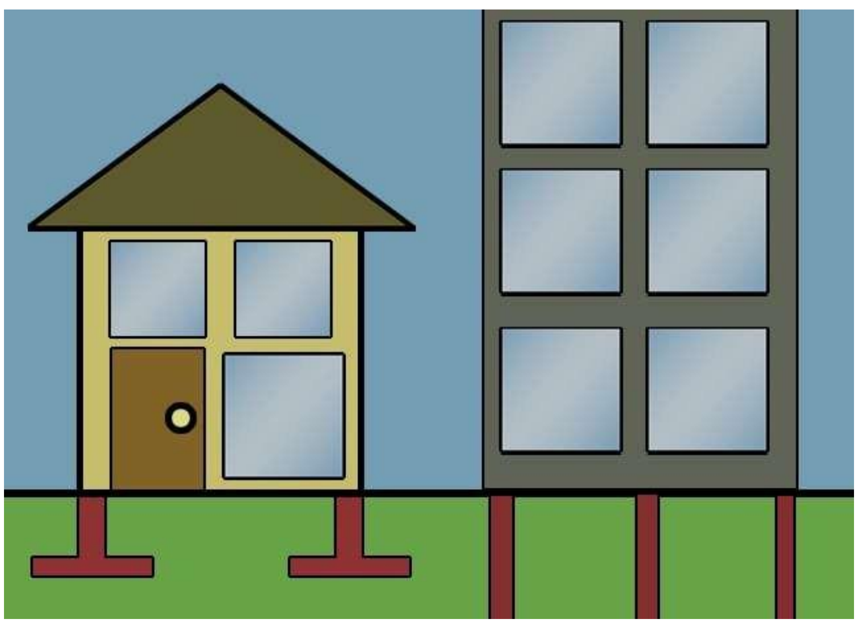
Sanjivani Rural Education Society's
Sanjivani College of Engineering, Kopargaon, 423603
An Autonomous Institute Affiliated to Savitribai Phule Pune University, Pune

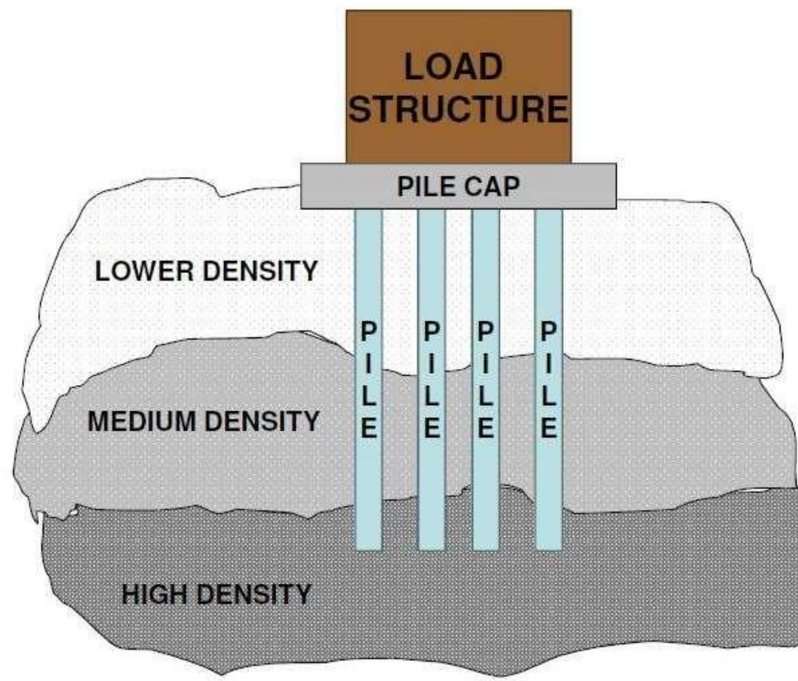
Subject: Foundation Engineering
B. Tech. (Civil Engg)
Unit-II: Bearing Capacity & Shallow Foundation

Department of Civil Engineering
Sanjivani College of Engineering, Kopargaon, 423603

FOUNDATION TYPES

1. Shallow Foundations ← *Focus of this course*
   a. D/B ≤ 1 (Terzaghi, 1943); later researchers said D/B can be up to 3-4.
   b. Depth generally less than 3m
2. Deep Foundations





TYPES OF SHALLOW FOUNDATIONS

1. Square Footings
2. Combined Footings
   a. Rectangular Footings
   b. Trapezoidal Footings
3. Strip Footings
4. Mat/Raft Footings
5. Floating Foundations

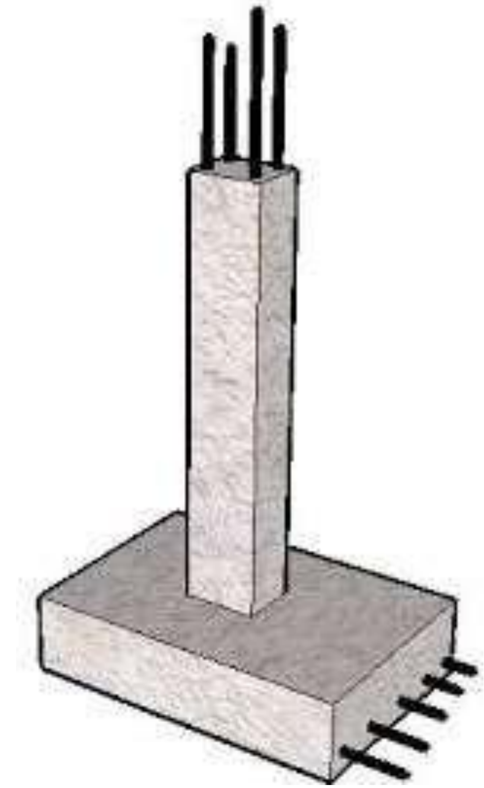
Spread Foundations (items 1–3)

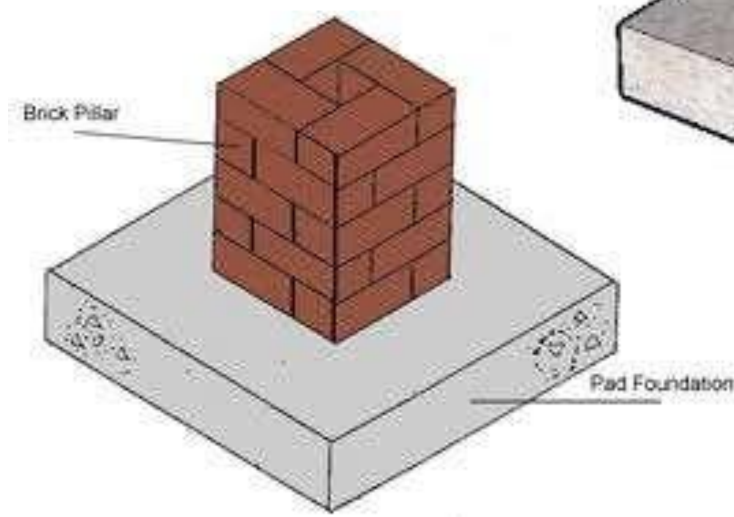
- The structural load is literally *spread* over a broad area under the building.
- Load is spread through a wider bottom part than the load-bearing foundation walls it supports.
- Most commonly used foundation type.

