جدول المعادلات

TABLE 4-1

Bearing-capacity equations by the several authors indicated

Terzaghi (1943). See Table 4-2 for typical values and for $K_{p\gamma}$ values.

$$q_{ult} = cN_c s_c + \bar{q}N_q + 0.5\gamma B N_\gamma s_\gamma \qquad N_q = \frac{a^2}{a\cos^2(45 + \phi/2)}$$

$$a = e^{(0.75\pi - \phi/2)\tan\phi}$$

$$N_c = (N_q - 1)\cot\phi$$

$$N_\gamma = \frac{\tan\phi}{2}\left(\frac{K_{p\gamma}}{\cos^2\phi} - 1\right)$$

For:	strip	round	square
s_c =	1.0	1.3	1.3
s_γ =	1.0	0.6	0.8

Meyerhof (1963).* See Table 4-3 for shape, depth, and inclination factors.

$$q_{ult} = cN_c s_c d_c i_c + \bar{q} N_q s_q d_q i_q + 0.5\gamma B N_\gamma s_\gamma d_\gamma i_\gamma$$

$$N_q = e^{\pi\tan\phi}\tan^2\left(45 + \frac{\phi}{2}\right)$$

$$N_c = (N_q - 1)\cot\phi$$

$$N_\gamma = (N_q - 1)\tan(1.4\phi)$$

Hansen (1970).* See Table 4-5 for shape, depth, and other factors.

General:† $q_{ult} = cN_c s_c d_c i_c g_c b_c + \bar{q}N_q s_q d_q i_q g_q b_q + 0.5\gamma B' N_\gamma s_\gamma d_\gamma i_\gamma g_\gamma b_\gamma$

when $\phi = 0$

use $q_{ult} = 5.14 s_u(1 + s'_c + d'_c - i'_c - b'_c - g'_c) + \bar{q}$

N_q = same as Meyerhof above

N_c = same as Meyerhof above

$$N_\gamma = 1.5(N_q - 1)\tan\phi$$

Vesić (1973, 1975).* See Table 4-5 for shape, depth, and other factors. Use Hansen's equations above.

N_q = same as Meyerhof above

N_c = same as Meyerhof above

$$N_\gamma = 2(N_q + 1)\tan\phi$$

*These methods require a trial process to obtain design base dimensions since width B and length L are needed to compute shape, depth, and influence factors.

†See Sec. 4-6 when $i_i < 1$.

جدول استخراج قيمة Ø لمعادلة Terzaghi

Table 4-2 Terzaghi Bearing capacity factors —Eqs. (4.15), (4.13), and (4.11).[a]

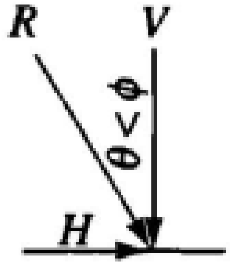
ϕ'	N_c	N_q	N_γ[a]	ϕ'	N_c	N_q	N_γ[a]
0	5.70	1.00	0.00	26	27.09	14.21	9.84
1	6.00	1.10	0.01	27	29.24	15.90	11.60
2	6.30	1.22	0.04	28	31.61	17.81	13.70
3	6.62	1.35	0.06	29	34.24	19.98	16.18
4	6.97	1.49	0.10	30	37.16	22.46	19.13
5	7.34	1.64	0.14	31	40.41	25.28	22.65
6	7.73	1.81	0.20	32	44.04	28.52	26.87
7	8.15	2.00	0.27	33	48.09	32.23	31.94
8	8.60	2.21	0.35	34	52.64	36.50	38.04
9	9.09	2.44	0.44	35	57.75	41.44	45.41
10	9.61	2.69	0.56	36	63.53	47.16	54.36
11	10.16	2.98	0.69	37	70.01	53.80	65.27
12	10.76	3.29	0.85	38	77.50	61.55	78.61
13	11.41	3.63	1.04	39	85.97	70.61	95.03
14	12.11	4.02	1.26	40	95.66	81.27	115.31
15	12.86	4.45	1.52	41	106.81	93.85	140.51
16	13.68	4.92	1.82	42	119.67	108.75	171.99
17	14.60	5.45	2.18	43	134.58	126.50	211.56
18	15.12	6.04	2.59	44	151.95	147.74	261.60
19	16.56	6.70	3.07	45	172.28	173.28	325.34
20	17.69	7.44	3.64	46	196.22	204.19	407.11
21	18.92	8.26	4.31	47	224.55	241.80	512.84
22	20.27	9.19	5.09	48	258.28	287.85	650.67
23	21.75	10.23	6.00	49	298.71	344.63	831.99
24	23.36	11.40	7.08	50	347.50	415.14	1072.80
25	25.13	12.72	8.34				

