Stress distribution in soil

Estimation of vertical stresses at any point in a soil-mass due to external vertical loadings are of great significance in the prediction of settlements of buildings, bridges, embankments and many other structures. Equations have been developed to compute stresses at any point in a soil mass on the basis of the theory of elasticity. According to elastic theory, constant ratios exist between stresses and strains.

When a load is applied to the soil surface, it increases the vertical stresses within the soil mass. The increased stresses are greatest directly under the loaded area, but extend indefinitely in all directions. Many formulas based on the theory of elasticity have been used to compute stresses in soils. They are all similar and differ only in the assumptions made to represent the elastic conditions of the soil mass. The formulas that are most widely used are the **Boussinesq** and **Westergaard** formulas. These formulas were first developed for point loads acting at the surface. These formulas have been integrated to give stresses below uniform strip loads and rectangular loads.

The extent of the elastic layer below the surface loadings may be any one of the following:

1. Infinite in the vertical and horizontal directions.
2. Limited thickness in the vertical direction underlain with a rough rigid.

The loads at the surface may act on flexible or rigid footings. The stress conditions in the elastic layer below vary according to the rigidity of the footings and the thickness of the elastic layer. All the external loads considered are vertical loads only as the vertical loads are of practical importance for computing settlements of foundations.

Boussinesq's formula for point load

Figure 1 shows a load **Q** acting at a point **0** on the surface of a semi-infinite solid. A semi-infinite solid is the one bounded on one side by a horizontal surface, here the surface of the earth, and infinite in all the other directions. The problem of determining stresses at any point **P** at a depth **z** as a result of a surface point load was solved by **Boussinesq** (1885) on the following assumptions.

1. The soil mass is elastic, isotropic, homogeneous and semi-infinite.
2. The soil is weightless.
3. The load is a point load acting on the surface.

The soil is said to be isotropic if there are identical elastic properties throughout the mass and in every direction through any point of it. The soil is said to be homogeneous if there are identical elastic properties at every point of the mass in identical directions.

The expression obtained by **Boussinesq** for computing vertical stress, at point **P** in **Fig. 1** due to a point load **Q** is

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

Where:
r is the horizontal distance between an arbitrary point **P** below the surface and the vertical axis through the point load **Q**.
z is the vertical depth of the point **P** from the surface.

$\mathbf{I_B}$ is Boussinesq stress coefficient.

$$I_B = \frac{3}{2\pi\left[1 + \left(\frac{r}{z}\right)^2\right]^{\frac{5}{2}}}$$

The values of **Boussinesq** coefficient $\mathbf{I_B}$ can be determined for a number of values of **r/z**. The variation of $\mathbf{I_B}$ with **r/z** in a graphical form is given in **Fig. 2**. It can be seen from this figure that $\mathbf{I_B}$ has a maximum value of **0.48** at **r/z** is **0**, indicating thereby that the stress is a maximum below the point load.

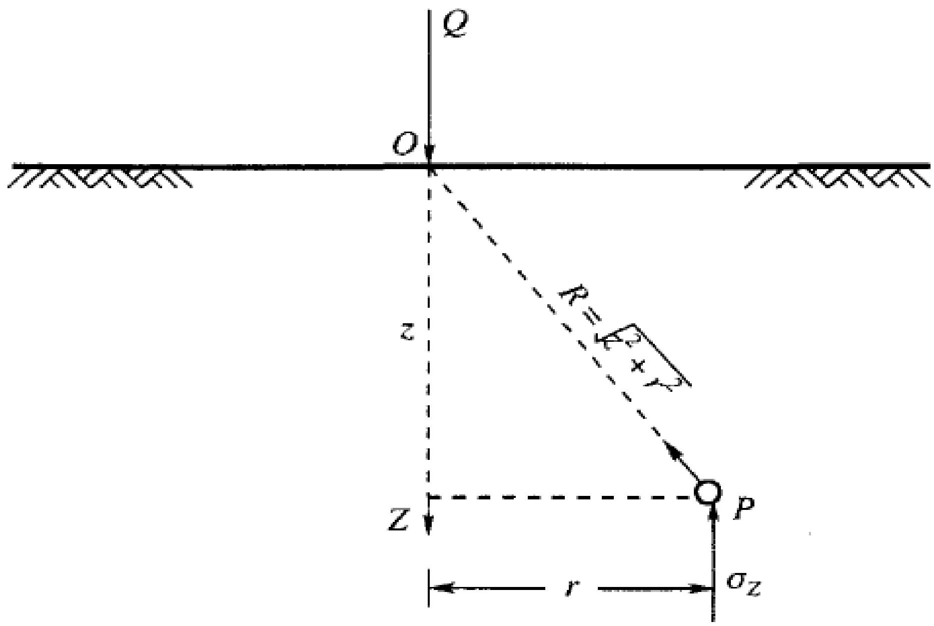


Fig. 1: Vertical pressure within an earth mass

Westergaard's formula for point load

Boussinesq assumed that the soil is elastic, isotropic and homogeneous for the development of a point load formula. However, the soil is neither isotropic or homogeneous. The most common type of soils that are met in nature are the water deposited sedimentary soils. When the soil particles are deposited in water, typical clay strata usually have their lenses of coarser materials within them. The soils of this type can be assumed as laterally reinforced by numerous, closely spaced, horizontal sheets of negligible thickness but of infinite rigidity, which prevent the mass as a whole from undergoing lateral movement of soil grains. **Westergaard**, a British Scientist, proposed (1938) a formula for the computation of vertical stress by a point load, **Q**, at the surface as

$$\sigma_z = \frac{Q\sqrt{(1-2\mu)/(2-2\mu)}}{2\pi z^2\left[(1-2\mu)/(2-\mu)+\left(\frac{r}{z}\right)^2\right]^{\frac{3}{2}}} = \frac{Q}{z^2} I_W$$

In which **μ** is **Poisson's** ratio. If **μ** is taken as zero practically, above equation simplifies to

$$\sigma_z = \frac{Q}{\pi z^2\left[1+2\left(\frac{r}{z}\right)^2\right]^{\frac{3}{2}}} = \frac{Q}{z^2} I_W \qquad (2)$$

Where:

I_W is the Westergaard stress coefficient. The variation of I_W with the ratios of **r/z** is shown graphically in **Fig. 2** along with the **Boussinesq's** coefficient I_B. The value of I_W at **r/z** equal to **0** is **0.32** which is less than that of I_B by **33** per cent. Geotechnical engineers prefer to use **Boussinesq's** solution as this gives conservative results.