TYPES OF SHALLOW FOUNDATIONS

Square Footings

- Square in plan
- Used to support individual columns

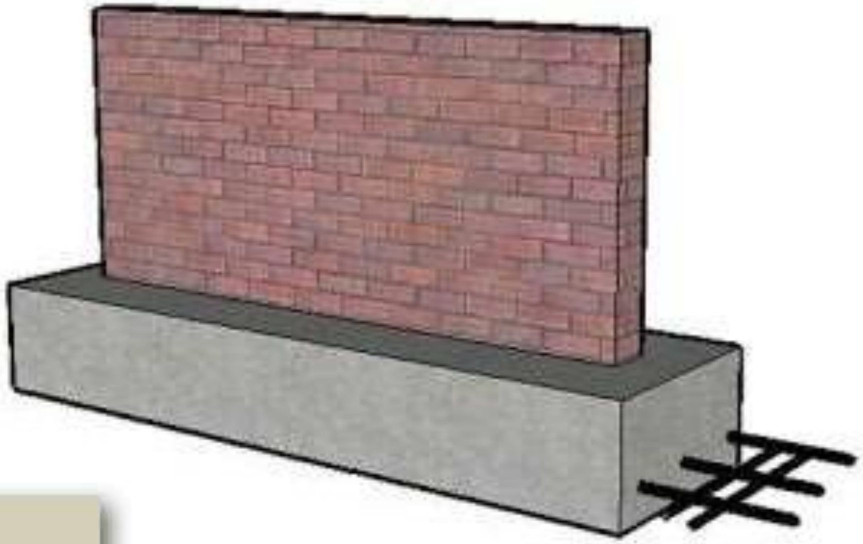


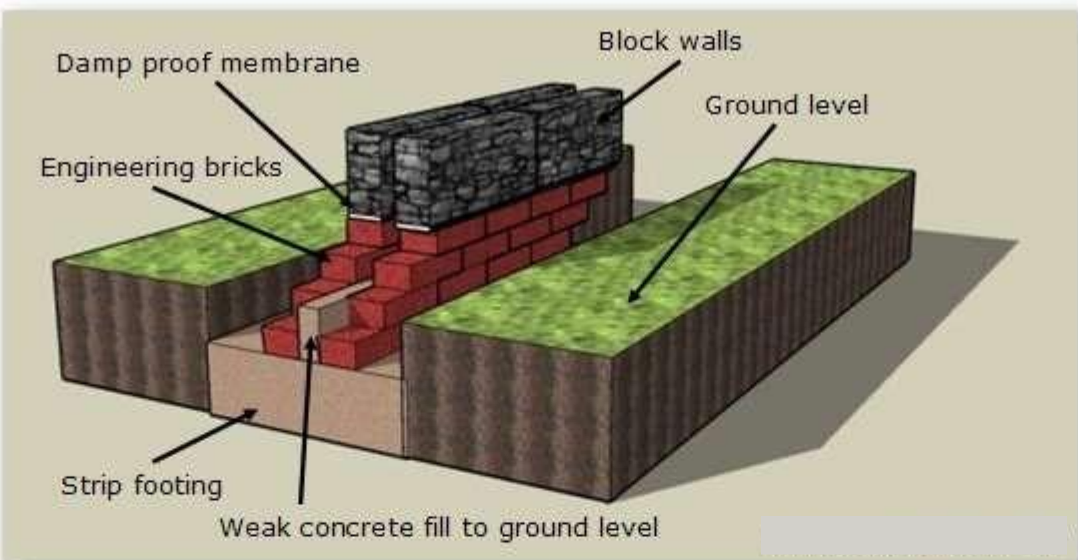


TYPES OF SHALLOW FOUNDATIONS

Strip Footings

- L/B ≥ 5
- To support wall loads

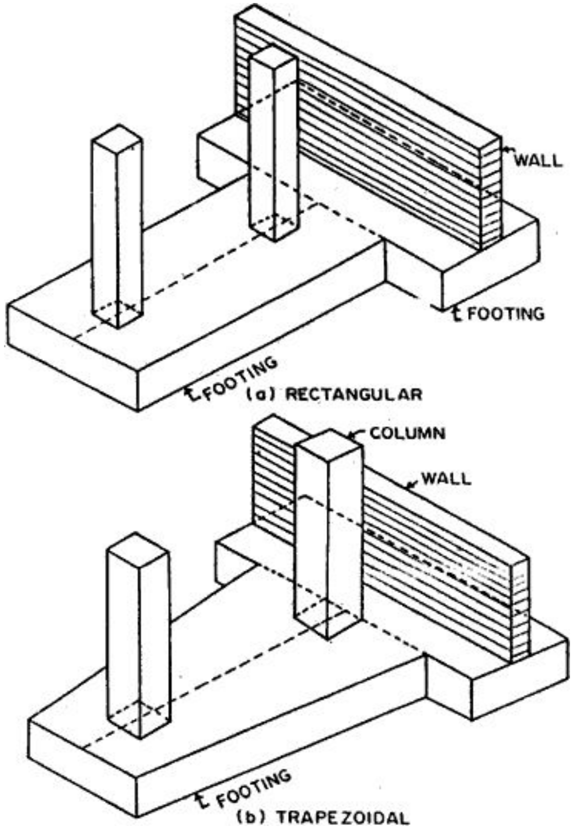


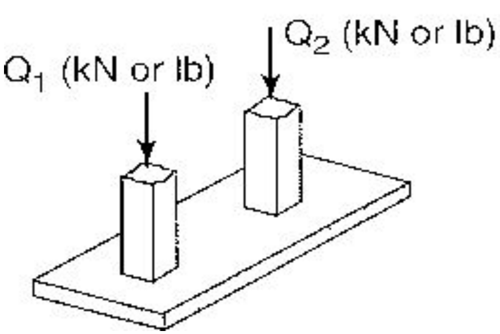


TYPES OF SHALLOW FOUNDATIONS

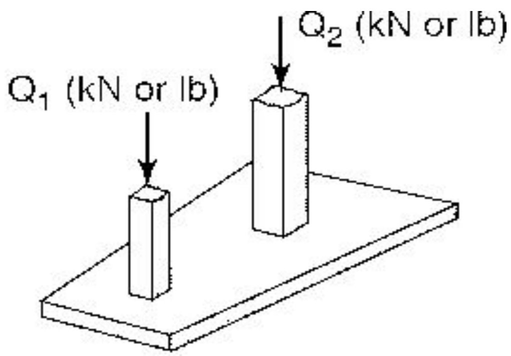
Combined Footings

- Rectangular/Trapezoidal
- To support two columns or machine base





Rectangular Footing

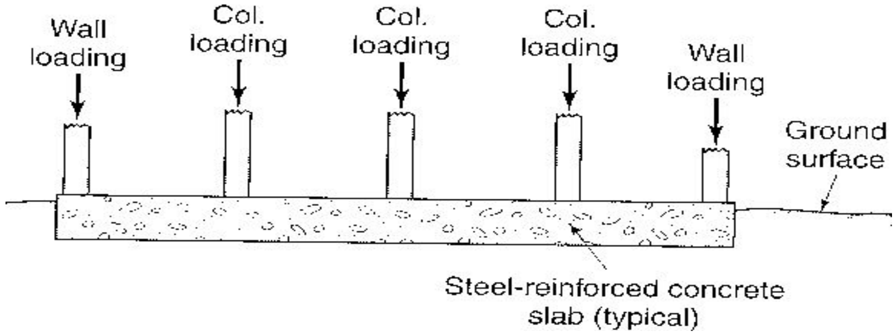


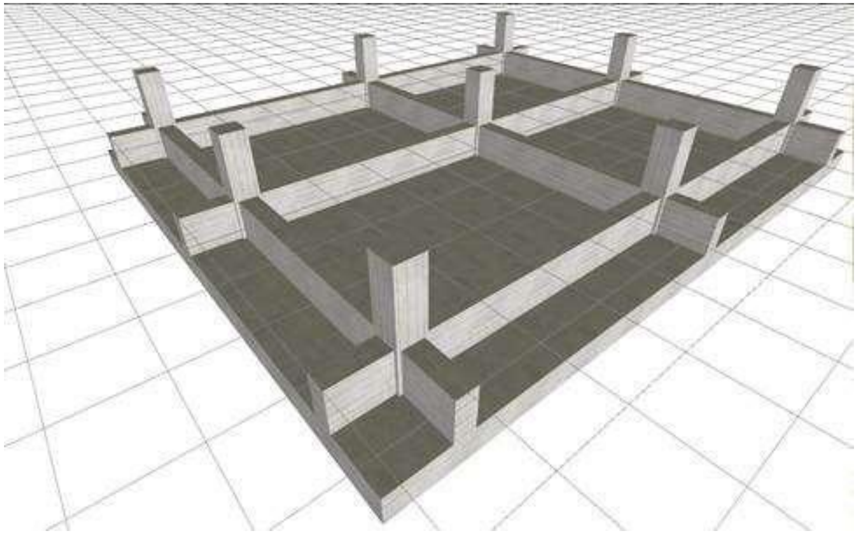
Trapezoidal Footing

TYPES OF SHALLOW FOUNDATIONS

Raft/Mat Footings

- To support a *very heavy structure* by spreading the contact pressure over a large area.
- For *weak soil* conditions
- To *reduce settlements*

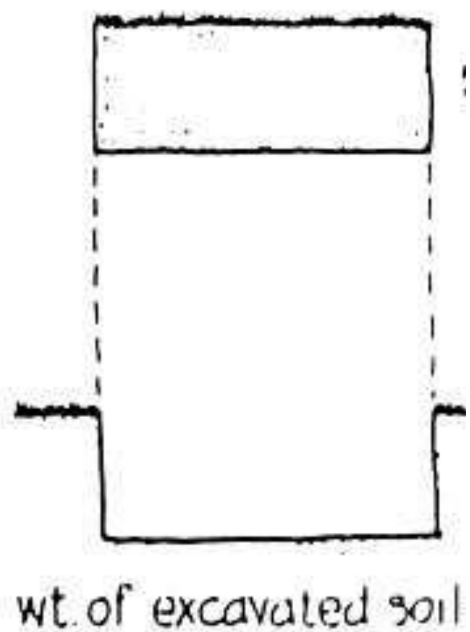




TYPES OF SHALLOW FOUNDATIONS

Floating Foundations

- Weight of the structure is equal to the weight of the soil displaced by foundations
- *Net increase of load* over the soil is (nearly) *zero*
- Where deep deposits of weak soil stratum exists



TYPES OF FOUNDATION FAILURE

1. Due to *excessive settlement*

   Maximum tolerable settlement

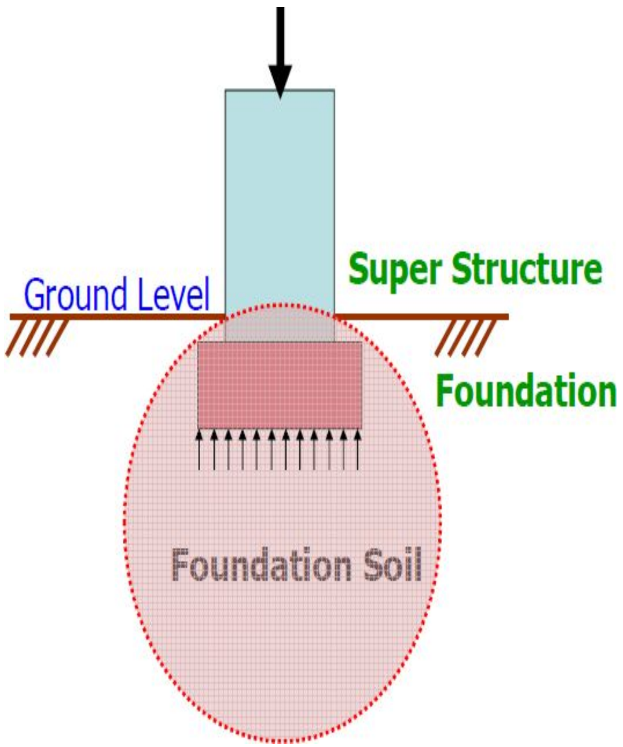
   – 25.4mm (1”) for square/strip footings

