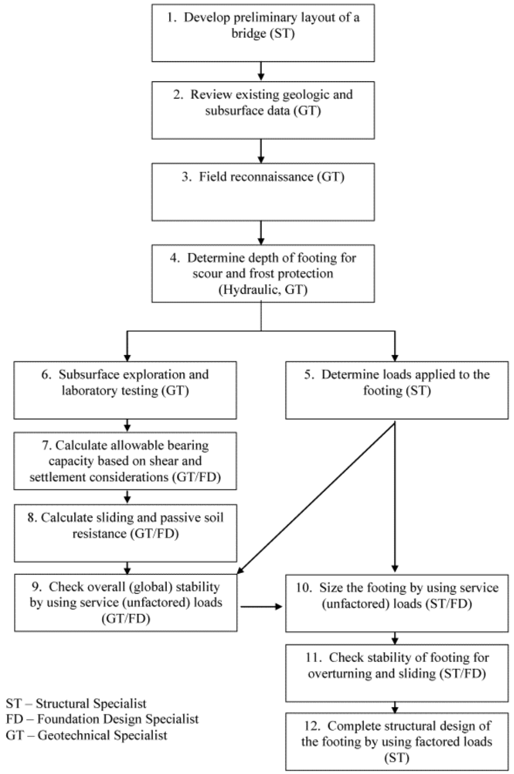


Figure 8-11. Design process flow chart – bridge shallow foundation (modified after FHWA, 2002c).

ENCE 4610
Foundation Analysis and Design

Lecture 3
Bearing Capacity of Shallow Foundations:
Eccentric Loading of Foundations
Effect of Water Table and Layered Soils

Bearing Capacity Correction Factors

8.4.3 Bearing Capacity Correction Factors

A number of factors that were not included in the derivations discussed earlier influence the ultimate bearing capacity of shallow foundations. Note that Equation 8-1 assumes a rigid strip footing with a rough base, loaded through its centroid, that is bearing on a level surface of homogeneous soil. Various correction factors have been proposed by numerous investigators to account for footing shape adjusted for eccentricity, location of the ground water table, embedment depth, sloping ground surface, an inclined base, the mode of shear, local or punching shear, and inclined loading. The general philosophy of correcting the theoretical ultimate bearing capacity equation involves multiplying each of the three terms in the bearing capacity equation by empirical factors to account for the particular effect. Each correction factor includes a subscript denoting the term to which the factor should be applied: "c" for the cohesion term, "q" for the surcharge term, and "γ" for the weight term. Each of these factors and suggestions for their application are discussed separately below. In most cases these factors may be used in combination.

The general form of the ultimate bearing capacity equation, including correction terms, is:

$$q_{ult} = cN_c s_c b_c + qN_q C_{wq} s_q b_q d_q + 0.5\gamma B_f N_\gamma C_{w\gamma} s_\gamma b_\gamma \qquad 8\text{-}6$$

where: s_c, s_γ and s_q are **shape correction factors**

b_c, b_γ and b_q are **base inclination correction factors**

$C_{w\gamma}$ and C_{wq} are **groundwater correction factors**

d_q is an **embedment depth correction factor** to account for the shearing resistance along the failure surface passing through cohesionless material above the bearing elevation. Recall that the embedment is modeled as a surcharge pressure applied at the bearing elevation. To be theoretically correct, the "q" in the surcharge term consists of two components, one the embedment depth surcharge to which the correction factor applies, the other an applied surcharge such as the traffic surcharge to which the correction factor, by definition, does not apply. Therefore, theoretically the "q" in the surcharge term should be replaced with ($q_a + \gamma D_f d_q$) where q_a is defined as an applied surcharge for cases where applied surcharge is considered in the analysis;

N_c, N_q and N_γ are **bearing capacity factors** that are a function of the friction angle of the soil. N_c, N_q and N_γ can be obtained from Table 8-2 or Figure 8-15 or they can be computed by Equation 8-3/8-4, 8-2 and 8-5, respectively. As discussed in Section 8.4.3.6, N_c and N_γ are replaced with N_{cq} and $N_{\gamma q}$ for the case of sloping ground or when the footing is located near a slope. In these cases the N_q term is omitted.

The following sections provide guidance on the use of the bearing capacity correction factors, and whether or not certain factors should be used in combination.

Shape Factors

Table 8-4

Shape correction factors (AASHTO, 2004 with 2006 Interims)

Factor	Friction Angle	Cohesion Term (s_c)	Unit Weight Term (s_γ)	Surcharge Term (s_q)
Shape Factors, s_c, s_γ, s_q	$\phi = 0$	$1+\left(\frac{B_f}{5L_f}\right)$	1.0	1.0
	$\phi > 0$	$1+\left(\frac{B_f}{L_f}\right)\left(\frac{N_q}{N_c}\right)$	$1-0.4\left(\frac{B_f}{L_f}\right)$	$1+\left(\frac{B_f}{L_f}\tan\phi\right)$

Note: Shape factors, s, should not be applied simultaneously with inclined loading factors, i. See Section 8.4.3.5.

Inclined Base Factors

8.4.3.4 Inclined Base

In general, inclined footings for bridges should be avoided or limited to inclination angles, α, less than about 8 to 10 degrees from the horizontal. Steeper inclinations may require keys, dowels or anchors to provide sufficient resistance to sliding. For footings inclined to the horizontal, Table 8-7 provides equations for the correction factors to be used in Equation 8-6.

Table 8-7

Inclined base correction factors (Hansen and Inan, 1970; AASHTO, 2004 with 2006 Interims)

Factor	**Friction Angle**	**Cohesion Term (c)**	**Unit Weight Term (γ)**	**Surcharge Term (q)**
		b_c	b_γ	b_q
Base Inclination Factors, b_c, b_γ, b_q	$\phi = 0$	$1-\left(\frac{\alpha}{147.3}\right)$	1.0	1.0
	$\phi > 0$	$b_q-\left(\frac{1-b_q}{N_c \tan\phi}\right)$	$(1\text{-}0.017\alpha \tan\phi)^2$	$(1\text{-}0.017\alpha \tan\phi)^2$
ϕ = friction angle, degrees; α = footing inclination from horizontal, upward +, degrees				

Groundwater Table Correction Factors

8.4.3.2 Location of the Ground Water Table

If the ground water table is located within the potential failure zone above or below the base of a footing, buoyant (effective) unit weight should be used to compute the overburden pressure. A simplified method for accounting for the reduction in shearing resistance is to apply factors to the two terms in the bearing capacity equation that include a unit weight term. Recall that the cohesion term is neither a function of soil unit weight nor effective stress. The ground water factors may be computed by interpolating values between those provided in Table 8-5 (D_W = depth to water from ground surface).

Table 8-5
Correction factor for location of ground water table
(AASHTO, 2004 with 2006 Interims)

D_W	$C_{W\gamma}$	C_{Wq}
0	0.5	0.5
D_f	0.5	1.0
$> 1.5B_f + D_f$	1.0	1.0

Note: For intermediate positions of the ground water table, interpolate between the values shown above.

Embedment Depth Factors

8.4.3.3 Embedment Depth

Because the effect on bearing capacity of the depth of embedment was accounted for by considering it as an equivalent surcharge applied at the footing bearing elevation, the effect of the shearing resistance due to the failure surface actually passing through the footing embedment cover was neglected in the theory. If the backfill or cover over the footing is known to be a high-quality, compacted granular material that can be assumed to remain in place over the life of the footing, additional shearing resistance due to the backfill can be accounted for by including in the surcharge term the embedment depth correction factor, d_q, shown in Table 8-6. Otherwise, the depth correction factor can be conservatively omitted.

Table 8-6
Depth correction factors
(Hansen and Inan, 1970; AASHTO, 2004 with 2006 Interims)

Friction Angle, ϕ (degrees)	D_f/B_f	d_q
32	1	1.20
	2	1.30
	4	1.35
	8	1.40
37	1	1.20
	2	1.25
	4	1.30
	8	1.35
42	1	1.15
	2	1.20
	4	1.25
	8	1.30

Note: The depth correction factor should be used only when the soils above the footing bearing elevation are as competent as the soils beneath the footing level; otherwise, the depth correction factor should be taken as 1.0.

