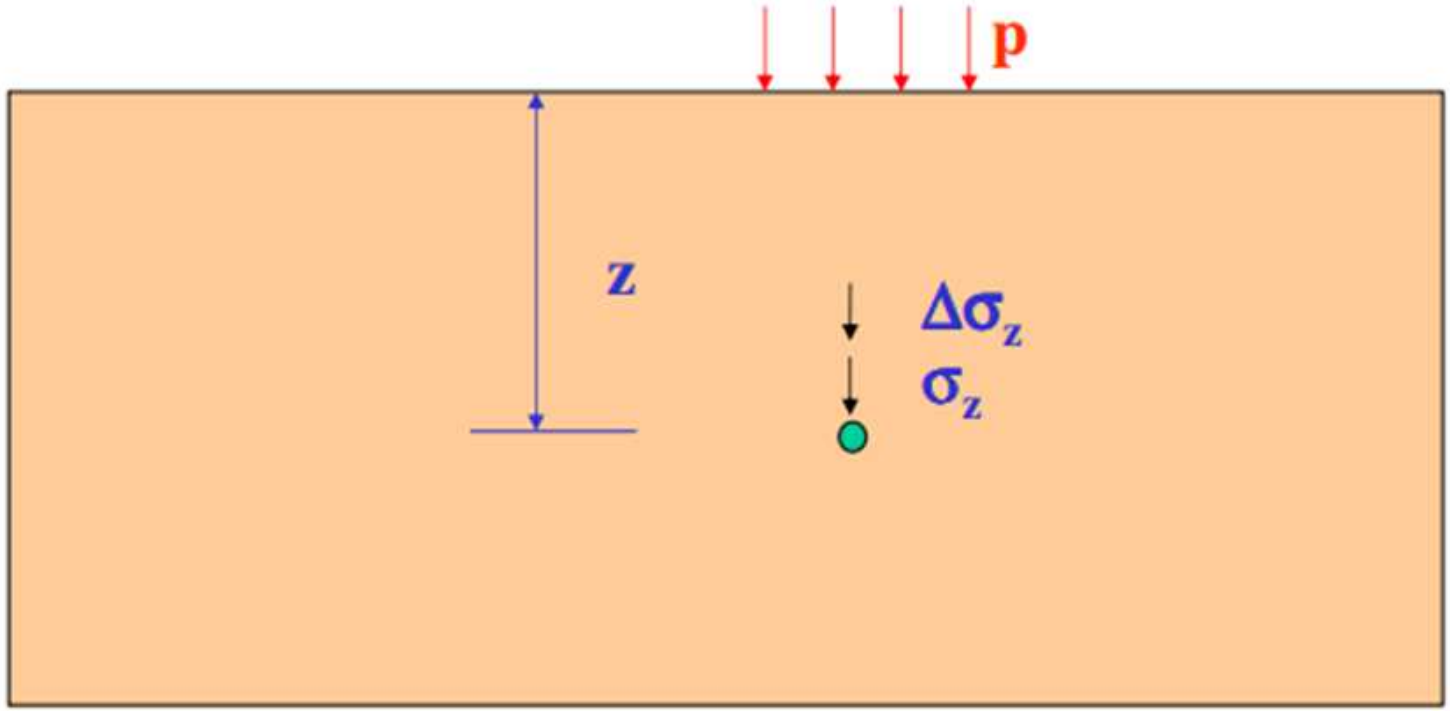
*** تذکر مهم ***

- فایل ارائه شده جهت آشنایی دانشجو با مبانی مکانیک خاک و صرفاً کمک آموزشی بوده و مبنای ارزشیابی، مطالب ارائه شده در کلاس و کتاب می باشد.
- ممکن است در بعضی اسلایدها از حروف و اندیس هایی استفاده شده باشد که مغایر با حروف و اندیس های ارائه شده درکلاس باشد، لطفا اصلاح فرمائید.

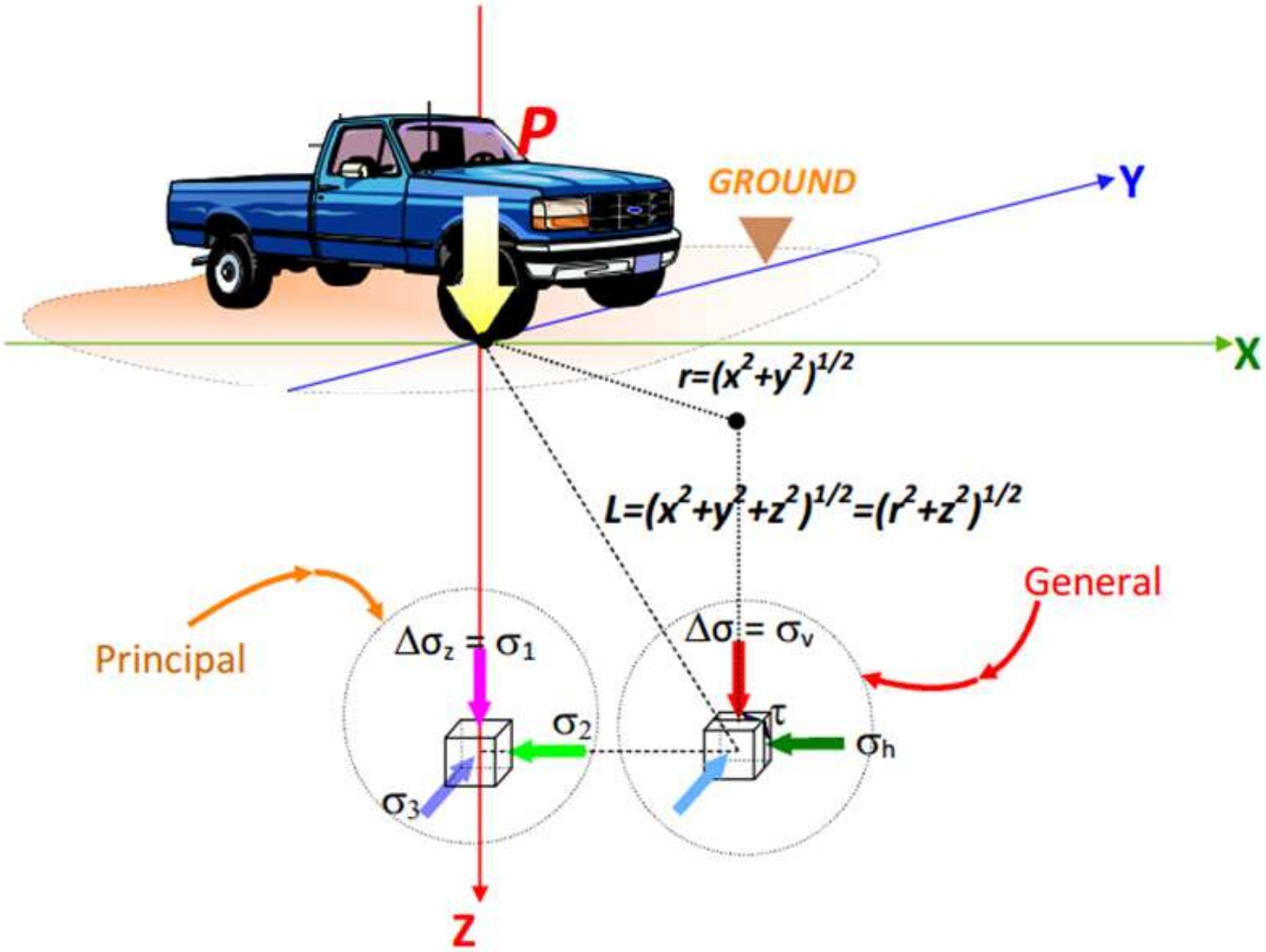
فصل :