   – 50.8mm (2”) for mat footings

2. Due to *shear failure* in soil ← *Focus of this chapter*

ϖ DEFENITION

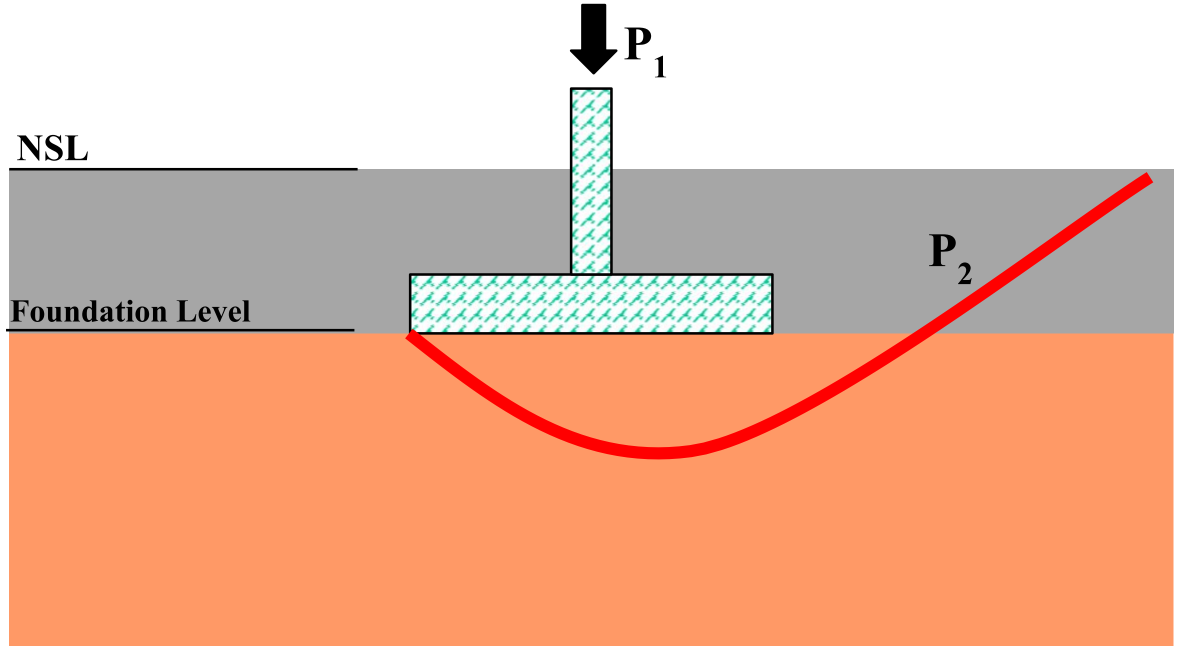
- The term ‘Bearing cpacity of soil‘ is used to indicate the maximum load per unit area which the soil will resist safely without displacement



- By dividing the ultimate bearing power of soil by a factor of safely,the bearing capacity of a soil is obtained………

BEARING CAPACITY
– Basic Definitions –

Bearing pressure/ contact pressure is the contact force per unit area along the bottom of the foundation.



P_1 = Structural/Net load on soil

P_2 = Weight of overburden soil

$P = P_1 + P_2$ = Total/Gross load supported by soil

BEARING CAPACITY
– Basic Definitions –

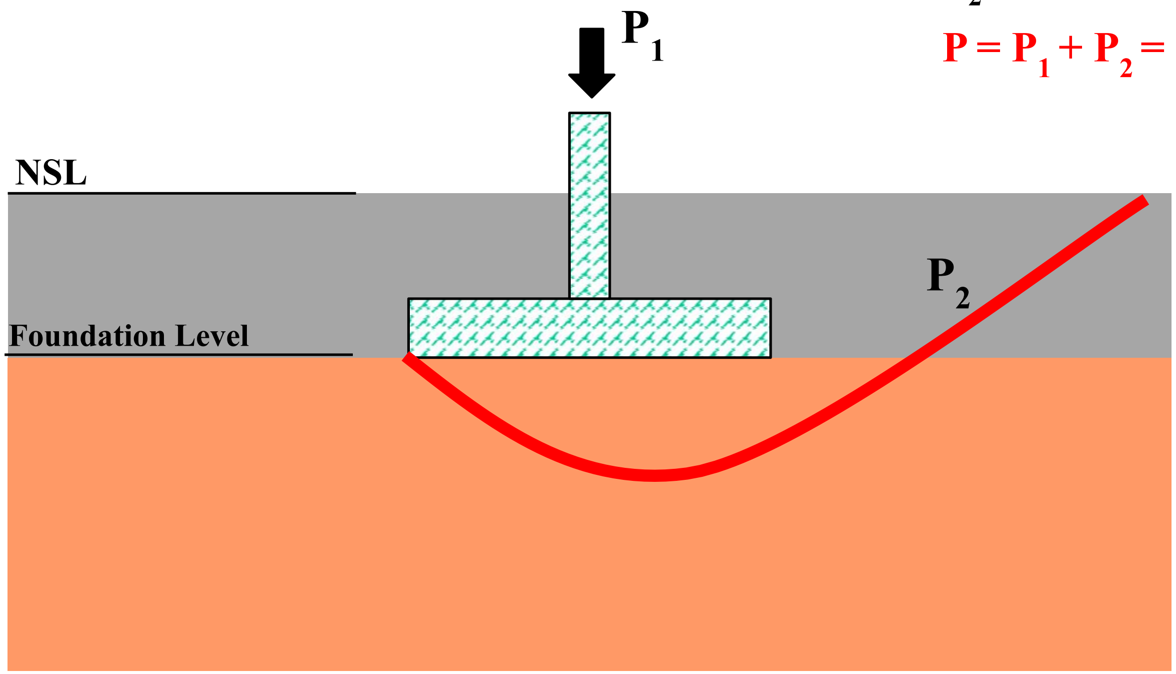
Ultimate Bearing Capacity (q_u or q_{ult})

The ultimate bearing capacity is the *gross pressure* at the base of the foundation at which soil *fails in shear*.

P_1 = Structural/Net load on soil

P_2 = Weight of overburden soil

$P = P_1 + P_2$ = Total/Gross load supported by soil



BEARING CAPACITY – Basic Definitions –

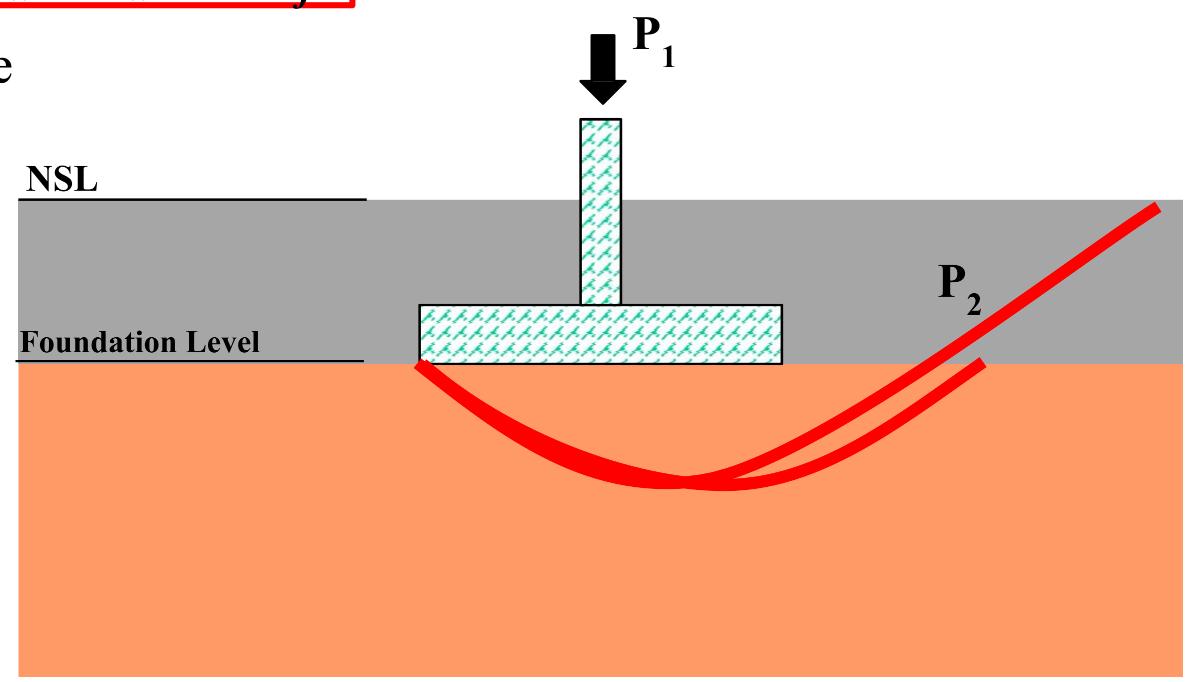
Net Ultimate Bearing Capacity (q_{nu})

It is the *net increase in pressure* at the base of foundation that cause *shear failure* of the soil. OR

It is the *structural load* that can be carried by soil without undergoing *shear failure*.

$$q_{nu} = q_u - \gamma . D_f$$

$\gamma . D_f$ = Overburden pressure



P_1 = Structural/Net load on soil

P_2 = Weight of overburden soil

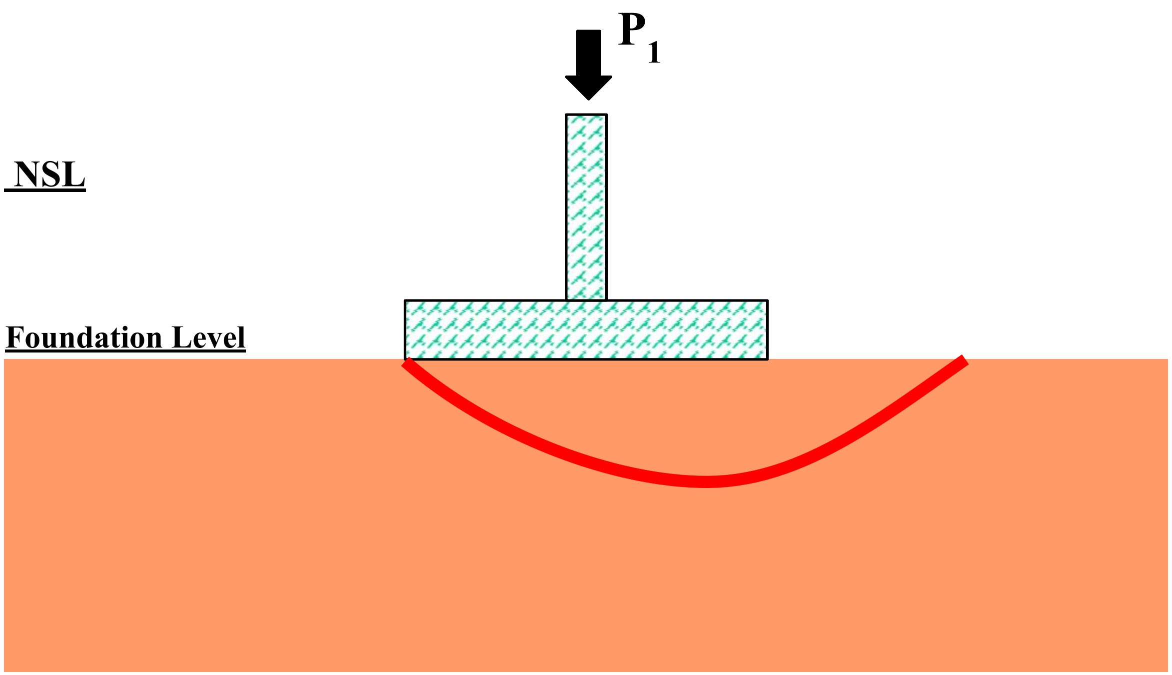
$P = P_1 + P_2$ = Total/Gross load supported by soil