Load Inclination Factors

- A convenient way to account for the effects of an inclined load applied to the footing by the column or wall stem is to consider the effects of the axial and shear components of the inclined load individually. If the vertical component is checked against the available bearing capacity and the shear component is checked against the available sliding resistance, the inclusion of load inclination factors in the bearing capacity equation can generally be omitted. The bearing capacity should, however, be evaluated by using effective footing dimensions, as discussed in Section 8.4.3.1 and in the footnote to Table 8-4, since large moments can frequently be transmitted to bridge foundations by the columns or pier walls. **The simultaneous application of shape and load inclination factors can result in an overly conservative design.**
- Unusual column geometry or loading configurations should be evaluated on a case-by-case basis relative to the foregoing recommendation before the load inclination factors are omitted. An example might be a column that is not aligned normal to the footing bearing surface. In this case, an inclined footing may be considered to offset the effects of the inclined load by providing improved bearing efficiency (see Section 8.4.3.4). Keep in mind that bearing surfaces that are not level may be difficult to construct and inspect. (FHWA NHI-06-089)

Allowable Bearing Capacity

Factors when considering selection of a factor of safety

Soil Type	Sand	⟷	Clay
Site Characterization Data	Extensive	⟷	Minimal
Soil Variability	Uniform	⟷	Erratic
Importance of Structure & Consequences of Failure	Low	⟷	High
Likehood of Design Load Occurring	Low	⟷	High
Design F — Extreme Values	2.0	⟷	4.0
Design F — Typical Range	2.5	⟷	3.5

- Most foundations designed by ASD for geotechnical strength (LRFD to be discussed later)

$$r_a = q_a = \frac{q_{ult}}{F} = \frac{r_u}{F}$$

- Foundation is then designed so that the allowable bearing pressure is not exceeded

Bearing Capacity Example

- Given
  - Square shallow foundation, 5’ x 5’
  - Foundation depth = 2’
  - Cohesionless
  - Unit weight 121 pcf
  - Internal friction angle 31 degrees
  - Load on foundation = 76 kips
  - Groundwater table very deep
- Find
  - Factor of safety against bearing capacity failure
- Solution
  - Governing equation:

$$q_{ult} = cN_c s_c b_c + qN_q C_{wq} s_q b_q d_q + 0.5\gamma B_f N_\gamma C_{w\gamma} s_\gamma b_\gamma$$

  - We can neglect factors due to groundwater table (C_w), load inclination (b) and depth (d)

Bearing Capacity Example

- Bearing capacity "N" factors for 31 degree friction angle
  - $N_c = 32.7$
  - $N_q = 20.6$
  - $N_\gamma = 26.0$

Table 8-2

Bearing Capacity Factors (AASHTO, 2004 with 2006 Interims)

ϕ	N_c	N_q	N_γ	ϕ	N_c	N_q	N_γ
0	5.14	1.0	0.0	23	18.1	8.7	8.2
1	5.4	1.1	0.1	24	19.3	9.6	9.4
2	5.6	1.2	0.2	25	20.7	10.7	10.9
3	5.9	1.3	0.2	26	22.3	11.9	12.5
4	6.2	1.4	0.3	27	23.9	13.2	14.5
5	6.5	1.6	0.5	28	25.8	14.7	16.7
6	6.8	1.7	0.6	29	27.9	16.4	19.3
7	7.2	1.9	0.7	30	30.1	18.4	22.4
8	7.5	2.1	0.9	31	32.7	20.6	26.0
9	7.9	2.3	1.0	32	35.5	23.2	30.2
10	8.4	2.5	1.2	33	38.6	26.1	35.2
11	8.8	2.7	1.4	34	42.2	29.4	41.1
12	9.3	3.0	1.7	35	46.1	33.3	48.0
13	9.8	3.3	2.0	36	50.6	37.8	56.3
14	10.4	3.6	2.3	37	55.6	42.9	66.2
15	11.0	3.9	2.7	38	61.4	48.9	78.0
16	11.6	4.3	3.1	39	67.9	56.0	92.3
17	12.3	4.8	3.5	40	75.3	64.2	109.4
18	13.1	5.3	4.1	41	83.9	73.9	130.2
19	13.9	5.8	4.7	42	93.7	85.4	155.6
20	14.8	6.4	5.4	43	105.1	99.0	186.5
21	15.8	7.1	6.2	44	118.4	115.3	224.6
22	16.9	7.8	7.1	45	133.9	134.9	271.8

Bearing Capacity Example

- Shape Factors
  - $s_c = 1+(5/5)(20.6/32.7) = 1.63$
  - $s_\gamma =1=0.4(5/5) = 0.6$
  - $s_q = 1+(5/5)(\tan(31)) = 1.6$

Table 8-4

Shape correction factors (AASHTO, 2004 with 2006 Interims)

Factor	Friction Angle	Cohesion Term (s_c)	Unit Weight Term (s_γ)	Surcharge Term (s_q)
Shape Factors, s_c, s_γ, s_q	$\phi = 0$	$1+\left(\frac{B_f}{5L_f}\right)$	1.0	1.0
	$\phi > 0$	$1+\left(\frac{B_f}{L_f}\right)\left(\frac{N_q}{N_c}\right)$	$1-0.4\left(\frac{B_f}{L_f}\right)$	$1+\left(\frac{B_f}{L_f}\tan\phi\right)$

Note: Shape factors, s, should not be applied simultaneously with inclined loading factors, i. See Section 8.4.3.5.

Bearing Capacity Example

- Other variables
  - c=0 (problem statement)
  - q=(121)(2) = 242 psf
  - γ = 121 pcf (problem statement)
- Substitute and solve
- q_{ult} = (0) + (242)(20.6)(1.6) + (0.5)(121)(5)(26.0)(0.6) = 0 + 7976.32 + 4719 = 12,695 psf
- Compute ultimate load
  - $Q_{ult} = q_{ult} * A$
  - (12695)(5)(5) = 317,383 lbs. = 317.3 kips
- Compute Factor of Safety
  - FS = 317.3/76 = 4.17
- It's also possible to do this using the pressures
  - q_a = 76,000/(25) = 3040 psf
  - FS = 12,695/3040 = 4.17

Groundwater and Layered Soil Effects

- Layered Soils are virtually unavoidable in real geotechnical situations
- Softer layers below the surface can and do significantly affect both the bearing capacity and settlement of foundations

