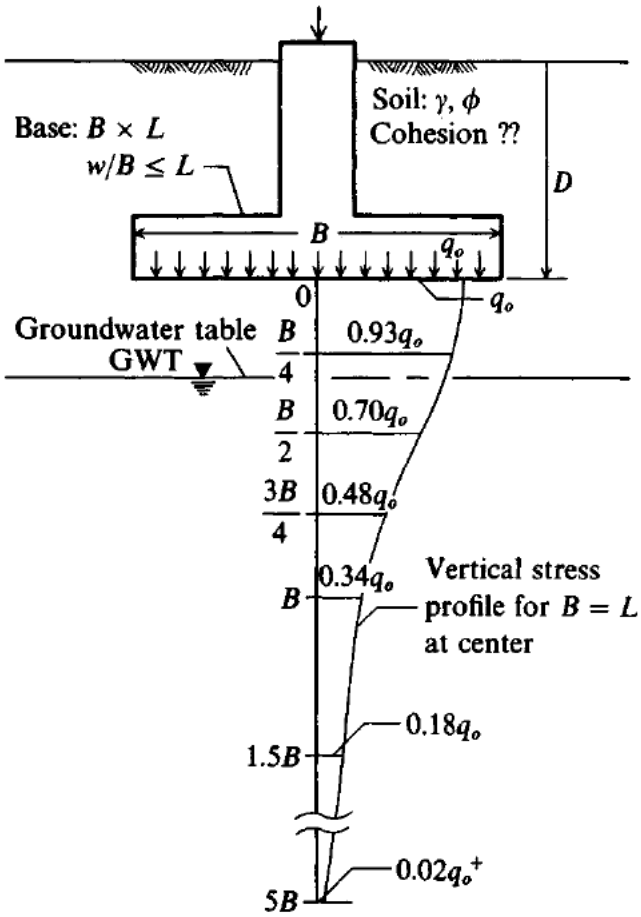
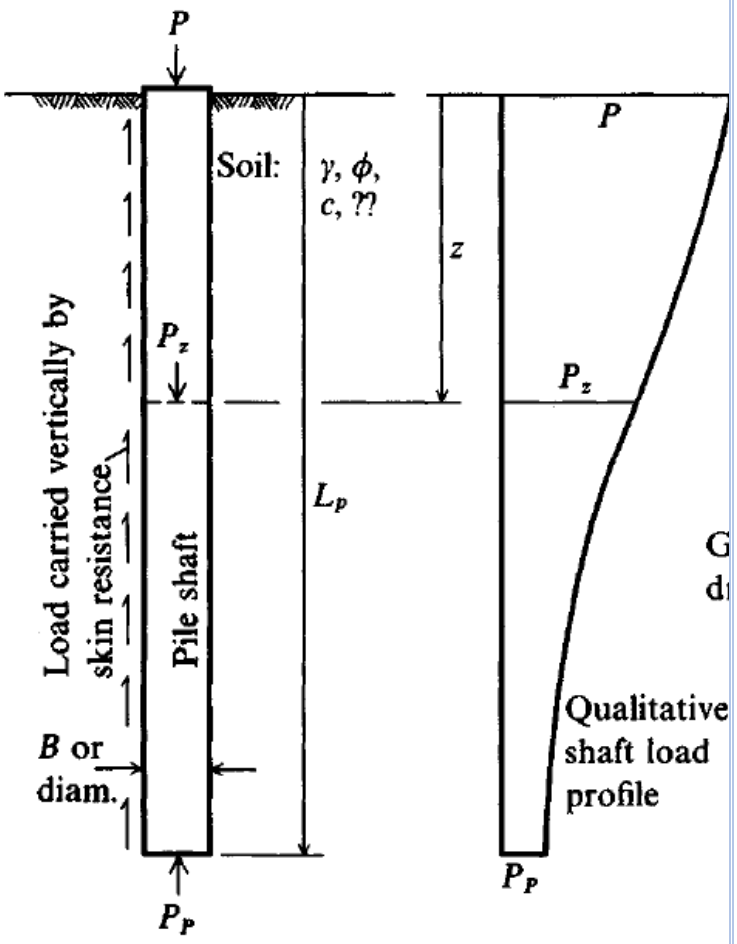
Number, spacing and depth of Bore hole