BEARING CAPACITY – Basic Definitions –

Net Safe Bearing Capacity (q_{ns})

It is the *net pressure* which can *'safely'* be applied to the soil considering only *shear failure*.

$$q_{ns} = q_{nu}/FOS$$



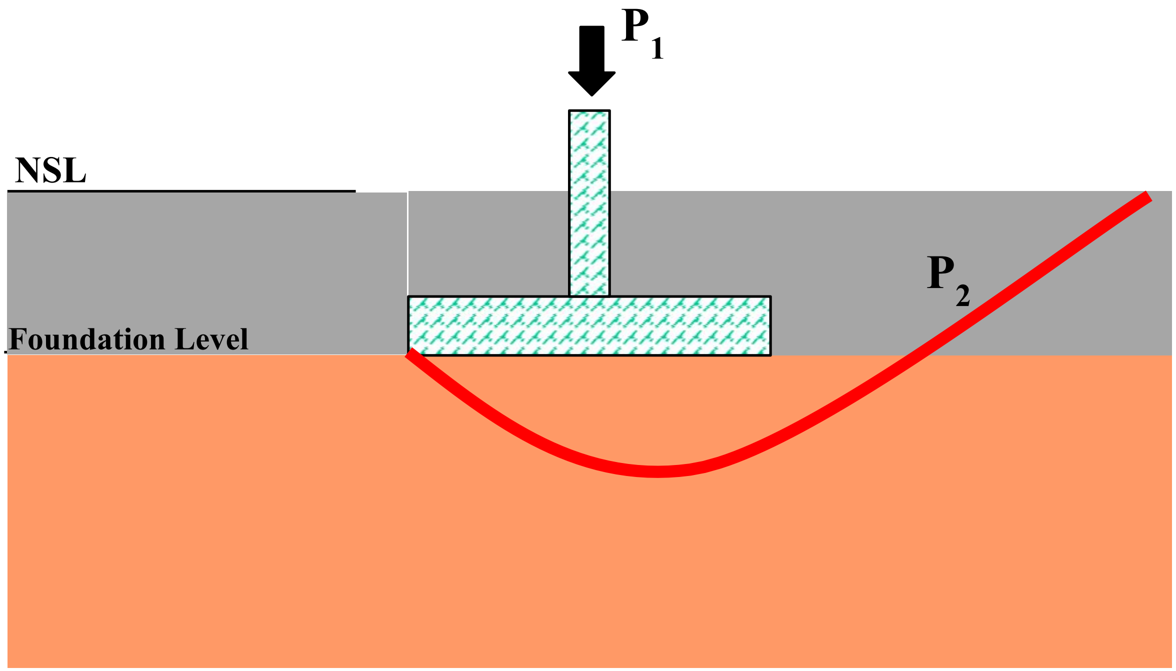
FOS - Factor of safety usually taken as 2.00 -3.00

BEARING CAPACITY – Basic Definitions –

Gross Safe Bearing Capacity (q_s)

It is the maximum gross pressure which the soil can carry safely without *shear failure*.

$$q_s = q_{nu} / FOS + \gamma . D_f$$



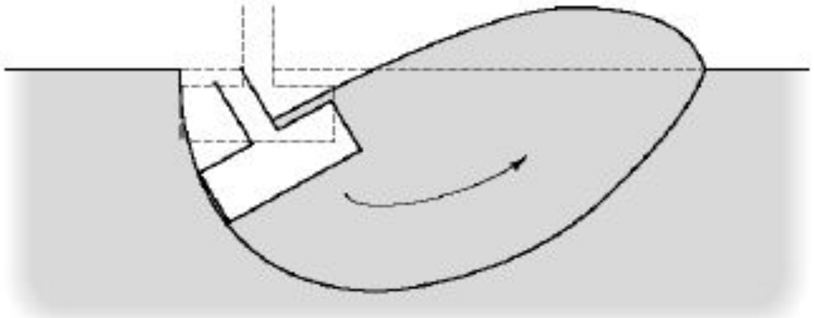
BEARING CAPACITY
– Basic Definitions –

Net Allowable Bearing Capacity (q_a or ABC)

It is the maximum pressure which the soil can carry safely without undergoing *shear failure* and *excessive settlement*.

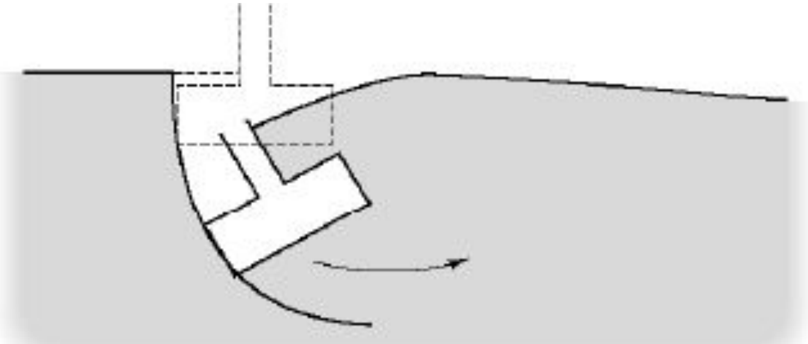
- **q_a is used for the design of foundation.**

TYPES OF SHEAR FAILURE



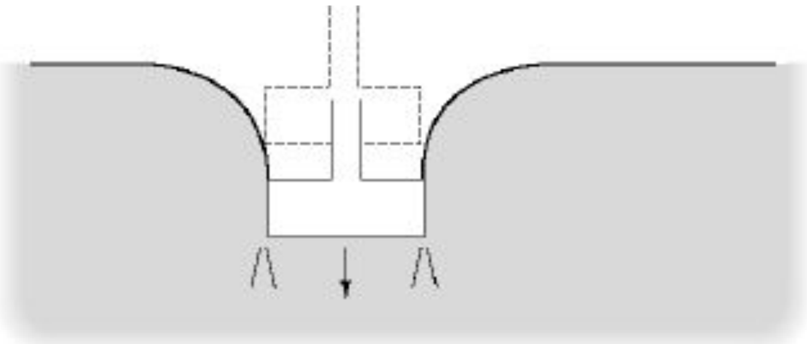
General Shear Failure

- *Fully developed* failure plane
- Sudden or *catastrophic failure*
- *Bulging* on ground surface adjacent to the foundation
- *Most common* type of shear failure
- Occur in relatively *strong soils* (Dense sand)



Local Shear Failure

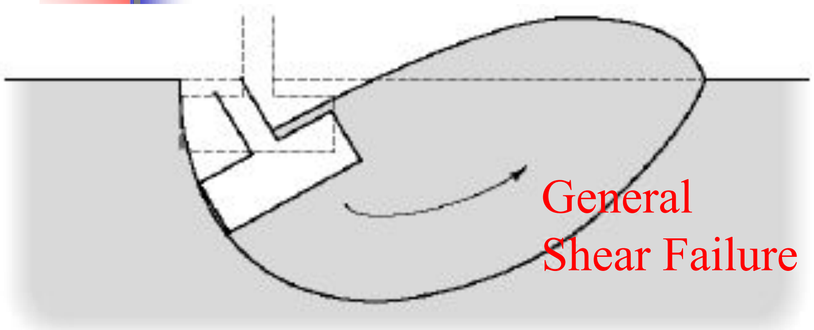
- Failure plane *not completely defined*
- Sudden *jerks at failure*
- *Small amount of bulging* might be observed
- Occur in sand or clay with *medium compaction*

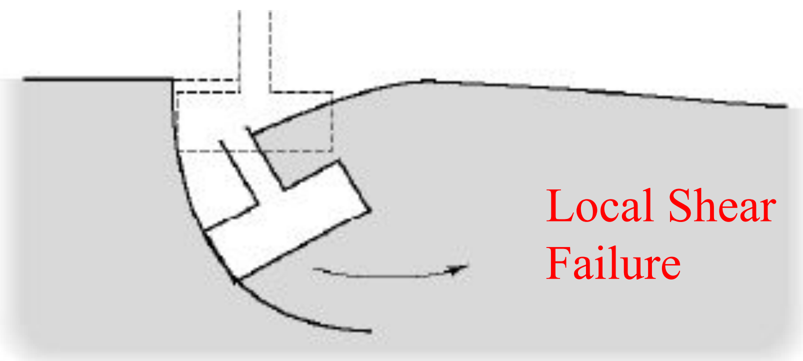


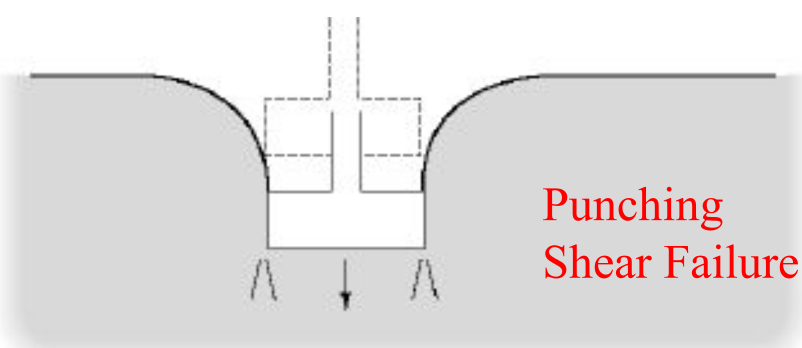
Punching Shear Failure

- Foundation *sinks* into soil like a punch
- Failure *surface do not extend up to the ground surface*
- Occurs in *very loose* sands weak clays

SHEAR BASED DESIGN
– GENERAL COMMENTS –







- Usually only necessary to analyze general shear failure.
- Local and punching shear failure can usually be anticipated by settlement analysis.

