA MENERUS/STRIP

- BOUSSINESQ

$$\sigma_z = \frac{q}{\pi}[\beta + \sin\beta\cos(\beta + 2\delta)]$$



BEBAN MERATA MENERUS/STRIP



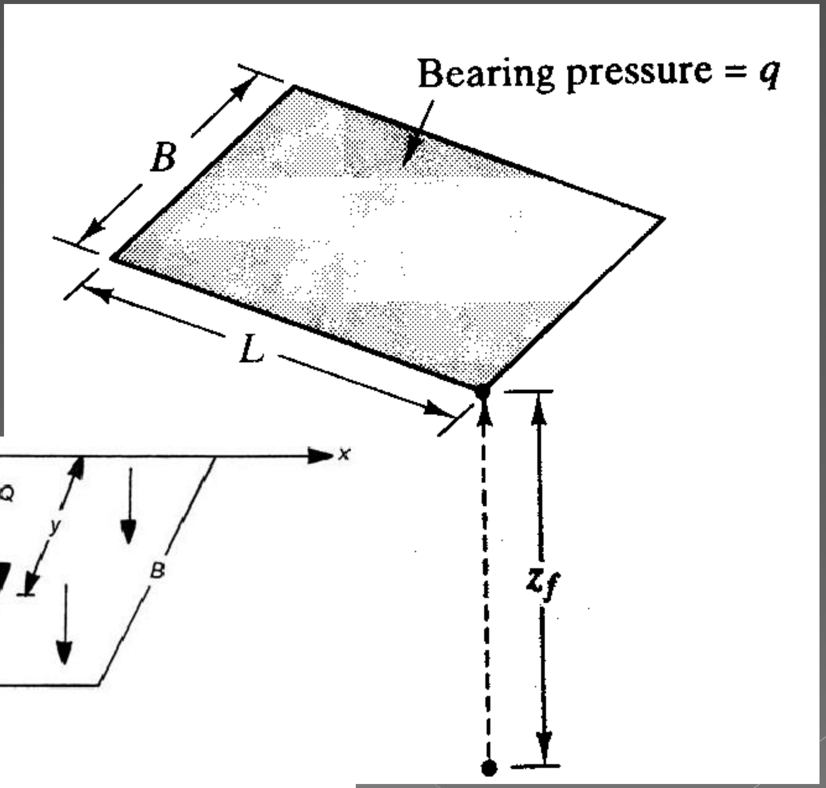
BEBAN MERATA PERSEGI

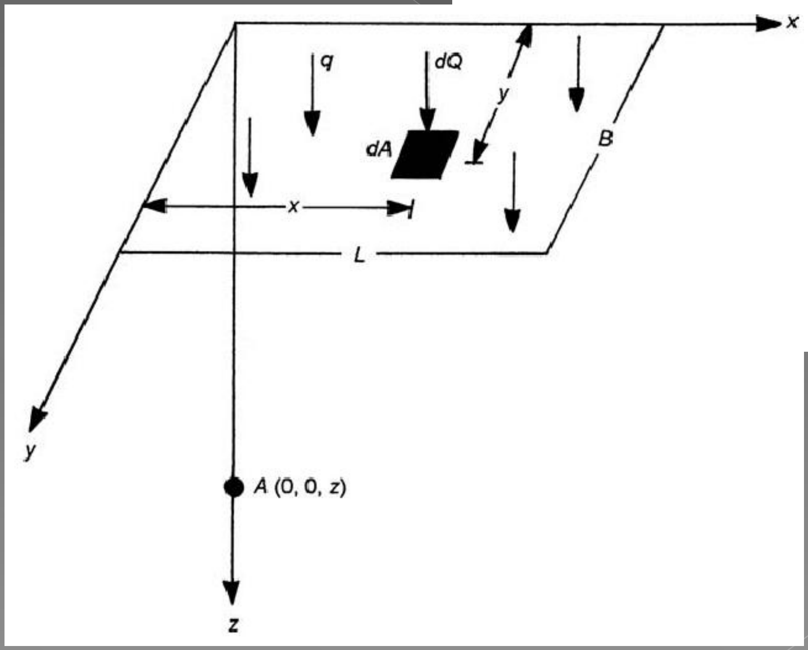
METODE BOUSSINESQ

ASUMSI : Tanah adalah isotropik (Tegangan ke segala arah sama, $K_0 = 1$)

$m = B/z$

$n = L/z$





METODE BOUSSINESQ

- Jika $m^2 + n^2 + 1 < m^2 n^2$

$$\Delta\sigma_v' = \frac{q'}{k\pi}\left[\frac{2mn\sqrt{m^2+n^2+1}}{m^2+n^2+1+m^2n^2}\cdot\frac{m^2+n^2+2}{m^2+n^2+1}+\pi-\sin^{-1}\left(\frac{2mn\sqrt{m^2+n^2+1}}{m^2+n^2+1+m^2n^2}\right)\right]$$