$$I_W = \frac{1}{\pi\left[1+2\left(\frac{r}{z}\right)^2\right]^{\frac{3}{2}}}$$

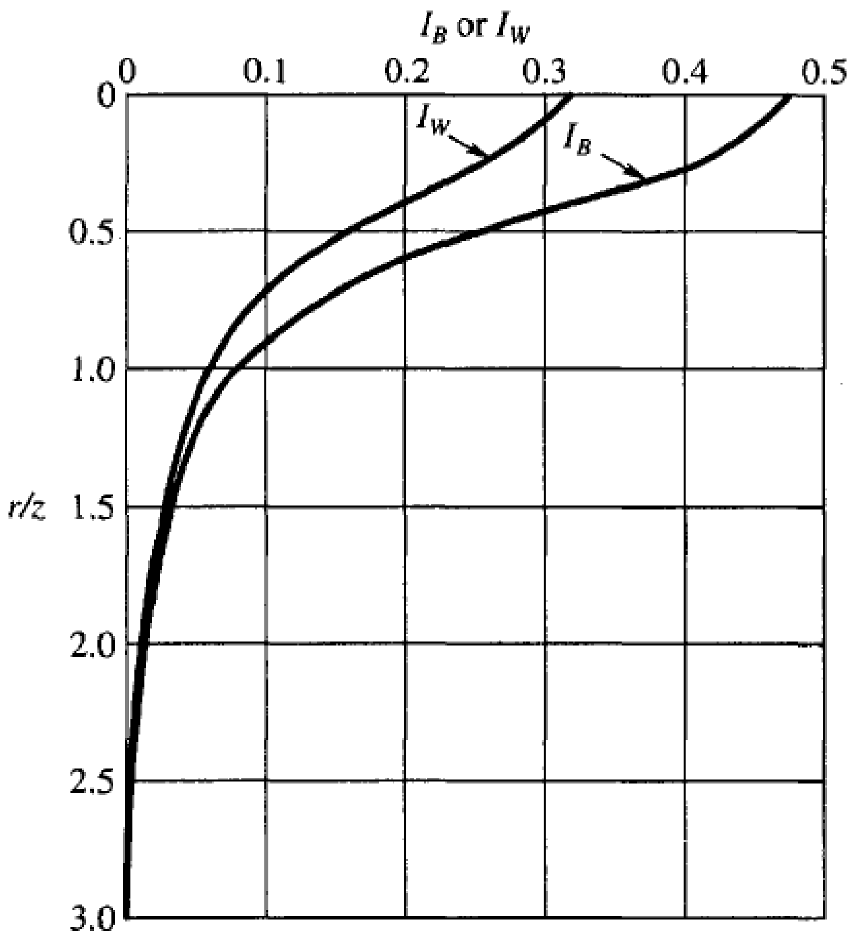


Fig. 2: Values of I_B or I_W for use in the Boussinesq or Westergaard formula

Line load

The basic equation used for computing a stress, at any point P in an elastic semi-infinite mass is **Eq. 1** of **Boussinesq**. By applying the principle of his theory, the stresses at any point in the mass due to a line load of infinite extent acting at the surface may be obtained. The state of stress encountered in this case is that of a plane strain condition. The strain at any point **P** in the **Y-direction** parallel to the line load is assumed equal to zero. The stress $\boldsymbol{\sigma_y}$ normal to the **XZ-plane** in **Fig. 3** is the same at all sections and the shear stresses on these sections are zero. By applying the theory of elasticity, stresses at any point **P** in **Fig. 3** may be obtained either in polar coordinates or in rectangular coordinates. The vertical stress $\boldsymbol{\sigma_z}$ at point **P** may be written in rectangular coordinates as

$$\sigma_z = \frac{2q}{\pi z\left[1+\left(\frac{x}{z}\right)^2\right]^2} = \frac{q}{z} I_z \qquad (3)$$

Where:

$\boldsymbol{I_z}$ is the influence factor equal to **0.637** at **x/z** is **0**.

$$I_z = \frac{2}{\pi\left[1+\left(\frac{x}{z}\right)^2\right]^2}$$

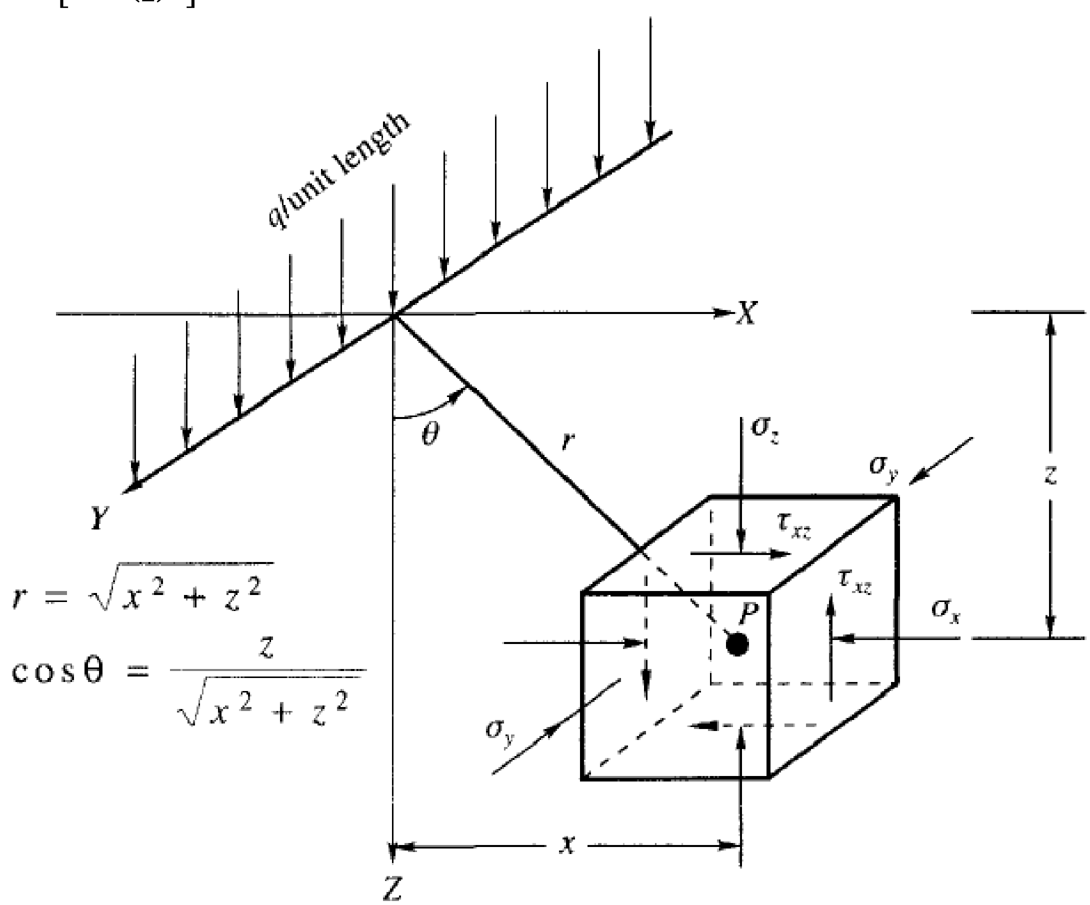


Fig. 3: Stresses due to vertical line load in rectangular coordinates

Stresses under uniformly loaded circular footing

Stresses Along the Vertical Axis of Symmetry

Figure 4 shows a plan and section of the loaded circular footing. The stress required to be determined at any point **P** along the axis is the vertical stress $\boldsymbol{\sigma_z}$.

