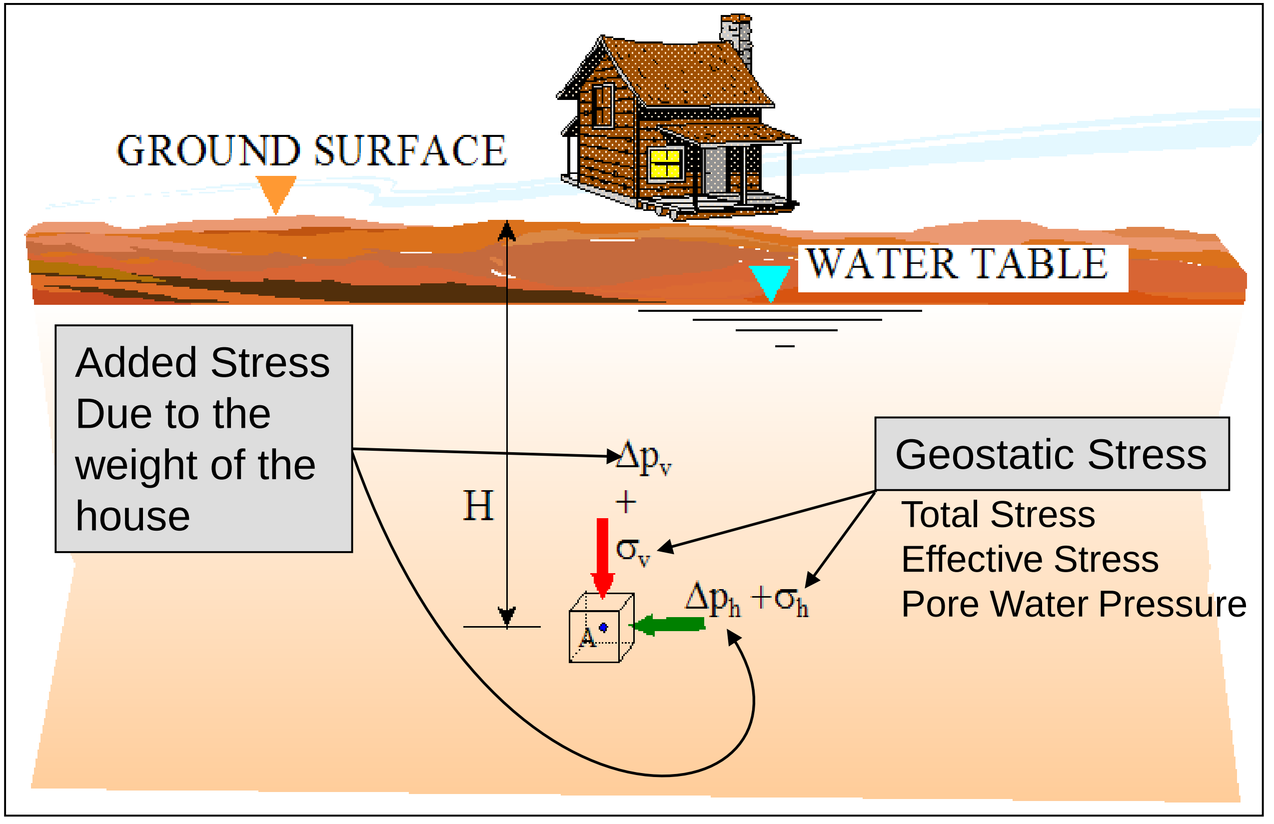
Lateral Stresses in Soil

By

Kamal Tawfiq, Ph.D., P.E.

Fall 2014

There are two types of lateral stresses in soil.



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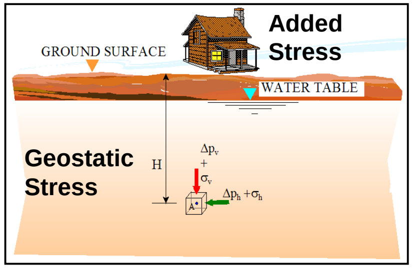


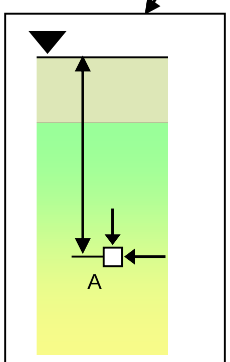
Stress Distribution in Soils

Geostatic Stresses

Total Stress
Effective Stress
Pore Water Pressure

Total Stress= Effective Stress+ Pore Water Pressure

$$\sigma_{total} = \sigma_{eff} + u$$



Added Stresses (Point, line, strip, triangular, circular, rectangular)

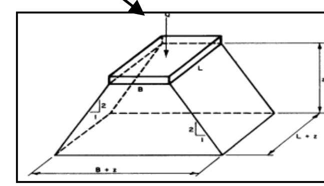
Westergaard's Method
(For Pavement)