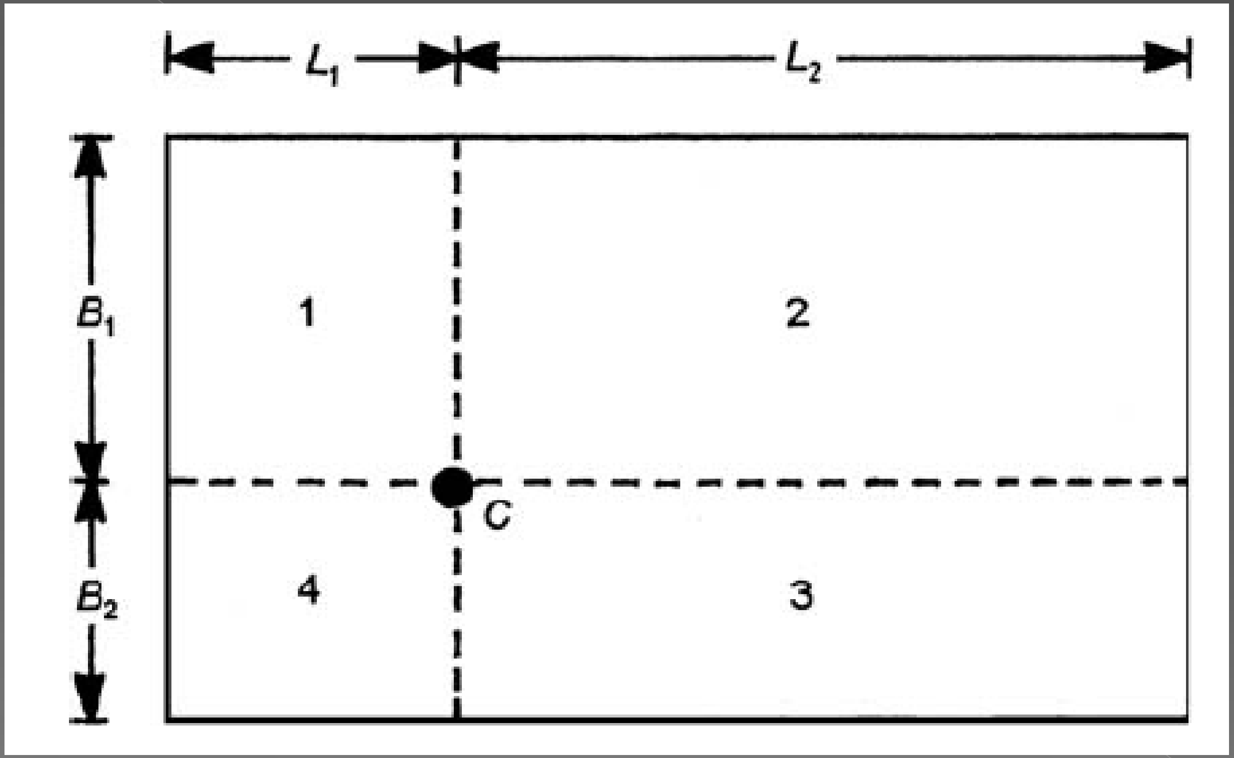
- Jika $m^2 + n^2 + 1 > m^2 n^2$

$$\Delta\sigma_v' = \frac{q'}{k\pi}\left[\frac{2mn\sqrt{m^2+n^2+1}}{m^2+n^2+1+m^2n^2}\cdot\frac{m^2+n^2+2}{m^2+n^2+1}+\sin^{-1}\left(\frac{2mn\sqrt{m^2+n^2+1}}{m^2+n^2+1+m^2n^2}\right)\right]$$

k = 4, untuk beban persegi dan titik di sudut

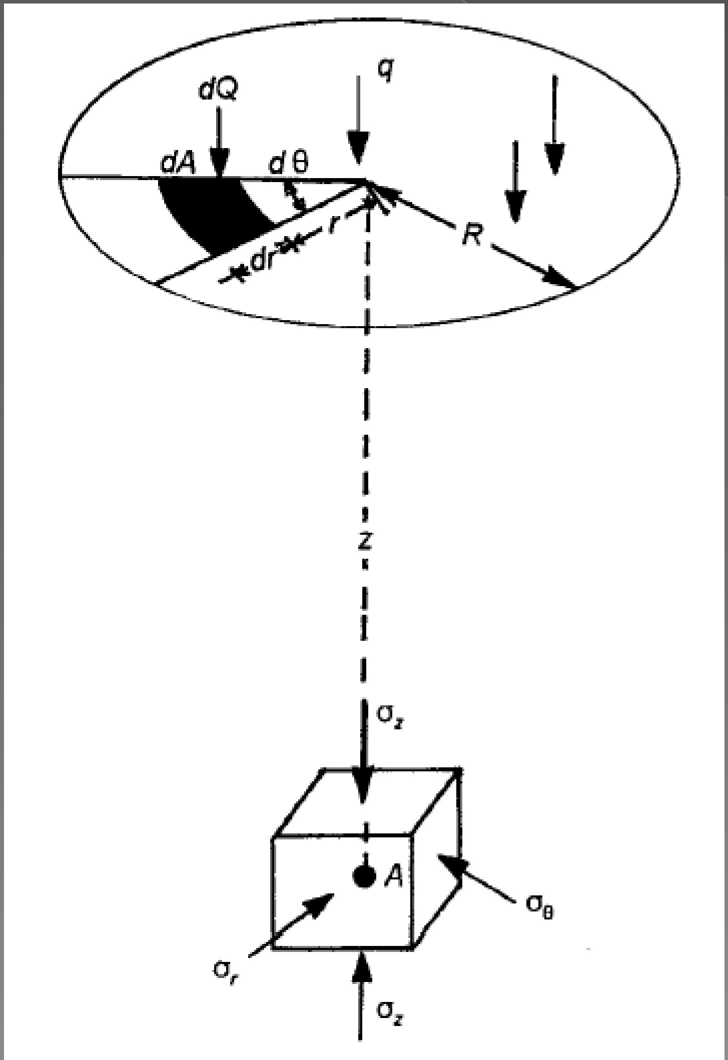
$\Delta\sigma$ = penambahan beban = q x I