گسترش تنش در توده خاک



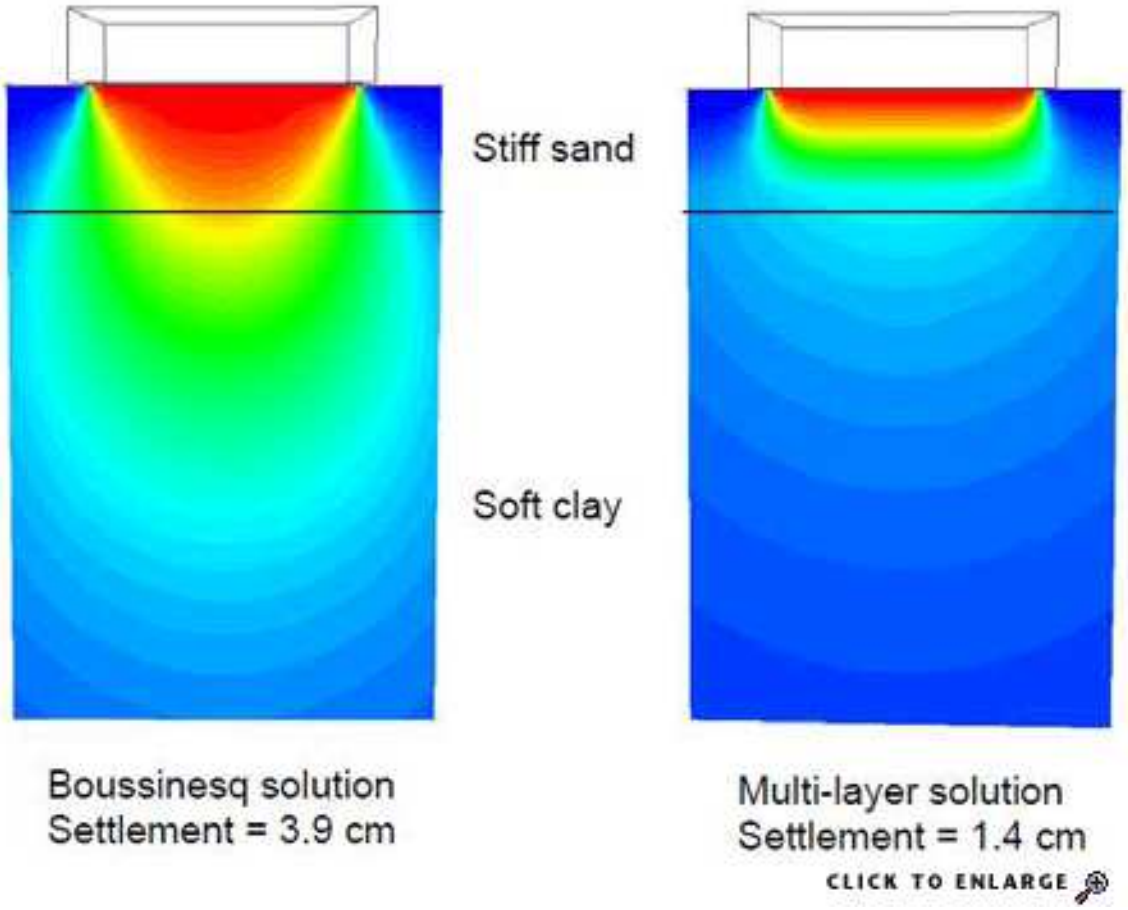
σ_z :ناشی از تنش ژئواستاتیک در عمق z

$\Delta\sigma_z$: اضافه تنش ناشی از بارگذاری خارجی(p) در عمق z

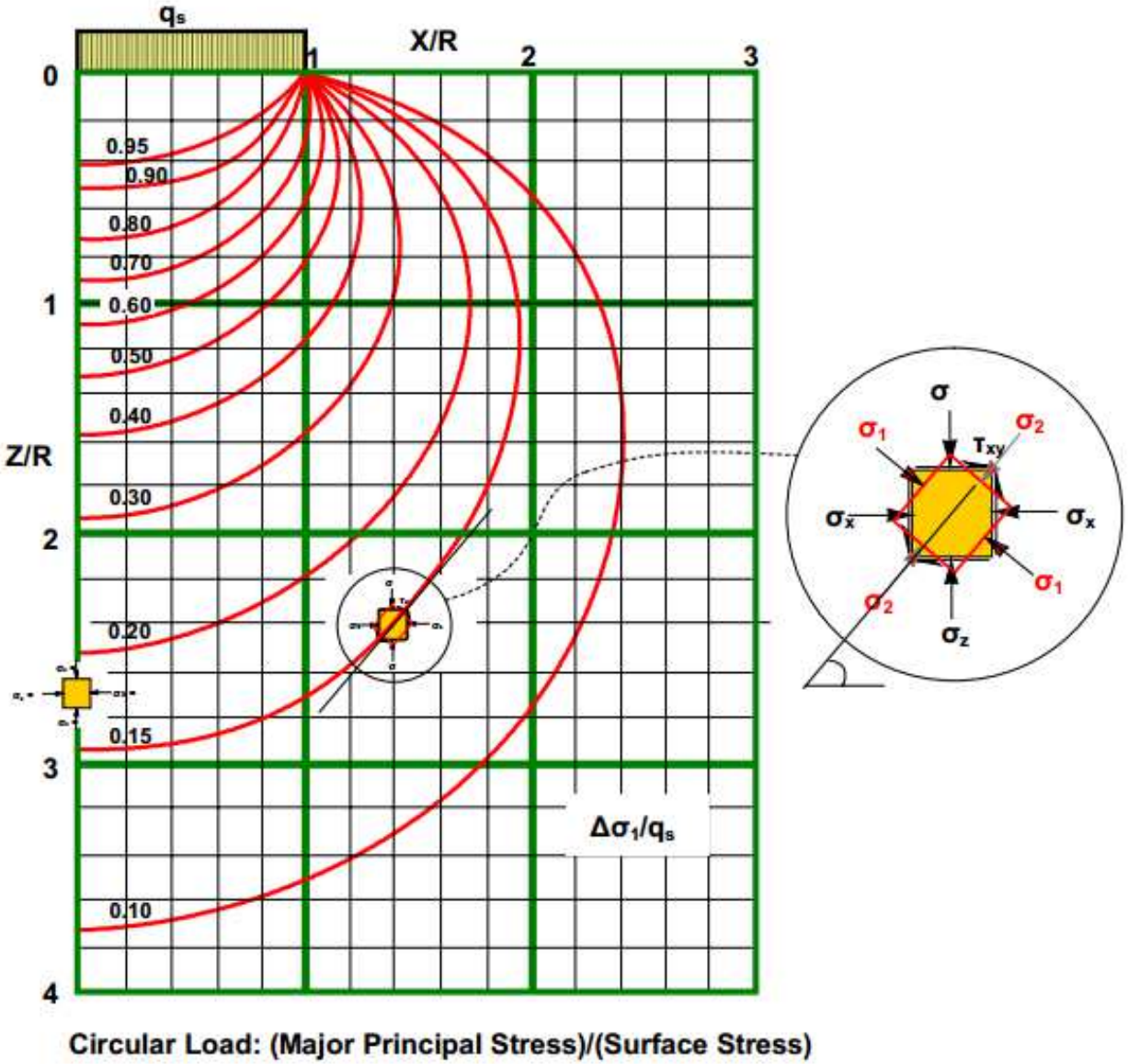

P
GROUND
Y
X
$r=(x^2+y^2)^{1/2}$
$L=(x^2+y^2+z^2)^{1/2}=(r^2+z^2)^{1/2}$
Principal
General
$\Delta\sigma_z = \sigma_1$
$\Delta\sigma_v = \sigma_v$
σ_2
σ_3
τ
σ_h
Z