[a]From Kumbhoikar (1993)

جدول متغيرات مايرهوف

TABLE 4-3

Shape, depth, and inclination factors for the Meyerhof bearing-capacity equations of Table 4-1

Factors	Value	For
Shape:	$s_c = 1 + 0.2K_p \frac{B}{L}$	Any ϕ
	$s_q = s_\gamma = 1 + 0.1K_p \frac{B}{L}$	$\phi > 10°$
	$s_q = s_\gamma = 1$	$\phi = 0$
Depth:	$d_c = 1 + 0.2\sqrt{K_p}\frac{D}{B}$	Any ϕ
	$d_q = d_\gamma = 1 + 0.1\sqrt{K_p}\frac{D}{B}$	$\phi > 10$
	$d_q = d_\gamma = 1$	$\phi = 0$
Inclination:	$i_c = i_q = \left(1 - \frac{\theta°}{90°}\right)^2$	Any ϕ
	$i_\gamma = \left(1 - \frac{\theta°}{\phi°}\right)^2$	$\phi > 0$
	$i_\gamma = 0$ for $\theta > 0$	$\phi = 0$

Where $K_p = \tan^2(45 + \phi/2)$ as in Fig. 4-2

θ = angle of resultant R measured from vertical without a sign; if $\theta = 0$ all $i_i = 1.0$.

B, L, D = previously defined

جدول متغيرات هانسن و فيزك

TABLE 4-5a

Shape and depth factors for use in either the Hansen (1970) or Vesić (1973, 1975b) bearing-capacity equations of Table 4-1. Use s'_c, d'_c when $\phi = 0$ only for Hansen equations. Subscripts H, V for Hansen, Vesić, respectively.

Shape factors	Depth factors
$s'_{c(H)} = 0.2\dfrac{B'}{L'}$ ($\phi = 0°$) $s_{c(H)} = 1.0 + \dfrac{N_q}{N_c} \cdot \dfrac{B'}{L'}$ $s_{c(V)} = 1.0 + \dfrac{N_q}{N_c} \cdot \dfrac{B}{L}$ $s_c = 1.0$ for strip	$d'_c = 0.4k$ ($\phi = 0°$) $d_c = 1.0 + 0.4k$ $k = D/B$ for $D/B \leq 1$ $k = \tan^{-1}(D/B)$ for $D/B > 1$ k in radians
$s_{q(H)} = 1.0 + \dfrac{B'}{L'}\sin\phi$ $s_{q(V)} = 1.0 + \dfrac{B}{L}\tan\phi$ for all ϕ	$d_q = 1 + 2\tan\phi(1 - \sin\phi)^2 k$ k defined above
$s_{\gamma(H)} = 1.0 - 0.4\dfrac{B'}{L'} \geq 0.6$ $s_{\gamma(V)} = 1.0 - 0.4\dfrac{B}{L} \geq 0.6$	$d_\gamma = 1.00$ for all ϕ

Notes:

1. Note use of "effective" base dimensions B', L' by Hansen but not by Vesić.
2. The values above are consistent with either a vertical load or a vertical load accompanied by a horizontal load H_B.
3. With a vertical load and a load H_L (and either $H_B = 0$ or $H_B > 0$) you may have to

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TABLE 4-5*b*

Table of inclination, ground, and base factors for the Hansen (1970) equations. See Table 4-5*c* for equivalent Vesić equations.