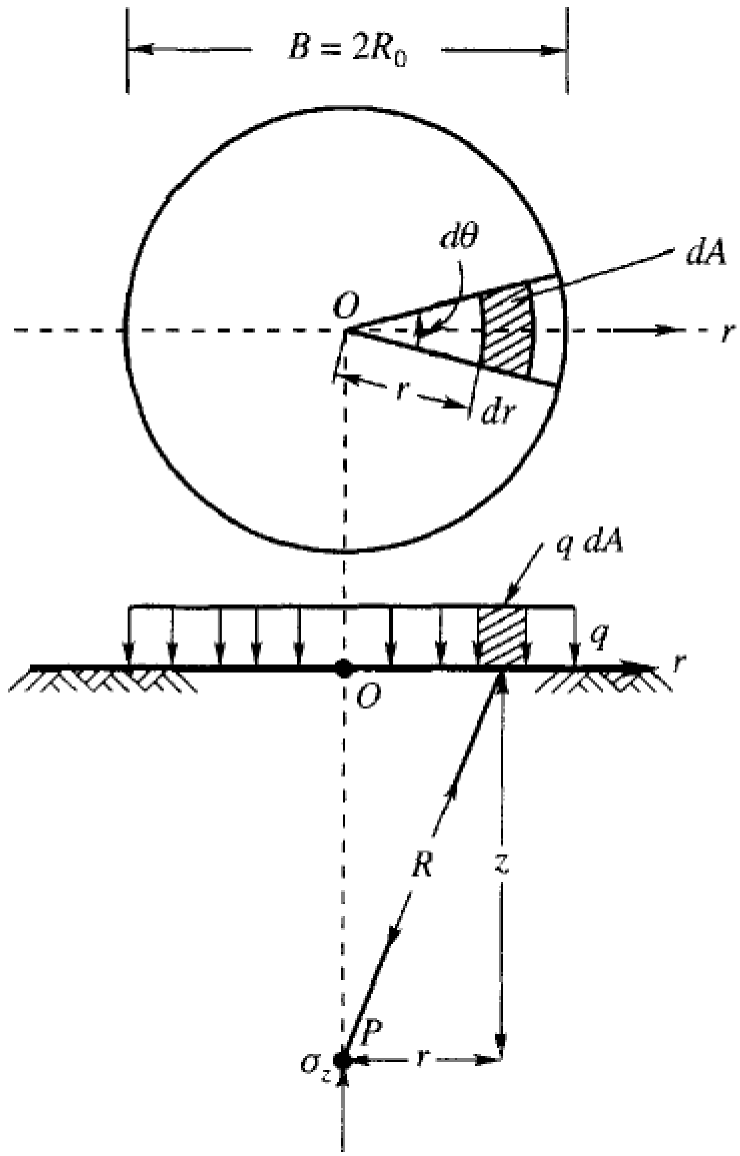


Fig. 4: Vertical stress under uniformly loaded circular footing

The stress at any point **P** on the axis of symmetry of a circular loaded area may be calculated by the use of **Eq. 4**. Vertical stresses $\boldsymbol{\sigma_z}$ may be calculated by using the influence coefficient as

$$\sigma_z = qI_z \tag{4}$$

where, $\mathbf{I_z}$ is the influence coefficient. Determined from the diagram given in **Fig. 5**.

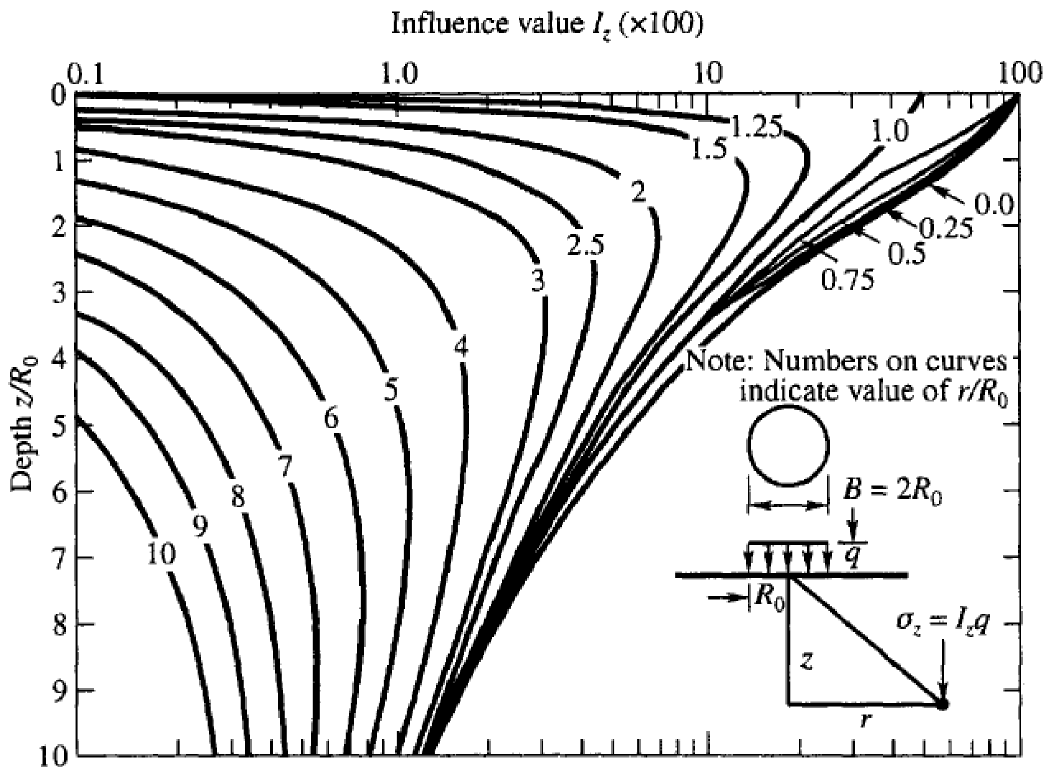


Fig. 5: Influence diagram for vertical normal stress at various points within an elastic half-space under a uniformly loaded circular area. (After Foster and Ahlvin, 1954)

Stresses beneath the corner of rectangular foundation

Consider an infinitely small unit of area of size **db**x**dl**, shown in **Fig. 6**. The pressure acting on the small area may be replaced by a concentrated load (**dQ=qdbdl)** applied to the center of the area.

