Chapter 10
Stresses in a Soil Mass

As discussed in Principles of Geotechnical Engineering by Das and Sobhan (2014)

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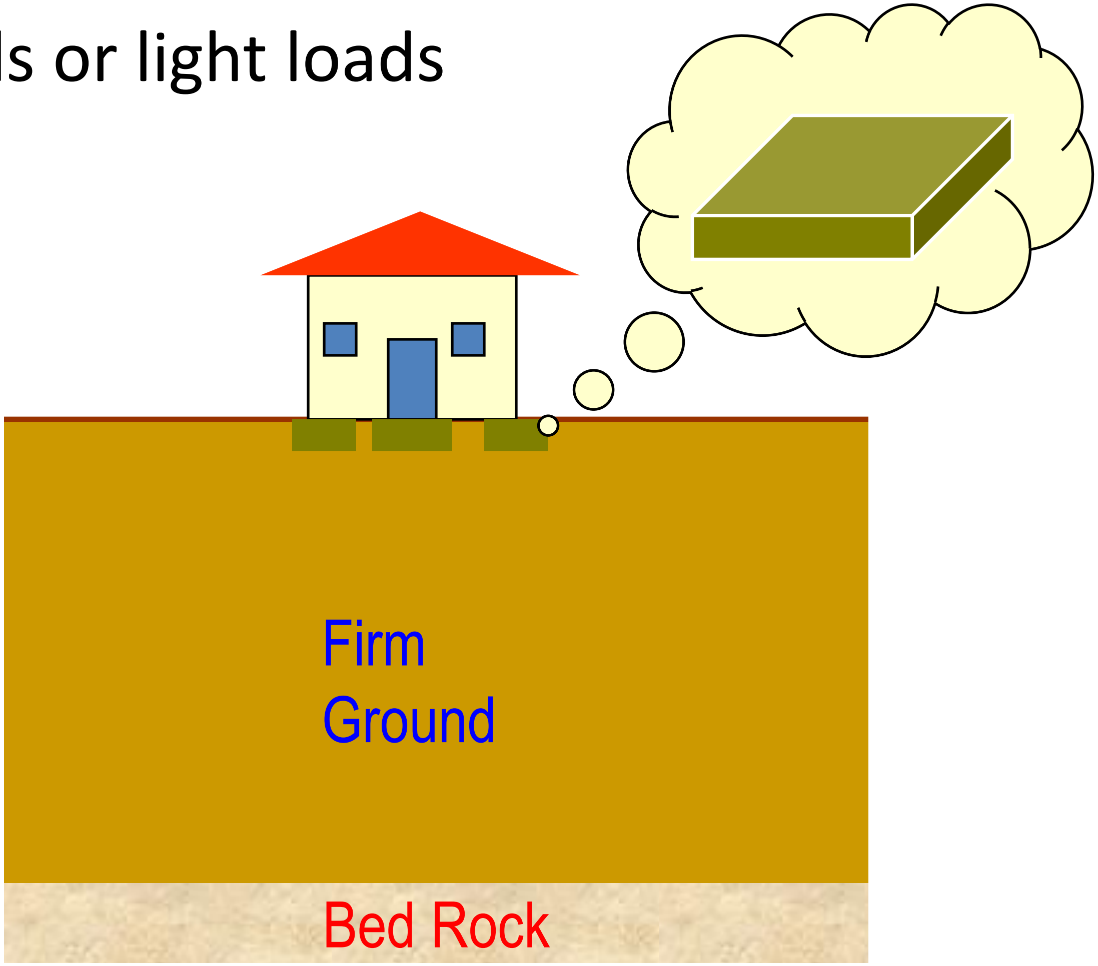
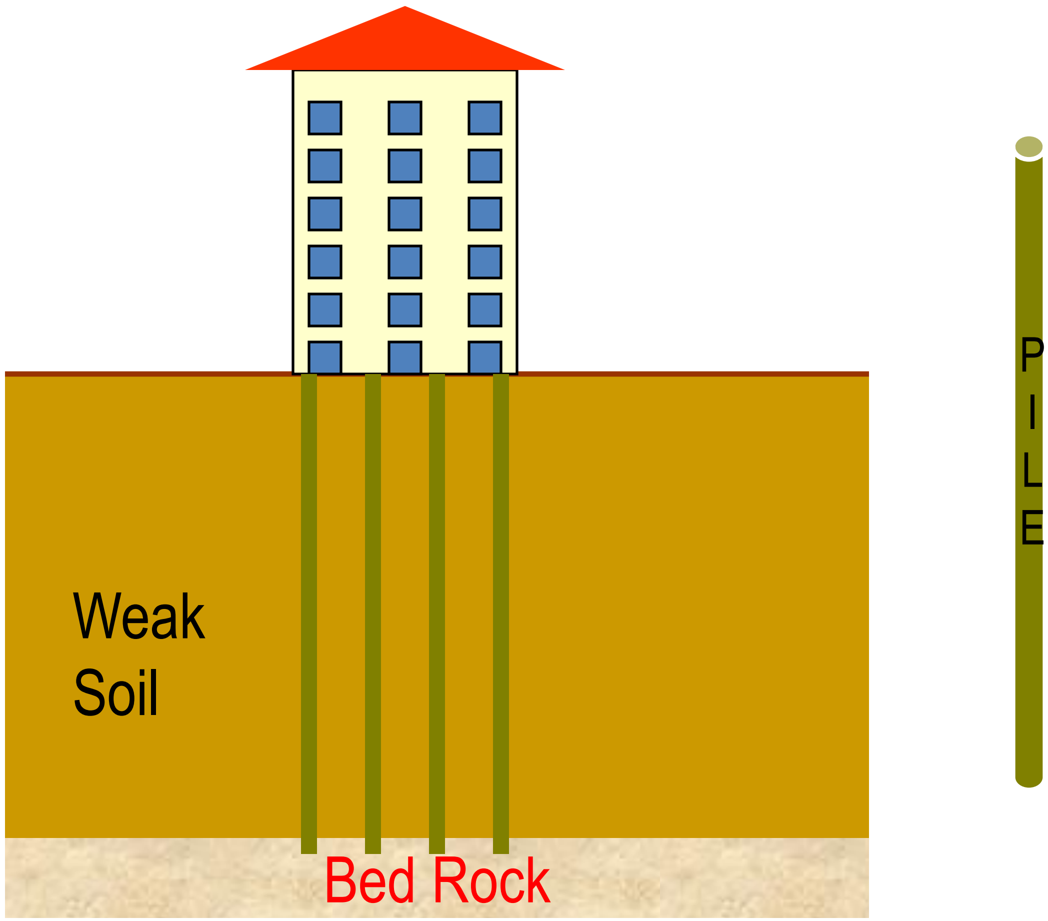
Shallow Foundations