Foundation layout

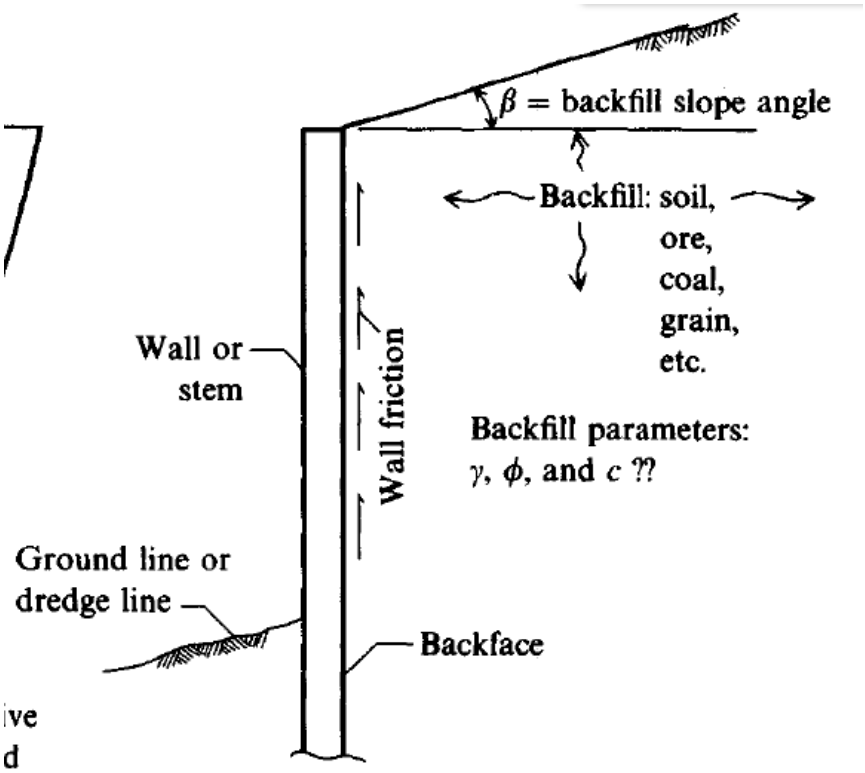


(*a*) Spread foundation. Base contact pressure

$$q_o = \frac{P}{BL} \text{ (units of kPa, usually)}$$



(*b*) Pile foundation. P_P = tip, point, or pile base load (units of kN)



(c) Retaining structure

1. Determine the number of boreholes:

Table (1) can be adopted as a recommended guide to determine the number of borings:

Phase of Investigation	Geological Structure	No. and Spacing of Boring	Location of Boring in the Field
Preliminary Investigation (to assess the suitability of site)	Uniform	5 to 10 boring per km^2	Depends on topography of the site
	Irregular or Unknown	10 to 30 borings per km^2	
Detailed Investigation (for individual building where location has been fixed)	Uniform	At least 3 borings (10 to 30 m apart)	As regular as possible network to suit individual buildings taking into consideration preliminary investigation
	Irregular or Unknown	3 to 5 borings for each building (10-30 m diagonal)	

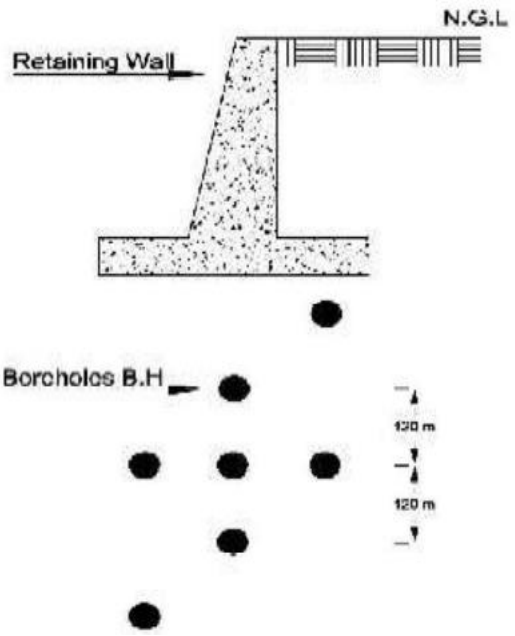
The following rules may be followed for finding the number of borings

1. For individual buildings of less than 300 m^2 plan area, 3 boreholes are the minimum (not to be on a straight line).
2. For large sites or group of buildings, 5 boreholes are the minimum (4 at corners and 1 at the middle).
3. As a guideline you may use Table (1).
4. For large site: probes are needed (penetration test, seismic method, electrical resistivity method) to obtain information in areas between boreholes.
5. In case of limestone rock (from geological information) use seismic method between boreholes to check any cavities.