Stress Distribution

توزیع تنش

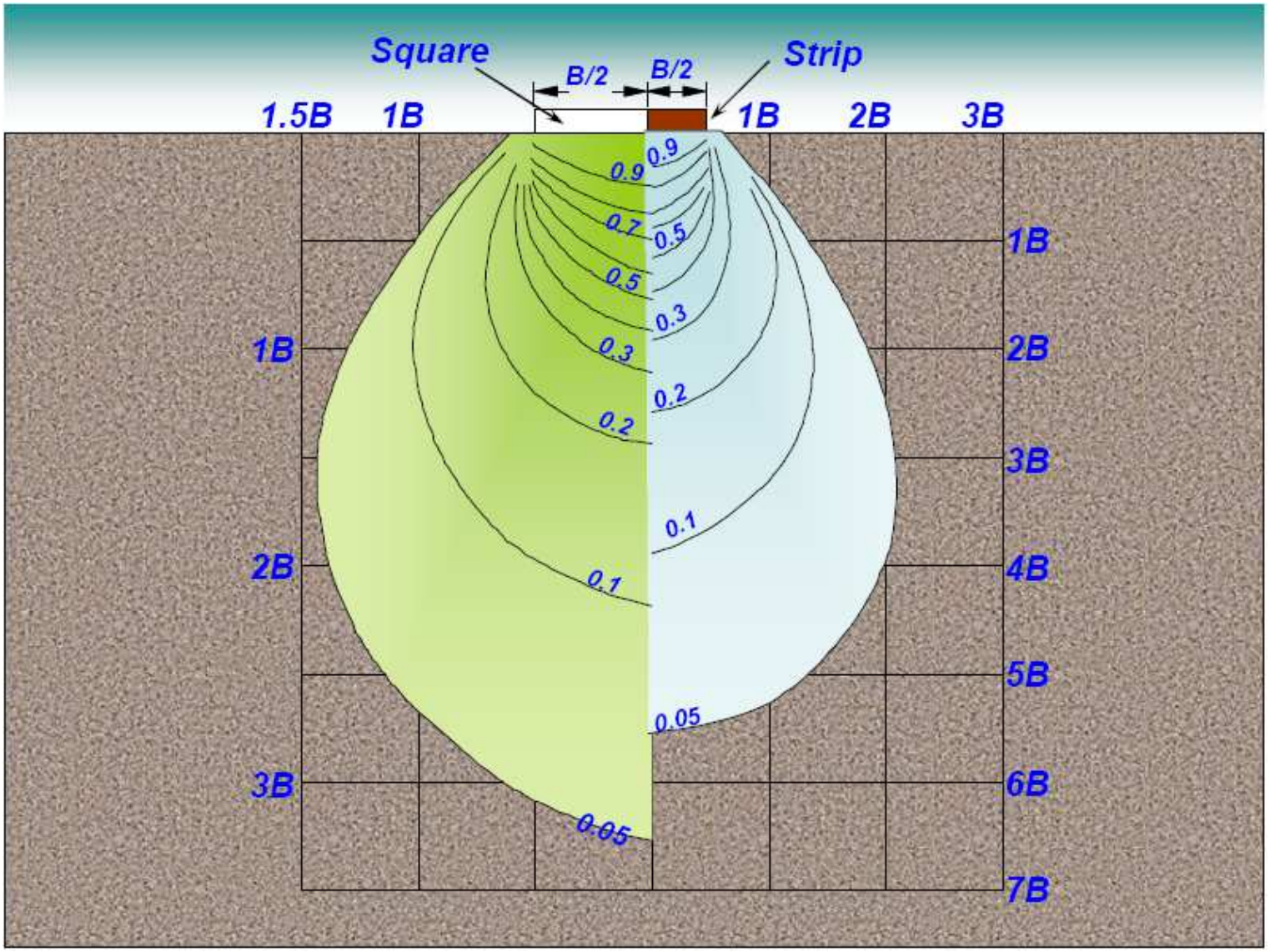


حباب تنش

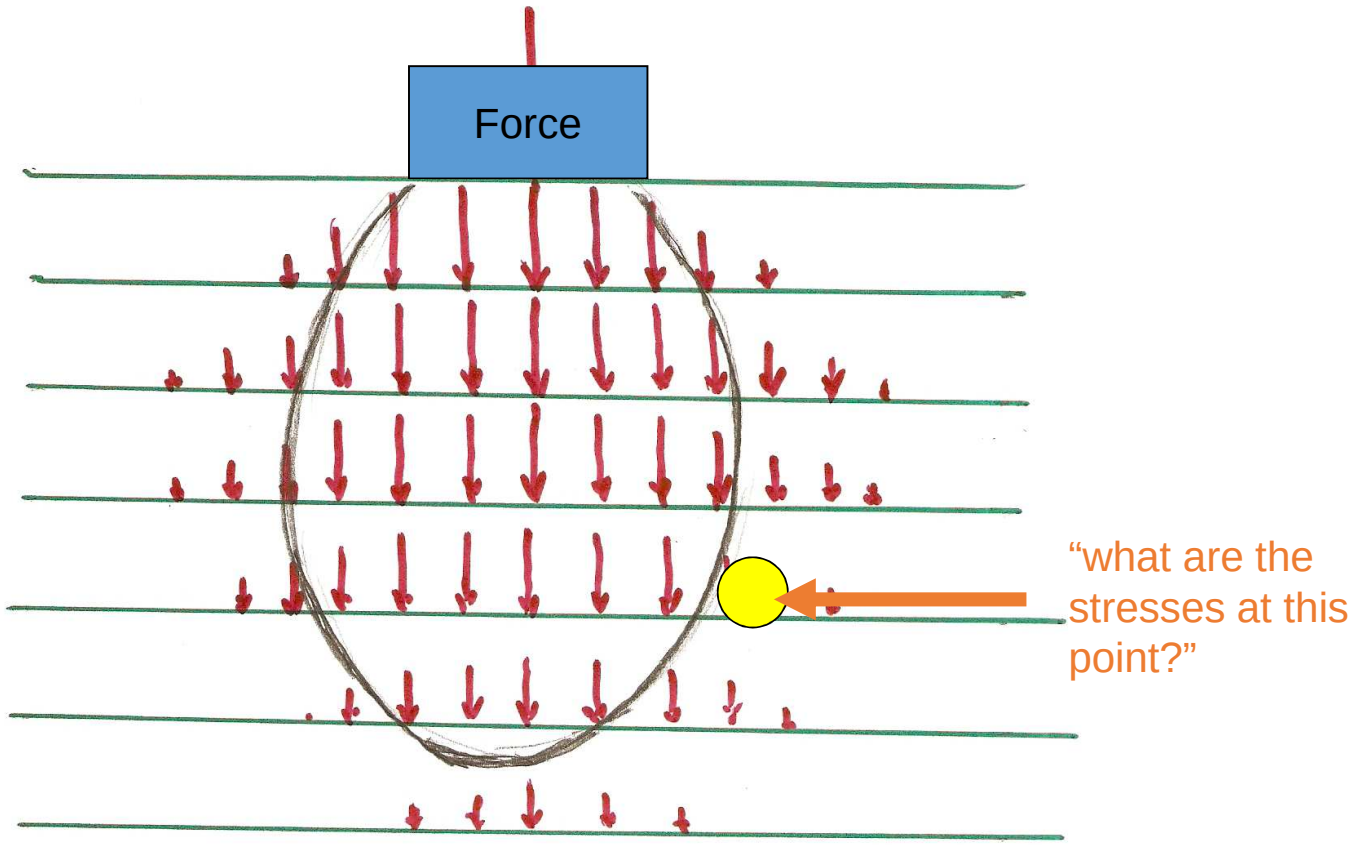


Circular Load: (Major Principal Stress)/(Surface Stress)

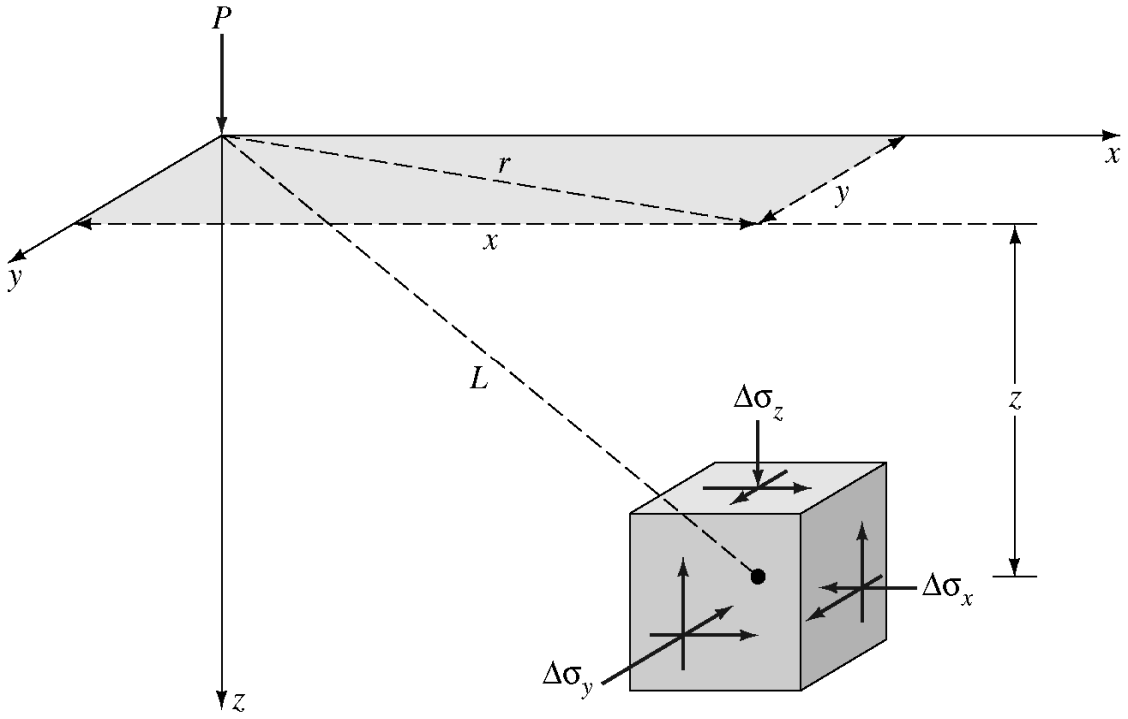
حباب تنش


Square
Strip
B/2
B/2
1.5B
1B
1B
2B
3B
0.9
0.9
0.7
0.5
0.5
0.3
0.3
0.2
0.2
0.1
0.1
0.05
0.05
1B
2B
3B