TERZAGHI'S METHOD

- Since soil cohesion can be difficult to quantify, conservativevaluesof c (cohesion) should be used.
- Frictional strength is more reliable and does not need to be as conservative ascohesion.
- Terzaghi'smethod is simple and familiar to many geotechnical engineers; however, it does not take into account many factors, nor does it consider cases such as rectangular foundations.

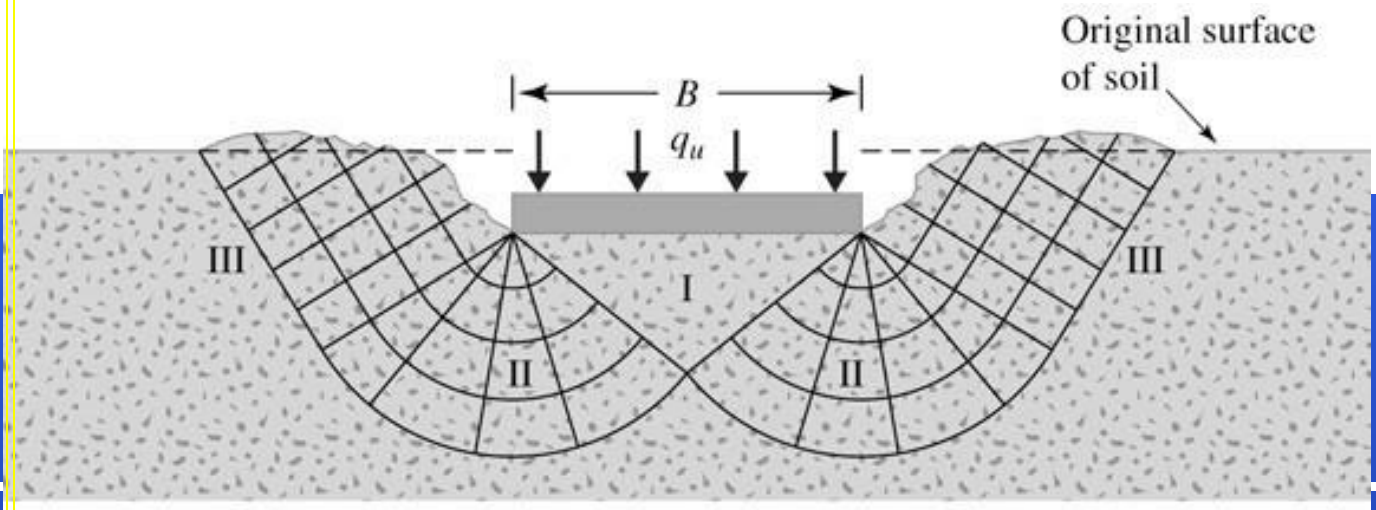
Assumptions For Terzaghi's Method

- *Depth of foundation is less than or equal to its width*
- *No sliding occurs between foundation and soil(rough foundation)*
- *Soil beneath foundation is homogeneous semi infinite mass*
- *Mohr-Coulomb model for soil*
- *General shear failure mode is the governing mode(but not the only mode)*
- *Footing is rough*

Assumptions For Terzaghi's Method

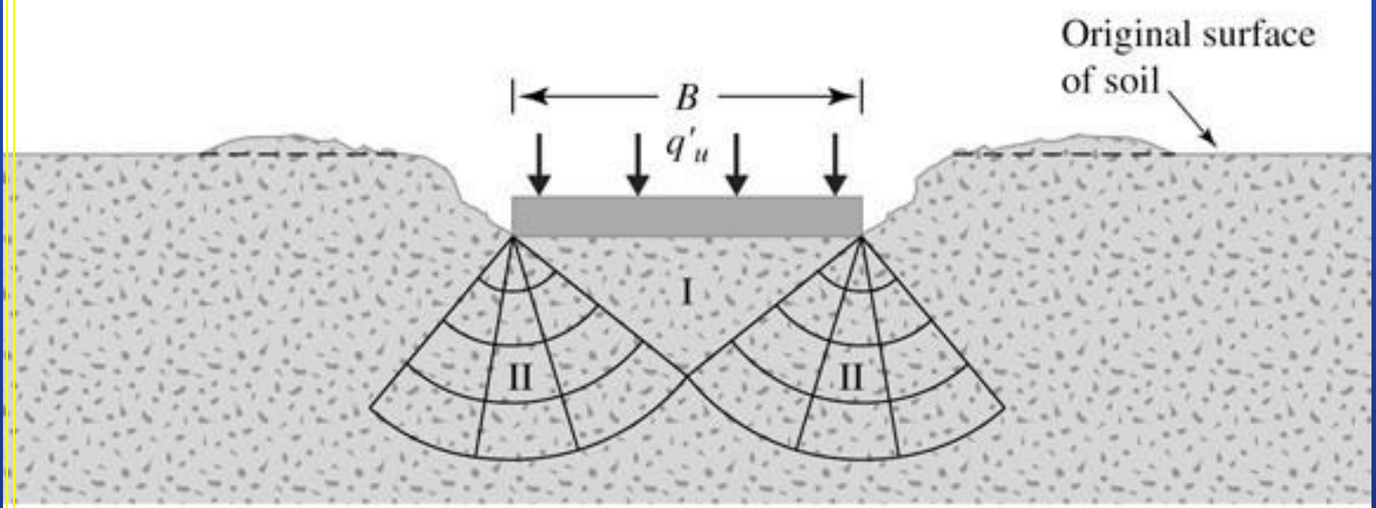
- *No soil consolidation occurs*
- *Foundation is very rigid relative to the soil.*
- *Soil above bottom of foundation has no shear strength; is only a surcharge load against the overturning load.*
- *Applied load is compressive and applied vertically to the centroid of the foundation*
- *No applied moments present*

Failure Modes for Shallow Foundations



(a)

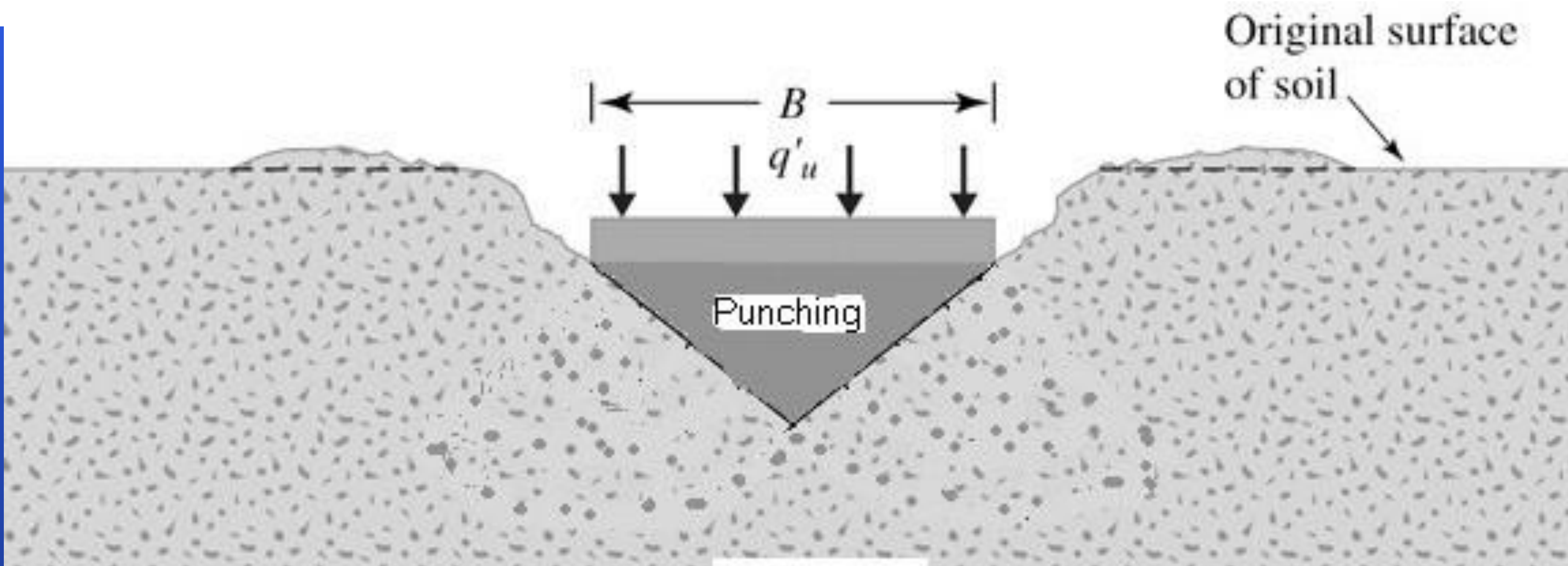
General Shear Failure,
Zones I, II, III,
Dense Sand



(b)

Local Shear Failure,
Zones I, II,
Medium Dense Sand

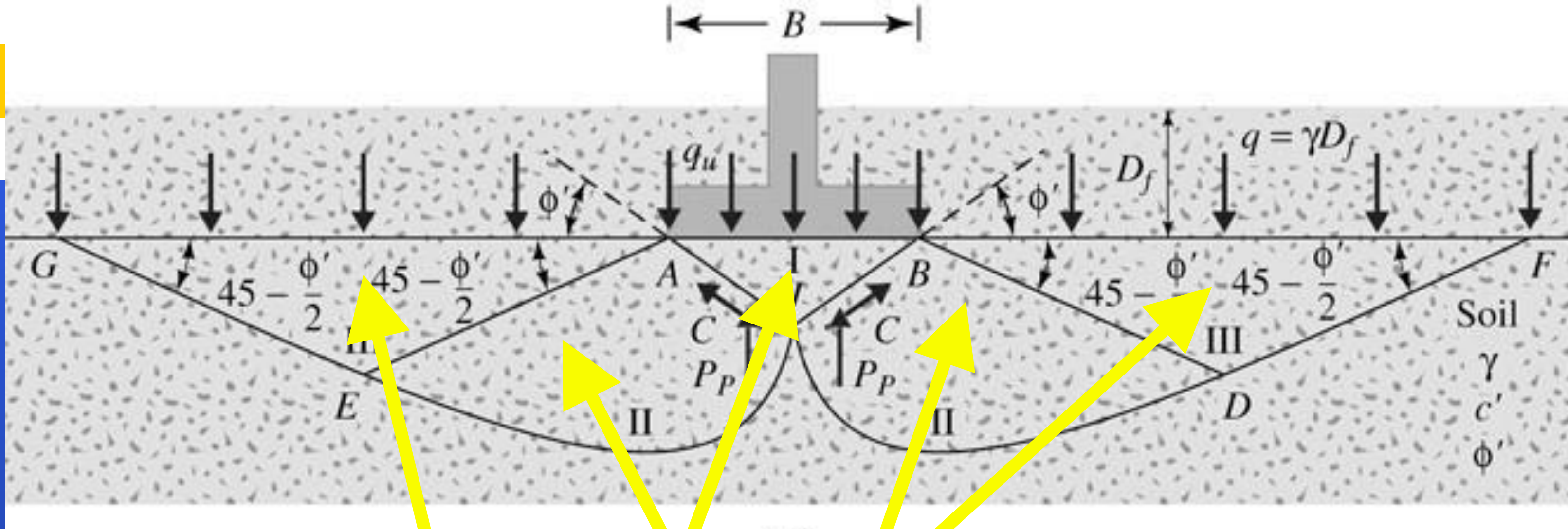
Failure Modes, Continued



(c)

Loose Sand and Soft Clay

Bearing Capacity Analysis



(a)

Zone I, Active.