METODE BOUSSINESQ



$$\Delta\sigma = q \times (I_1 + I_2 + I_3 + I_4)$$

METODE BOUSSINESQ



$$\sigma_z = q\left[1 - \frac{z^3}{(R^2 + z^2)^{3/2}}\right]$$

METODE BOUSSINESQ PONDASI MENERUS

METODE BOUSSINESQ

Untuk pondasi menerus :

- Jika m > 1 :

$$\Delta\sigma_v' = \frac{q'}{k\pi}\left[\frac{2m}{1+m^2} + \pi - \sin^{-1}\left(\frac{2m}{1+m^2}\right)\right]$$

- Jika m < 1 :

$$\Delta\sigma_v' = \frac{q'}{k\pi}\left[\frac{2m}{1+m^2} + \sin^{-1}\left(\frac{2m}{1+m^2}\right)\right]$$

Catatan : $\sin^{-1}$ dinyatakan dalam radian

METODE BOUSSINESQ

SHAPE	POSITION	k	m	n
Square	Corner	1	0.5 x B/z	0.5 x L/z
Square	Midpoint of edge	2	0.5 x Bz	L/z
Square	Corner	4	B/z	L/z
Rectangular	Corner	1	0.5 x B/z	0.5 x L/z
Rectangular	Midpoint of short edge	2	0.5 x B/z	L/z
Rectangular	Midpoint of long edge	2	B/z	0.5 x L/z
Rectangular	**Corner**	**4**	**B/z**	**L/z**
Continuous	Corner line	1	0.5 x B/z	
Continuous	**Edge**	**2**	**B/z**	

METODE WESTERGAARD

ASUMSI : Tanah adalah material lunak yang <u>elastis</u>, bisa untuk tanah anisotropi

$$\Delta\sigma_v' = \frac{2q'}{k\pi}\cot^{-1}\sqrt{\left(\frac{1-2\nu_p}{2-2\nu_p}\right)\left(\frac{1}{m^2}+\frac{1}{n^2}\right)+\left(\frac{1-2\nu_p}{2-2\nu_p}\right)\left(\frac{1}{m^2n^2}\right)}$$

dimana :

ν_p = Poisson's ratio ($\upsilon_p < 0.5$)

Cot^{-1} dinyatakan dalam radian

Untuk pondasi segi empat

METODE SEDERHANA

Untuk pondasi segi empat atau bujursangkar :

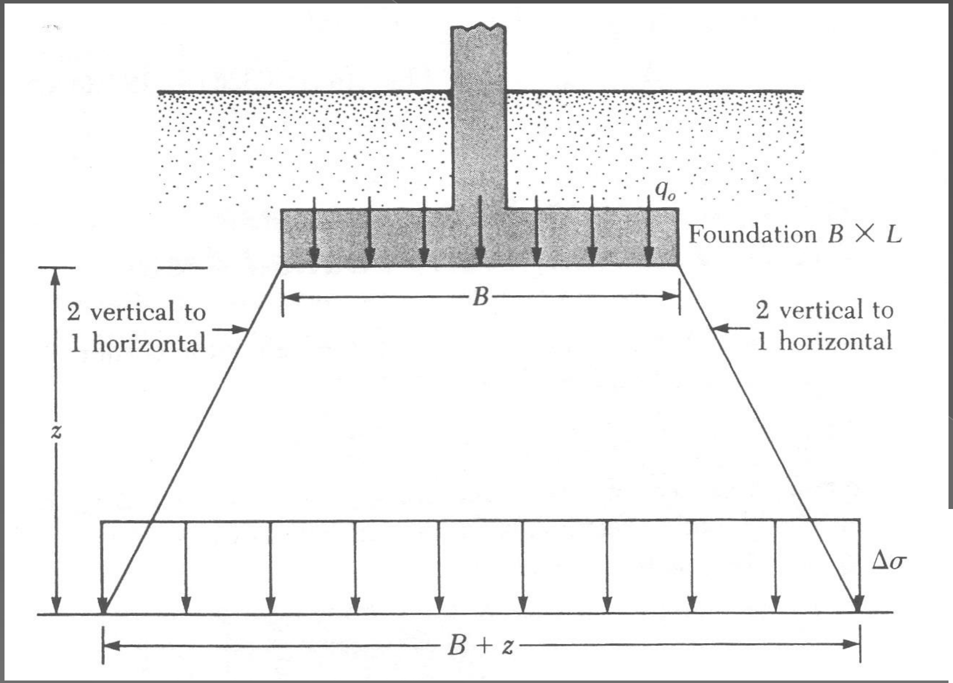
$$\Delta\sigma_v' = \left(\frac{1.7P}{(B+z_f)(L+z_f)}\right) - 0.05q' \qquad 0 \leq \Delta\sigma_v' \leq q'$$