- Transferring building loads to underlying ground
- Mostly for firm soils or light loads



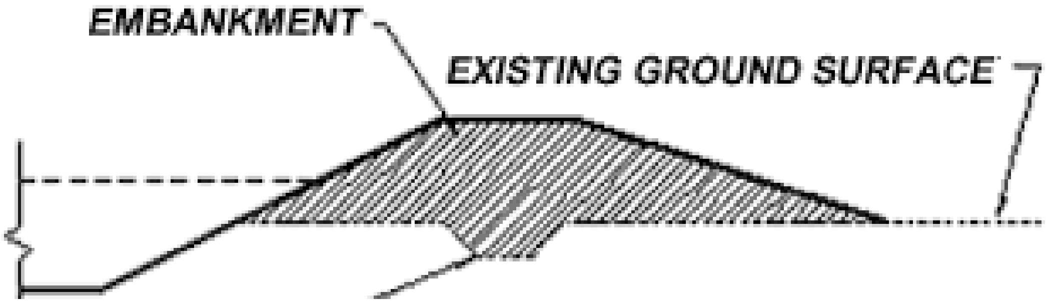
Deep Foundations

- Transferring building loads to underlying ground
- Mostly for weak soils or heavy loads



Embankment

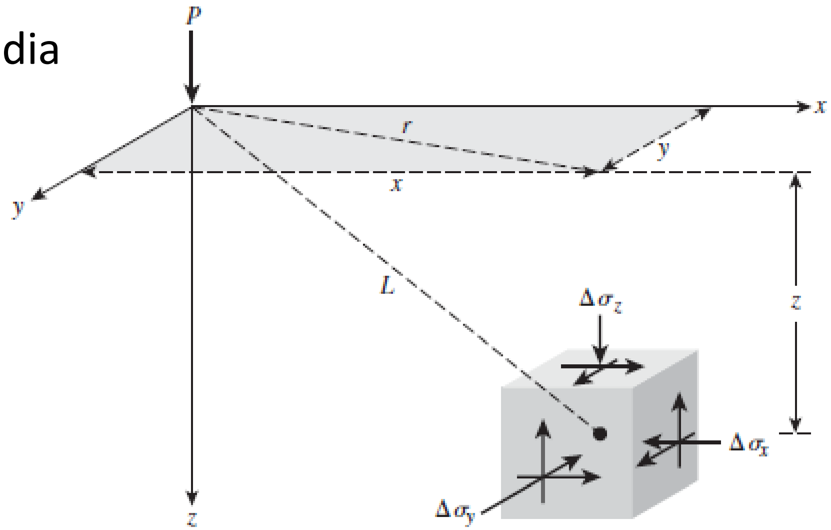

Track structure – ballast, ties, rail
Embankment
Thaw Stable Sand and Gravel
Ice Rich Soils


EMBANKMENT
EXISTING GROUND SURFACE

10.4 Stresses Caused by a Point Load

Boussinesq (1883)

Homogenous, elastic, and Isotropic soil media



$$\Delta\sigma_z = \frac{P}{z^2}\left\{\frac{3}{2\pi}\frac{1}{[(r/z)^2+1]^{5/2}}\right\} = \frac{P}{z^2}I_1$$

$\Delta\sigma_z$=vertical stress increase

where $r = \sqrt{x^2 + y^2}$

$$L = \sqrt{x^2 + y^2 + z^2} = \sqrt{r^2 + z^2}$$

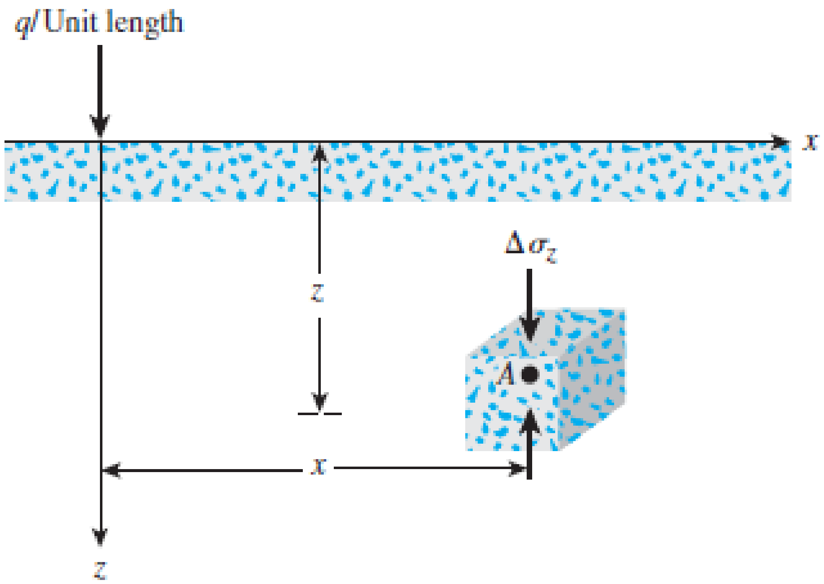
$$I_1 = \frac{3}{2\pi}\frac{1}{[(r/z)^2+1]^{5/2}}$$

The variation of I_1 for various values of r/z is given in Table 10.1.