4B
5B
6B
7B
1B
2B
3B

حباب تنش



اضافه تنش قائم در خاک ناشی از بار نقطه ای



$$\Delta\sigma_z = \frac{3P}{2\pi}\frac{z^3}{L^5} = \frac{3P}{2\pi}\frac{z^3}{(r^2+z^2)^{5/2}}$$

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

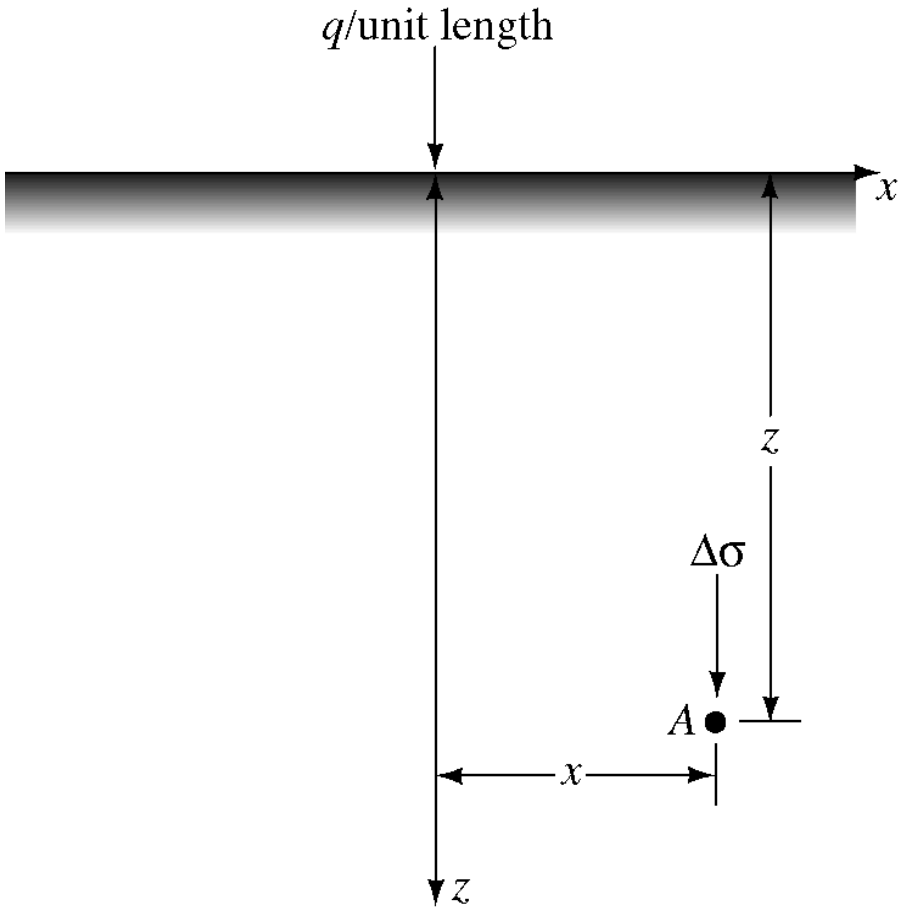
$$I_1 = \frac{3}{2\pi}\frac{1}{\left[(r/z)^2+1\right]^{5/2}}$$