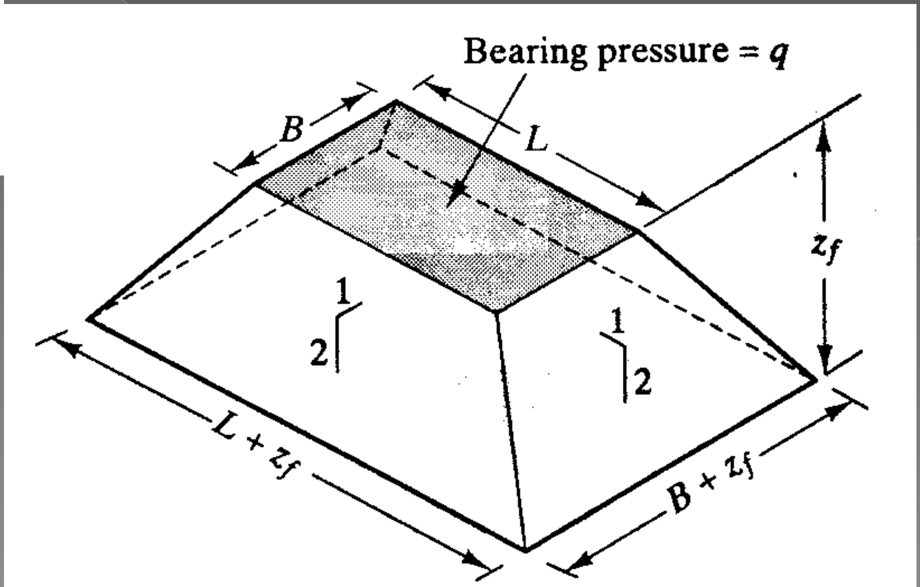
Untuk pondasi menerus :

$$\Delta\sigma_v' = \left(\frac{1.4\frac{P}{b}}{(B+1.3z_f)}\right) - 0.05q' \qquad 0 \leq \Delta\sigma_v' \leq q'$$

$\Delta\sigma_v'$	= peningkatan tegangan vertikal di titik yang ditinjau pada tengah pondasi
P	= beban kolom
P/b	= beban dinding per satuan panjang
B	= lebar pondasi
L	= panjang pondasi
z_f	= kedalaman dihitung dari dasar pondasi
q'	= beban kerja

METODE 2 : 1 (Fled)





METODE 2 : 1 (Fled)

$$\Delta\sigma = \frac{q_o \ x \ B \ x \ L}{(B + z)\ (L + z)} \text{ atau } \Delta\sigma = \frac{Q}{(B + z)\ (L + z)}$$

dimana :

$\Delta\sigma$ = peningkatan tegangan (t/m^2)

q_o = ground pressures (t/m^2)

B = lebar pondasi (m)

L = panjang pondasi (m)

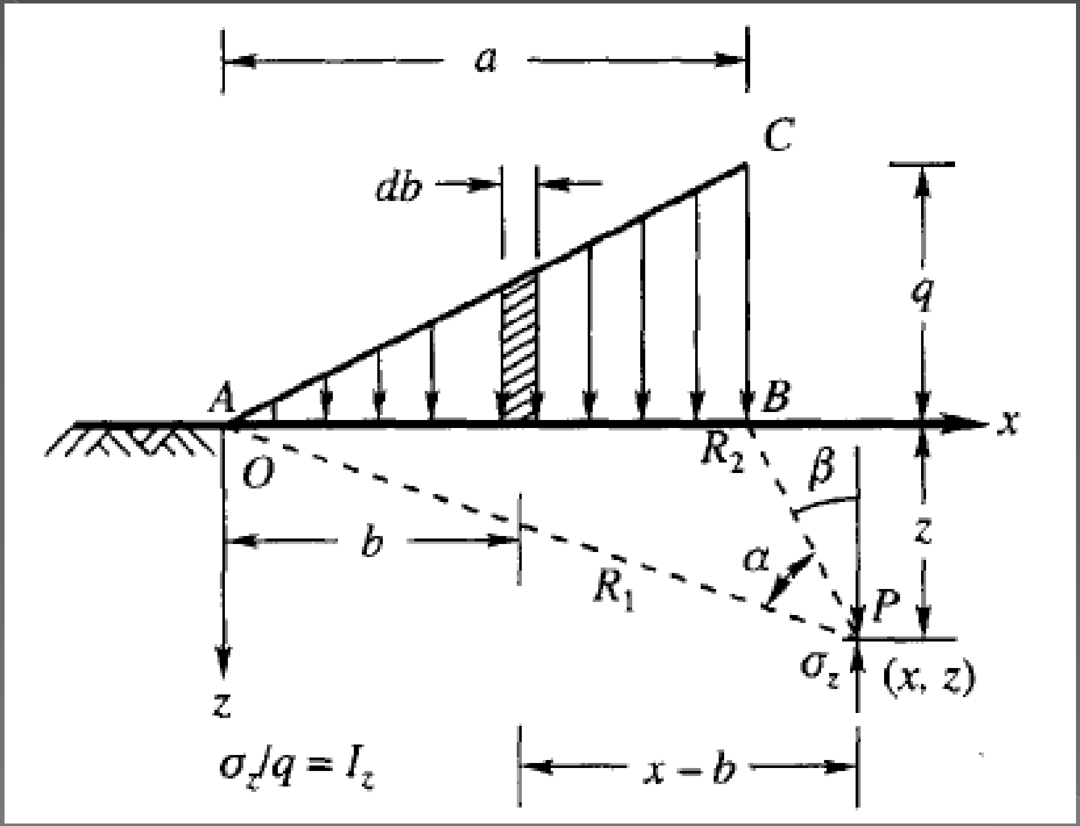
z = kedalaman (m)

Q = beban kerja (ton)

Formula ini mempunyai asumsi bahwa tegangan pondasi menyebar melalui garis dengan kemiringan vertikal terhadap horisontal sebesar 2 : 1,