Zones II, Transition.

Zones III, Passive.

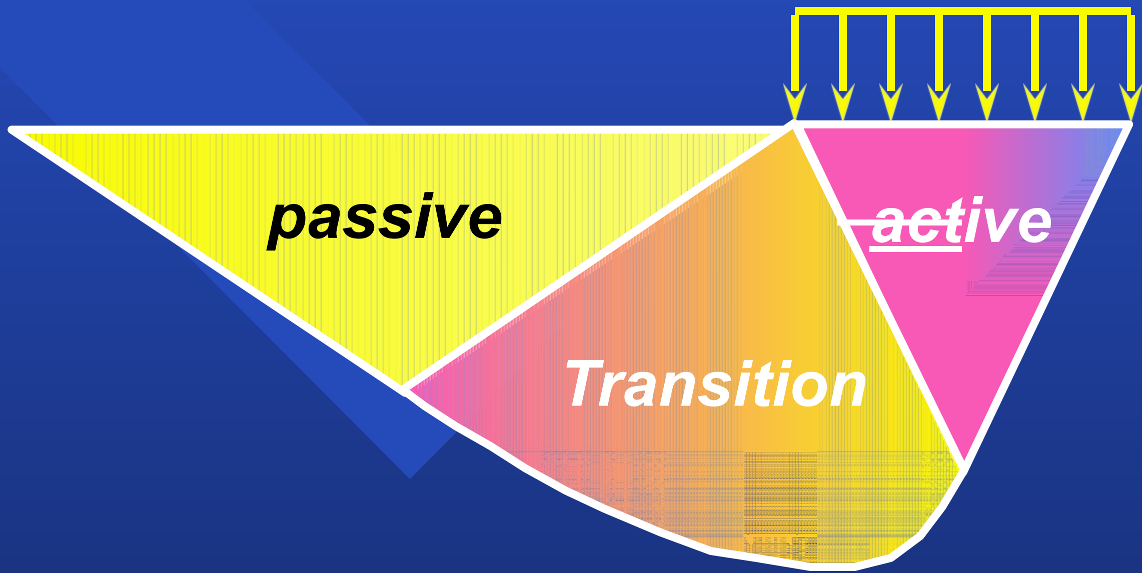
Terzaghi B/C Assumptions

Three zones do exist:

1 Active zone, just below the foundation.

2 Transition zone, between the active and passive zones.

3 Passive zone, near the ground surface, just beside the foundation.



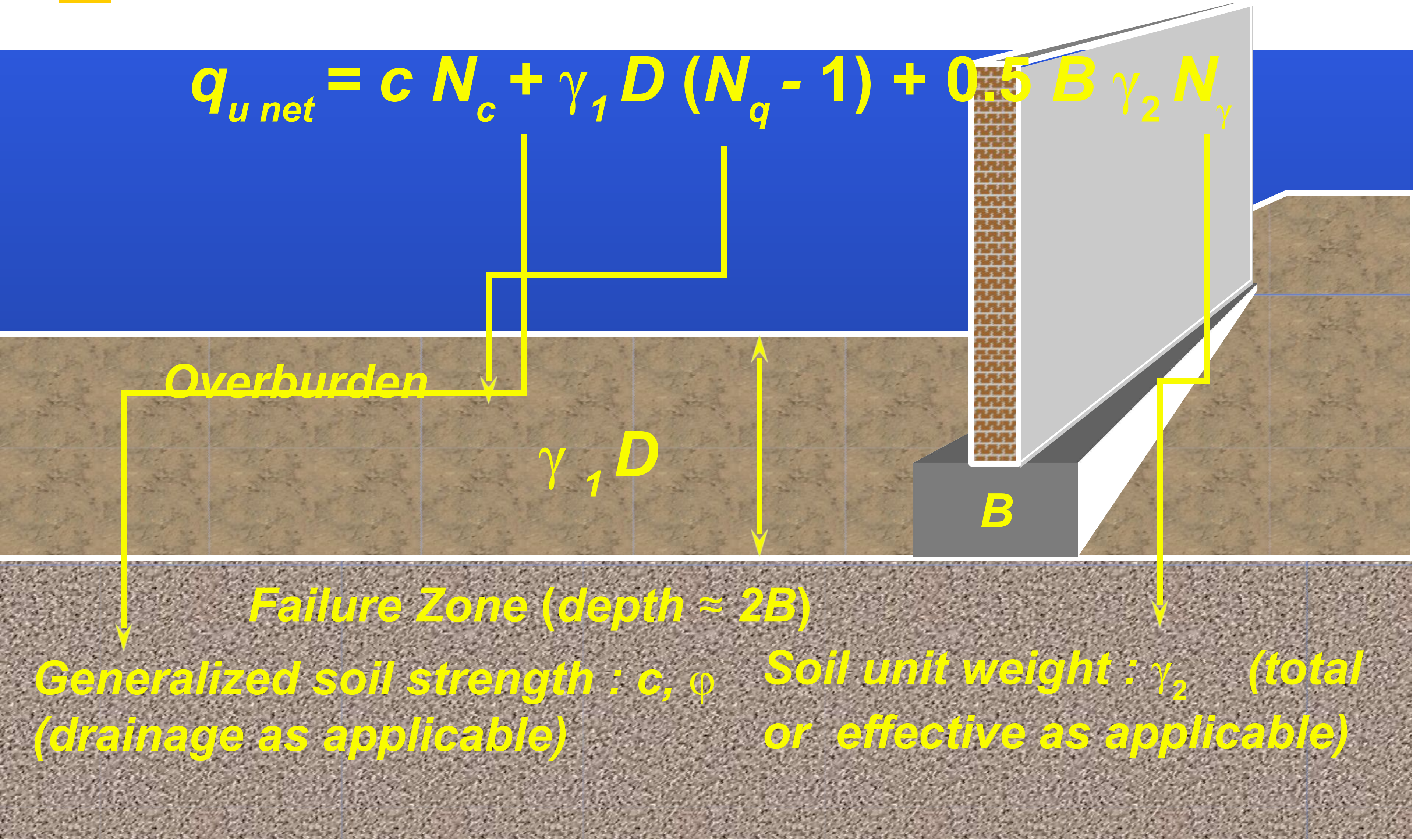
Zone I → Elastic zone – This is a rigid triang body of soil abc which sinks into the ground along with the footing ~~along with the footing~~ CB, CA rising at an angle of β

Zone II → Zone of Radial Shear → This is a zon of plastic failure in which shearing takes place along radial directions.

Zone III → Zone of plane Shear – This is a zone of plastic failure in which shearing takes place along plane surf causing upward movement of the soil

Terzaghi Bearing Equation for *Strip Footing*

$$q_{u\,net} = c\,N_c + \gamma_1 D\,(N_q - 1) + 0.5\,B\,\gamma_2\,N_\gamma$$



Terzaghi Bearing Equation

$$q_{ult} =$$

$$q_{ult} = c N_c$$ Cohesion Term

$$q_{ult} = c N_c + \gamma_1 D N_q$$ Above F.L.

$$q_{ult} = c N_c + \gamma_1 D N_q + 0.5 B \gamma_2 N_\gamma$$

Below F.L.

Terzaghi Bearing Equation

- N_c, N_q, N_γ **are Terzaghi B/C Coefficients,** *f*(φ)

C, φ are the soil shear strength parameters

Based on Terzaghi's bearing capacity theory, column load P is resisted by shear stresses at edges of three zones under the footing and the overburden pressure, q (=γD) above the footing. The first term in the equation is related to cohesion of the soil. The second term is related to the depth of the footing and overburden pressure. The third term is related to the width of the footing and the length of shear stress area. The bearing capacity factors, Nc, Nq, Nγ, are function of internal friction angle, φ.