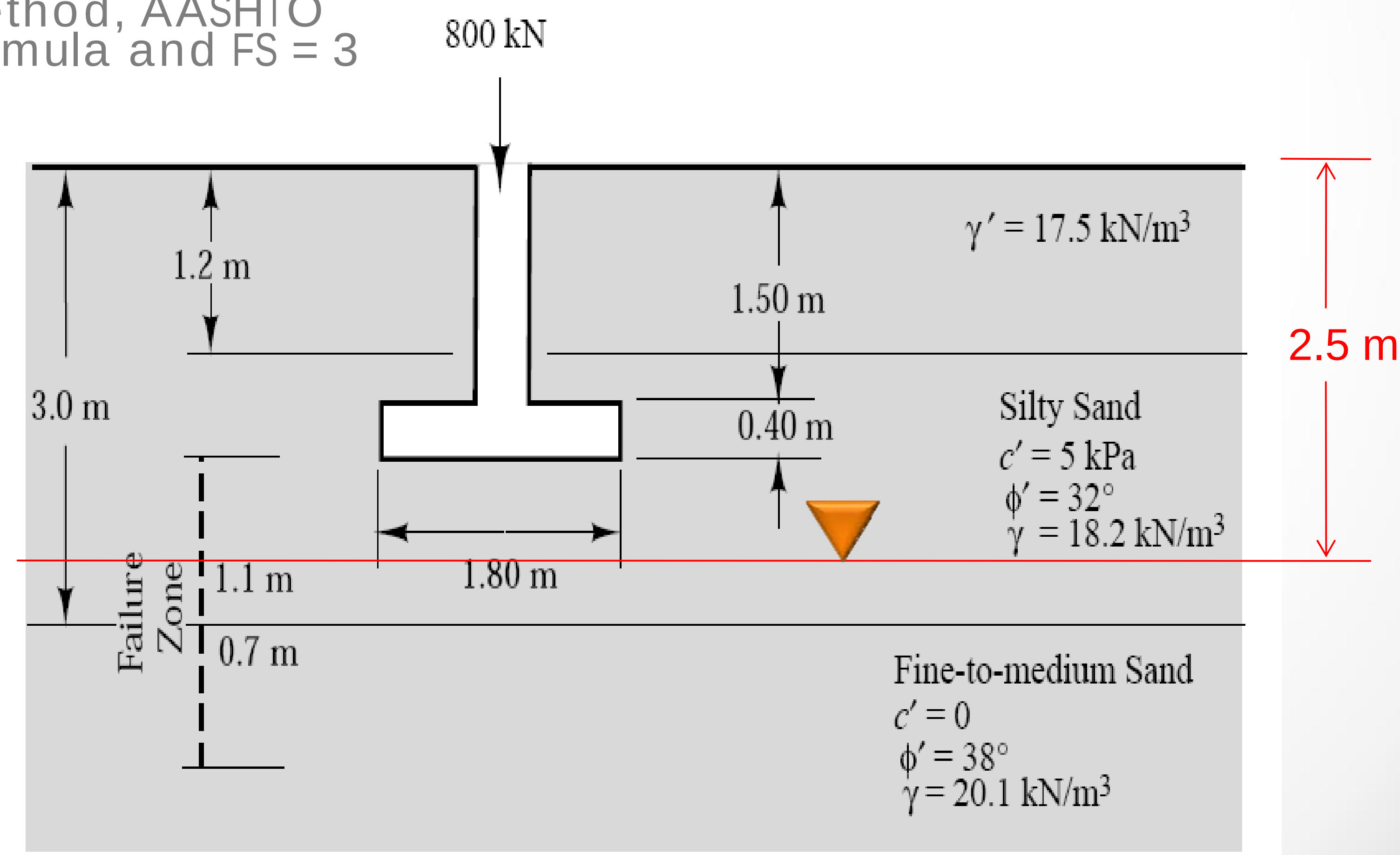
- Shallow groundwater affects shear strength in two ways:
  - Reduces apparent cohesion that takes place when soils are not saturated; may necessitate reducing the cohesion measured in the laboratory
  - Pore water pressure increases; reduces both effective stress and shear strength in the soil (same problem as is experienced with unsupported slopes)

Solution for Effect of Groundwater Table on Bearing Capacity

- Three ways to analyze layered soil profiles:
  - **Use the lowest of values of shear strength, friction angle and unit weight below the foundation. Simplest but most conservative. Use groundwater factors in conjunction with this.**
  - Use weighted average of these parameters based on relative thicknesses below the foundation. Best balance of conservatism and computational effort. Use width of foundation B as depth for weighted average
  - Consider series of trial surfaces beneath the footing and evaluate the stresses on each surface (similar to slope failure analysis.) Most accurate but calculations are tedious; use only when quality of soil data justify the effort

Example with Layered Soils and Groundwater

- Find
  - Check adequacy against bearing capacity failure using weighted average method, AASHTO Formula and FS = 3
- Given
  - Square spread footing as shown



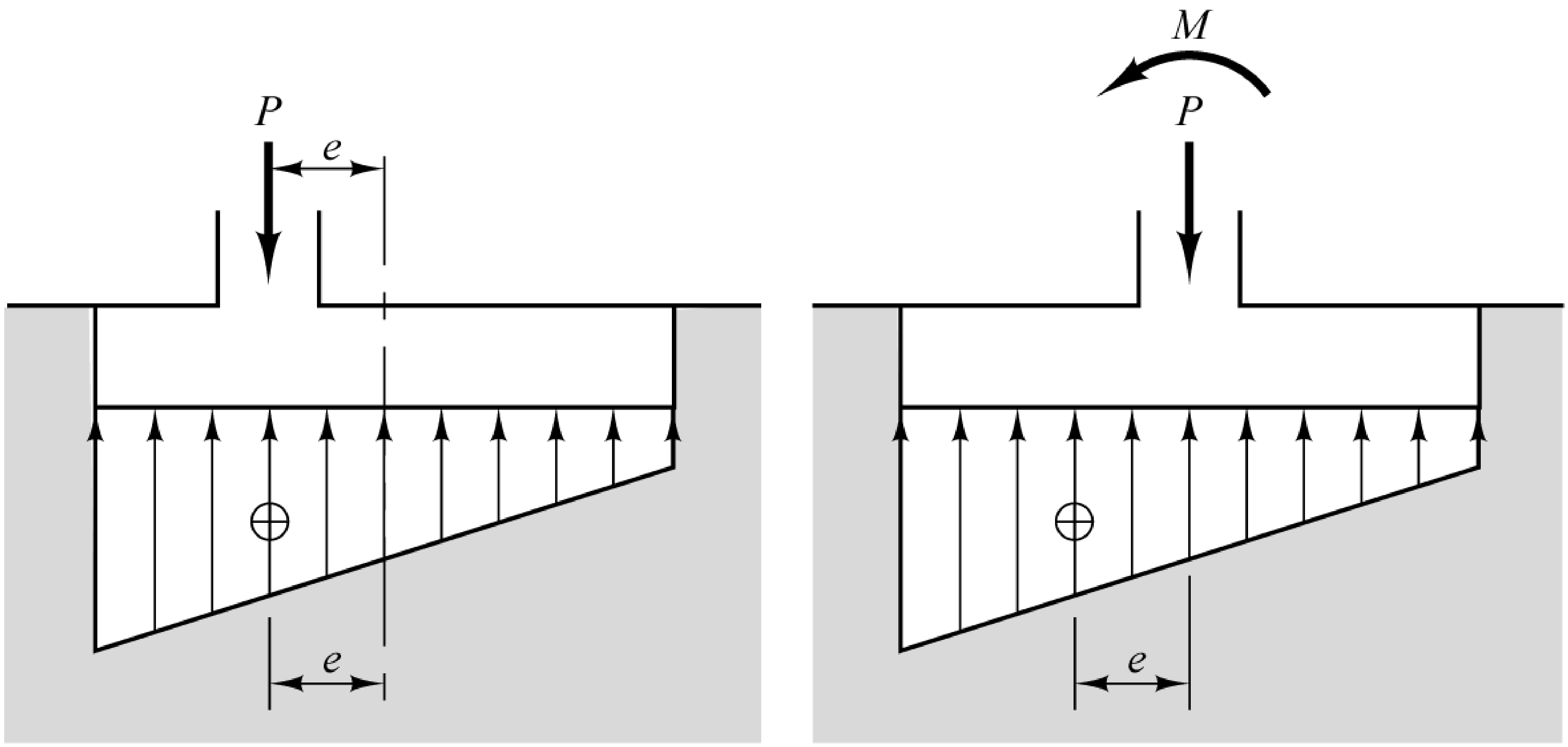
$$q_{ult} = cN_c s_c b_c + qN_q C_{wq} s_q b_q d_q + 0.5\gamma B_f N_\gamma C_{w\gamma} s_\gamma b_\gamma$$