Example 10.3

10.5 Vertical Stress Caused by a Vertical Line Load

$$\Delta\sigma_z = \frac{2qz^3}{\pi(x^2 + z^2)^2}$$



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

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

Table 10.2 Variation of $\Delta\sigma_z/(q/z)$ with x/z

Example 10.4

10.6 Vertical Stress Caused by a Horizontal Line Load

$$\Delta\sigma_z = \frac{2q}{\pi} \frac{xz^2}{(x^2 + z^2)^2}$$

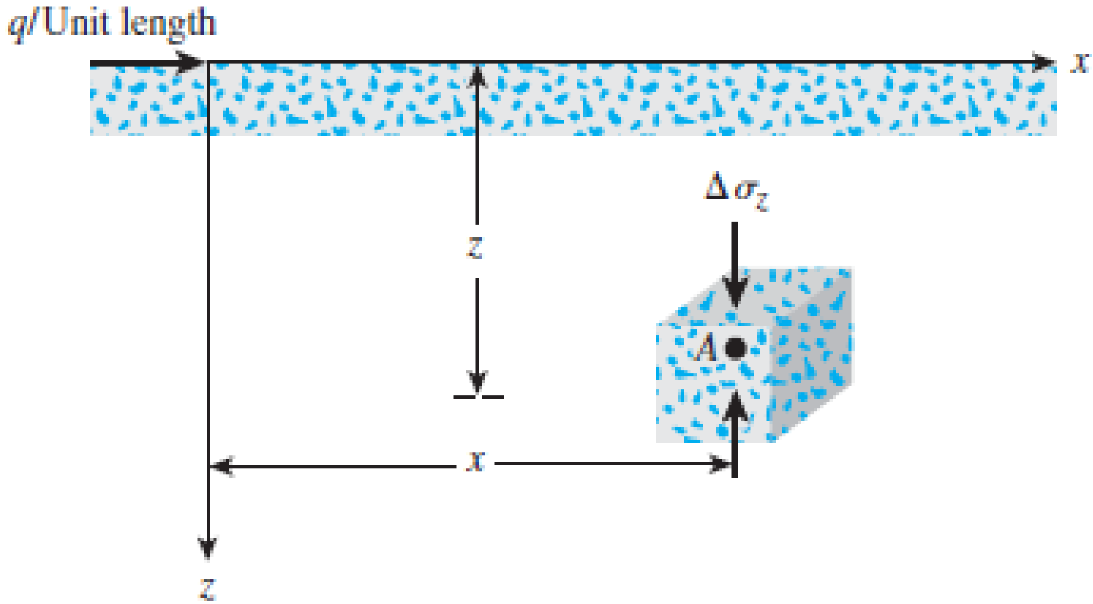
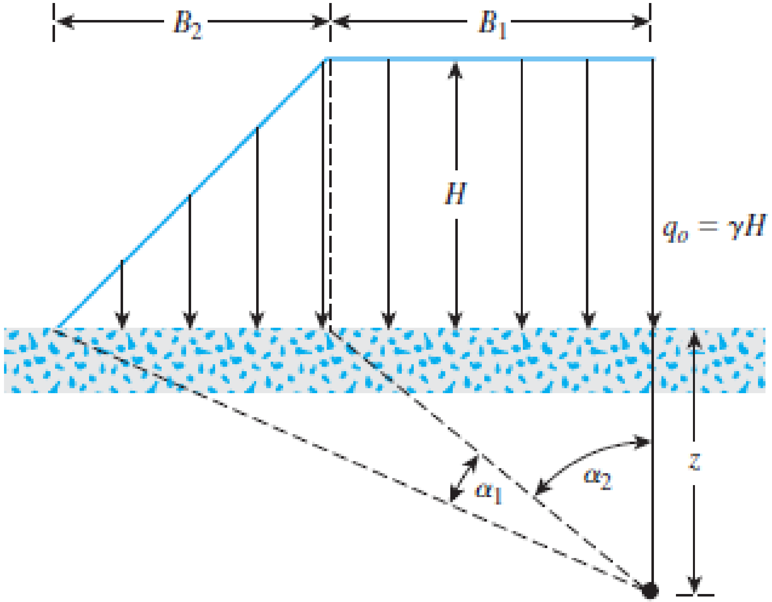


Table 10.3 gives the variation of $\Delta\sigma_z/(q/z)$ with x/z.