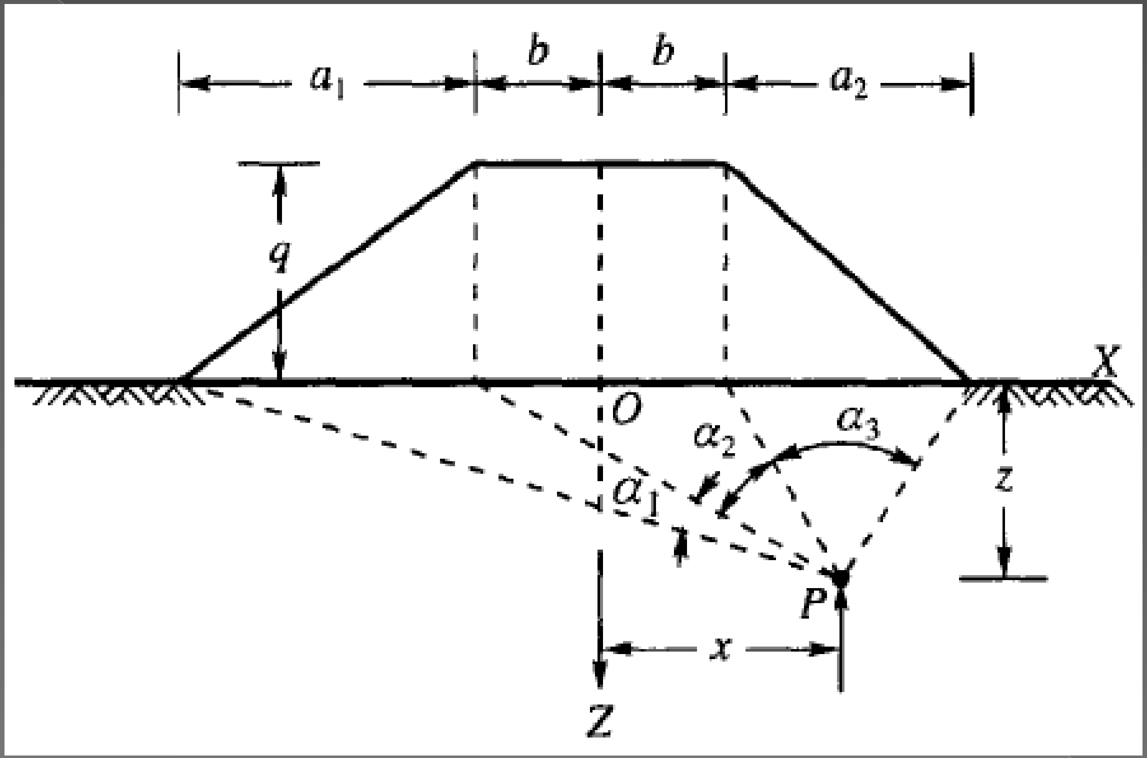
BEBAN TIMBUNAN

BEBAN MERATA SEGITIGA



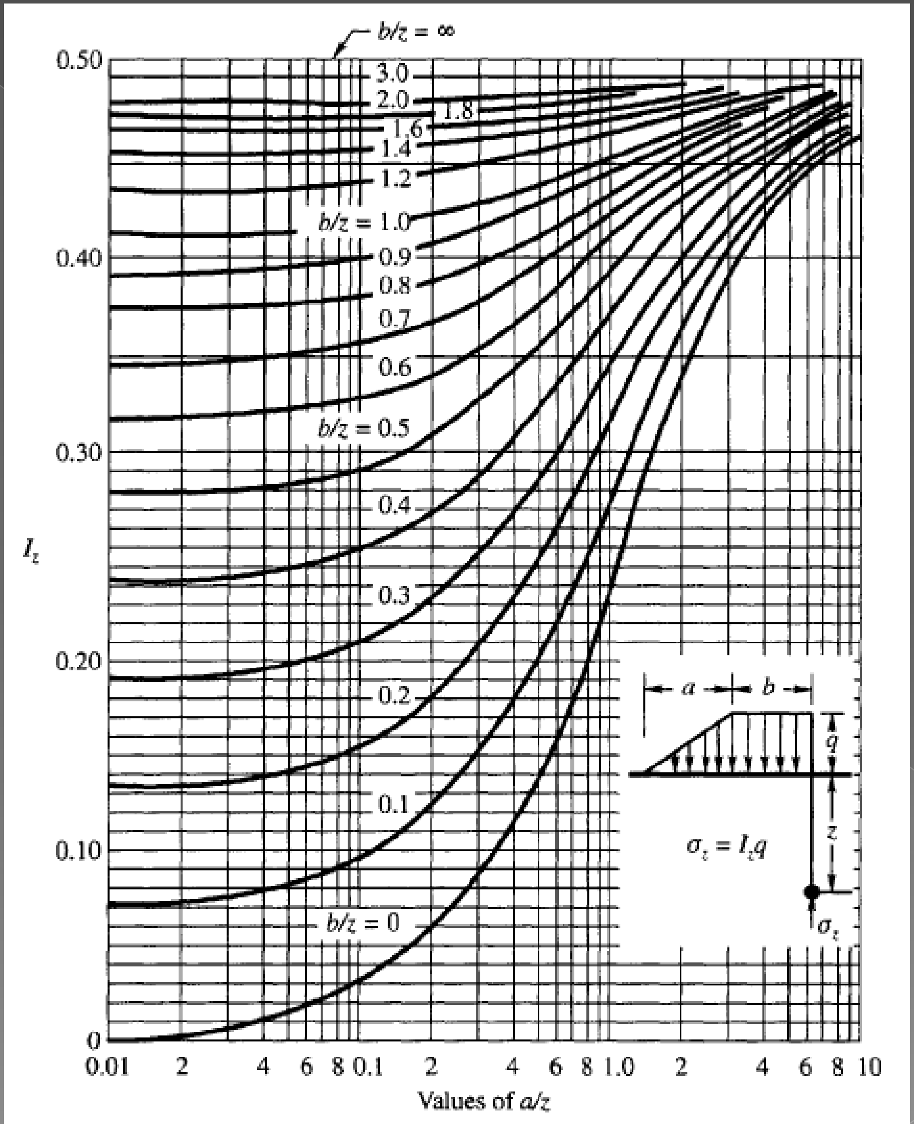
$$\sigma_z = \frac{q}{2\pi}\left(\frac{2x}{a}\alpha - \sin 2\beta\right) = qI_z$$