6. For some special structures

a. Retaining walls

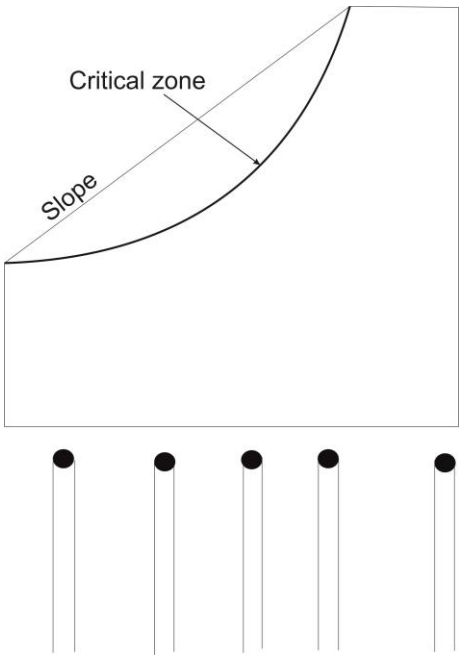
Minimum spacing is 120m at the centerline with some of these BH located at both sides of the centerline.



b. Slop stability

3 to 4 BH under the critical zones and at least 1 outside the critical zone

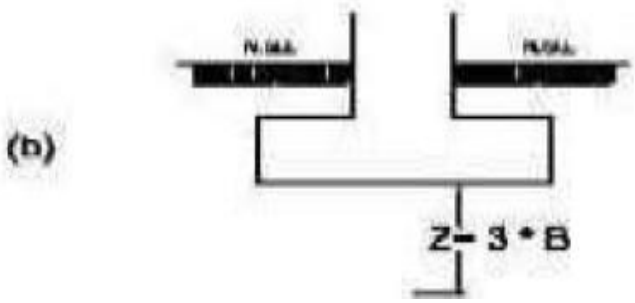
Bore holes under slopes



2. Depth of boreholes

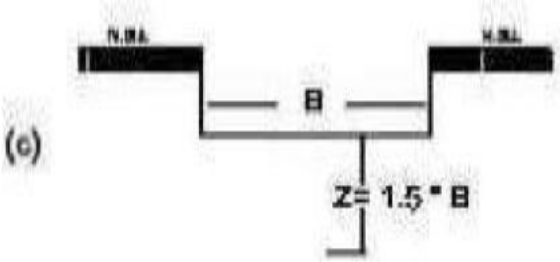
The Following points can be followed step by step to determine borehole depths

1. Highway and airfields: minimum depth of borings is 3m but should extend below organic soil, muck, artificial fill or compressible layers such as soft clays.
2. Retaining Walls and slope stability problems:
   a. Below organic soil, muck, artificial fill or compressible layers.
   b. Deeper than possible surface of sliding.
   c. Deeper than the width of the base of wall (increase of retaining wall).
   d. Equal to the width at bottom of cuts.
3. Structural Foundation: depends upon soil profile and the type of feasible foundation
   a. Below organic soil, muck, artificial fill or compressible layers.
   b. Single separate narrow strip footings:
      - Depth = 3 x width of footing >6m

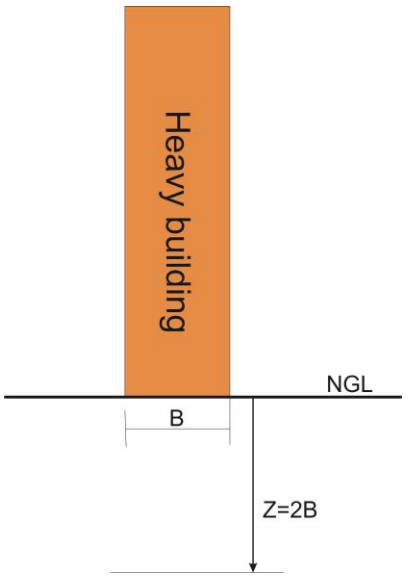


c. Group of overlapping footings or raft.