Example 10.5

10.9 Vertical Stress Due to Embankment Loading

$$\Delta\sigma_z = \frac{q_o}{\pi}\left[\left(\frac{B_1 + B_2}{B_2}\right)(\alpha_1 + \alpha_2) - \frac{B_1}{B_2}(\alpha_2)\right]$$



where $q_o = \gamma H$
γ = unit weight of the embankment soil
H = height of the embankment

$$\alpha_1\,(\text{radians}) = \tan^{-1}\left(\frac{B_1 + B_2}{z}\right) - \tan^{-1}\left(\frac{B_1}{z}\right)$$

$$\alpha_2 = \tan^{-1}\left(\frac{B_1}{z}\right)$$

$$\Delta\sigma_z = q_o I_2$$

where I_2 = a function of B_1/z and B_2/z.
The variation of I_2 with B_1/z and B_2/z is shown in Figure 10.20

Example 10.8

10.10 Vertical Stress below the Center of a Uniformly Loaded Circular Area

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

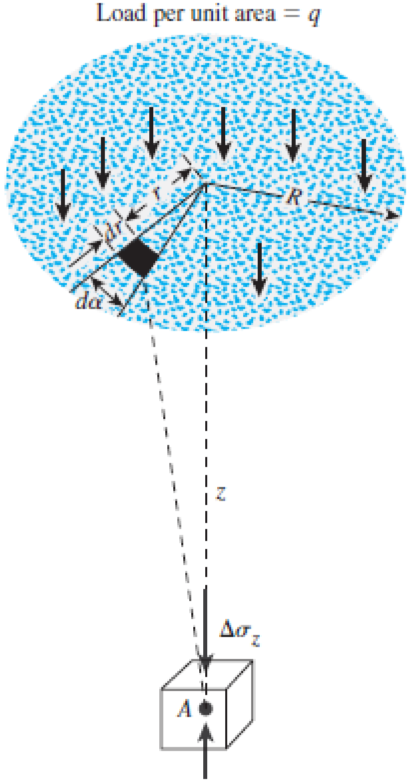
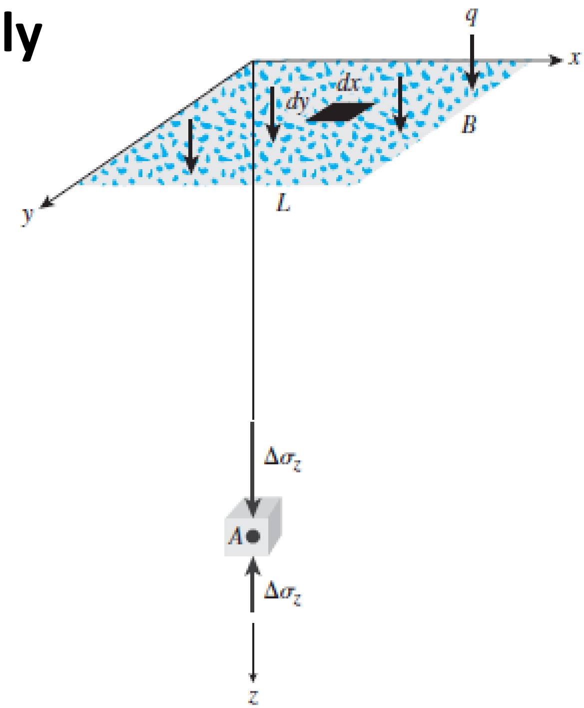


Table 10.6 shows the variation of $\Delta\sigma_z/q$ with z/R

10.12 Vertical Stress Caused by a Rectangularly Loaded Area

1) Point "A" is located at the corner of a uniformly loaded flexible rectangular area area