Inclination factors

$$i'_c = 0.5\text{-}0.5\sqrt{1 - \frac{H_i}{A_f C_a}}$$

$$i_c = i_q - \frac{1 - i_q}{N_q - 1}$$

$$i_q = \left[1 - \frac{0.5H_i}{V + A_f c_a \cot\phi}\right]^{\alpha_1}$$

$$2 \le \alpha_1 \le 5$$

$$i_\gamma = \left[1 - \frac{0.7H_i}{V + A_f c_a \cot\phi}\right]^{\alpha_2}$$

$$i_\gamma = \left[1 - \frac{(0.7 - \eta^\circ/450^\circ)H_i}{V + A_f c_a \cot\phi}\right]^{\alpha_2}$$

$$2 \le \alpha_2 \le 5$$

Ground factors (base on slope)

$$g'_c = \frac{\beta^\circ}{147^\circ}$$

$$g_c = 1.0 - \frac{\beta^\circ}{147^\circ}$$

$$g_q = g_\gamma = (1 - 0.5\tan\beta)^5$$

Base factors (tilted base)

$$b'_c = \frac{\eta^\circ}{147^\circ} \qquad (\phi = 0)$$

$$b_c = 1 - \frac{\eta^\circ}{147^\circ} \qquad (\phi > 0)$$

$$b_q = \exp(-2\eta\tan\phi)$$

$$b_\gamma = \exp(-2.7\eta\tan\phi)$$

η in radians

Notes:

1. Use H_i as either H_B or H_L, or both if $H_L > 0$.
2. Hansen (1970) did not give an i_c for $\phi > 0$. The value above is from Hansen (1961) and also used by Vesić.
3. Variable c_a = base adhesion, on the order of 0.6 to 1.0 × base cohesion.
4. Refer to sketch for identification of angles η and β, footing depth D, location of H_i (parallel and at top of base slab; usually also produces eccentricity). Especially note V = force *normal* to base and is not the resultant R from combining V and H_i.

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TABLE 4-5c

Table of inclination, ground, and base factors for the Vesic (1973, 1975) bearing-capacity equations. See notes below and refer to sketch for identification of terms.

Inclination factors

$$i'_c = 1 - \frac{mH_i}{A_f c_a N_c} \qquad (\phi = 0)$$

$$i_c = i_q - \frac{1 - i_q}{N_q - 1} \qquad (\phi > 0)$$

i_q, and m defined below

$$i_q = \left[1.0 - \frac{H_i}{V + A_f c_a \cot\phi}\right]^m$$

$$i_\gamma = \left[1.0 - \frac{H_i}{V + A_f c_a \cot\phi}\right]^{m+1}$$

$$m = m_B = \frac{2 + B/L}{1 + B/L}$$

$$m = m_L = \frac{2 + L/B}{1 + L/B}$$

Ground factors (base on slope)

$$g'_c = \frac{\beta}{5.14} \qquad \beta \text{ in radians}$$

$$g_c = i_q - \frac{1 - i_q}{5.14 \tan\phi} \qquad \phi > 0$$

i_q defined with i_c

$$g_q = g_\gamma = (1.0 - \tan\beta)^2$$

Base factors (tilted base)

$$b'_c = g'_c \qquad (\phi = 0)$$

$$b_c = 1 - \frac{2\beta}{5.14 \tan\phi}$$

$$b_q = b_\gamma = (1.0 - \eta \tan\phi)^2$$

Notes:

1. When $\phi = 0$ (and $\beta \neq 0$) use $N_\gamma = -2\sin(\pm\beta)$ in N_γ term.
2. Compute $m = m_B$ when $H_i = H_B$ (H parallel to B) and $m = m_L$ when $H_i = H_L$ (H parallel to L). If you have both H_B and H_L use $m = \sqrt{m_B^2 + m_L^2}$. Note use of B and L, not B', L'.
3. Refer to Table sketch and Tables 4-5*a,b* for term identification.
4. Terms N_c, N_q, and N_γ are identified in Table 4-1.
5. Vesić always uses the bearing-capacity equation given in Table 4-1 (uses B' in the N_γ term even when $H_i = H_L$).
6. H_i term ≤ 1.0 for computing i_q, i_γ (always).