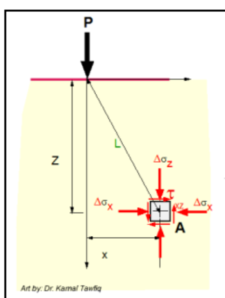
Bossinisque Equations

1. Point Load
2. Line Load
3. Strip Load
4. Triangular Load
5. Circular Load
6. Rectangular Load

σ_y
σ_x
τ_{xy}

Approximate Method
1:2 Method

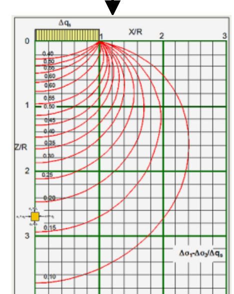




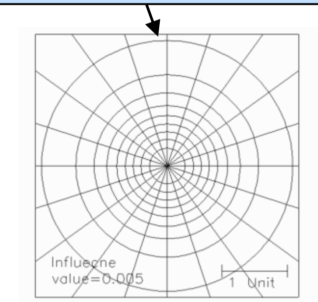
Influence Charts

$$\Delta\sigma_z = I_\sigma \cdot q$$

Stress Bulbs

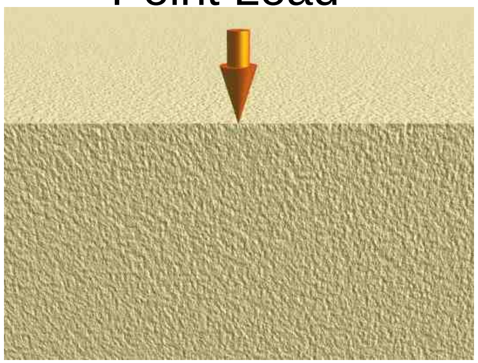


Newmark Charts

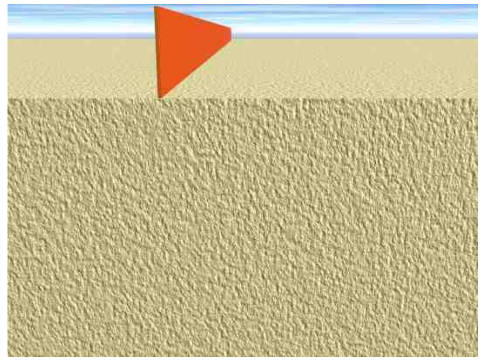


Types of Loads

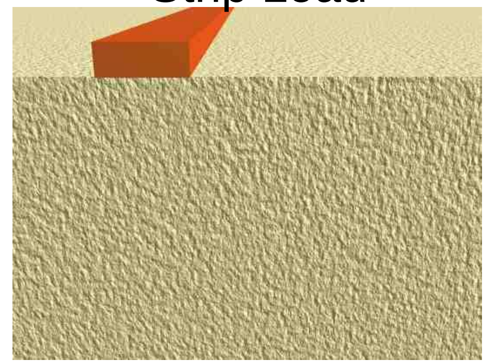
Point Load