BEBAN TIMBUNAN TRAPESIUM



$$\sigma_z = \frac{q}{\pi}\left[(\alpha_1 + \alpha_2 + \alpha_3) + \frac{b}{a_1}(\alpha_1 + R\alpha_3) + \frac{x}{a_1}(\alpha_1 - R\alpha_3)\right]$$

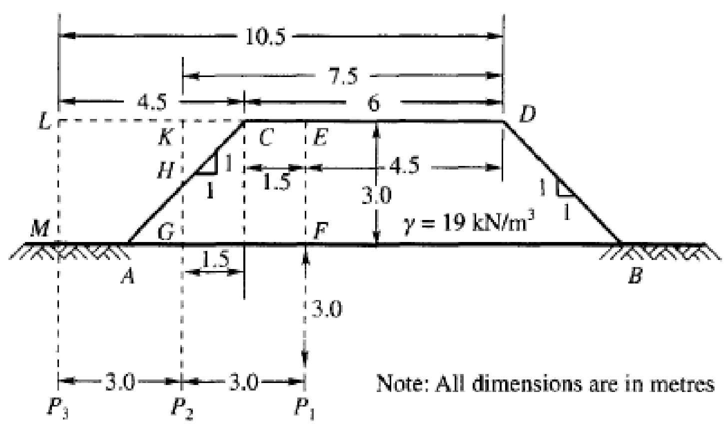
BEBAN TIMBUNAN TRAPESIUM



BEBAN TIMBUNAN TRAPESIUM

- Contoh

A 3 m high embankment is to be constructed as shown in Fig. Ex. 6. 11. If the unit weight of soil used in the embankment is 19.0 kN/m^3, calculate the vertical stress due to the embankment loading at points P_1, P_2, and P_3.



Note: All dimensions are in metres

Figure Ex. 6.11 Vertical stresses at P_1, P_2 & P_3

Solution

$q = \gamma H = 19 \times 3 = 57$ kN/m^2, $z = 3$ m

The embankment is divided into blocks as shown in Fig. Ex. 6.11 for making use of the graph given in Fig. 6. 15. The calculations are arranged as follows:

BEBAN TIMBUNAN TRAPESIUM

Solution

$$q = \gamma H = 19 \times 3 = 57 \text{ kN/m}^2, z = 3 \text{ m}$$

The embankment is divided into blocks as shown in Fig. Ex. 6.11 for making use of the graph given in Fig. 6. 15. The calculations are arranged as follows:

Point	Block	b (m)	a (m)	b/z	a/z	I
P_1	*ACEF*	1.5	3	0.5	1	0.39
	EDBF	4.5	3	1.5	1	0.477
P_2	*AGH*	0	1.5	0	0.5	0.15
	GKDB	7.5	3	2.5	1.0	0.493
	HKC	0	1.5	0	0.5	0.15
P_3	*MLDB*	10.5	3.0	3.5	1.0	0.498
	MACL	1.5	3.0	0.5	1.0	0.39