Terzaghi's Bearing capacity equations:

Strip footings: $Q_u = c N_c + q N_q + 0.5 \gamma B N_\gamma$

Square footings: $Q_u = 1.3 c N_c + q N_q + 0.4 \gamma B N_\gamma$

Circular footings: $Q_u = 1.3 c N_c + q N_q + 0.3 \gamma B N_\gamma$

Where

$$\mathbf{q = \gamma D}$$

The values of B.C. factors in the Terzaghi eqn for shallow footing in general & local shear conditions

Angle of friction $\phi°$	B.C. factors					
	N_c	N_q	N_γ	N'_c	N'_q	N'_γ
0	5.7	1.0	0	5.7	1.0	0.0
5	7.3	1.6	0.5	6.7	1.4	0.2
10	9.6	2.7	1.2	8.0	1.9	0.5
15	12.9	4.4	2.5	9.7	2.7	0.9
20	17.7	7.4	5.0	11.8	3.9	1.7
25	25.1	12.7	9.7	14.8	5.6	3.2
30	37.2	22.5	19.7	19.0	8.3	5.7
35	57.8	41.3	42.4	25.2	12.6	10.1
40	95.7	81.3	100.4	34.9	20.5	18.8
45	172.3	173.3	297.4	51.2	37.1	37.7
50	347.5	415.1	1153.2	81.3	65.6	87.1

Net Bearing Capacity (NBC) :- (q_{un})

By deducting surcharge γD_f

$\therefore q_{un} = q_u - q$

$$q_{un} = cN_c + q(N_q - 1) + 0.5\,\gamma B N_\gamma$$

$= cN_c + qN_q + 0.5\gamma B N_\gamma - q$

$= cN_c + q(N_q - 1) + 0.5\gamma B N_\gamma$

Safe Bearing Capacity (SBC) :-

$$q_s = \frac{q_{un}}{F_s} + \gamma D_f$$

If surcharge is not effective

$$\therefore q_s = \frac{q_{un}}{F_s}$$

① Determine the ultimate and net bearing Capacity for a footing 2m×2m, on a soil with density of 1800 kg/m³, $\phi = 15^0$, $c = 15$ kN/m³, if it is laid at a depth of 1·5m.

for $\phi = 15^\circ$, $N_c = 12.9$, $N_q = 4.4$, $N_\gamma = 2.5$

$\left\{ \begin{array}{l} c' = 0.67\ c \\ \phi' = 0.67 \tan\phi \end{array} \right\}$ local shear failure. $N_c' = 9.7$ $N_q' = 2.7$ $N_\gamma' = 0.9$

<u>solution</u>: Let us use Terzaghi Equation - for square fo[oting]

ⓐ Consider <u>General shear</u>:

$$q_u = 1.3\,c N_c + \gamma D_f N_q + 0.4\,\gamma B N_\gamma$$

(q)

$$= 1.3 \times 15 \times (12.9) + 1800 \times 9.8 \times 10^{-3} \times 1.5 \times 4.4 + 0.4\,(1800 \times 9.8 \times 10^{-3}) \times 2 \times 2.5$$

$$= 232.20 + 116.42 + 35.28$$

403.25

$$q_u = 383.2 \ \text{kN/m}^2$$

& $\therefore q_{nu} = q_u - \gamma D_f = \dfrac{383.2 - 17.64 \times 1.5}{}= 356.74$ kN/m²

Secondly, let us consider Local Shear failure

$$[\ c' = 0.67c\ ]$$

$$q_u = 1.3c'N_c' + \gamma D_f \cdot N_q' + 0.4\gamma B N_\gamma'$$

$$= 1.3(0.67)\,15\,(9.7) + 1.80\times 9.8\,(1.5)(2.7)$$

$$+ 0.4(1.8\times 9.8)(2)(0.9).$$

$$\boxed{q_u = 200.54\ KN/m^2}$$

$$\therefore q_{nu} = q_u - \text{Surcharge}\ (\gamma D_f)$$

$$= 200.54 - 1.8\times(9.8)(1.5)$$

$$\boxed{q_{nu} = 174.08\ KN/m^2}$$

(2) Determine the B.C. of a circular footing (dia = 2m), resting on a clayey layer at a depth of 1.5 m. The shear strength of soil $S_u = 25\ kN/m^2$ & $\gamma = 20\ kN/m^3$.

Sol^n For a circular footing, Terzaghi eq^n gives.

$$q_u = 1.3\,c N_c + \gamma D_f N_q + 0.3\,\gamma B N_\gamma.$$

for $\phi = 0$, $N_c = 5.7$, $N_q = 1$, $N_\gamma = 0$

$$q_u = 1.3 \times 25 \times (5.7) + 20(1.5)\,1 + 0$$

$$= 171 + 30.00$$

$$q_u = 201\ kN/m^2$$

21.5.21 kN/m²

∴ Net ultimate B.C $q_{nu} = q_u - \gamma D_f$

$= 201 - 20 \times 1.5$

$\boxed{q_{nu} = 171 \text{ kN/m}^2}$

$= 185.25 \text{ kN/m}^2$

Prob - 03. Determine the S.B.C. in prob ① with a FOS = 3

Soln

$$\boxed{q_s = \frac{q_{nu}}{3} + \gamma D_f}$$

ⓐ General Shear.

$$q_s = \frac{357.44}{3} + 1.8 \times 9.8 \times (1.5)$$

$$= \boxed{147 \text{ KN/m}^2}$$

ⓑ Local shear :

$$q_s = \frac{174.08}{3} + 1.8(9.8) \times 1.5$$

$$\boxed{q_s = 84.487 \text{ KN/m}^2}$$

(5) Determine the B.C. of a Circular footing (dia = 2m) resting on a clayey layer at a depth of 1.5m. the shear strength of soil $S_u = 25\ kN/m^2$ & $\gamma = 20\ kN/m^3$

assume $\phi = 0$, $N_c = 5.7$, $N_q = 1$, $N_\gamma = 0$.

Sol^n $D = 2m$.

$D_f = 1.5m$.

For Circular footing, Terzaghi's eq^n gives

$$q_u = 1.3\,CN_c + \gamma D_f N_q + 0.3\gamma D N_\gamma.$$

$$= 1.3(25)(5.7) + 20(1.5)\times 1 + 0$$

$$q_u = \underline{\quad ? \quad}\ KN/m^2$$

$$q_{un} = q_u - \gamma D_f$$

$$= q_u - 20\times 1.5$$

$$q_{nu} = \underline{\qquad}\ KN/m^2.$$

(*) If we want to calculate SBC, with $F = 3$ or 4

then, $\therefore$ $q_s = \dfrac{q_{nu}}{F} + \gamma D_f$ KN/m^2.

(6) For a General $C-\phi$ soil cohesion C is 50 kPa, the total unit wt γ_t is 20 kN/m³ and Bearing capacity factors are $N_c = 8$, $N_q = 3$, $N_\gamma = 2$. Using Terzaghi's formula, calculate Net ultimate bearing capacity for a strip footing of width B = 2m at a depth Z = 1m considering shear failure only, estimate safe load on footing 10m long by 2m wide strip footing using a FOS = 3 (PU-Dec-13, 6)

Solⁿ Given

Cohesion $C = 50\ kPa = 50\ kN/m^2$

unit weight $\gamma = 20\ kN/m^3$

B.C. Factor $N_c = 8$, $N_q = 3$, $N_\gamma = 2$

width(B) = 2m, Depth (Df) = 1m, Length(L) = 10m
FoS = 3

By Terzaghi's equation, UBC.

(i) $q_u = cN_c + \gamma D_f N_q + 0.5\gamma B N_\gamma$

$= (50 \times 8) + (20 \times 1 \times 3) + (0.5 \times 20 \times 2.0 \times 2.0)$

$q_u = 500\ kN/m^2$

(ii) Net Ultimate B.C.

$q_{nu} = q_u - \gamma \cdot D_f$

$= 500 - 20 \times 1.0$

$q_{nu} = 480\ kN/m^2$

(iii) Safe Bearing Capacity

$q_s = \frac{q_{nu}}{F} + \gamma D$

$= \frac{480}{3} + 20 \times 1$

$= 160 + 20 = 180\ kN/m^2$

∴ Safe load $(W_s) = q_s \times A$

$= 180 \times (10 \times 2)$

$W_s = 3600\ kN$

Illustrative Example 23.1. *Determine the ultimate bearing capacity of a strip footing, 1.20 m wide, and having the depth of foundation of 1.0 m. Use Terzaghi's theory and assume general shear failure. Take* $\phi' = 35°$, $\gamma = 18\ kN/m^3$, *and* $c' = 15\ kN/m^2$.

Solution. From Eq. 23.25, $$q_u = c' N_c + \gamma D_f N_q + 0.5 \gamma B N_\gamma$$

For $\phi' = 35°$, Table 23.1 gives $N_c = 57.8$, $N_q = 41.4$ and $N_\gamma = 42.4$.

Now
$$q_u = 15.0 \times 57.8 + 18.0 \times 1.0 \times 41.4 + 0.5 \times 18.0 \times 1.2 \times 42.4$$
$$= 2070\ kN/m^2$$

Illustrative Example 23.2. *Determine the allowable gross load and the net allowable load for a square footing of 2m side and with a depth of foundation of 1.0 m. Use Terzaghi's theory and assume local shear failure. Take a factor of safety of 3.0. The soil at the site has γ = 18 kN/m^3, c' = 15 kN/m^2 and ϕ' = 25°.*

Solution. From Table 23.1, for $\phi' = 25°$

$$N_c' = 14.8, \quad N_q' = 5.6 \quad \text{and} \quad N_\gamma' = 3.2$$

From Eq. 23.37, taking $c_m' = 2/3\ c' = 10\ \text{kN/m}^2$

$$q_u = 1.2 \times 10.0 \times 14.8 + 18 \times 1.0 \times 5.6 + 0.4 \times 18 \times 2 \times 3.2$$

$$= 325\ \text{kN/m}^2$$

From Eq. 23.1, $$q_{nu} = 325 - 18 \times 1.0 = 307\ \text{kN/m}^2$$

From Eq. 23.2, $$q_{ns} = \frac{q_{nu}}{F} = \frac{307}{3.0} = 102.3\ \text{kN/m}^2$$

Net allowable load $= 102.3 \times (2 \times 2) = 409.2$ kN

From Eq. 23.3, $$q_s = q_{ns} + \gamma D_f = 102.3 + 18 \times 1.0 = 120.3\text{kN/m}^2$$

Gross allowable load $= 120.3 \times (2 \times 2) =$ **481.2 kN**

PRESUMPTIVE BEARING CAPACITY

- ♣ Building codes of various organizationsin different countries gives the allowable bearing capacity that can be used for proportioning footings.
- ♣ These presumptive bearing capacity values based on experience with other structures already built.
- ♣ As presumptive values are based only on visual classification of surface soils, they are not reliable.
- ♣ These valuesdon't consider important factors affecting the bearing capacity such as the shape, width, depth of footing,

- Generally these valuesareconservative and can be used for preliminary design or even for final design of small unimportant structure.
- IS1904- 1978 recommends that the safe bearing capacity should be calculated on the basis of the soil test data. But, in absence of such data, the values of safe bearing capacity can be taken equal to the presumptive bearing capacity values.
- It is further recommended that for non-cohesive soils, the values should be reduced by 50% if the water table is above or near base of footing.

Table 4.1 Presumptive bearing capacity values as per IS1904-1978.