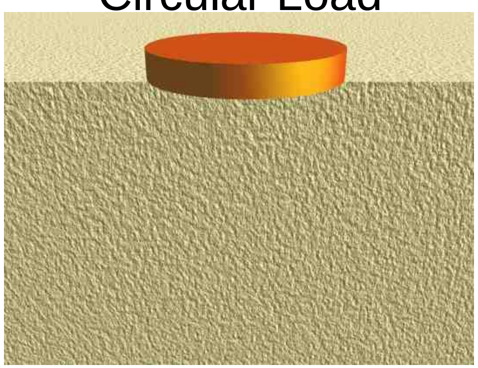
Line Load



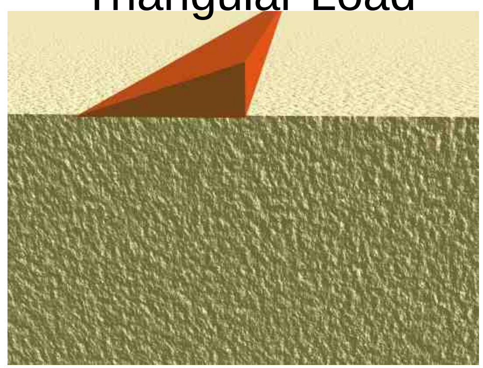
Strip Load



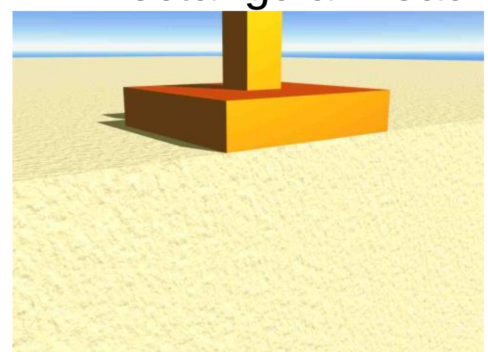
Circular Load



Triangular Load



Rectangular Load



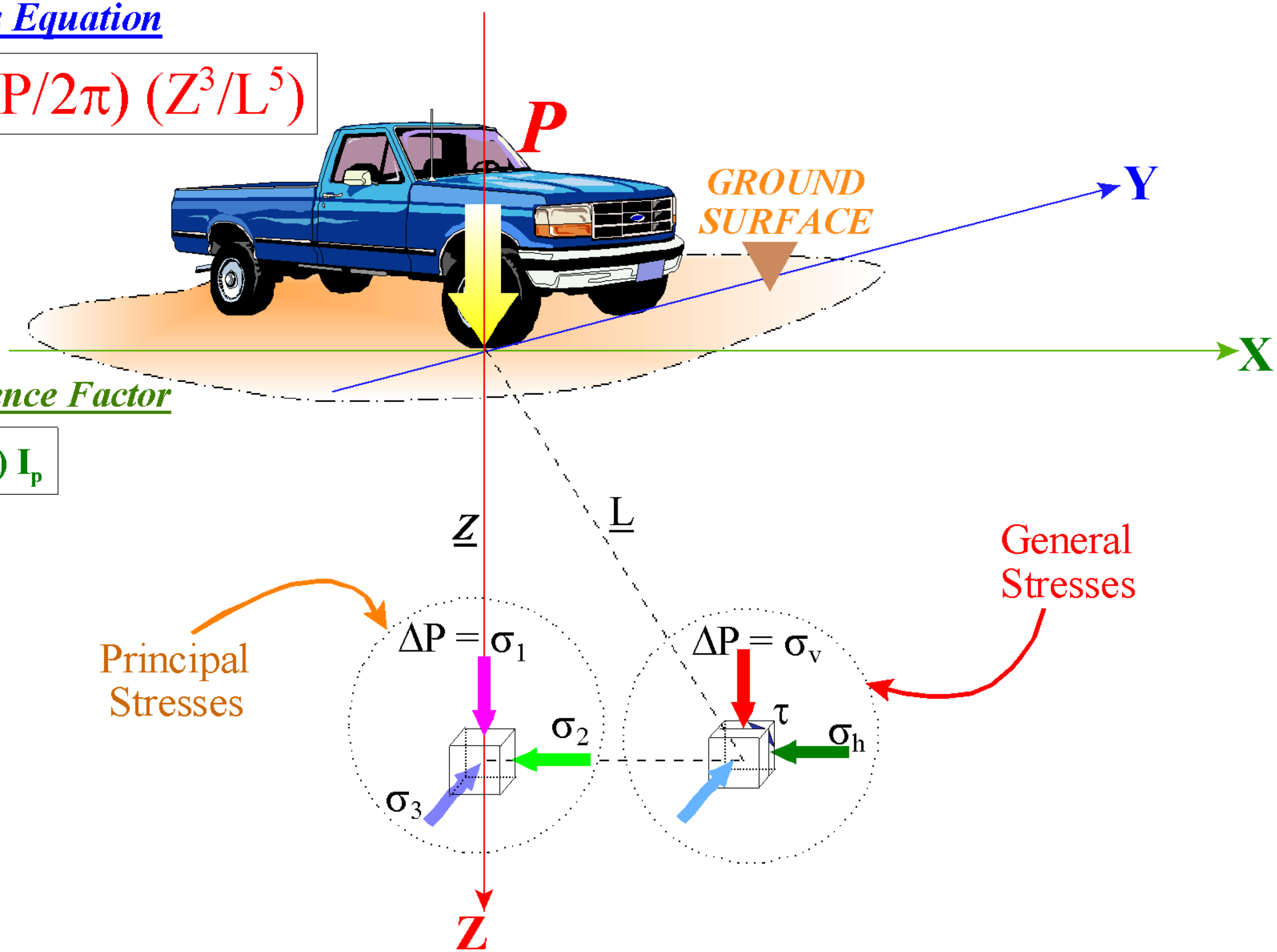
1. STRESSES CAUSED BY A POINT LOAD

Boussinesq's Equation

$$\Delta P_z = (3P/2\pi)\,(Z^3/L^5)$$

Using Influence Factor

$$\Delta P = (P/Z^2)\, I_p$$



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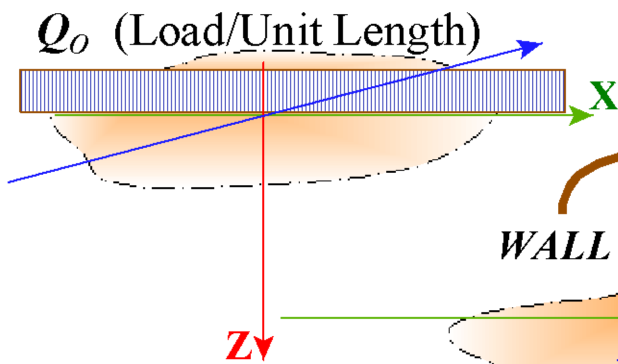
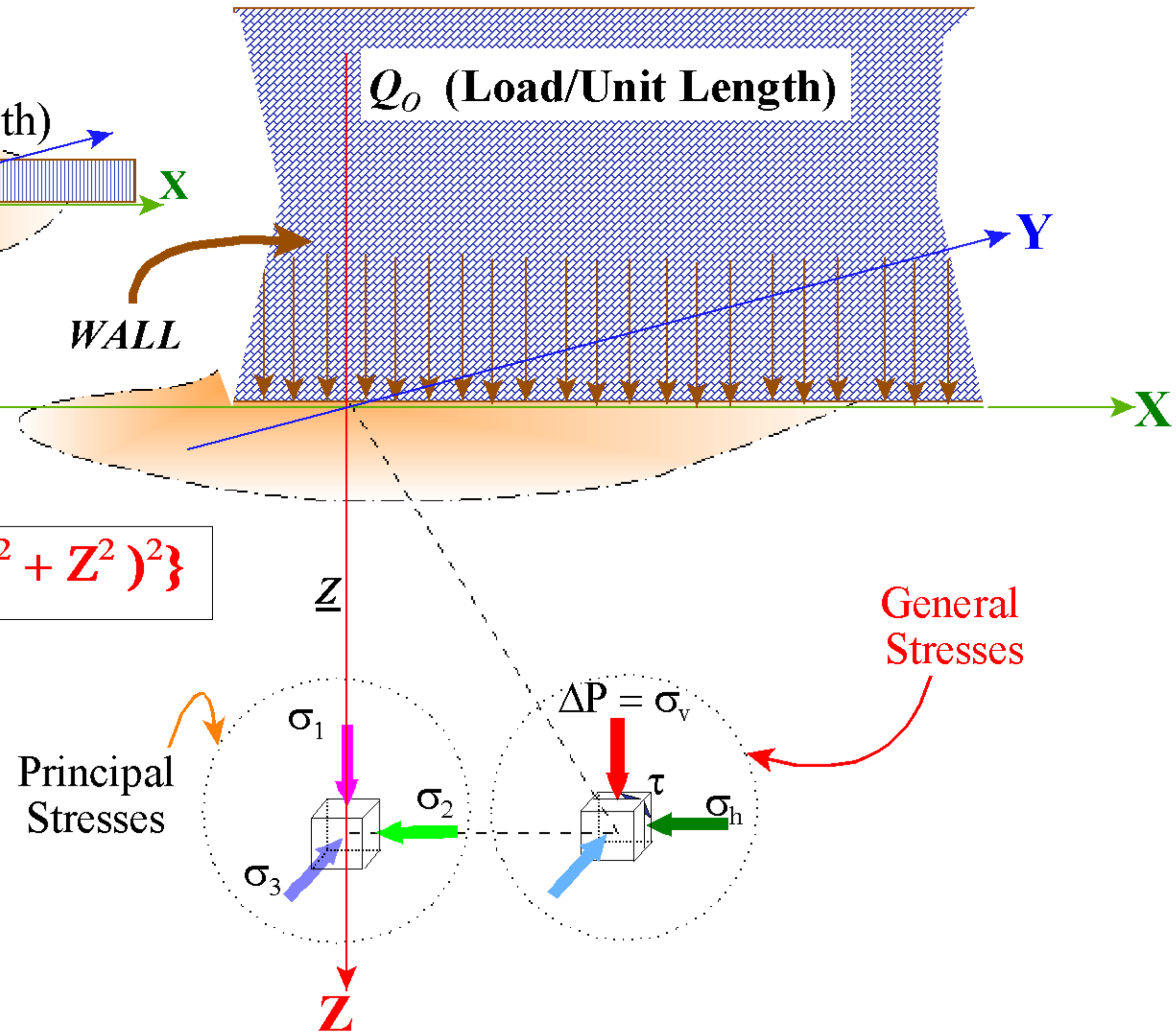
2. STRESSES CAUSED BY A LINE LOAD