اضافه تنش قائم در خاک ناشی از بار نقطه ای

Table 6.1 Variation of I_1 (Das, FGE 2006).

r/z	I_1	r/z	I_1
0	0.4775	0.9	0.1083
0.1	0.4657	1.0	0.0844
0.2	0.4329	1.5	0.0251
0.3	0.3849	1.75	0.0144
0.4	0.3295	2.0	0.0085
0.5	0.2733	2.5	0.0034
0.6	0.2214	3.0	0.0015
0.7	0.1762	4.0	0.0004
0.8	0.1386	5.0	0.00014

اضافه تنش قائم در خاک ناشی از بار خطی یکنواخت



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

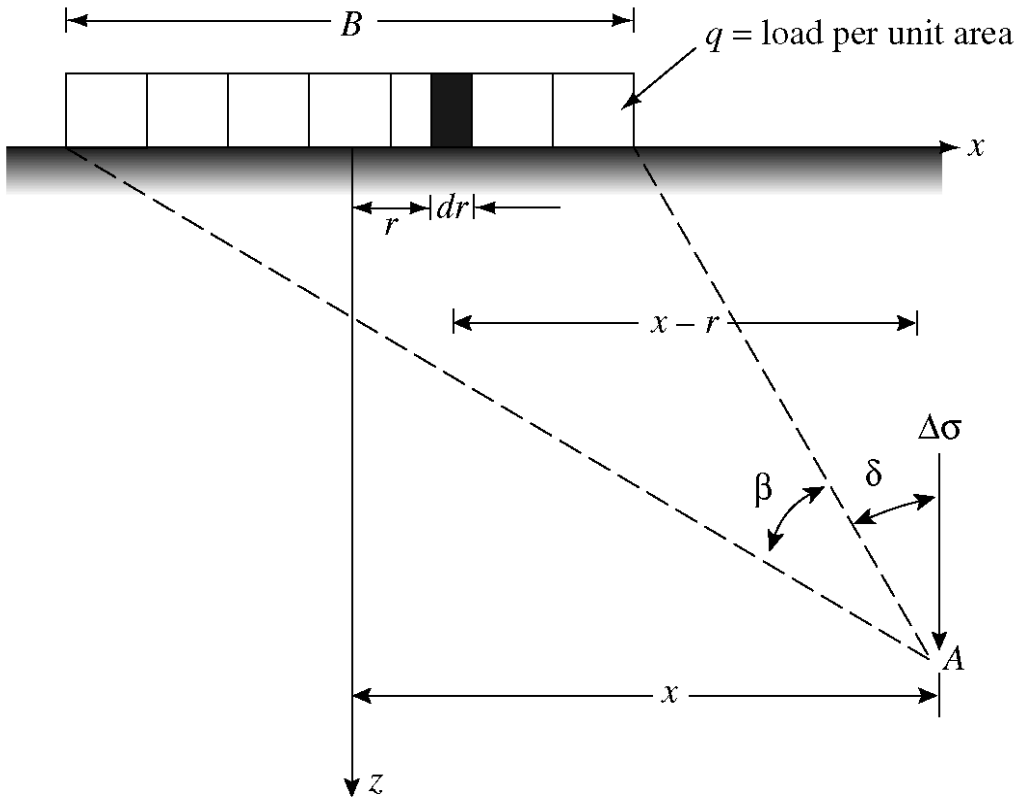
$$\frac{\Delta\sigma}{(q/z)} = \frac{2}{\pi\left[\left(\frac{x}{z}\right)^2+1\right]^2}$$

اضافه تنش قائم در خاک ناشی از بار خطی یکنواخت

Table 6.3 Variation of $\Delta\sigma/(q/z)$ with x/z (Das, FGE 2006).

x/z	$\frac{\Delta\sigma}{q/z}$	x/z	$\frac{\Delta\sigma}{q/z}$
0	0.637	0.7	0.287
0.1	0.624	0.8	0.237
0.2	0.589	0.9	0.194
0.3	0.536	1.0	0.159
0.4	0.473	1.5	0.060
0.5	0.407	2.0	0.025
0.6	0.344	3.0	0.006

اضافه تنش قائم در خاک ناشی از بار نواری یکنواخت



$$\Delta\sigma = \frac{q}{\pi}\left[\beta + \sin\beta\cos(\beta + 2\delta)\right]$$

Where:

Angles measured in counter-clockwise direction are taken as positive

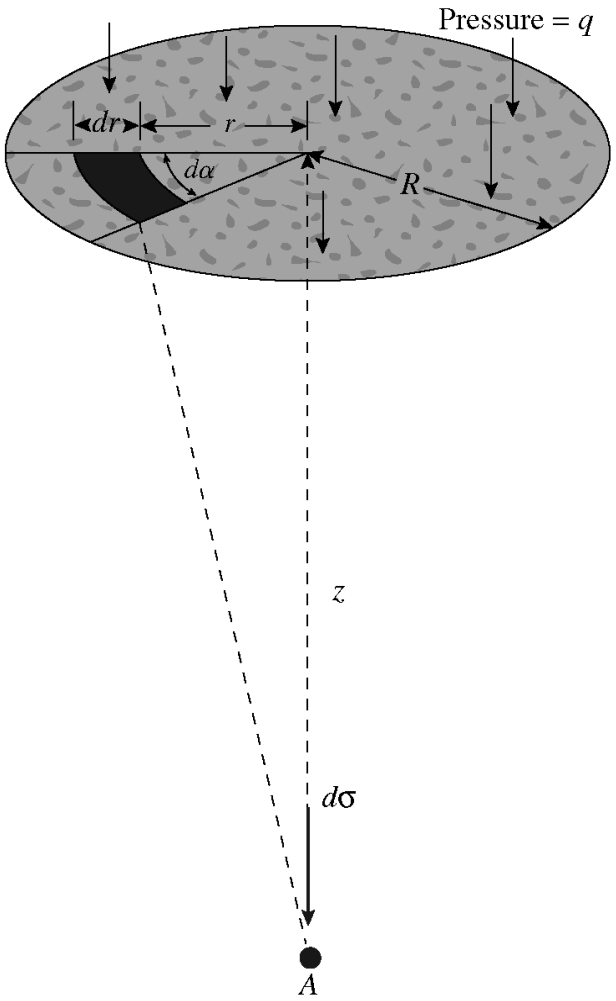
اضافه تنش قائم در خاک ناشی از بار نواری یکنواخت

Table 6.4 Variation of $\Delta\sigma/q$ with 2z/*B* and *2x/B* (Das, FGE 2006).