The increase in the stress, at point "A" caused by the entire loaded area can be determined by:

$$\Delta\sigma_z = \int d\sigma_z = \int_{y=0}^{B}\int_{x=0}^{L} \frac{3qz^3(dx\,dy)}{2\pi(x^2+y^2+z^2)^{5/2}} = qI_3$$

$$I_3 = \frac{1}{4\pi}\left[\frac{2mn\sqrt{m^2+n^2+1}}{m^2+n^2+m^2n^2+1}\left(\frac{m^2+n^2+2}{m^2+n^2+1}\right) + \tan^{-1}\left(\frac{2mn\sqrt{m^2+n^2+1}}{m^2+n^2-m^2n^2+1}\right)\right]$$

$$m = \frac{B}{z} \qquad n = \frac{L}{z}$$

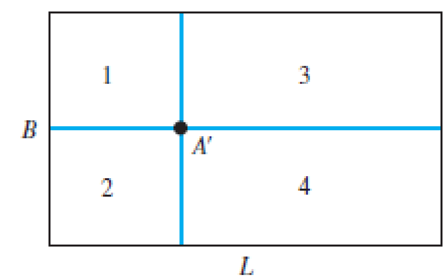


Table 10.9 and Figure 10.26 show the variation of I_3 with "*m*" and "*n*"

10.12 Con't Vertical Stress Caused by a Rectangularly Loaded Area

2) Point "A" is located at the center of a uniformly loaded flexible rectangular area area

$$\Delta\sigma_z = qI_4$$

$$I_4 = \frac{2}{\pi}\left[\frac{m_1 n_1}{\sqrt{1 + m_1^2 + n_1^2}}\frac{1 + m_1^2 + 2n_1^2}{(1 + n_1^2)(m_1^2 + n_1^2)} + \sin^{-1}\frac{m_1}{\sqrt{m_1^2 + n_1^2}\sqrt{1 + n_1^2}}\right]$$

$$m_1 = \frac{L}{B} \qquad n_1 = \frac{z}{b} \qquad b = \frac{B}{2}$$

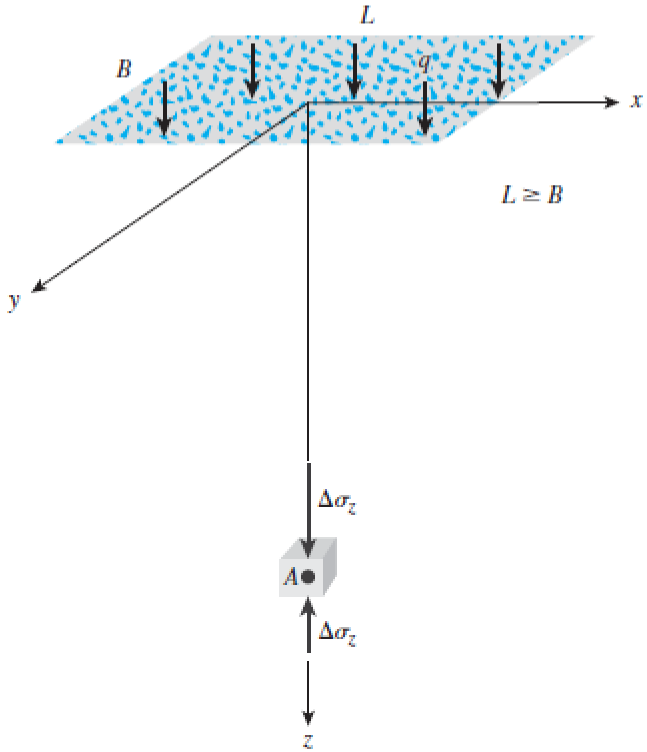
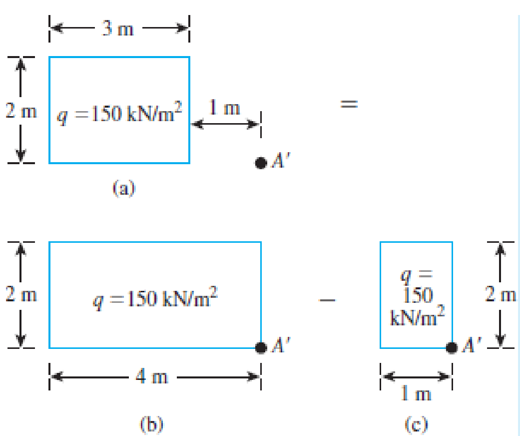


Table 10.10 and Figure 10.29 show the variation of I_4 with "m_1" and "n_1"



Example 10.10