Boussinesq's Equation

$$\Delta P_z = \{2\, Q_o\, Z^3 / \pi\, (X^2 + Z^2)^2\}$$

Using Influence Factor

$$\Delta P = (P/Z)\, I_L$$

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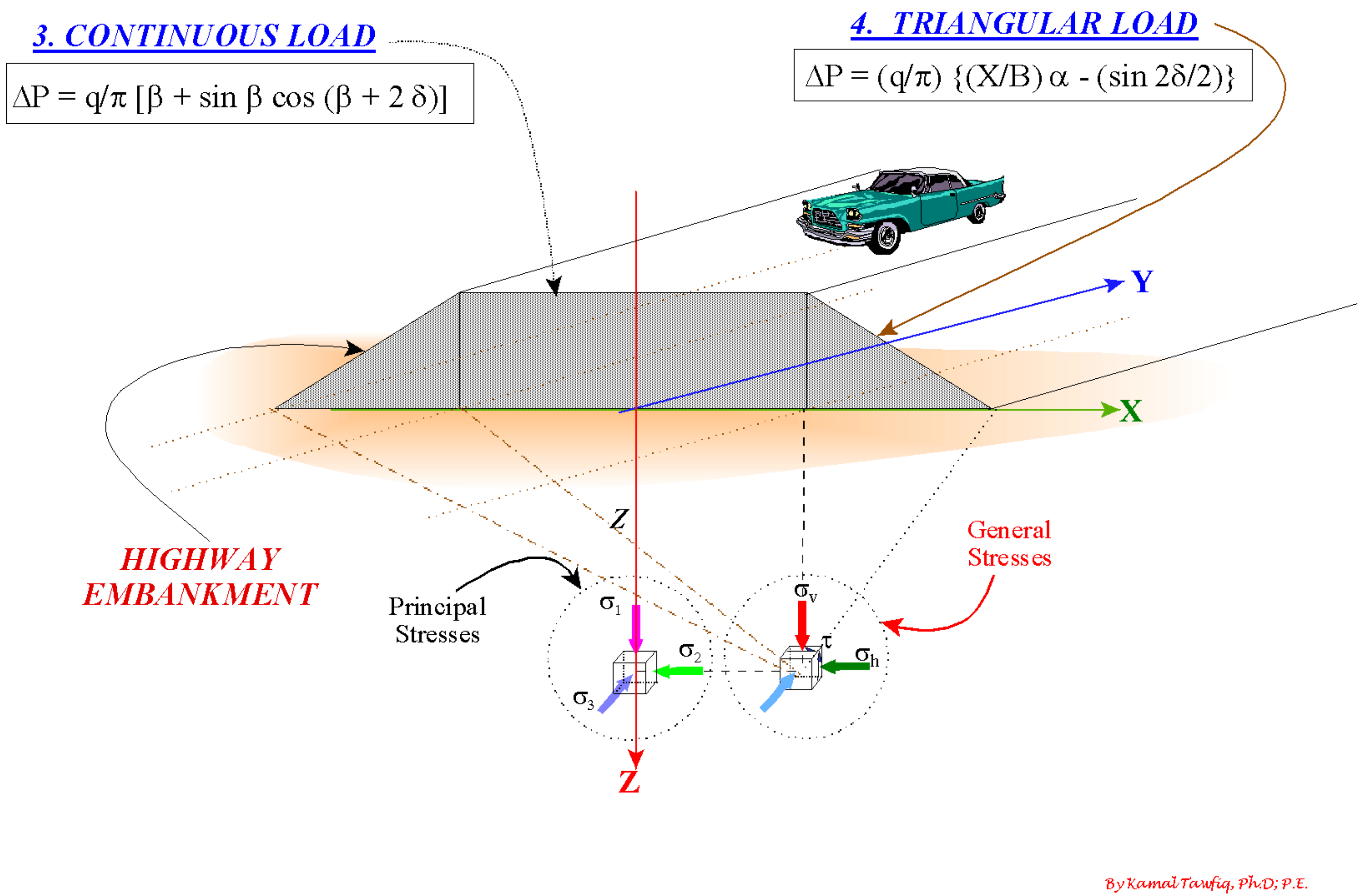