Groundwater Example

- Use silty sand for bearing capacity and other values
  - $N_c = 35.5$
  - $N_q = 23.2$
  - $N_\gamma = 30.2$
- Use same shape factors as previous example (both square)
  - $s_c = 1+(5/5)(20.6/32.7) = 1.63$
  - $s_\gamma =1=0.4(5/5) = 0.6$
  - $s_q = 1+(5/5)(\tan(31)) = 1.6$
- Groundwater factors:
  - $1.5B_f + D_f = (1.5)(1.8) + (1.9) = 4.6$ m
  - Water table depth = 2.5 m
  - For $C_{w\gamma}$, we interpolate and obtain $C_{w\gamma} = 0.5+0.5*(2.5-1.9)/(4.6-1.9) = 0.61$
  - $C_{wq} = 1.0$ for any groundwater below the base of the foundation
- Other variables
  - c = 5 kPa (problem statement)
  - q = (1.2)(17.5)+(0.7)(18.2) = 33.74 kPa
  - γ = 18.2 pcf (problem statement)

q_{ult} = (5)(35.5)(1.63) + (33.74)(23.2)(1)(1.6) + (0.5)(18.2)(30.2)(0.61)(0.6) = 1642.3 kPa

Expressions of Eccentric Loading



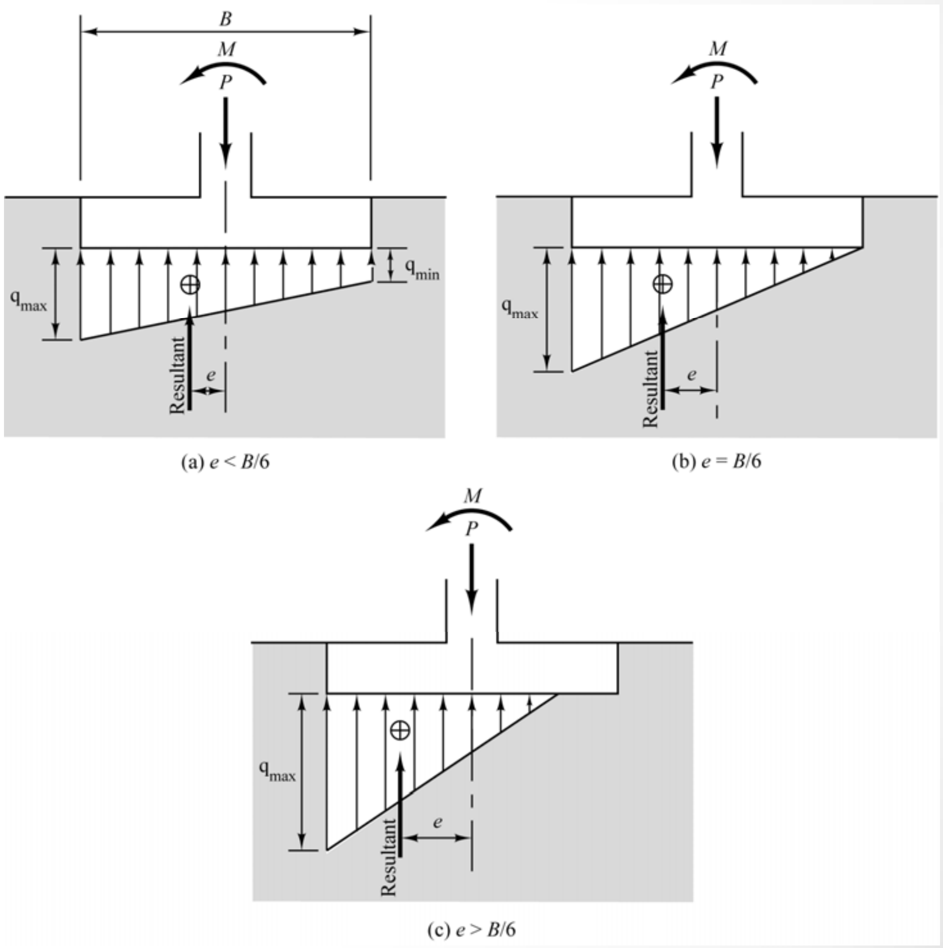
(a) (b)

Expressing Load Eccentricity and Inclination

- Load Divided by Inclination Angle
  - Total Load Q
  - Total Vertical Load Q_v
  - Total Horizontal Load Q_h
  - Angle of Inclination $\alpha = \arctan(Q_h/Q_v)$
  - Load can be concentric or eccentric
- Load and Eccentricity
  - Total Vertical Load Q
  - Eccentricity from centroid of foundation e
  - Horizontal Load (if any) not included
- Moment and Eccentric Load
  - Total eccentric vertical Load Q with eccentricity e
  - Replace with concentric vertical load Q and eccentric moment M=Qe
- Continuous Foundations
  - Moments, loads expressed as per unit length of foundation, thus Q/b or M/b

One Way Loading

- One-way loading is loading along one of the centre axes of the foundation
- Three cases to consider
- Resultant loads outside the “middle third” result in foundation lift-off and are thus not permitted at all



Equations for One-Way Pressures with Eccentric/Moment Loads

Finite (Square/Rectangular) Footings:

W_f is foundation weight

$$q_{max,min} = \left(\frac{P + W_f}{A}\right)\left(1 \pm \frac{6e}{B}\right)$$

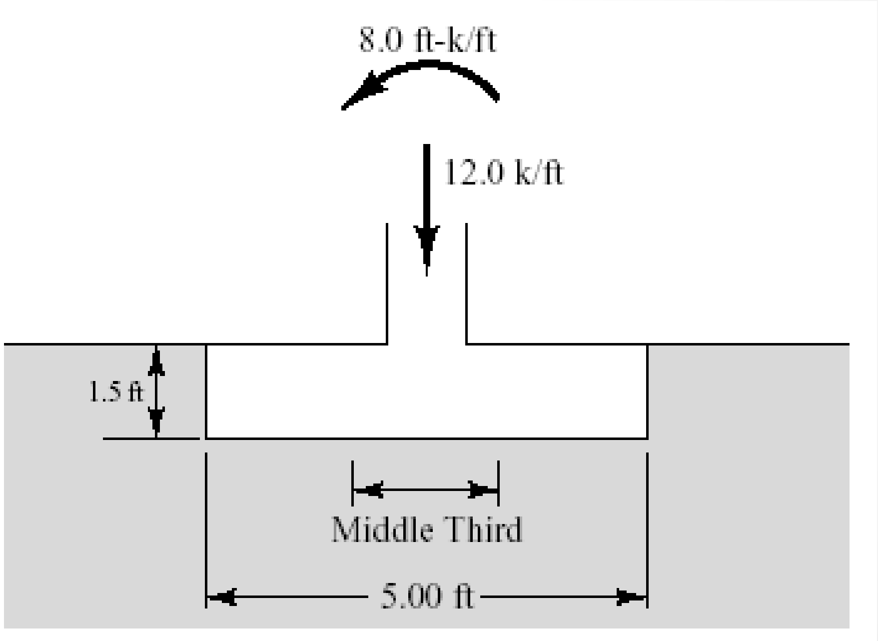
"Infinite" (Continuous) Footings:

If q at any point is less than zero, resultant is outside the middle third

$$q_{max,min} = \left(\frac{\frac{P}{b} + \frac{W_f}{b}}{B}\right)\left(1 \pm \frac{6e}{B}\right)$$

Example of One Way Eccentricity

- Given
  - Continuous Foundation as shown
  - Groundwater table at great depth
  - Weight of foundation (concrete) not included in load shown
- Find
  - Whether resultant force acts in middle third
  - Minimum and maximum bearing pressures



Example of One Way Eccentricity

- Compute Weight of Foundation
  - $W_f/b = (5)(1.5)(150) = 1125\ lb/ft$
- Compute eccentricity
  - $$e = \frac{(M/b)}{Q/b} = \frac{8000}{12000+1125} = 0.61\ ft.$$
    $$\frac{B}{6} = \frac{5}{6} = 0.833\ ft. > 0.61\ ft.$$
  - Thus, eccentricity is within the “middle third” of the foundation and foundation can be analysed further without enlargement at this point

Example of One Way Eccentricity

- Compute minimum and maximum bearing pressures

$$q_{min} = \left(\frac{\frac{Q}{b} + \frac{W_f}{b}}{B}\right)\left(1 - \frac{6e}{B}\right)$$