	2x/B				
2z/B	**0**	**0.5**	**1.0**	**1.5**	**2.0**
0	1.000	1.000	0.500	—	—
0.5	0.959	0.903	0.497	0.089	0.019
1.0	0.818	0.735	0.480	0.249	0.078
1.5	0.668	0.607	0.448	0.270	0.146
2.0	0.550	0.510	0.409	0.288	0.185
2.5	0.462	0.437	0.370	0.285	0.205
3.0	0.396	0.379	0.334	0.273	0.211
3.5	0.345	0.334	0.302	0.258	0.216
4.0	0.306	0.298	0.275	0.242	0.205
4.5	0.274	0.268	0.251	0.226	0.197
5.0	0.248	0.244	0.231	0.212	0.188

اضافه تنش قائم در خاک ناشی از بار گسترده دایره ای یکنواخت

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



Where:

$\Delta\sigma$ = Change in Vertical Stress

q = Load per Unit Area

z = Depth

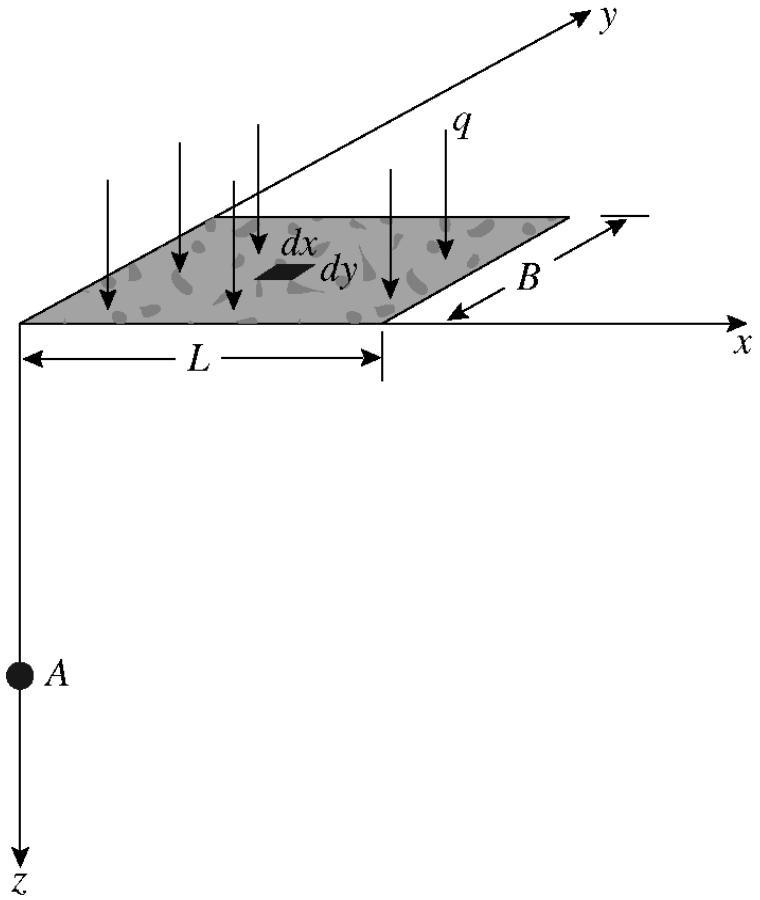
R = Radius

اضافه تنش قائم در خاک ناشی از بار گسترده دایره ای یکنواخت

Table 6.5 Variation of $\Delta\sigma/q$ with z/*R* (Das, FGE 2006).

z/R	$\Delta\sigma/q$	z/R	$\Delta\sigma/q$
0	1	1.0	0.6465
0.02	0.9999	1.5	0.4240
0.05	0.9998	2.0	0.2845
0.10	0.9990	2.5	0.1996
0.2	0.9925	3.0	0.1436
0.4	0.9488	4.0	0.0869
0.5	0.9106	5.0	0.0571
0.8	0.7562		

اضافه تنش قائم در خاک ناشی از بار گسترده یکنواخت مستطیلی



$$\Delta\sigma = \int d\sigma = \int_{y=0}^{B}\int_{x=0}^{L} \frac{3qz^3(dxdy)}{2\pi(x^2+y^2+z^2)^{5/2}} = qI_2$$

$$I_2 = \frac{1}{4\pi}\left[\frac{2mn\sqrt{m^2+n^2+1}}{m^2+n^2+m^2n^2+1}\left(\frac{m^2+n^2+2}{m^2+n^2+1}\right) + \tan^{-1}\left(\frac{2mn\sqrt{m^2+n^2+1}}{m^2+n^2-m^2n^2+1}\right)\right]$$

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

ratios $M = B/z$; $N = L/z$ beneath the *corner* of a base $B \times L$.

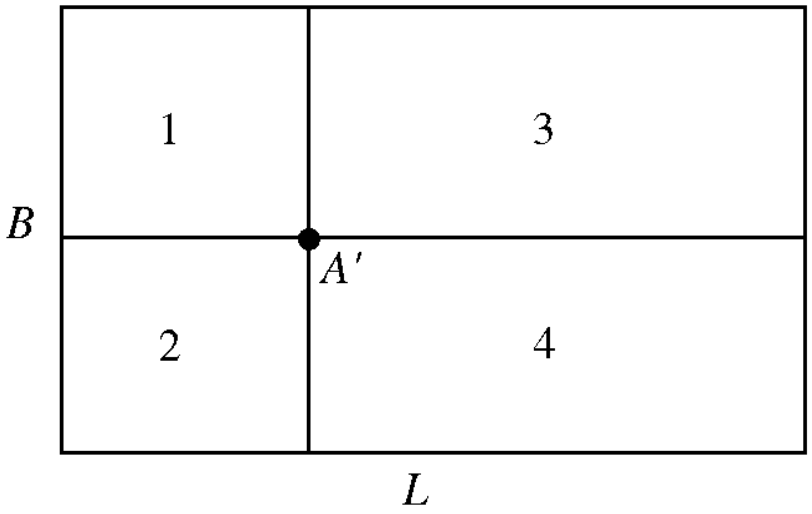
M and N are interchangeable.

N \ M	.100	.200	.300	.400	.500	.600	.700	.800	.900	1.000
.1	.005	.009	.013	.017	.020	.022	.024	.026	.027	.028
.2	.009	.018	.026	.033	.039	.043	.047	.050	.053	.055
.3	.013	.026	.037	.047	.056	.063	.069	.073	.077	.079
.4	.017	.033	.047	.060	.071	.080	.087	.093	.098	.101
.5	.020	.039	.056	.071	.084	.095	.103	.110	.116	.120
.6	.022	.043	.063	.080	.095	.107	.117	.125	.131	.136
.7	.024	.047	.069	.087	.103	.117	.128	.137	.144	.149
.8	.026	.050	.073	.093	.110	.125	.137	.146	.154	.160
.9	.027	.053	.077	.098	.116	.131	.144	.154	.162	.168
1.0	.028	.055	.079	.101	.120	.136	.149	.160	.168	.175
1.1	.029	.056	.082	.104	.124	.140	.154	.165	.174	.181
1.2	.029	.057	.083	.106	.126	.143	.157	.168	.178	.185
1.3	.030	.058	.085	.108	.128	.146	.160	.171	.181	.189
1.4	.030	.059	.086	.109	.130	.147	.162	.174	.184	.191
1.5	.030	.059	.086	.110	.131	.149	.164	.176	.186	.194
2.0	.031	.061	.089	.113	.135	.153	.169	.181	.192	.200
2.5	.031	.062	.089	.114	.136	.155	.170	.183	.194	.202
3.0	.031	.062	.090	.115	.137	.155	.171	.184	.195	.203
5.0	.032	.062	.090	.115	.137	.156	.172	.185	.196	.204
10.0	.032	.062	.090	.115	.137	.156	.172	.185	.196	.205