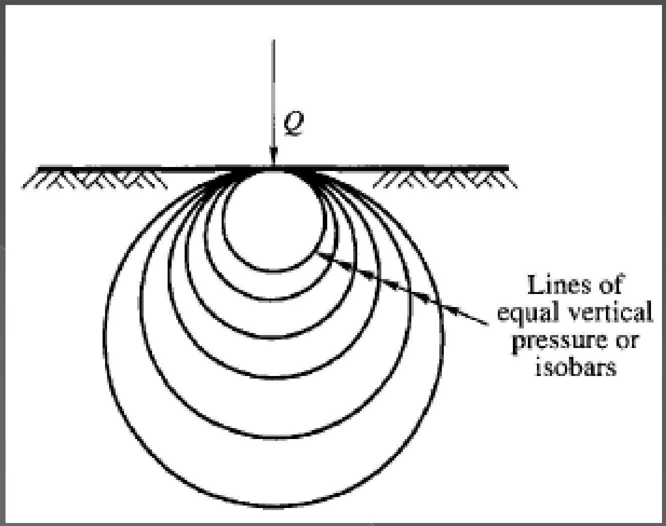
Vertical stress σ_z

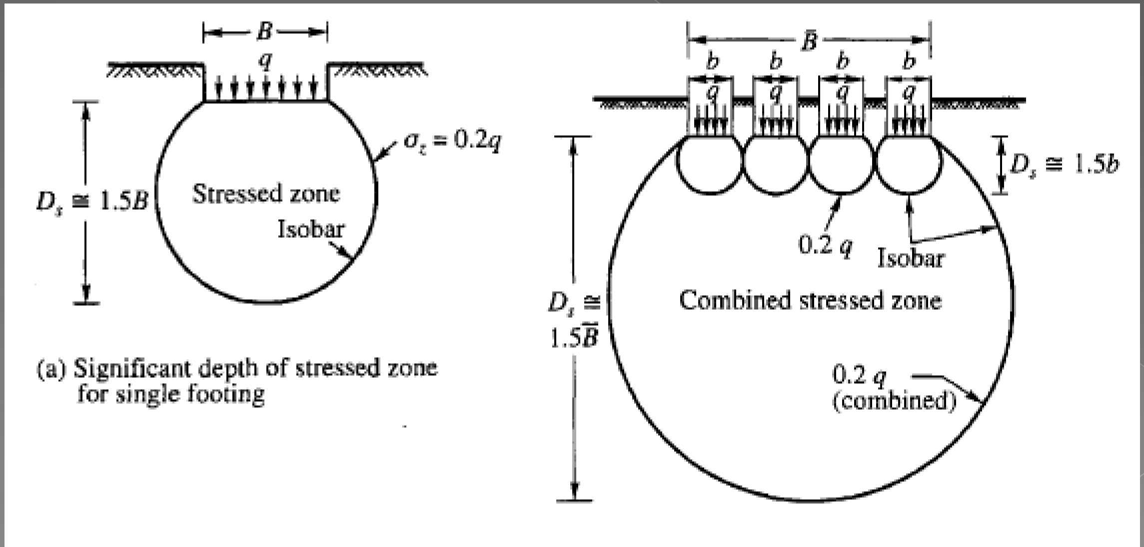
At point P_1, $\sigma_z = (0.39 + 0.477) \times 57 = 49.4 \text{ kN/m}^2$

At point P_2, $\sigma_z = 0.15 \times (57/2) + 0.493 \times 57 - 0.15 \times (57/2) = 28.1 \text{ kN/m}^2$