3. CONTINUOUS LOAD
ΔP = q/π [β + sin β cos (β + 2 δ)]
4. TRIANGULAR LOAD
ΔP = (q/π) {(X/B) α - (sin 2δ/2)}
Y
X
Z
Z
HIGHWAY EMBANKMENT
Principal Stresses
General Stresses
σ1
σ2
σ3
σv
τ
σh
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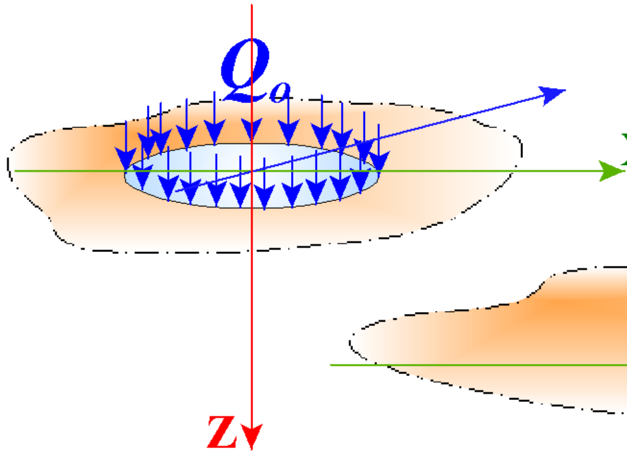
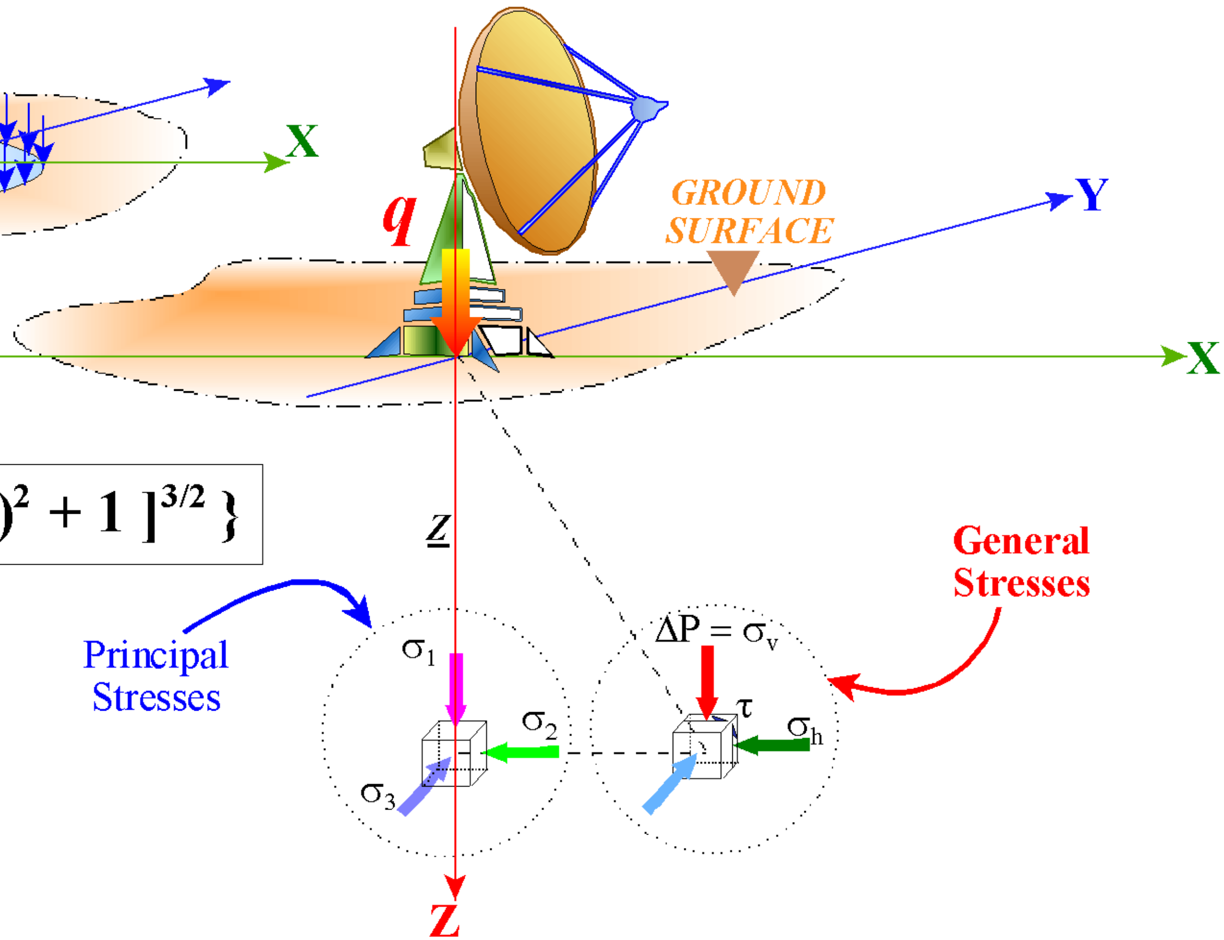
5. VERTICAL STRESS DUE TO CIRCULAR LOAD



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



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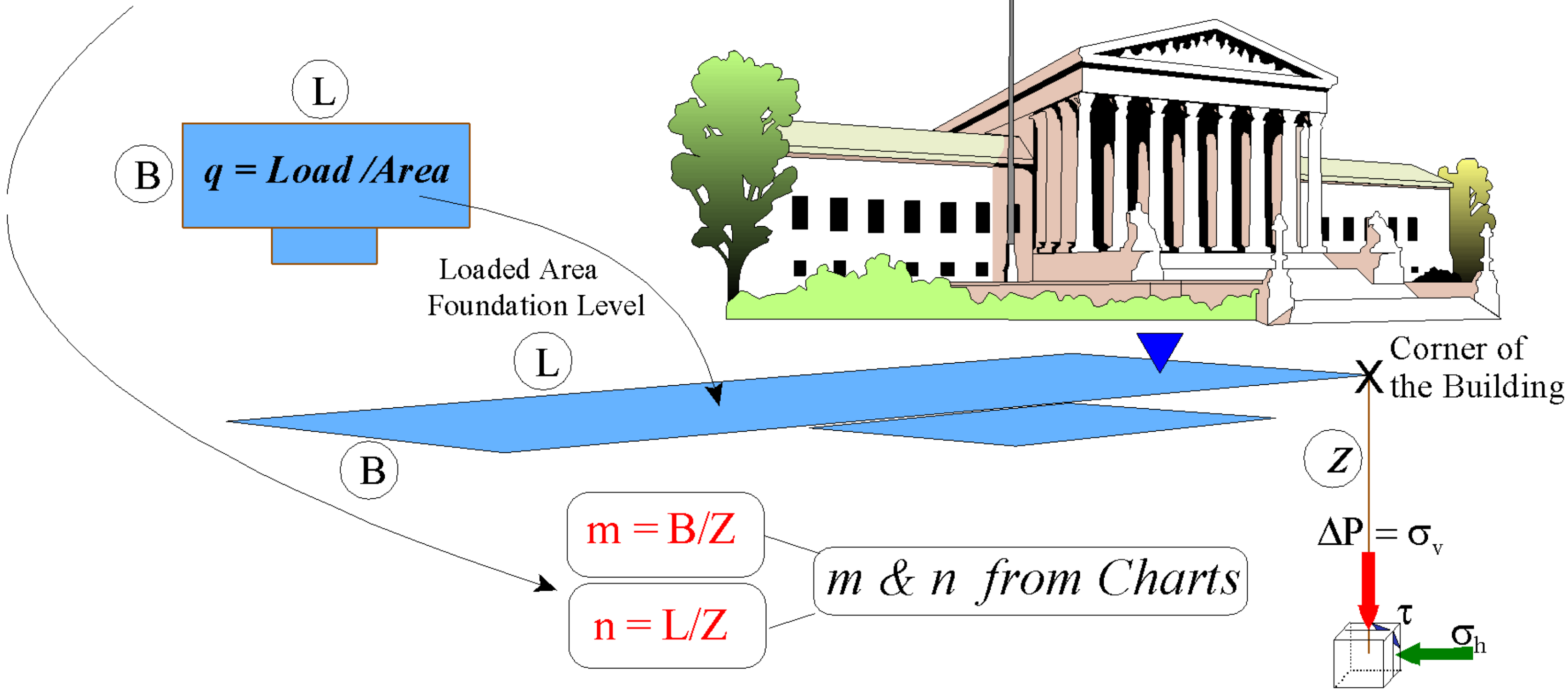
6. VERTICAL STRESS DUE TO RECTANGULAR LOAD

$$\Delta P = q\, I_R$$

$$I_R = 1/4\pi \{[(2.\ m.n\ (m^2 + n^2 + 1)^{1/2}) / (m^2 + n^2 + m^2.\ n^2 + 1)]\ [(m^2 + n^2 + 2)/(m^2 + n^2 + 1)] + \tan^{-1} (2.m\ .n\ (m^2 + n^2 + 1)^{1/2} / (m^2 + n^2 - m^2 .\ n^2 + 1)\}$$