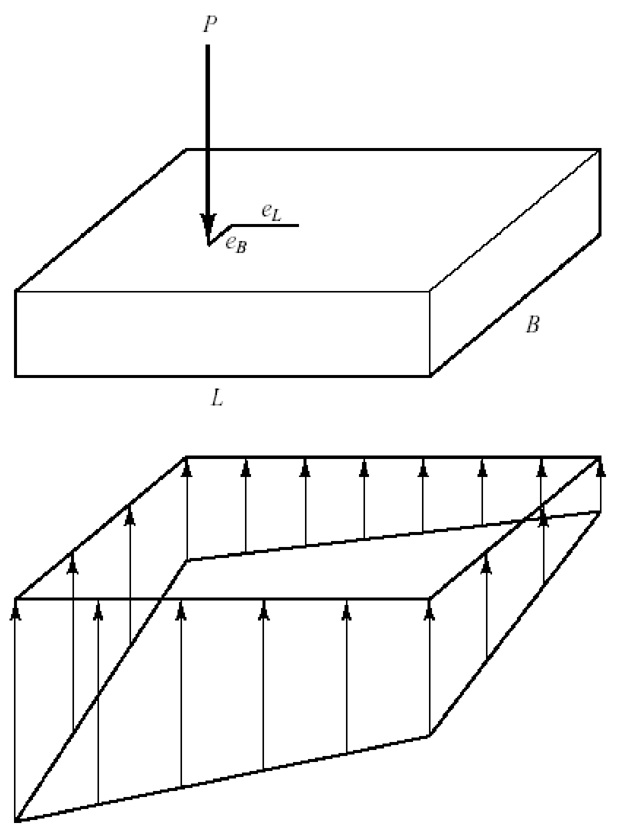
$$q_{min} = \left(\frac{12000 + 1125}{5}\right)\left(1 - \frac{6 \times 0.61}{5}\right) = 703\, psf$$

$$q_{max} = \left(\frac{\frac{Q}{b} + \frac{W_f}{b}}{B}\right)\left(1 + \frac{6e}{B}\right)$$

$$q_{max} = \left(\frac{12000 + 1125}{5}\right)\left(1 + \frac{6 \times 0.61}{5}\right) = 4546\, psf$$

Two-Way Eccentricity

Eccentricity in both “B” and “L” directions produces a planar distribution of stress

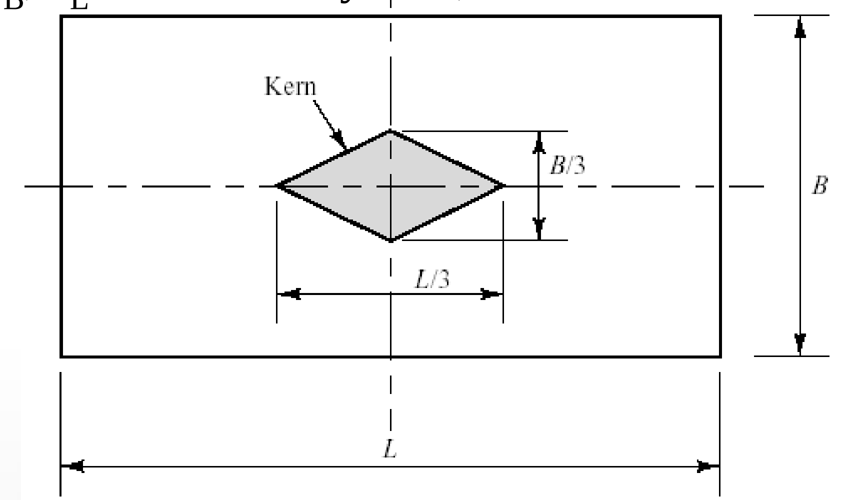


Kern of Stability

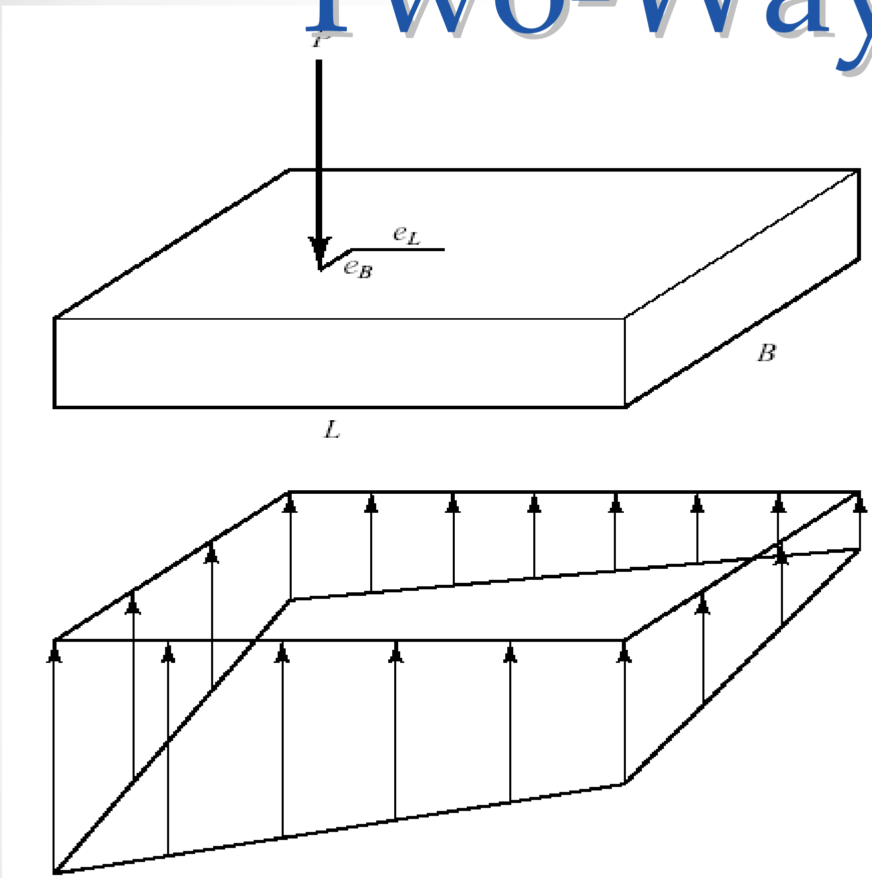
- Foundation stable against overturn only if resultant falls in the kern in the centre of the foundation
- Resultant in the kern if

$$\frac{6e_B}{B} + \frac{6e_L}{L} \leq 1$$

e_B, e_L = eccentricity in B, L directions



Bearing Pressure at Corners Two-Way Eccentricity

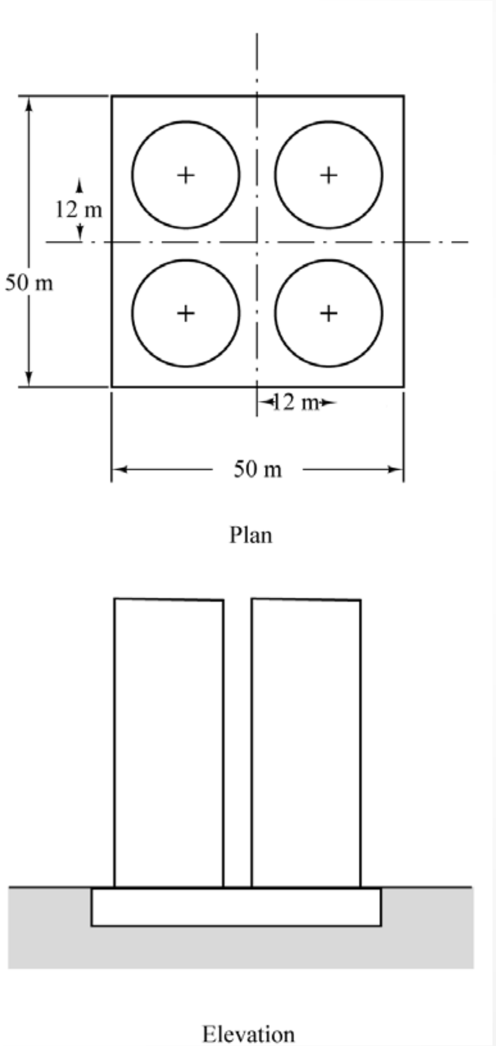


- Helpful hint to prevent confusion of eccentricity of finite vs. infinite (continuous) foundations
  - Always use one-way eccentricity equations for continuous foundations
  - Always use two-way eccentricity equations for finite foundations
  - Two-way equations will reduce to one-way equations if one of the eccentricities (e_B, e_L) is zero