At point P_3, $\sigma_z = (0.498 - 0.39)\, 57 = 6.2 \text{ kN/m}^2$

METODE GRAFIS UNTUK PONDASI

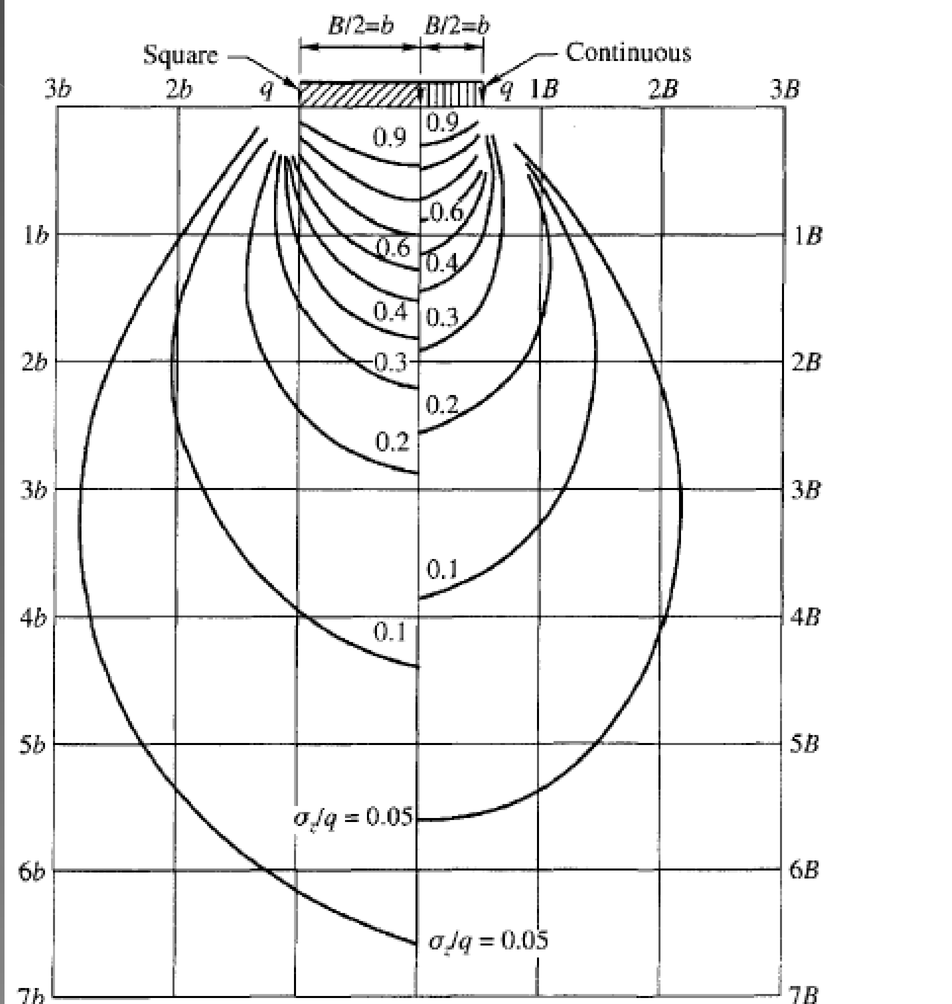




(a) Significant depth of stressed zone for single footing

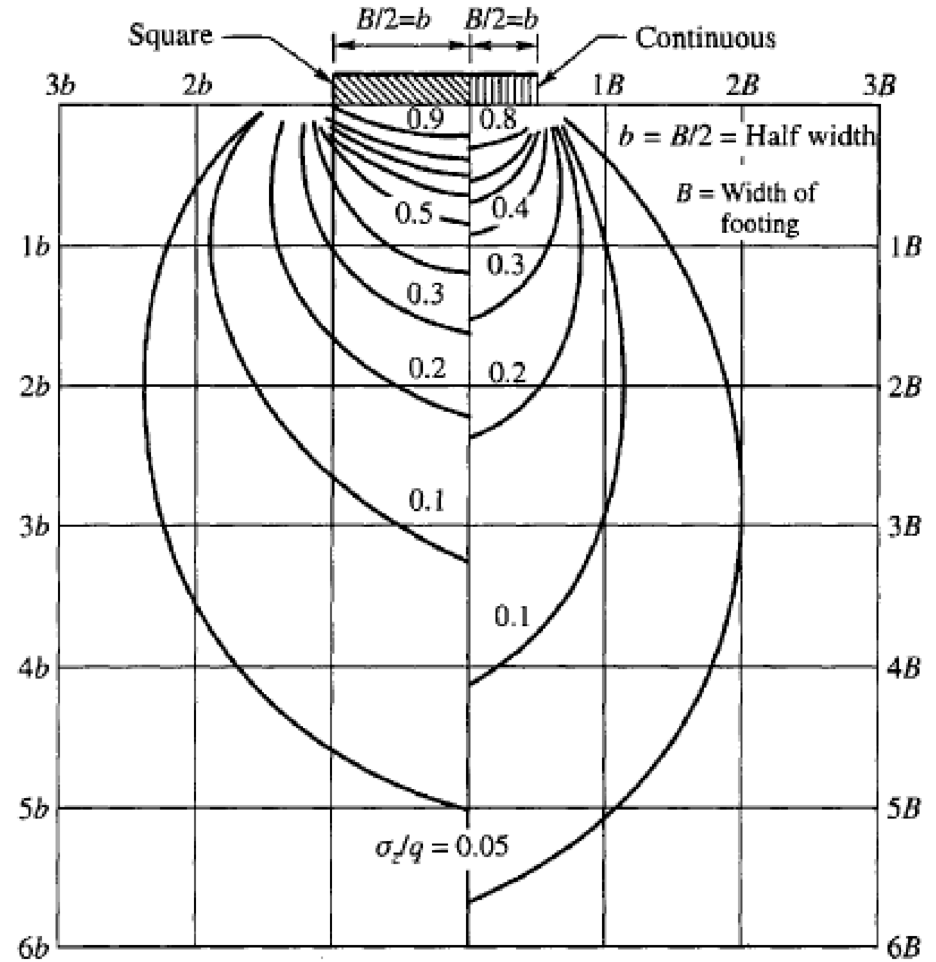
(b) Effect of closely placed footings

METODE GRAFIS UNTUK PONDASI



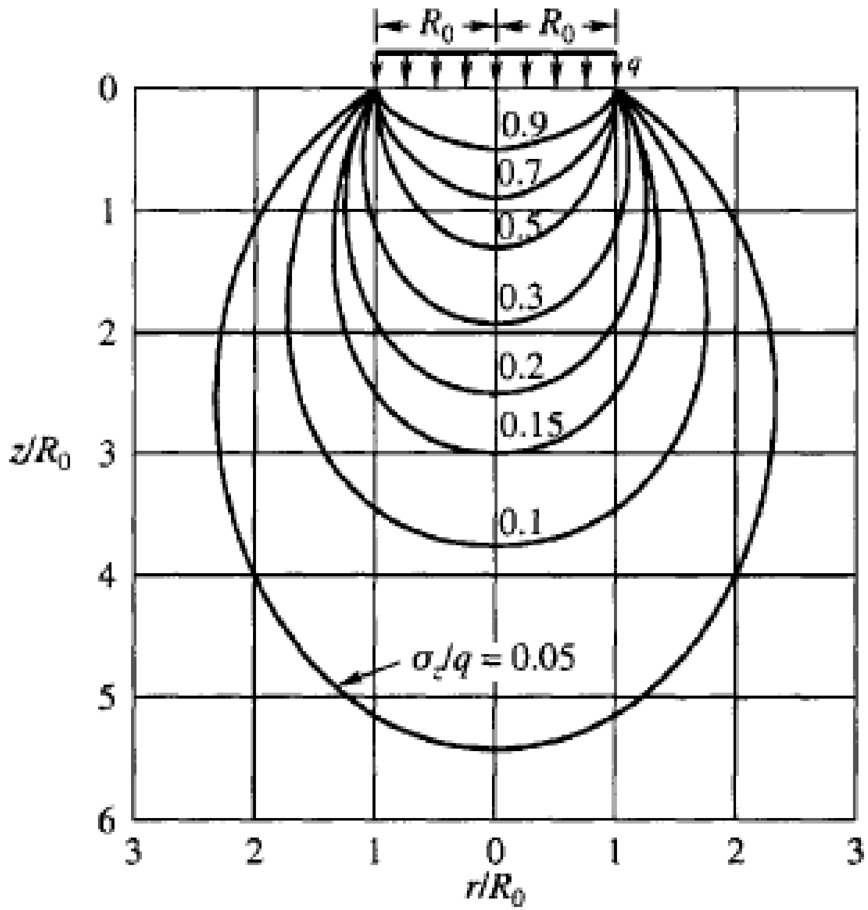
21 Pressure isobars based on Boussinesq equation for square and continuous footings

METODE GRAFIS UNTUK PONDASI



23 Pressure isobars based on Westergaard equation for square and continuous footing

METODE GRAFIS UNTUK PONDASI



Pressure isobars based on Boussinesq equation for uniformly loaded circular footings

BEBAN TIMBUNAN TAK HINGGA

- $\sigma_z = \gamma \times h$