The increase of the vertical stress due to the load **dQ** can be expressed as

$$d\sigma_z = \frac{3dQz^3}{2\pi[z^2 + r^2]^{\frac{5}{2}}}$$

The stress produced by the pressure **q** over the entire rectangle (**bxl**) can then be obtained by expressing **dl**, **db** and **r** in terms of the angles **α** and **β**, and integrating. The one of solution that is normally used is of the following form

$$\sigma_z = \frac{q}{4\pi}\left[\frac{2mn(m^2+n^2+1)^{\frac{1}{2}}(m^2+n^2+2)}{(m^2+n^2+m^2n^2+1)(m^2+n^2+1)} + \tan^{-1}\frac{2mn(m^2+n^2+1)^{\frac{1}{2}}}{(m^2+n^2-m^2n^2+1)}\right]$$

$$\sigma_z = qI \qquad (4)$$

$$I = \frac{1}{4\pi}\left[\frac{2mn(m^2+n^2+1)^{\frac{1}{2}}(m^2+n^2+2)}{(m^2+n^2+m^2n^2+1)(m^2+n^2+1)} + \tan^{-1}\frac{2mn(m^2+n^2+1)^{\frac{1}{2}}}{(m^2+n^2-m^2n^2+1)}\right]$$

Where, (m=b/z), (n=L/z), are pure numbers. **I** is a dimensionless factor and represents the influence of a surcharge covering a rectangular area on the vertical stress at a point located at a depth **z** below one of its corners.

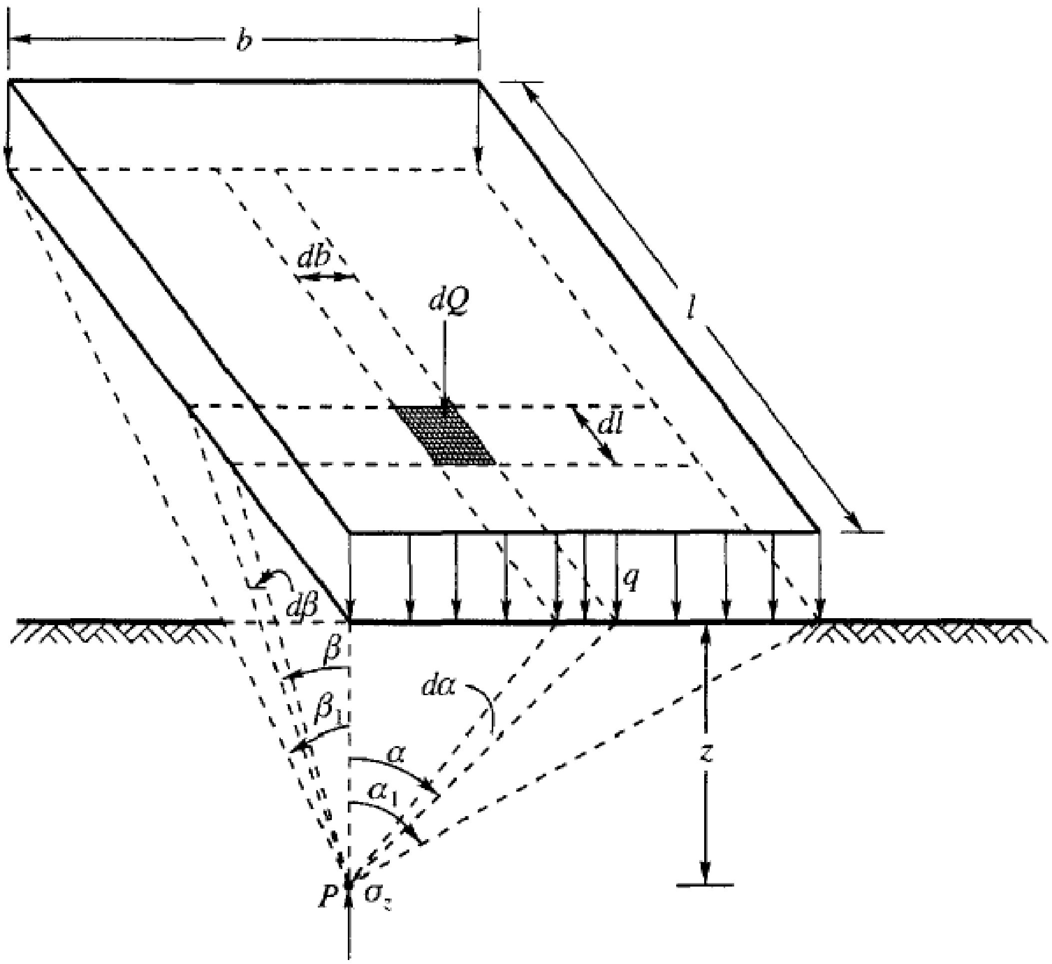


Fig. 6: Vertical stress under the corner of a rectangular foundation

Fig. 7 used for computing the influence value **I** based on the values of **m** and **n** and may also be used to determine stresses below points that lie either inside or outside the loaded areas as follows.

When the Point is Inside

Let **O** be an interior point of a rectangular loaded area ABCD shown in **Fig. 8. a**. It is required to compute the vertical stress below this point **O** at a depth **z** from the surface. For this purpose, divide the rectangle ABCD into four rectangles marked **1** to **4** in the **Fig. 8. a** by drawing lines through **O**. For each of these rectangles, compute the influence coefficient **I** for each rectangular and the total stress at **P** is therefore