Type of soil/rock	Safe/allowable bearing capacity (KN/ m^2)
Rock	3240
Soft rock	440
Coarse sand	440
Medium sand	245
Fine sand	440
Soft shell / stiff clay	100
Soft clay	100
Very soft caly	50

MEYERHOF'S ANALYSIS

ϖ Assumptions

- ♣ Failure zones to extend above base level of the footing.
- ♣ The logarithmic spiral extends right up to the ground surface.
- ♣ Meyerhof (1951, 1963) proposed an equation for ultimate bearing capacity of strip footing which is similar in form to that of Terzaghi but includes shape factors,
- ♣ depth factors and inclination factors.

Meyerhof's equation is

$$q_f = cN_c s_c d_c i_c + q_o N_q s_q d_q i_q + 0.5\,\gamma B N_\gamma s_\gamma d_\gamma i_\gamma$$

VESIC'S BEARING CAPACITY THEORY

- Vesic(1973) confirmed that the basic nature of failure surfaces in soil as suggested by Terzaghi as incorrect.
- Developed formulas based on theoretical and experimental findings.
- Vesić retained Terzaghi's basic format and added additional factors, which produces more accurate bearing capacity values.
- Applies to a much broader range of loading and geometry conditions.

♣ The bearing capacity formula is re- written as

$$q_{ult} = c'N_c s_c d_c i_c b_c g_c + \sigma'_{zD} N_q s_q d_q i_q b_q g_q + 0.5\gamma' B N_\gamma s_\gamma d_\gamma i_\gamma b_\gamma g_\gamma$$

- s_c, s_q, s_γ = shape factors
- d_c, d_q, d_γ = depth factors
- i_c, i_q, i_γ = load inclination factors
- b_c, b_q, b_γ = base inclination factors
- g_c, g_q, g_γ = ground inclination factors

SKEMPTON'S ANALYSIS

- ♣ Skempton (1951) based on his investigations of footings on saturated clays observed that the bearing capacity factor �$_c$ is a function of ratio D/ B in the case of strip footing and square or circular footings, for $\Phi = 0$ condition.
- ♣ Bearing capacity factors in Terzaghi's equation tends to increase with depth for a cohesive soil.

For (D_f/B) < 2.5, (where D_f is the depth of footing and B is the base width).

(N_c) for rectangular footing = $5\left(1+\frac{0.2D_f}{B}\right)\left(1+\frac{0.2B}{L}\right) \le 9$

(N_c) for circular and rectangular footing = $6\left(1+\frac{0.2D_f}{B}\right)\left(1+\frac{0.2B}{L}\right) \le 9$

For (D_f/B) >= 2.5, (N_c) for rectangular footing = $7.5\left(1+\frac{0.2B}{L}\right) \le 9$

Ultimate bearing capacity

For $\phi_u = 0, N_q = 1, N_\gamma = 0$,

$q_u = c_u N_c + \gamma D_f$, where c_u is the undrained cohesion of the soil.

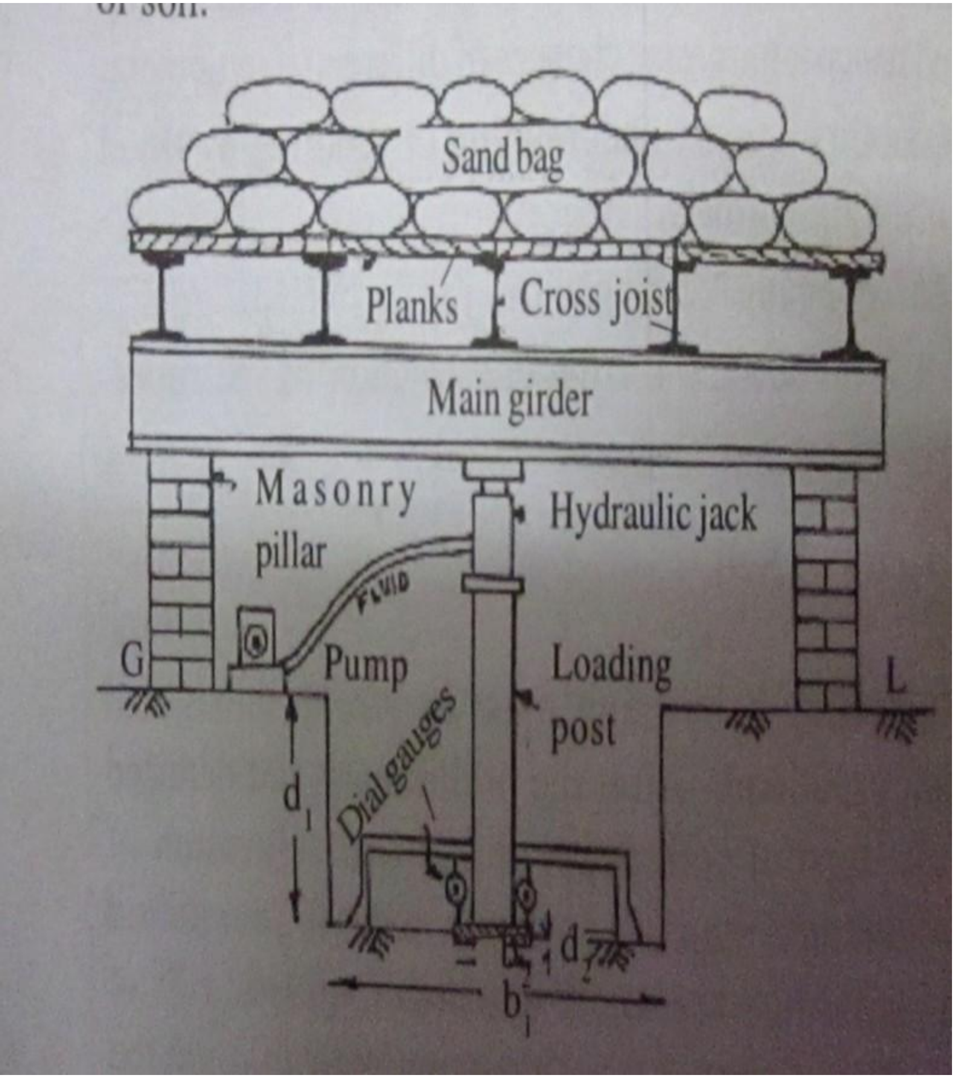
FIELD TESTS: DIRECT DETERMINATION OF BEARING CAPACITY OF SOIL

- Plate Load Test
- Vane Shear test
- Dynamic cone penetration
- Field-Density (approximation)
- Field observation
- Previous Knowledge
- Field Sample Collection

PLATE LOAD TEST

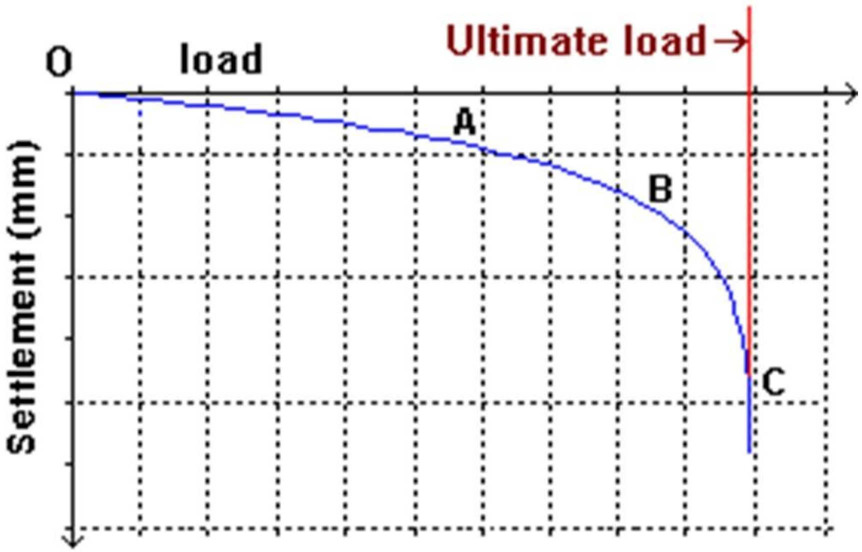
- **Simplest and widely used field test- plate load test**

- ♣ A square pit of sides equal to five times the width of test plate is dug up to the required depth.
- ♣ Test plates are iron plates of size 60cm square for clayey soil 30cm square for sandy soil.
- ♣ At the centre of the pit, a square hole of size equal to the test plate is dug.The bottom of the test plate should be along the proposed foundation level. (b1/d1=b2/d2)


Sand bag
Planks
Cross joist
Main girder
Masonry pillar
Hydraulic jack
FLUID
G
Pump
Loading post
L
Dial gauges
d_1
d_2
b_1

- Seat the plate accurately over the centre of pit and it should be in contact with the soil over the whole area
- A loading post and hydraulic jack is provided above the test plate.Hydraulic jack support a gravity loading platform. The loading is done with sand bags,concrete blocks.
- Load is increased in regular increments of 250kg or 1/5th of ultimate bearing capacity whichever is less

- Each loading increment is kept in postion until no further measurable settlement occurs. Settlement of the plate is measured by two sensitive dial guage of sensitivity 0.02mm.
- Plot a graph between settlement and load.
- From the graph measure maximum load upto which settlement is proportional



- ultimate Bearing capacity of soil = Maximum load/area of test plate

- Safe bearing capacity

FACTOR OF SAFETY MAY BE 2 OR 3

METHODS FOR IMPROVING BEARING CAPACITY OF SOIL

- Increase the depth of foundation

- By draining the soil
- Water content in soil will decreases its bearing capacity
- By draining sandy soil and gravel by gravity pipe drainage system- improve bearing capacity

- By compacting the soil
- Reduces the open spaces between the individual particles
- By grouting

Cement mortar can be injected under pressure into the subsoil to seal off voids in between subsoil and foundation.

- By confining the soil
  - Sheet piles are driven around the structure to form an enclosure
  - Which will prevent the movement of soil.
- Chemical treatment
  - Chemical solution are injected under pressure into the soil
  - Forms a gel and keep soil particles together to form a compact mass.
- By grouting
  - Cement mortar can be injected under pressure into the subsoil to seal off voids in between subsoil and foundation.

FIELD TESTS: CALCULATION BASED ON ENGINEERING PROPERTIES

- ♣ Shear tests: measuring shear strength of soil
- ♣ Triaxial test : measurement of shear strength in all three dimensions
- ♣ Consolidation test: expulsion of water under static sustained load.
- ♣ Settlement Analysis: analysis of load bearing based on settlement of soil.