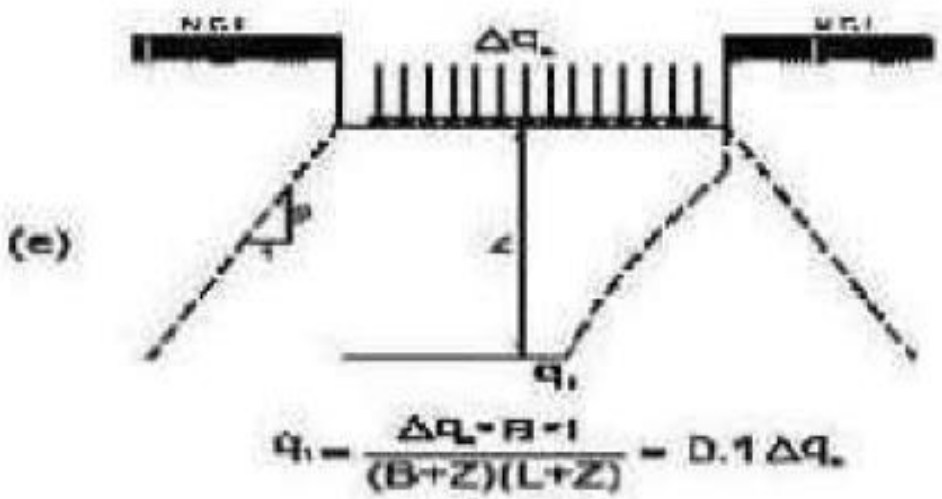
- Depth = 1.5 x least width of the group or raft.



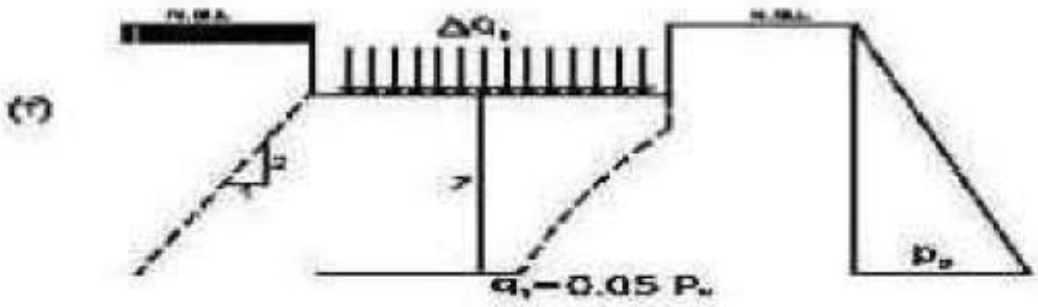
d. For heavy structures the depths of one of the boreholes should extend to 2 x width of footing (Heavy loads >20 T/m^2=200 kPa).



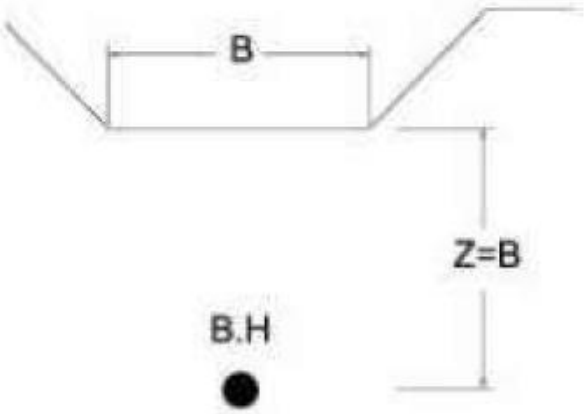
e. The depth of boreholes should extend to the point where the net increase in stress due to the action of the load of the building is less than 10% of the total surface load.



f. The depth of the borehole should extend to the point where the net increase in stress due to building (Δq_s) is less than 5% of the overburden stress in soil.



g. For pile foundation, depth of boring should extend to the bearing strata + (3 x pile diameter).