N \ M	1.100	1.200	1.300	1.400	1.500	2.000	2.500	3.000	5.000	10.000
.1	.029	.029	.030	.030	.030	.031	.031	.031	.032	.032
.2	.056	.057	.058	.059	.059	.061	.062	.062	.062	.062
.3	.082	.083	.085	.086	.086	.089	.089	.090	.090	.090
.4	.104	.106	.108	.109	.110	.113	.114	.115	.115	.115
.5	.124	.126	.128	.130	.131	.135	.136	.137	.137	.137
.6	.140	.143	.146	.147	.149	.153	.155	.155	.156	.156
.7	.154	.157	.160	.162	.164	.169	.170	.171	.172	.172
.8	.165	.168	.171	.174	.176	.181	.183	.184	.185	.185
.9	.174	.178	.181	.184	.186	.192	.194	.195	.196	.196
1.0	.181	.185	.189	.191	.194	.200	.202	.203	.204	.205
1.1	.186	.191	.195	.198	.200	.207	.209	.211	.212	.212
1.2	.191	.196	.200	.203	.205	.212	.215	.216	.217	.218
1.3	.195	.200	.204	.207	.209	.217	.220	.221	.222	.223
1.4	.198	.203	.207	.210	.213	.221	.224	.225	.226	.227
1.5	.200	.205	.209	.213	.216	.224	.227	.228	.230	.230
2.0	.207	.212	.217	.221	.224	.232	.236	.238	.240	.240
2.5	.209	.215	.220	.224	.227	.236	.240	.242	.244	.244
3.0	.211	.216	.221	.225	.228	.238	.242	.244	.246	.247
5.0	.212	.217	.222	.226	.230	.240	.244	.246	.249	.249
10.0	.212	.218	.223	.227	.230	.240	.244	.247	.249	.250

اضافه تنش قائم در خاک ناشی از بار گسترده یکنواخت مستطیلی

مثال : نحوه محاسبه اضافه تنش درون ناحیه مستطیلی



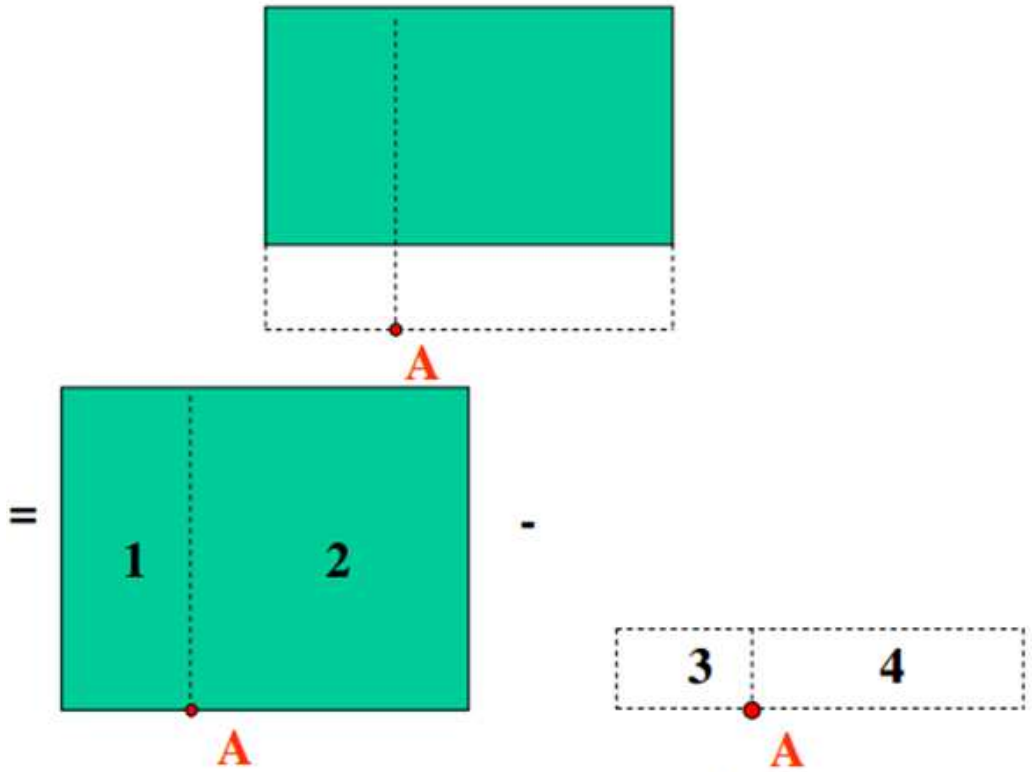
$$\Delta\sigma = q\left[I_{(1)} + I_{(2)} + I_{(3)} + I_{(4)}\right]$$

$$\Delta\sigma_c = qI_c$$

$$I_c = f(m_1, n_1)$$

اضافه تنش قائم در خاک ناشی از بار گسترده یکنواخت مستطیلی

مثال : نحوه محاسبه اضافه تنش خارج از ناحیه مستطیلی



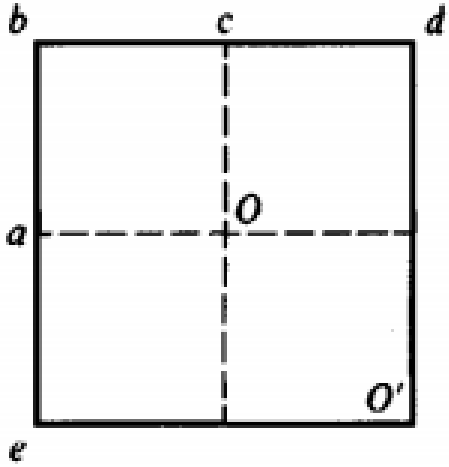
$$\Delta\sigma_z = p[I_1 + I_2 - I_3 - I_4]$$

Find the stress beneath the center (point O) and corner of Fig. 5-5*a* for the following

$B \times B = 2\text{ m} \times 2\text{ m}$ $\quad Q = 800\text{ kN}$

At corner $\quad z = 2\text{ m}$

At center for $\quad z = 0, 1, 2, 3,$ and 4 m



(*a*) Square loaded area = *O'ebd*.
For point *O*: use 4 × *Oabc*.
For point *O'*: use *O'ebd*.