$I_R = f\,(m,n)$



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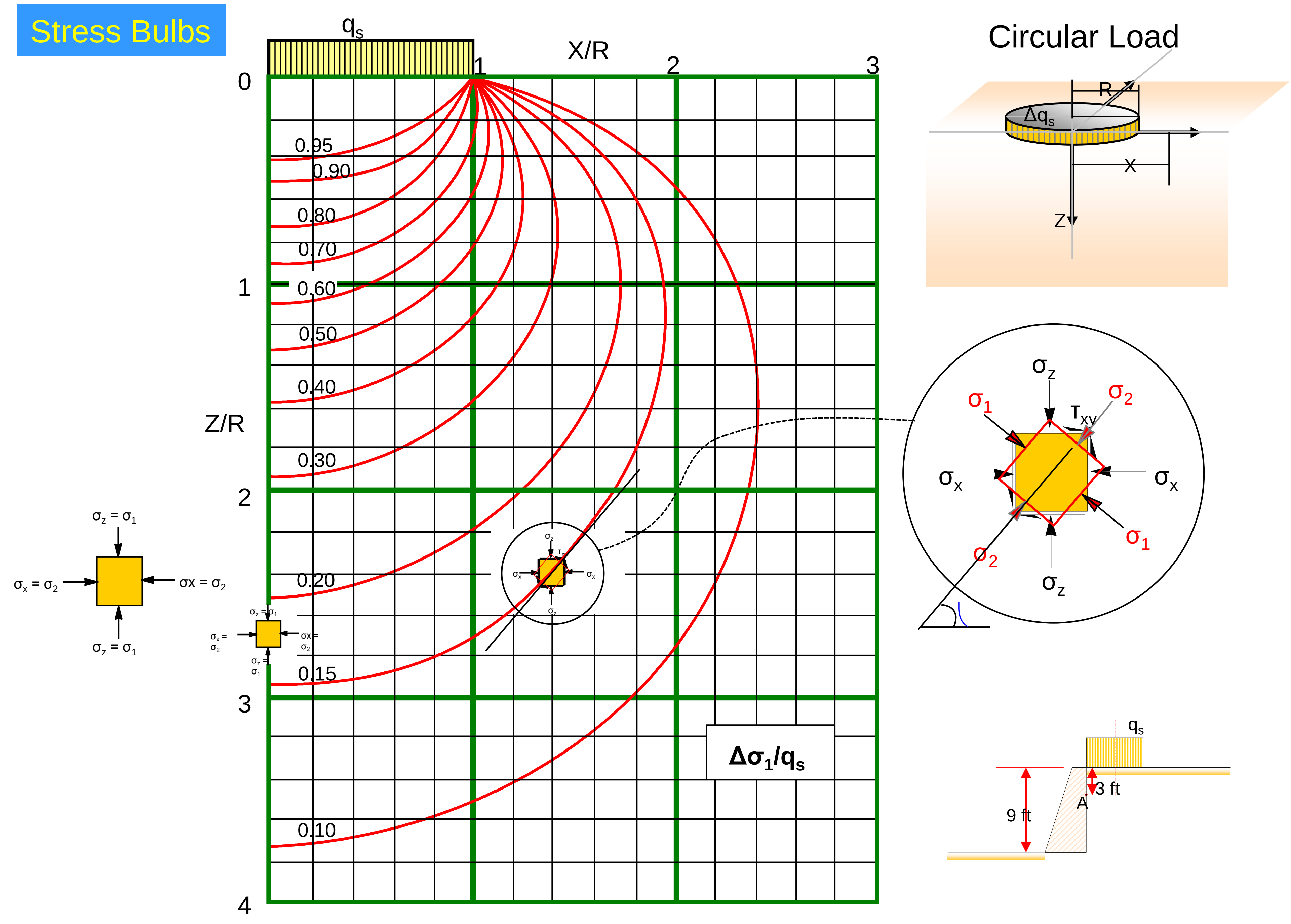
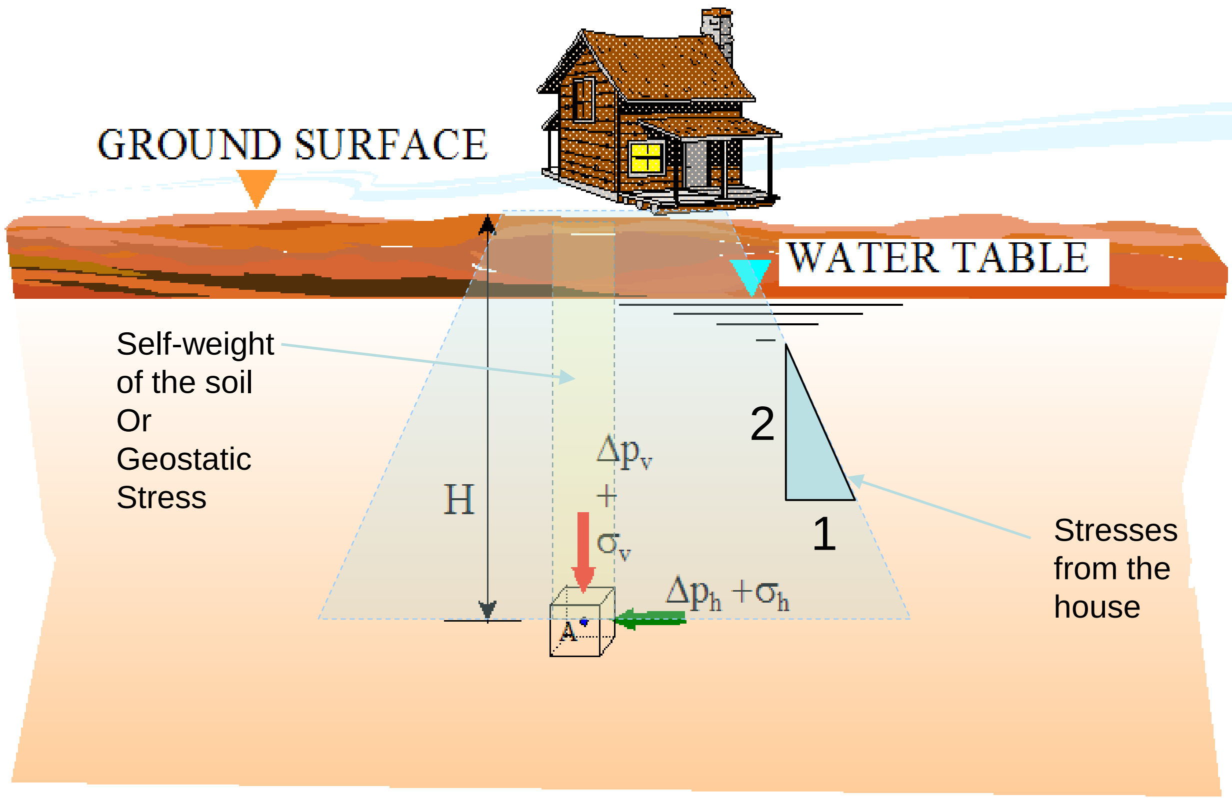
Stress Bulbs