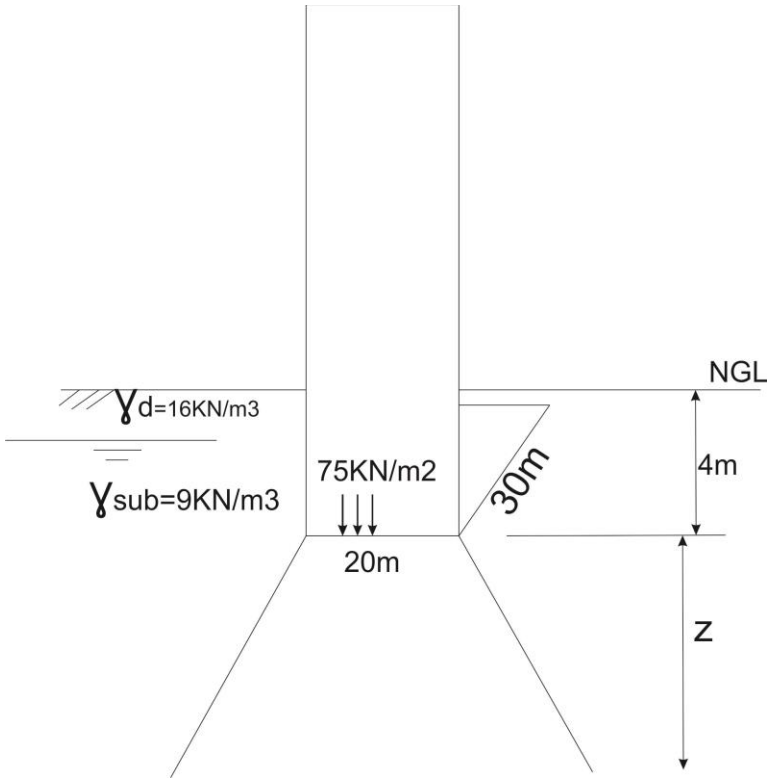
Cut of Slope Stability Case

Example 1:

Four storey building (20mx30m) with a basement (depth= 4m below ground surface) is proposed. The net pressure (Δ qs) of the building at the basement level is 75 kPa. The soil is silty clay with a dry and submerged unit weight equal to 16 kN/m3 and 9 kN/m3 respectively. The water table was found at elevation 1 m below ground surface. Determine for a detailed soil investigation the number, layout and depth of the boreholes.

Solution:

1. No. of B.H : Area = 30 x 20 = 600 m2 > 300 m2 → use 5



Layout: use 4 BH at corners and 1 at the center

Since it is a raft foundation

c) $Z = 1.5 * 20n = 30m$

e) assuming 2:1 distribution

$\Delta qBL = 0.1\Delta q(B + z)(L + z)$

$\frac{BL}{(B+z)(L+z)} = 0.1$

$\frac{20*30}{(20+z)(30+z)} = 0.1$, solving for z, the $z = 52.6m$

f) effective stress at depth z; $P_o = 1 * \frac{16KN}{m3} + (3 + Z) * \frac{9KN}{m3} = 43 + 9Z$

$0.05P_o = \frac{\Delta qLB}{(B+Z)(L+Z)}$

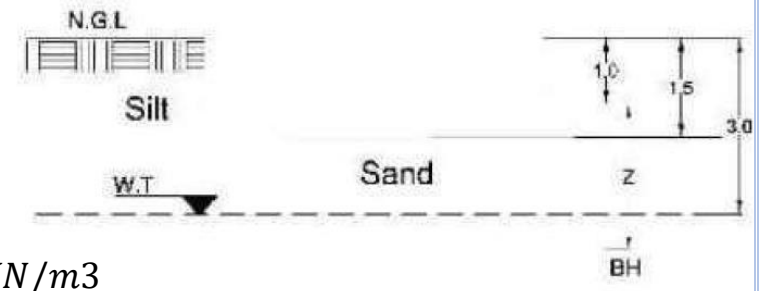
$0.05(43 + 9Z) = \frac{75*20*30}{(20+Z)(30+Z)}$, solving for Z

$Z = 29.4m \approx 30m$, the same as in C

Therefore, $Z = 30 + 4 = 34m$

Example 2: A square building of 9 columns bears loads as below;

Col	No.	Load KN
C1	5	1500
C2	4	2500



$\gamma_{sat} of\ sand = 19KN/m3$, $\gamma_{dry} of\ silt = 17KN/m3$

Estimate Z if B = 8.5m and number of boring

$A = 8.5^2 = 72.25m2 < 300m2$, therefore use 3 BH

$\Delta q = \frac{P}{A} = \frac{P}{BL} = \frac{5*1500KN+4*2500kN}{8.5m*8.5m} = \frac{235KN}{m2} > 200KN/m2$, therefore it is a heavy building

$Z = 8.5 * 2 = 17m$

e) $\frac{8.5*8.5}{(8.5+z)(8.5+z)} = 0.1,\ Z = 18.3m$

f) $0.05P_o = \frac{\Delta qLB}{(B+Z)(L+Z)}$

$$0.05(1.5 * \frac{17KN}{m3} + 1.5 * \frac{19KN}{m3} + (Z-3) * 9KN/m3 = \frac{17500}{(8.5+Z)(8.5+Z)}$$

$Z = 27.26m$

Use the minimum Z , $Z = 17 + 0.5m * 2 = 18m$ Below NGL.