جدول حساب Ø لمعادلات مايرهوف و هانسن و فيزك

الجدول (2–3) : معاملات قابلية التحمل بحسب مايرهوف وهانسن وفيزك

			مايرهوف	هانسن	فيزك				مايرهوف	هانسن	فيزك
ϕ	N_c	N_q	N_γ	N_γ	N_γ	ϕ	N_c	N_q	N_γ	N_γ	N_γ
0	5.14	1.00	0.00	0.00	0.00	26	22.25	11.85	8.00	7.94	12.54
1	5.38	1.09	0.00	0.00	0.07	27	23.94	13.20	9.46	9.32	14.48
2	5.63	1.20	0.01	0.01	0.15	28	25.80	14.72	11.19	10.94	16.72
3	5.90	1.31	0.02	0.02	0.24	29	27.86	16.44	13.24	12.84	19.34
4	6.19	1.43	0.04	0.05	0.34	30	30.14	18.40	15.67	15.07	22.40
5	6.49	1.57	0.07	0.07	0.45	31	32.67	20.63	18.56	17.69	25.99
6	6.81	1.72	0.11	0.11	0.57	32	35.49	23.18	22.02	20.79	30.22
7	7.16	1.88	0.15	0.16	0.71	33	38.64	26.09	26.17	24.44	35.19
8	7.53	2.06	0.21	0.22	0.86	34	42.16	29.44	31.15	28.77	41.06
9	7.92	2.25	0.28	0.30	1.03	35	46.12	33.30	37.15	33.92	48.03
10	8.35	2.47	0.37	0.39	1.22	36	50.59	37.75	44.43	40.05	56.31
11	8.80	2.71	0.47	0.50	1.44	37	55.63	42.92	53.27	47.38	66.19
12	9.28	2.97	0.60	0.63	1.69	38	61.35	48.93	64.07	56.17	78.03
13	9.81	3.26	0.74	0.78	1.97	39	67.87	55.96	77.33	66.76	92.25
14	10.37	3.59	0.92	0.97	2.29	40	75.31	64.20	93.69	79.54	109.41
15	10.98	3.94	1.13	1.18	2.65	41	83.86	73.90	113.99	95.05	130.22
16	11.63	4.34	1.37	1.43	3.06	42	93.71	85.38	139.32	113.96	155.55
17	12.34	4.77	1.66	1.73	3.53	43	105.11	99.02	171.14	137.10	186.54
18	13.10	5.26	2.00	2.08	4.07	44	118.37	115.31	211.41	165.58	224.64
19	13.93	5.80	2.40	2.48	4.68	45	133.88	134.88	262.74	200.81	271.76
20	14.83	6.40	2.87	2.95	5.39	46	152.10	158.51	328.73	244.65	330.35
21	15.82	7.07	3.42	3.50	6.20	47	173.64	187.21	414.33	299.52	403.67
22	16.88	7.82	4.07	4.13	7.13	48	199.26	222.31	526.45	368.67	496.01
23	18.05	8.66	4.82	4.88	8.20	49	229.93	265.51	674.92	456.40	613.16
24	19.32	9.60	5.72	5.75	9.44	50	266.89	319.07	873.86	568.57	762.89
25	20.72	10.66	6.77	6.76	10.88						

جدول تخمين قيم خواص التربة من خلال فحص SPT

TABLE 3-4

Empirical values for ϕ, D_r, and unit weight of granular soils based on the SPT at about 6 m depth and normally consolidated [approximately, $\phi = 28° + 15° D_r$ (±2°)]

Description		Very loose	Loose	Medium	Dense	Very dense
Relative density D_r		0	0.15	0.35	0.65	0.85
SPT N'_{70}:	fine	1–2	3–6	7–15	16–30	?
	medium	2–3	4–7	8–20	21–40	> 40
	coarse	3–6	5–9	10–25	26–45	> 45
ϕ:	fine	26–28	28–30	30–34	33–38	
	medium	27–28	30–32	32–36	36–42	< 50
	coarse	28–30	30–34	33–40	40–50	
γ_{wet}, kN/m³		11–16*	14–18	17–20	17–22	20–23

* Excavated soil or material dumped from a truck has a unit weight of 11 to 14 kN/m³ and must be quite dense to weigh much over 21 kN/m³. No existing soil has a D_r = 0.00 nor a value of 1.00. Common ranges are from 0.3 to 0.7.