$$\sigma_z = q(I_1 + I_2 + I_3 + I_4) \qquad (4.1)$$

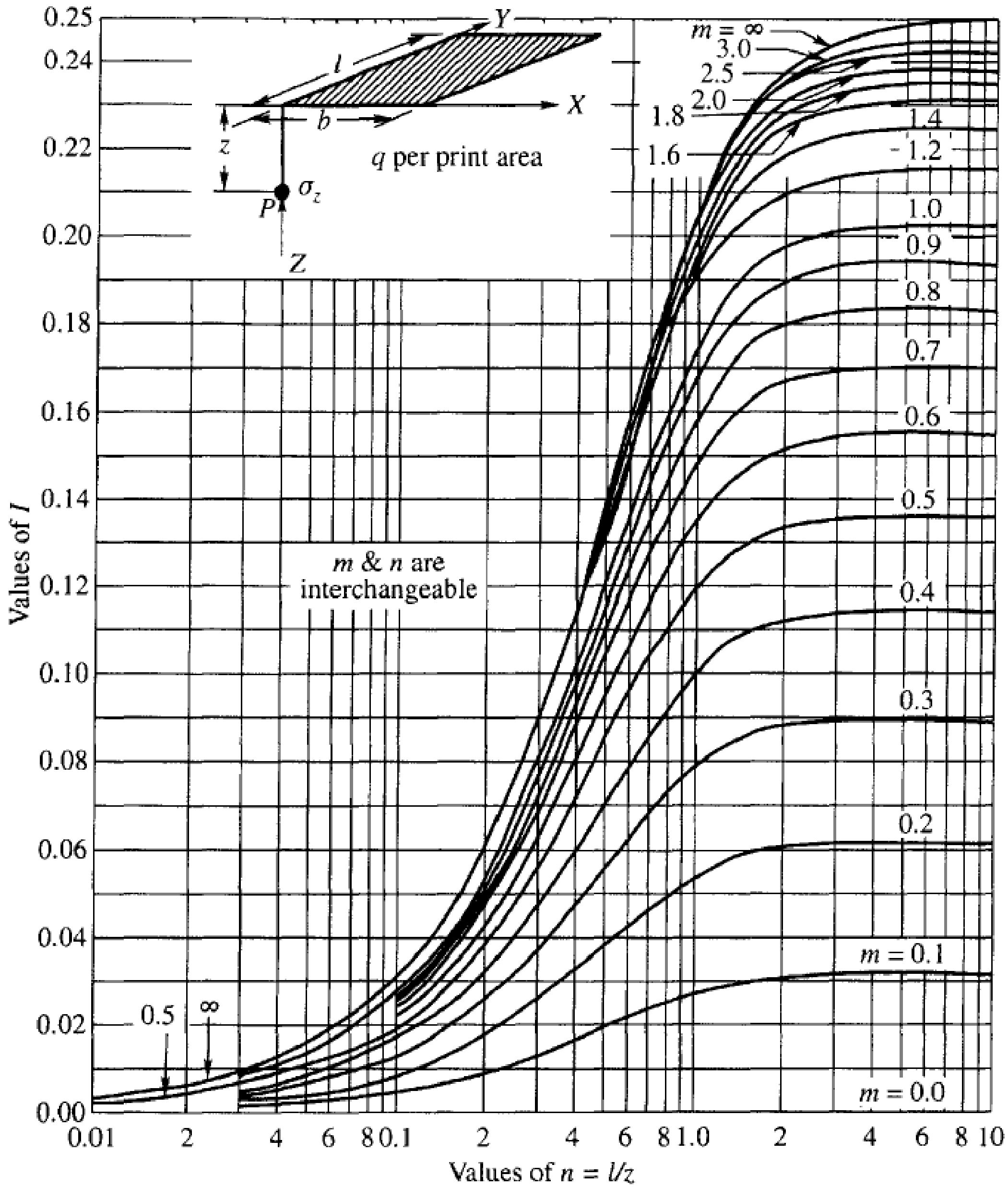


Fig. 7: Graph for determining influence value for vertical normal stress at point **P** located beneath one corner of a uniformly loaded rectangular area. (After Fadum, 1948)

When the Point is Outside

Let **O** be an exterior point of loaded rectangular area ABCD shown in **Fig. 8. b**. It is required to compute the vertical stress below point **0** at a depth **z** from the surface.

Construct rectangles as shown in the figure. The point **O** is the corner point of the rectangle OB_1CD_1. From the figure it can be seen that

$A_{ABCD} = A_{OB_1CD_1} - A_{OB_1BD_2} - A_{OD_1DA_1} + A_{OA_1AD_2}$

The vertical stress at point **P** located at a depth **z** below point **0** due to a surcharge **q** per unit area of ABCD is equal to the algebraic sum of the vertical stresses produced by loading each one of the areas with **q** per unit of area. If $\mathbf{I_1}$ to $\mathbf{I_4}$ are the influence factors of each of these areas, the total vertical stress is

$$\sigma_z = q(I_1 - I_2 - I_3 + I_4) \tag{4.2}$$

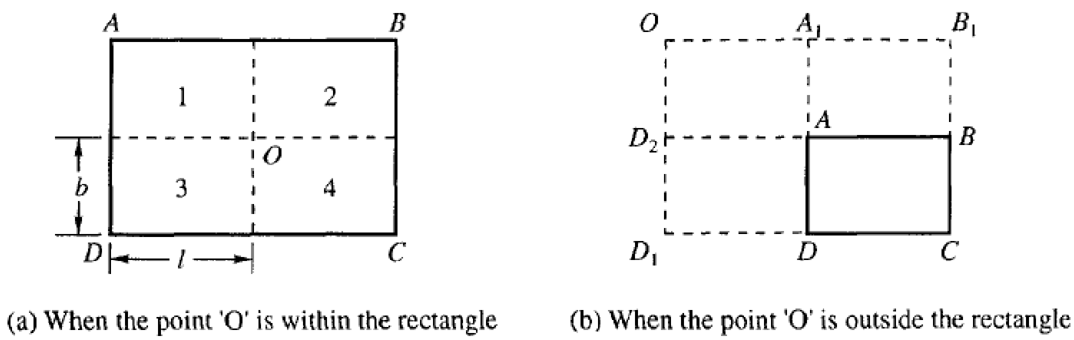


Fig. 8: Computation of vertical stress below a point

Approximate method for computing vertical stress (2:1 method)

In this method, the stress is assumed to be distributed uniformly over areas lying below the foundation. The size of the area at any depth is obtained by assuming that the stresses spread out at an angle of **2** (vertical) to **1** (horizontal) from the edges of the loaded areas shown in **Fig. 9**. The average stress at any depth **z** is

$$\sigma_z = \frac{Q}{(B + z)(L + z)} \tag{5}$$

The maximum stress $\boldsymbol{\sigma_m}$ by an exact method below the loaded area is different from the average stress $\boldsymbol{\sigma_a}$ at the same depth. The value of $\boldsymbol{\sigma_m / \sigma_a}$ reaches a maximum of about 1.6 at the ratio **z/b** from **0** to **5**, where **b** is half width.

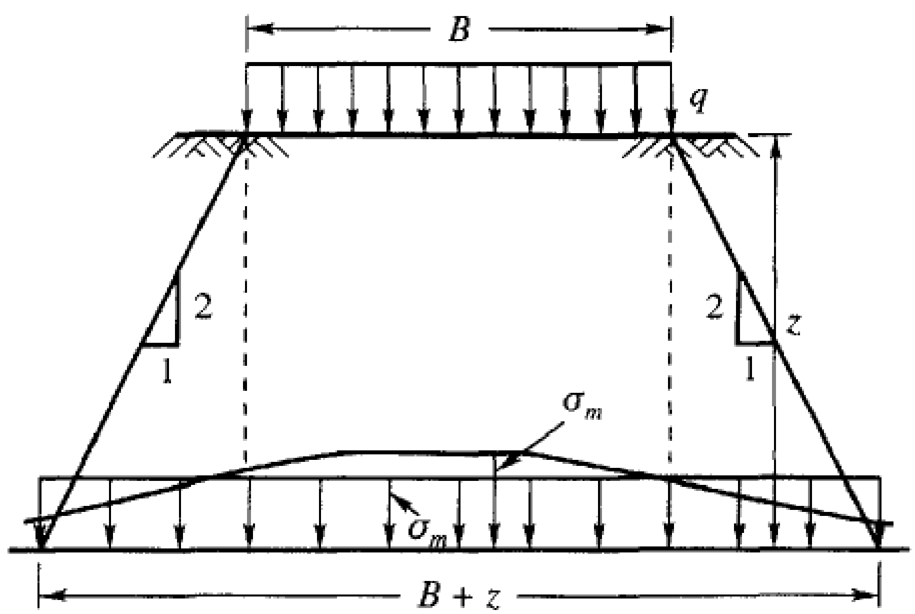


Fig. 9: $\boldsymbol{\sigma_m}$ 2:1 method

Example. 1

A concentrated load of 1000kN is applied at the ground surface. Compute the vertical pressure at a depth of 4 m below the load, and at a distance of 3 m at the same depth. Use Boussinesq and Westergaard formulas.