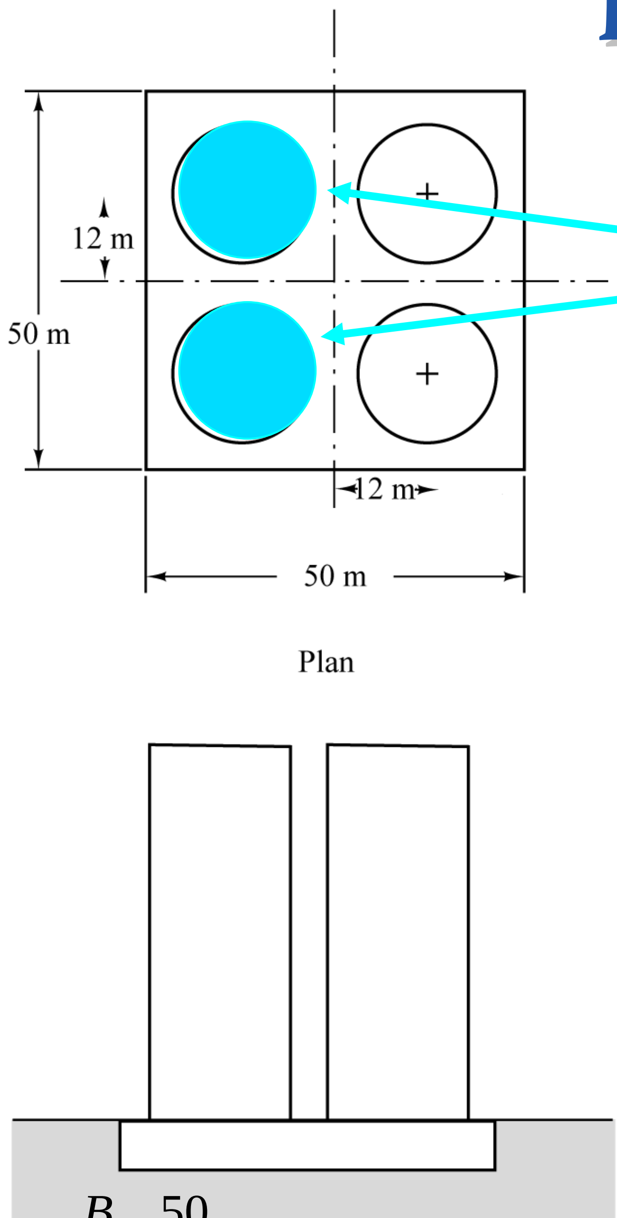
$$q_{1,2,3,4} = \left(\frac{Q + W_f}{BL} \right) \left(1 \pm \frac{6e_B}{B} \pm \frac{6e_L}{L} \right)$$

Two-Way Eccentricity Example

- Given
  - Grain silo design as shown
  - Each silo has an empty weight of 29 MN; can hold up to 110 MN of grain
  - Weight of mat = 60 MN
  - Silos can be loaded independently of each other
- Find
  - Whether or not eccentricity will be met with the various loading conditions possible
  - Eccentricity can be one-way or two-way



Two-Way Eccentricity Example



$$\frac{B}{6} = \frac{50}{6} = 8.33\,m > 6.67\,m$$

Elevation

- One-Way Eccentricity
  - Largest Loading: two adjacent silos full and the rest empty
  - Q = (4)(29) + 2(110) + 60 = 396 MN
  - M = (2)(110)(12) = 2640 MN-m