Circular Load: (Major Principal Stress)/(Surface Stress)

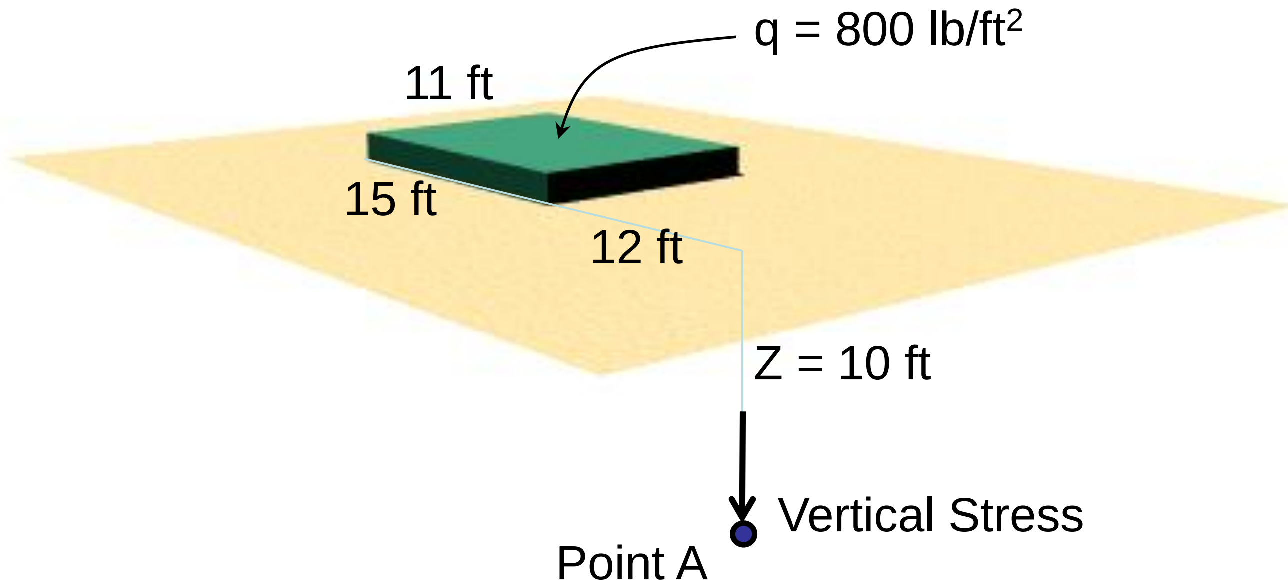
Geostatic Stresses
&
Stress Distribution in Soils