Solution

Boussinesq's formula

Vertical pressure at depth 4m below the load

$$I_B = \frac{3}{2\pi\left[1+\left(\frac{r}{z}\right)^2\right]^{\frac{5}{2}}} = \frac{3}{2\pi\left[1+\left(\frac{0}{4}\right)^2\right]^{\frac{5}{2}}} = 0.48$$

$$\sigma_z = \frac{Q}{z^2} I_B = \frac{1000}{4^2} * 0.48 = 30\,\text{kN/m}^2$$

Vertical pressure at depth 4m and at distance 3m

$$I_B = \frac{3}{2\pi\left[1+\left(\frac{3}{4}\right)^2\right]^{\frac{5}{2}}} = 0.156$$

$$\sigma_z = \frac{Q}{z^2} I_B = \frac{1000}{4^2} * 0.156 = 9.75\,\text{kN/m}^2$$

Westergaard's formula

Vertical pressure at depth 4m below the load

$$I_W = \frac{1}{\pi\left[1+2\left(\frac{r}{z}\right)^2\right]^{\frac{3}{2}}} = \frac{1}{\pi\left[1+2\left(\frac{0}{4}\right)^2\right]^{\frac{3}{2}}} = 0.32$$

$$\sigma_z = \frac{Q}{z^2} I_W = \frac{1000}{4^2} * 0.32 = 20\,\text{kn/m}^2$$

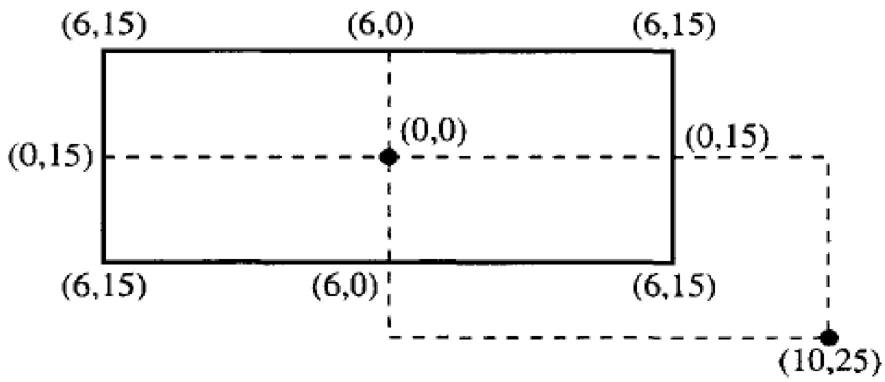
Vertical pressure at depth 4m and at distance 3m

$$I_W = \frac{1}{\pi\left[1+2\left(\frac{3}{4}\right)^2\right]^{\frac{3}{2}}} = 0.103$$

$$\sigma_z = \frac{Q}{z^2} I_W = \frac{1000}{4^2} * 0.103 = 6.44\,\text{kn/m}^2$$

Example. 2

A rectangular raft of size 30 x 12 m founded at a depth of 2.5 m below the ground surface is subjected to a uniform pressure of 150 kPa. Assume the center of the area is the origin of coordinates (0, 0). and the corners have coordinates (6, 15). Calculate stresses at a depth of 20 m below the foundation level by the methods of (a) Boussinesq, and (b) Westergaard at coordinates of (0, 0), (0, 15), (6, 0) (6, 15) and (10, 25). Also determine the ratios of the stresses as obtained by the two methods. Neglect the effect of foundation depth



Solution

$Q = q * A = 150 * 30 * 12 = 54000\text{kN}$

Location, (10, 25) at depth 20m and at distance 26.92m from the point at applied load

$$I_B = \frac{3}{2\pi\left[1+\left(\frac{r}{z}\right)^2\right]^{\frac{5}{2}}} = \frac{3}{2\pi\left[1+\left(\frac{26.92}{20}\right)^2\right]^{\frac{5}{2}}} = 0.036$$

$$\sigma_z = \frac{Q}{z^2} I_B = \frac{54000}{20^2} * 0.036 = 5\,\text{kn/m}^2$$

$$I_W = \frac{1}{\pi\left[1+2\left(\frac{r}{z}\right)^2\right]^{\frac{3}{2}}} = \frac{1}{\pi\left[1+2\left(\frac{26.92}{20}\right)^2\right]^{\frac{3}{2}}} = 0.03$$

$$\sigma_z = \frac{Q}{z^2} I_W = \frac{54000}{20^2} * 0.03 = 4\,\text{kn/m}^2$$

Location	r/z	Boussinesq		Westergaard		ratio
		I_B	σ	I_W	σ	
(0, 0)	0	0.48	65	0.32	43	1.51
(6, 0)	0.3	0.39	53	0.25	34	1.56
(0, 15)	0.75	0.16	22	0.10	14	1.57
(6, 15)	0.81	0.14	19	0.09	12	1.58
(10, 25)	1.35	0.036	5	0.03	4	1.25

Example. 3

A water tank is required to be constructed with a circular foundation having a diameter of 16m founded at a depth of 2m below the ground surface. The estimated distributed load on the foundation is 325kN/m^2. Assuming that the subsoil extends to a great depth and is isotropic and homogeneous, determine the stresses at depth 16m, under the point of applied load and at distance 8m. Neglect the effect of the depth of the foundation on the stresses.

Solution

Stress at the point of applied

r/R_o ratio is equal to zero and Z/R_o is equal to 2, and from Fig. 5. I_z is 0.3, then

$\sigma_z = qI_z = 325 * 0.3 = 97.5\,\text{kN/m}^2$

Stress at the distance 8m from the point of applied
r/R_o ratio is equal to 1 and Z/R_o is equal to 2, and from Fig. 5. I_z is 0.2, then

$$\sigma_z = qI_z = 325 * 0.2 = 65\,\text{kN/m}^2$$

Example. 4

A rectangular raft of size 30 x 12 m founded on the ground surface is subjected to a uniform pressure of 150 kN/m^2. Assume the center of the area as the origin of coordinates (0,0), and corners with coordinates (6, 15). Calculate the induced stress at a depth of 20 m by the exact method at location (0, 0).

Solution

Divide the rectangle 12 x 30 m into four equal parts of size 6 x 15m.

The stress below the corner of each footing may be calculated by using charts given by Fadum in Fig. 7.