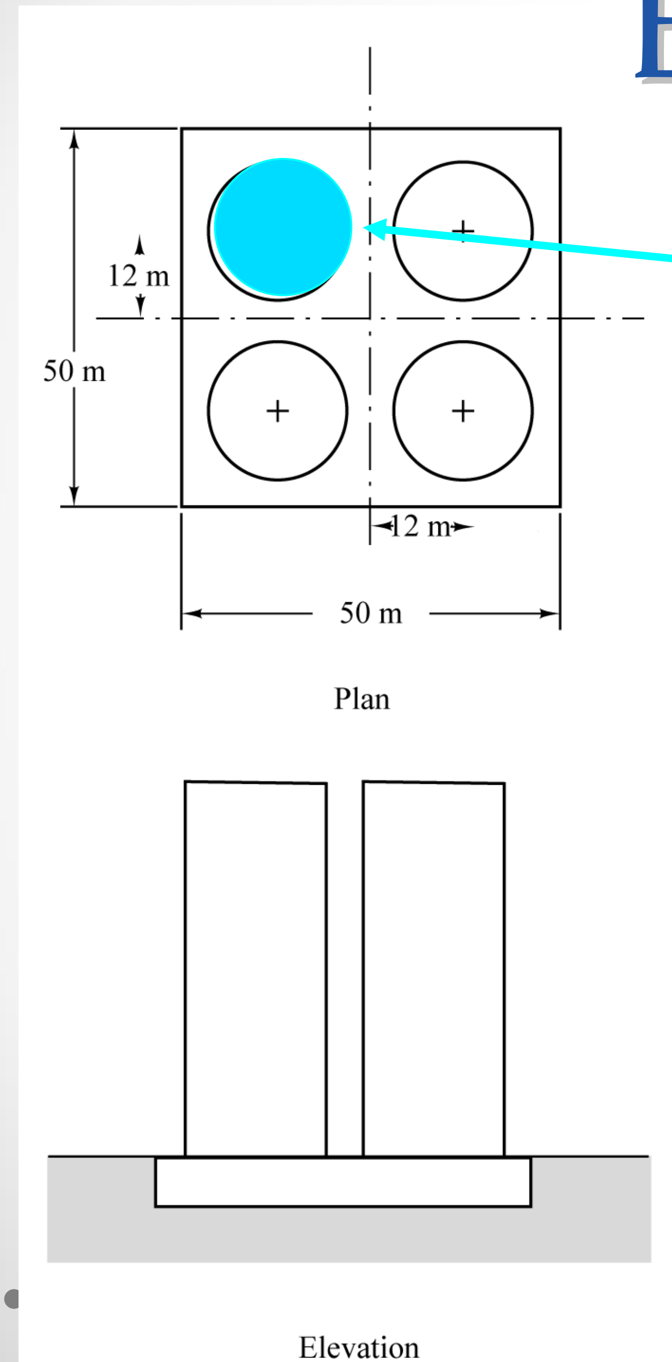
$$e = \frac{M}{Q}$$

$$e = \frac{2640}{396}$$

$$e = 6.67\,m$$

Eccentricity OK for one-way eccentricity

Two-Way Eccentricity Example



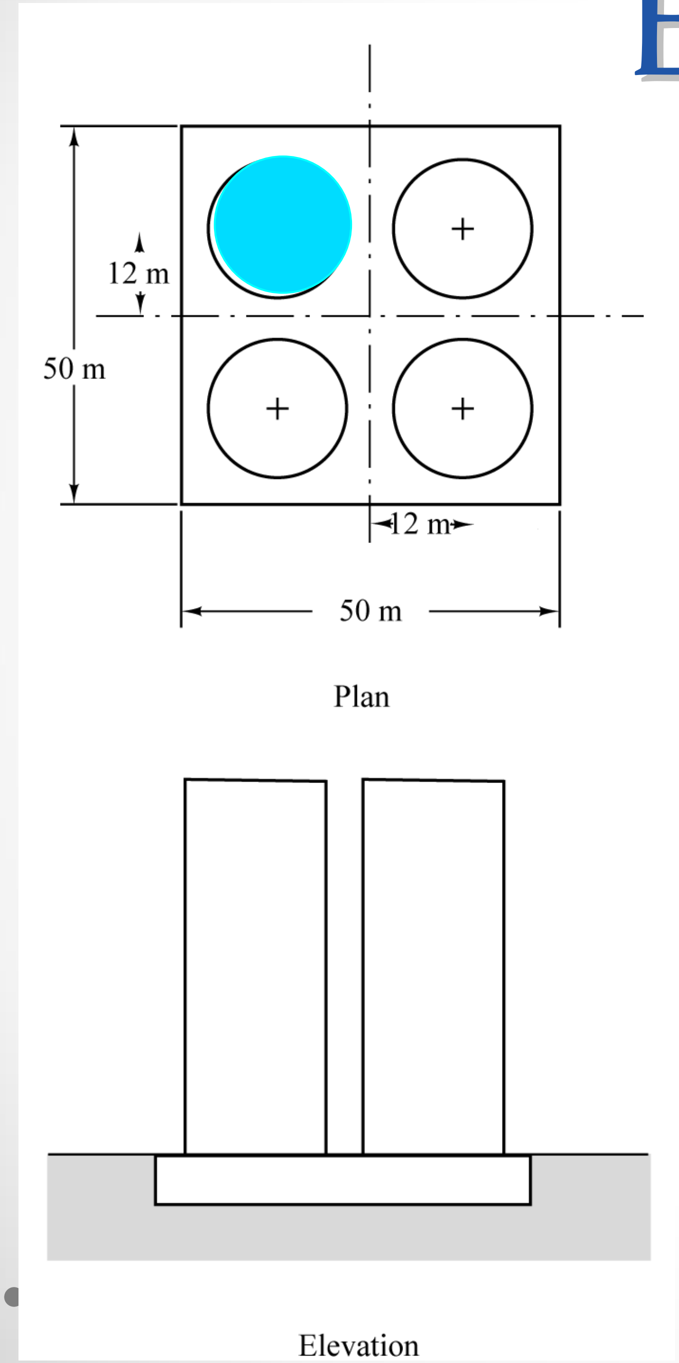
- Two-Way Eccentricity
  - Largest Loading: one silo full and the rest empty
  - P = (4)(29) + 110 + 60 = 286 MN
  - $M_B = M_L$ = (110)(12) = 1320 MN-m

$$e_B = e_L = \frac{M}{Q} = \frac{1320}{286} = 4.62\text{m}$$

$$\frac{6e_B}{B} + \frac{6e_L}{L} = 2\left(\frac{(6)(4.62)}{50}\right) = 1.11 > 1$$

Not acceptable

Two-Way Eccentricity Example



- Two-Way Eccentricity
  - Solution to Eccentricity Problem: increase the size of the mat

$$\frac{6e_B}{B}+\frac{6e_L}{L}=2\left(\frac{(6)(4.62)}{B}\right)=1$$

$$B=L=55.4\,m$$

  - Necessary to also take other considerations into account (bearing failure, settlement, etc.)

Eccentricity and Equivalent Footing Procedure

8.4.3.1 Footing Shape (Eccentricity and Effective Dimensions)

The following two issues are related to footing shape:

- Distinguishing a strip footing from a rectangular footing. The general bearing capacity equation is applicable to strip footings, i.e., footings with $L_f/B_f \geq 10$. Therefore, footing shape factors should be included in the equation for the ultimate bearing capacity for rectangular footings with L_f/B_f ratios less than 10.
- Use of the effective dimensions of footings subjected to eccentric loads. Eccentric loading occurs when a footing is subjected to eccentric vertical loads, a combination of vertical loads and moments, or moments induced by shear loads transferred to the footing. Abutments and retaining wall footings are examples of footings subjected to this type of loading condition. Moments can also be applied to interior column footings due to skewed superstructures, impact loads from vessels or ice, seismic loads, or loading in any sort of continuous frame. Eccentricity is accounted for by distributing the non-uniform pressure distribution due to the eccentric load as an equivalent uniform pressure over an "effective area" that is smaller than the actual area of the original footing such that the point of application of the eccentric load passes through the centroid of the "effective area." The eccentricity correction is usually applied by reducing the width (B_f) and length (L_f) such that:

$$B'_f = B_f - 2e_B \qquad 8\text{-}7$$

$$L'_f = L_f - 2e_L \qquad 8\text{-}8$$

where, as shown in Figure 8-16, e_B and e_L are the eccentricities in the B_f and L_f directions, respectively. These eccentricities are computed by dividing the applied moment in each direction by the applied vertical load. It is important to maintain consistent sign conventions and coordinate directions when this conversion is done. The reduced footing dimensions B'_f and L'_f are termed the effective footing dimensions. When eccentric load occurs in both directions, the equivalent uniform bearing pressure is assumed to act over an effective fictitious area, A', where (AASHTO, 2004 with 2006 Interims):

$$A' = B'_f L'_f \qquad 8\text{-}9$$

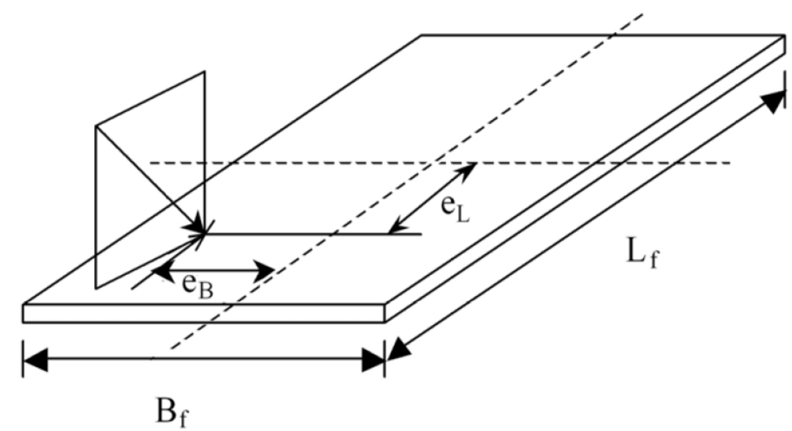


Figure 8-16. Notations for footings subjected to eccentric, inclined loads (after Kulhawy, 1983).

Eccentricity and Equivalent Footing Procedure

The concept of an effective area loaded by an equivalent uniform pressure is an approximation made to account for eccentric loading and was first proposed by Meyerhof (1953). Therefore, the equivalent uniform pressure is often referred to as the "**Meyerhof pressure**." The concept of equivalent footing and Meyerhof pressure is used for geotechnical analysis during sizing of the footing, i.e., bearing capacity and settlement analyses. However, the structural design of a footing should be performed using the actual trapezoidal or triangular pressure distributions that model the pressure distribution under an eccentrically loaded footing more conservatively. A comparison of the two loading distributions is shown in Figure 8-17.