1. For the corner at $z = 2$ m

$$M = 2/2 = N = 1 \qquad \text{giving the table factor } 0.175 = I_\sigma$$

$$\Delta q = q_o m(0.175) = \frac{800}{2 \times 2} \times 1 \times 0.175 = \mathbf{35}\text{ kPa}$$

2. For the center $B' = 2/2 = 1$; $L' = 2/2 = 1$ and with $m = 4$ contributions; for $M = N = \infty$ use 10.

z	M	N	Δq, kPa
0	∞	∞	$200 \times 0.250 \times 4 =$ **200** kPa*
1	1	1	$200 \times 0.175 \times 4 =$ **140**
2	0.5	0.5	$200 \times 0.084 \times 4 =$ **67**
3	0.333	0.333	$200 \times 0.045 \times 4 =$ **36**
4	0.25	0.25	$200 \times 0.027 \times 4 =$ **22**

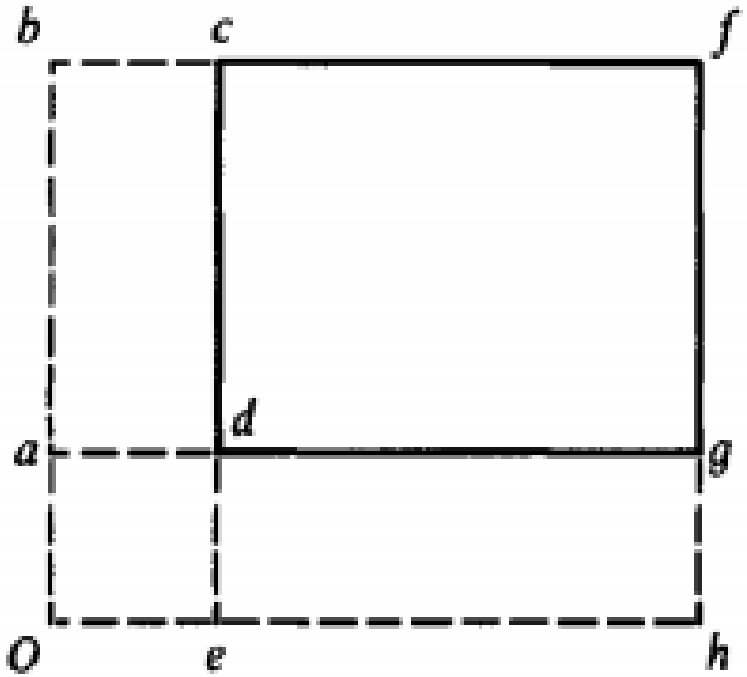
*at $z = 0$, $\Delta q = 800/(2 \times 2) = 200$ kPa

Example 5-4. Find the stress at point O of Fig. 5-5c if the loaded area is square, with $dg = dc = 4$ m, $ad = 1$ m, and $ed = 3$ m for $q_o = 400$ kPa and depth $z = 2$ m.

Solution. From the figure the stress I_σ is the sum of $Obfh - Obce - Oagh + Oade$, and $m = 1$.

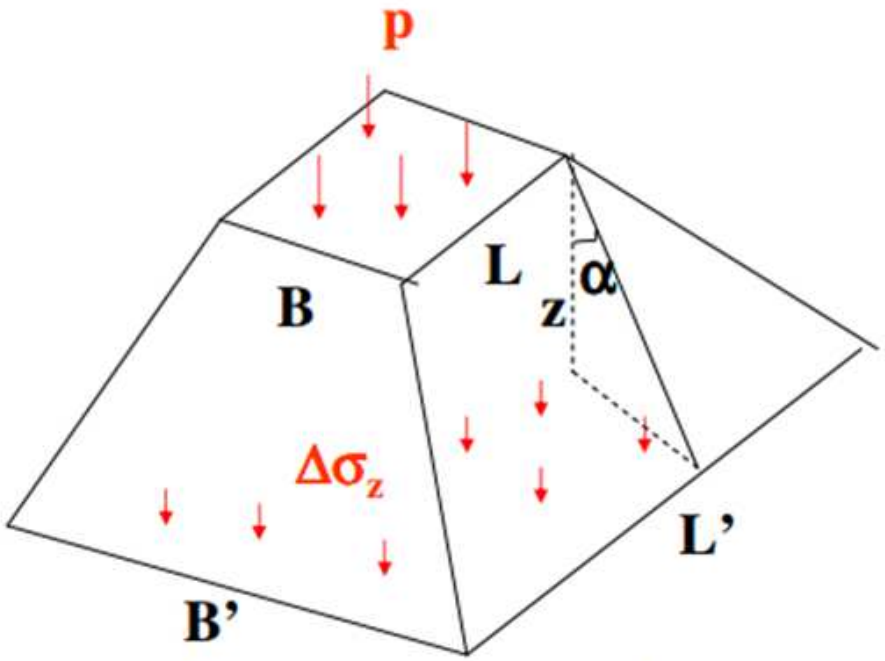
For	M	N	I_σ
$Obfh$	5/2	7/2	+0.243
$Obce$	1/2	7/2	−0.137
$Oagh$	3/2	5/2	−0.227
$Oade$	1/2	3/2	+0.131
		I_σ =	**+0.010**

$q_v = 400(1)(0.010) = \mathbf{4}$ kPa



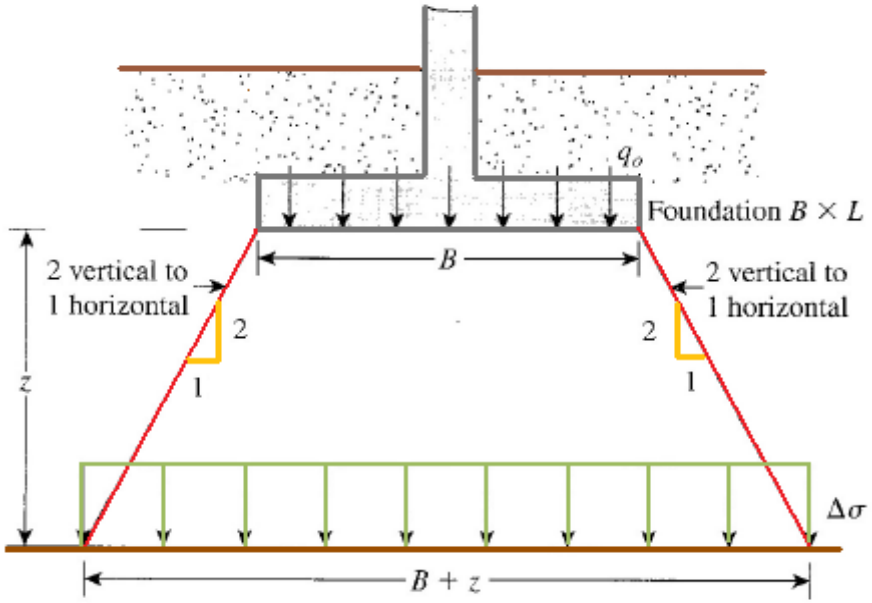
(*c*) Point outside loaded area = *dcfg*. For point *O*: use *Obfh* − *Obce* − *Oagh* + *Oade*.

روش تقریبی توزیع تنش۲ به ۱



$$\Delta\sigma_z = p\frac{LB}{L'B'} = p\frac{LB}{(L+2z\tan\alpha)(B+2z\tan\alpha)}$$

If $\tan\alpha = 1/2$ ⟹ $$\Delta\sigma_z = p\frac{LB}{(L+z)(B+z)}$$



2:1 method of finding stress increase under a foundation

$$\Delta\sigma = \frac{q_o BL}{(B+z)(L+z)}$$

Approximate methods

$$\Delta\sigma'_{av} = \frac{1}{6}(\Delta\sigma'_t + 4\Delta\sigma'_m + \Delta\sigma'_b)$$

where $\Delta\sigma'_t$, $\Delta\sigma'_m$, and $\Delta\sigma'_b$ are, respectively, the effective pressure increases at the *top, middle,* and *bottom* of the clay layer that are caused by the construction of the foundation.