For a rectangle 6 x 15 m,

$$n = \frac{L}{z} = \frac{15}{20} = 0.75$$

$$m = \frac{b}{z} = \frac{6}{20} = 0.3$$

$$I = 0.07$$

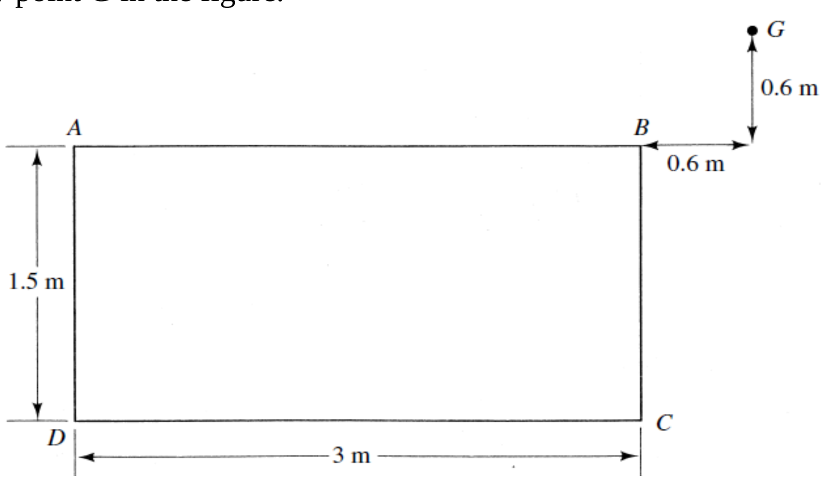
$$\sigma_z = q(I_1 + I_2 + I_3 + I_4) = 4qI = 4 * 150 * 0.07 = 42\,\text{kN/m}^2$$

Problem. 1

A circular area carrying a uniformly distributed load 100kN/m^2 is applied to the ground surface. The radius of the circular area is 3m. determine the vertical stress increment due to this uniform load, at a point 6m below the center of the circular area and at a point 6m below the ground surface at a horizontal distance of 1.5m from the center of the circular area.

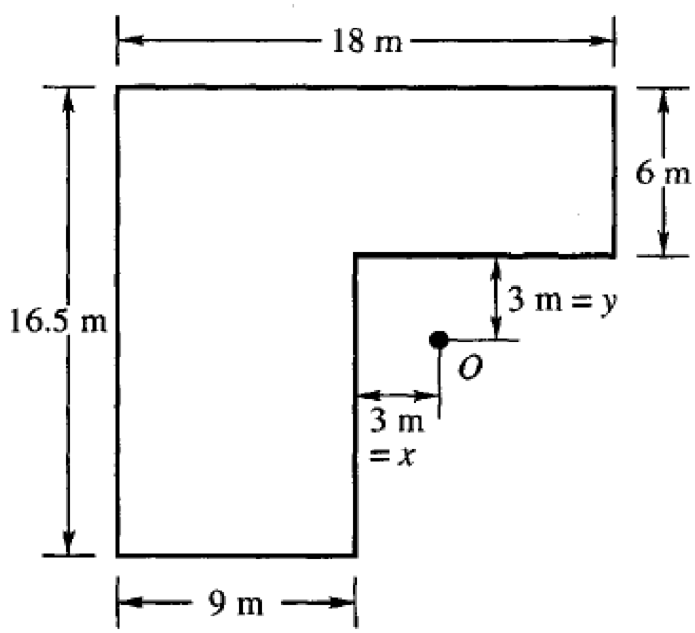
Problem. 2

A rectangular loaded area ABCD shown in plan in Figure below. The load exerted on the area is 80kN/m^2. Determine the vertical stress increment due to the exerted load at a depth of 3 m below point G in the figure.



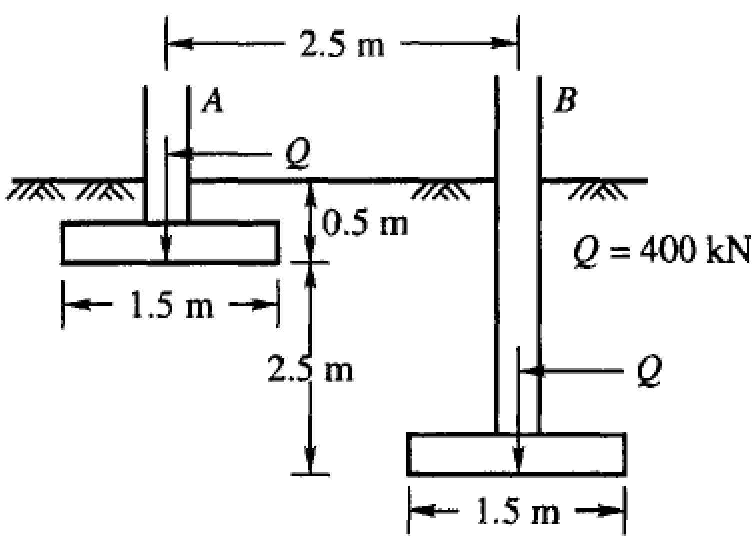
Problem. 3

A raft foundation of the size given in figure below, carries a uniformly distributed load of 300kN/m^2. Estimate the vertical pressure at a depth 9 m below the point O marked in the figure.



Problem. 4

A and B are two footings of size 1.5 x 1.5 m each placed in position as shown in figure below. Each of the footings carries a column load of 400kN. Determine by the Boussinesq method, the excess load footing B carries due to the effect of the load on A. Assume the loads at the centers of footings act as point loads.



Problem. 5

If both footings A and B in in problem. 3 are at the same level at a depth of 0.5 m below the ground surface, compute the stress, midway between the footings at a depth of 3 m from the ground surface. Neglect the effect of the size for point load method.

Problem. 6

Three concentrated loads Q_l is 1135kN, Q_2 is 2000kN and Q_3 is 3000kN act in one vertical plane and they are placed in the order Q_1-Q_2-Q_3. Their spacings are 4m-3m. Determine the vertical pressure at a depth of 1.5m along the center line of footings using Boussinesq's point load formula.

Problem. 7

A long masonry wall footing carries a uniformly line load of 100kN/m. If the width of the footing is 0.6m, determine the vertical pressures at a depth of 3 m below the center of footing, and distance 2m from the footing.

6.12 PROBLEMS

6.1 A column of a building transfers a concentrated load of 225 kips to the soil in contact with the footing. Estimate the vertical pressure at the following points by making use of the Boussinesq and Westergaard equations.

(i) Vertically below the column load at depths of 5, 10, and 15 ft.

(ii) At radial distances of 5, 10 and 20 ft and at a depth of 10 ft.

6.2 Three footings are placed at locations forming an equilateral triangle of 13 ft sides. Each of the footings carries a vertical load of 112.4 kips. Estimate the vertical pressures by means of the Boussinesq equation at a depth of 9 ft at the following locations :

(i) Vertically below the centers of the footings.

(ii) Below the center of the triangle.

6.3 A reinforced concrete water tank of size 25 ft × 25 ft and resting on the ground surface carries a uniformly distributed load of 5.25 kips/ft^2. Estimate the maximum vertical pressures at depths of 37.5 and 60 ft by point load approximation below the center of the tank.