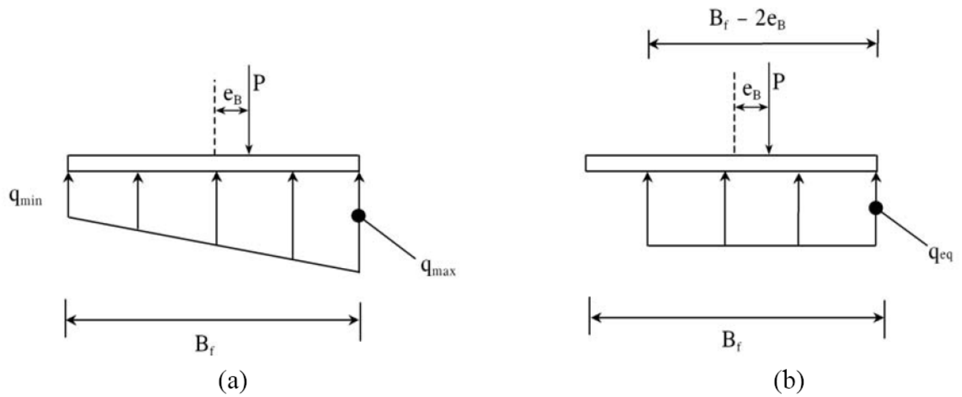
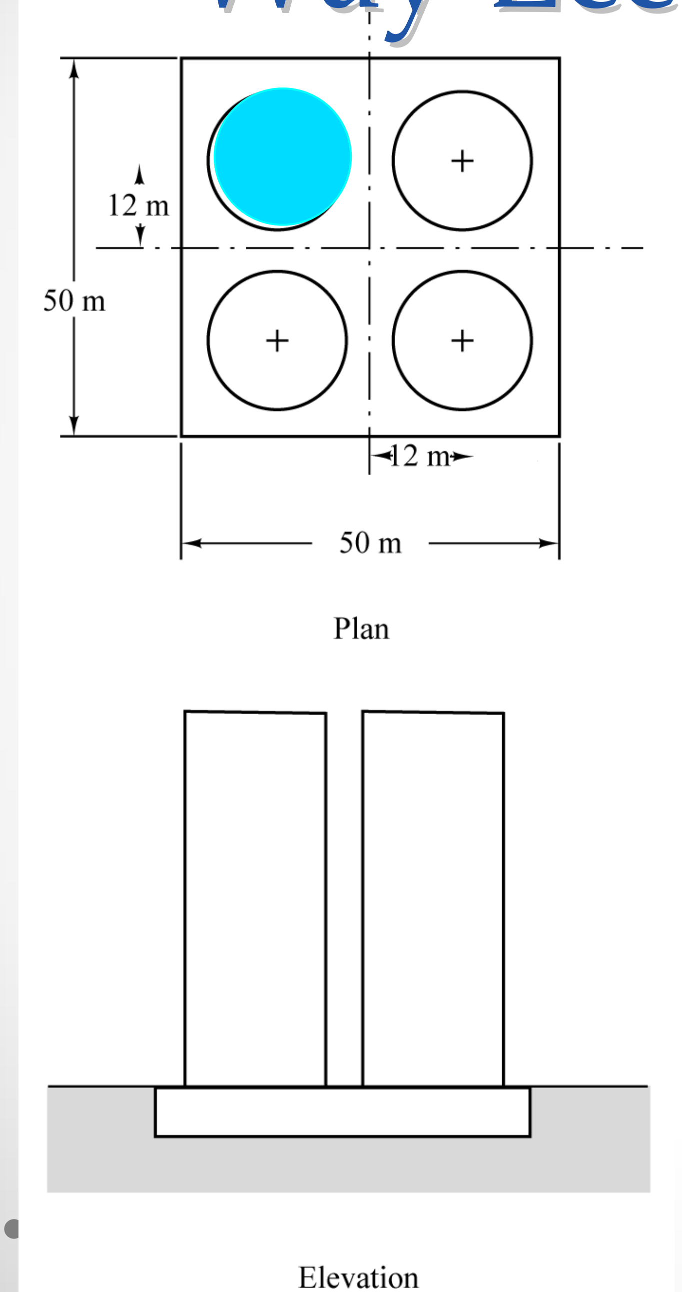


Figure 8-17. Eccentrically loaded footing with (a) Linearly varying pressure distribution (structural design), (b) Equivalent uniform pressure distribution (sizing the footing).

Limiting eccentricities are defined to ensure that zero contact pressure does not occur at any point beneath the footing. These limiting eccentricities vary for soil and rock. Footings founded on soil should be designed such that the eccentricity in any direction (e_B or e_L) is less than one-sixth (1/6) of the actual footing dimension in the same direction. For footings founded on rock, the eccentricity should be less than one-fourth (1/4) of the actual footing dimension. If the eccentricity does not exceed these limits, a separate calculation for stability with respect to overturning need not be performed. If eccentricity does exceed these limits, the footing should be resized.

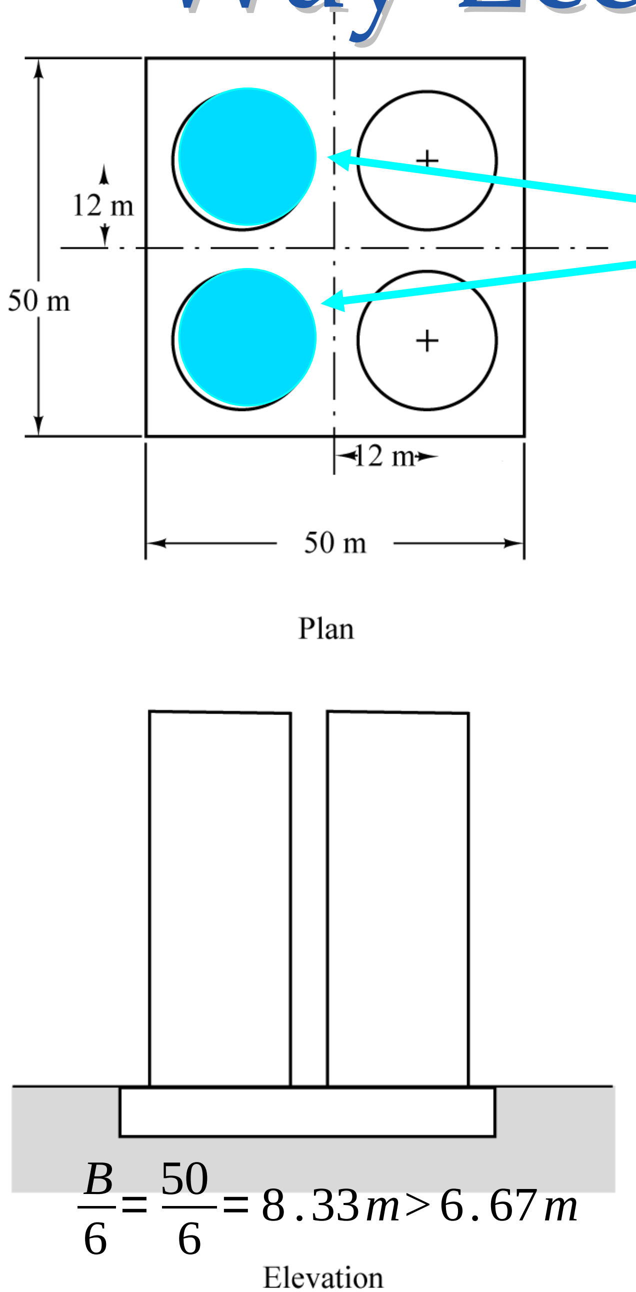
The shape correction factors are summarized in Table 8-4. For eccentrically loaded footings, AASHTO (2004 with 2006 Interims) recommends use of the effective footing dimensions, B'_f and L'_f, to compute the shape correction factors. However, in routine foundation design, use of the effective footing dimensions is not practical since the effective dimensions will change for various load cases. Besides, the difference in the computed shape correction factors for actual and effective footing dimensions will generally be small. Therefore the geotechnical engineer should make reasonable assumptions about the footing shape and dimensions and compute the correction factors by using the equations in Table 8-4.

Equivalent Footing Using Two-Way Eccentricity Example



- Largest Loading: one silo full and the rest empty
- Result of Two-Way Eccentricity Analysis
- $e_B = e_L = 4.62$ m
- B = L = 55.4 m (expanded foundation)
- Equivalent Footing Dimensions
- $B' = B - 2e_B = 55.4 - (2)(4.62)$
- $B' = 45.8$ m $= L'$ (as $B = L$ and $e_B = e_L$)

Equivalent Footing Using Two-Way Eccentricity Example



$$\frac{B}{6} = \frac{50}{6} = 8.33\,m > 6.67\,m$$

- One-Way Eccentricity
  - Largest Loading: two adjacent silos full and the rest empty
  - B = L = 55.4 m (expanded foundation)
  - e_B = 6.67m
  - e_L = 0 m
  - B' = B'-2e_B = 55.4 – (2)(6.67) = 42.1 m
  - L = L' = 55.4 m

Questions?