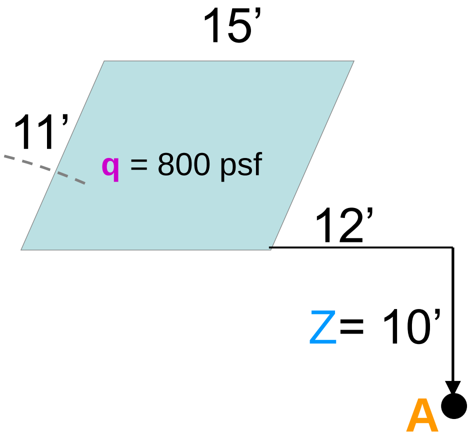


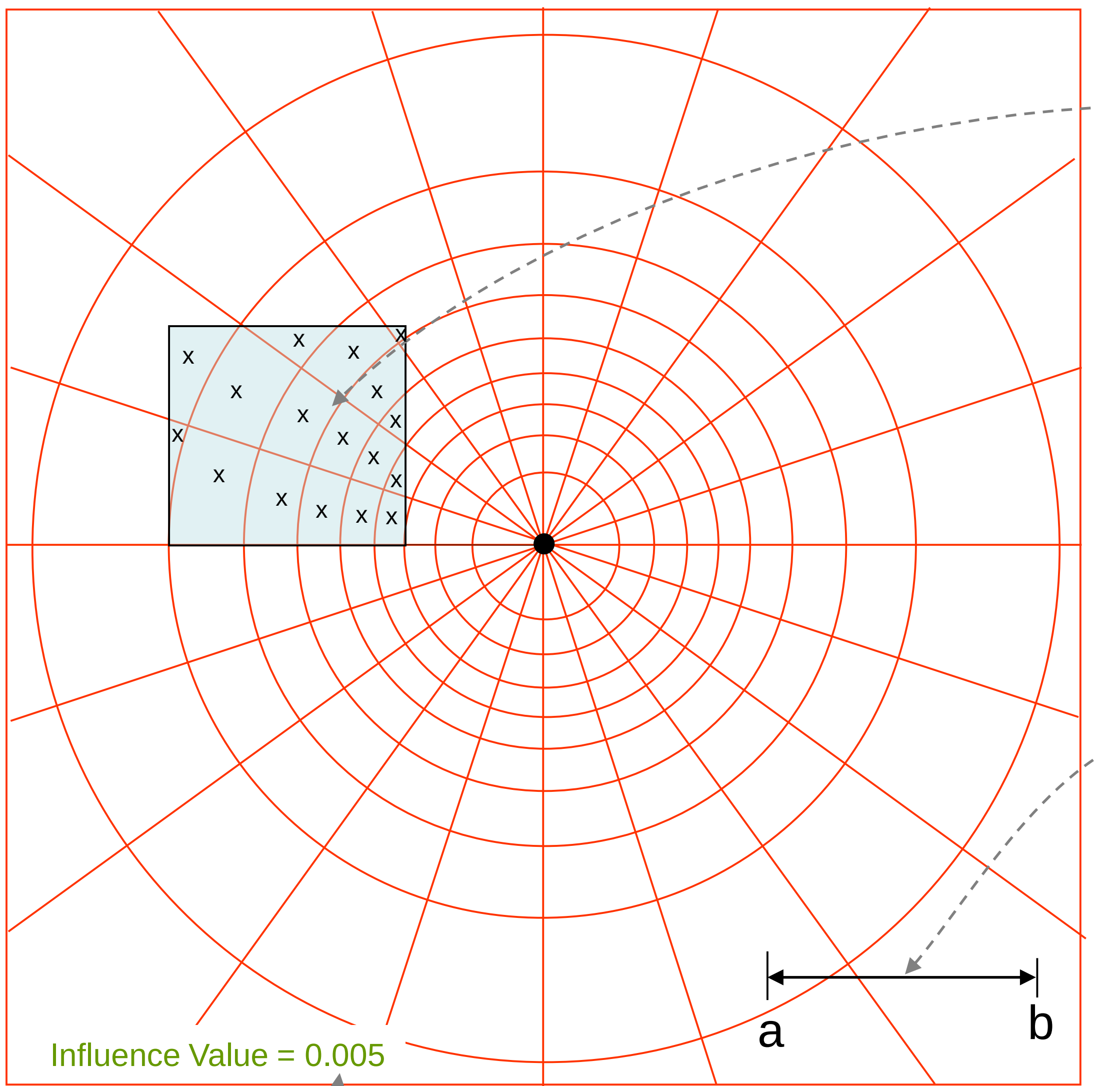
2: 1 Approximate Method

Newmark's Charts

Find:
Vertical Stress at Point A







Steps to determine Vertical Stress Using Newmark’s Charts:

1- Select a scale to draw the shape shown above

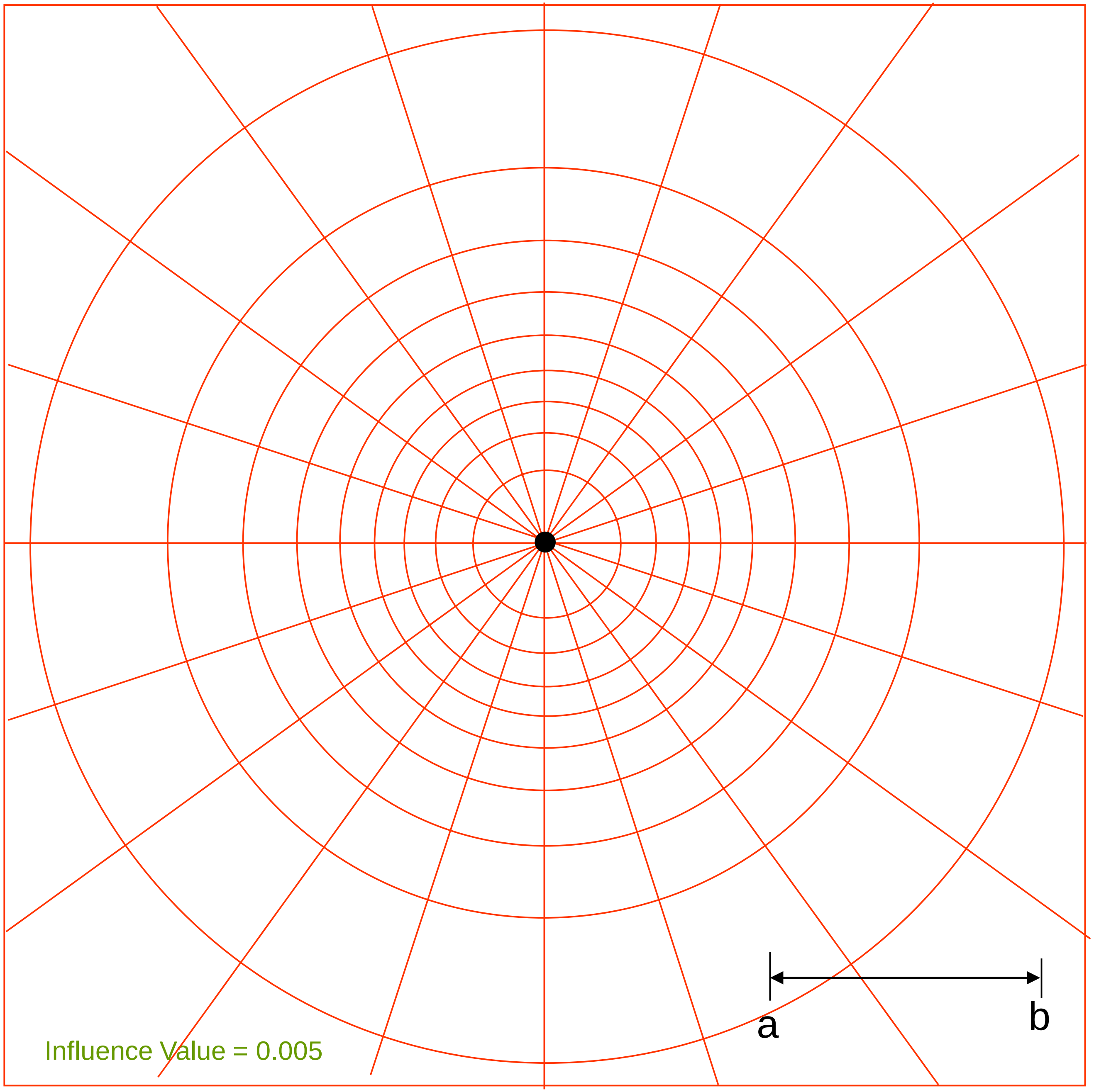
2- The scale is
Z = length of line **ab**

3- Draw the shape using the selected scale

4- Place the shape on Newmark chart so that point A is at the center

5- Count the stress fields **n**

6- The stress at point A = **n** x **q** x 0.005


a
b
Influence Value = 0.005