6.4 Two footings of sizes 13 × 13 ft and 10 × 10 ft are placed 30 ft center to center apart at the same level and carry concentrated loads of 337 and 281 kips respectively. Compute the vertical pressure at depth 13 ft below point C midway between the centers of the footings.

6.5 A and B are two footings of size 1.5 × 1.5 m each placed in position as shown in Fig. Prob. 6.5. Each of the footings carries a column load of 400 kN. Determine by the

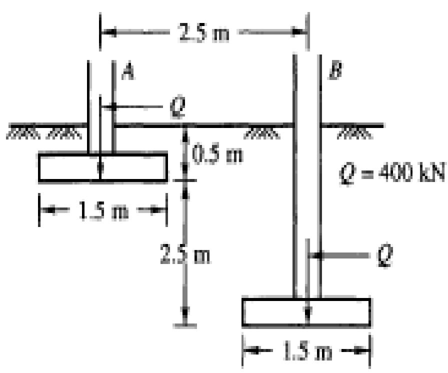


Figure Prob. 6.5

Boussinesq method, the excess load footing B carries due to the effect of the load on A. Assume the loads at the centers of footings act as point loads.

6.6 If both footings A and B in Fig. Prob. 6.5 are at the same level at a depth of 0.5 m below the ground surface, compute the stress σ_z midway between the footings at a depth of 3 m from the ground surface. Neglect the effect of the size for point load method.

6.7 Three concentrated loads Q_1 = 255 kips, Q_2 = 450 kips and Q_3 = 675 kips act in one vertical plane and they are placed in the order Q_1–Q_2–Q_3. Their spacings are 13 ft–10 ft. Determine the vertical pressure at a depth of 5 ft along the center line of footings using Boussinesq's point load formula.

6.8 A square footing of 13 × 13 ft is founded at a depth of 5 ft below the ground level. The imposed pressure at the base is 8732 lb/ft^2. Determine the vertical pressure at a depth of 24 ft below the ground surface on the center line of the footing.

6.9 A long masonry wall footing carries a uniformly distributed load of 200 kN/m ^{2}. If the width of the footing is 4 m, determine the vertical pressures at a depth of 3 m below the (i) center, and (ii) edge of the footing.

6.10 A long foundation 0.6 m wide carries a line load of 100 kN/m. Calculate the vertical stress σ_z at a point P, the coordinates of which are x = 2.75 m, and z = 1.5 m, where the x-coordinate is normal to the line load from the central line of the footing.

6.11 A strip footing 10 ft wide is loaded on the ground surface with a pressure equal to 4177 lb/ft^2. Calculate vertical stresses at depths of 3, 6, and 12 ft under the center of the footing.

6.12 A rectangular footing of size 25 × 40 ft carries a uniformly distributed load of 5200 lb/ft^2. Determine the vertical pressure 20 ft below a point O which is located at a distance of 35 ft from the center of the footing on its longitudinal axis by making use of the curves in Fig. 6.8.

6.13 The center of a rectangular area at the ground surface has cartesian coordinate (0,0) and the corners have coordinates (6,15). All dimensions are in foot units. The area carries a uniform pressure of 3000 lb/ft^2. Estimate the stresses at a depth of 30 ft below ground surface at each of the following locations: (0,0), (0,15), (6,0).

6.14 Calculate the vertical stress at a depth of 50 ft below a point 10 ft oubide the corner (along the longer side) of a rectangular loaded area 30 × 80 ft carrying a uniform load of 2500 lb/ft^2.

6.15 A rectangular footing 6 × 3 m carries a uniform pressure of 300 kN/m^2 on the surface of a soil mass. Determine the vertical stress at a depth of 4.5 m below the surface on the center line 1.0 m inside the long edge of the foundation.

6.16 A circular ring foundation for an overhead tank transmits a contact pressure of 300 kN/m^2. Its internal diameter is 6 m and external diameter 10 m. Compute the vertical stress on the center line of the footing due to the imposed load at a depth of 6.5 m below the ground level. The footing is founded at a depth of 2.5 m.

6.17 In Prob. 6.16, if the foundation for the tank is a raft of diameter 10 m, determine the vertical stress at 6.5 m depth on the center line of the footing. All the other data remain the same.

6.18 How far apart must two 20 m diameter tanks be placed such that their combined stress overlap is not greater than 10% of the surface contact stress at a depth of 10 m?

6.19 A water tower is founded on a circular ring type foundation. The width of the ring is 4 m and its internal radius is 8 m. Assuming the distributed load per unit area as 300 kN/m^2, determine the vertical pressure at a depth of 6 m below the center of the foundation.

6.20 An embankment for road traffic is required to be constructed with the following dimensions :

Top width = 8 m, height = 4 m, side slopes= 1 V : 1.5 Hor

The unit weight of soil under the worst condition is 21 kN/m^3. The surcharge load on the road surface may be taken as 50 kN/m^2. Compute the vertical pressure at a depth of 6 m below the ground surface at the following locations:

(i) On the central longitudinal plane of the embankment.

(ii) Below the toes of the embankment.

6.21 If the top width of the road given in Prob. 6.20 is reduced to zero, what would be the change in the vertical pressure at the same points?

6.22 A square footing of size 13×13 ft founded on the surface carries a distributed load of 2089 lb/ft^2. Determine the increase in pressure at a depth of 10 ft by the 2:1 method

6.23 A load of 337 kips is imposed on a foundation 10 ft square at a shallow depth in a soil mass. Determine the vertical stress at a point 16 ft below the center of the foundation (a) assuming the load is uniformly distributed over the foundation, and (b) assuming the load acts as a point load at the center of the foundation.

6.24 A total load of 900 kN is uniformly distributed over a rectangular footing of size 3×2 m. Determine the vertical stress at a depth of 2.5 m below the footing at point C (Fig. Prob. 6.24), under one corner and D under the center. If another footing of size 3×1 m with a total load of 450 kN is constructed adjoining the previous footing, what is the additional stress at the point C at the same depth due to the construction of the second footing?

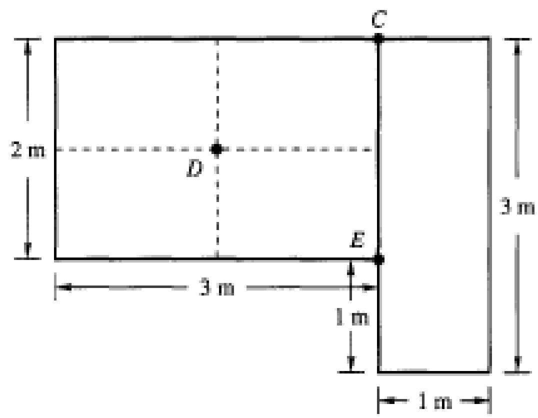


Figure Prob. 6.24

6.25 Refer to Prob. 6.24. Determine the vertical stress at a depth of 2.5 m below point E in Fig. Prob. 6.24. All the other data given in Prob. 6.24 remain the same.