Chapter 3

Site Investigation and Bearing Capacity of Soil

3.1 Preliminary

Buildings are heavy structures that are placed on and supported by the earths crust i.e., soils and rocks below them. Foundations of any kind of structure are building elements that ultimately transfers the building load to the underlying earth's crust. Thus, we need to investigate the site carefully.
Site investigations or subsurface explorations are done for obtaining the information about subsurface conditions at the site of proposed construction and their impact on the design.

Site investigation is done to detain to obtain the information that is useful for one or more of the following purposes.

A) For New Structures

1. To select the type and depth of foundation for a given structure.
2. To determine the bearing capacity of the soil.
3. To estimate the probable maximum and differential settlements.
4. To establish the ground water level and to determine the properties of water.
5. To predict the lateral earth pressure against retaining walls and abutments
6. To select suitable construction techniques
7. To predict and to solve potential foundation problems.
8. To check the degree of compaction of soil;
9. To ascertain the suitability of the soil as a construction material.

B) For Existing Structures

1. To investigate the safety of the structures and to suggest the remedial measures.
2. For prediction of settlement; and
3. For determination of remedial measures if the structure is unsafe or will suffer detrimental settlement

The materials that constitute the earth's crust and that support a building are arbitrarily divided by the civil engineer in to two types i.e., soil and rock. They constitute the main structural material with which a foundation or civil engineer deals, and a complete knowledge of the origin and characteristics of these materials is essential for better understanding in foundation design and construction.

Rock

Rock is a natural aggregate of mineral grains connected by strong and permanent cohesive forces. Rocks may be exposed on the surface or may be covered by layers of soil. They may not be solid over large areas, but may be broken into relatively small units by faults, joints and other structural weaknesses. These faults may lie in horizontal, vertical or sloping plane. Layers of rock may be separated by layers of slippery clay that will allow the rock to move or slip when it is disturbed, ether by man or by nature, as in case of earthquakes.

Rocks, if encountered as a layer, on which a building is to be constructed, ensure a good support for the building. Rocks can take a heavy loads without causing significant settlement or failure. However, care must be taken to see that:

- The rock is solid and not a tin layer with sub-soil of inferior quality;
- The rock should not have too many cracks as risk of future settlement of building is involved;
- The surface ought to be quite level or otherwise there is a possibility that the foundation wall may slip; and
- That the rock surface should be so hard that it will not move quickly than the building itself. Loose soil must be excavated and only solid rock should be used as foundation base for important high rise buildings.

The above requirements are compulsory when multistory buildings have to be constructed. Although rock would provide an ideal surface for constructing a building, yet it is not met in abundance at building sites usually.

Soil

Soil is a natural aggregate of mineral grains with or without organic matter, that can be separated by gentle mechanical means, such as agitation of water, wind, frost, etc. Soils are found in a wide range of particle size, shape and composition.

In reality there is no clear distinction b/n rock and soil why?

Classification of rock

Rock can be classified in to three groups according to their mode of formation. These are Igneous, Sedimentary and Metamorphic rocks. (See construction materials-chapter 1)

Soil classification

Soils are classified in many different ways: by their use, origin, size, texture, color and property. However, the two most commonly used classifications by engineers are: classification by grain size and classification by physical properties.

a) Classification of soil by grain size

a) Stones

It consists of boulders (>200mm) and cobbles (60-200mm). Stones are considered as one of the best foundation surfaces.

b) Gravel

Gravel consists of particles of course material resulting from the disintegration of rocks. It is cohesion less aggregates of rounded or angular fragments of unaltered rocks or minerals. They are often transported by water from their original source. Particles vary in size between 2-200mm are classified as gravels and they are formed due to wear and tear during transportation. They never swell and shrink depending on the moisture condition. They have high strength to be the loads coming over them. Thus, gravel deposits form the second best foundation surface for buildings.

c) Sand

Sand consists of coarse particles of silica formed due to the disintegration of rocks. Their particle sizes vary between 0.06-2mm. They are visible to the naked eye and have rough surface. Clean sand particles fall apart when collected in dry state. Pure sand deposits are not affected by the action of frost. They do not swell in size whenever water penetrates into them and no shrinkage occurs when they are dried from a moist condition. Course sand do not allow water to rise through capillary action and are very permeable. Pure sand in a dense state provide a good foundation surface for buildings and there are no settlement problems associated with them.

d) Silt

It is a finer variety of soils, usually equi-dimensional in size ranging from 0.002mm to 0.06mm. They have a smooth texture and relatively impervious. They may also exhibit a slight tendency of swelling or shrinkage. Silt deposit may also provide a foundation surface for small and medium building loads.

If silt layers are in lower density due to looseness in structure they can bear stress of small magnitude. The settlements on account of loading may also be significant.

e) Clay

Clay is an aggregate of microscopic particles less than 0.002mm in size derived from the chemical decomposition of rock constituents or excessive weathering of course particles of rock. They have a smooth and flaky appearance. There is a very small space between individual particles of clays and hence water can not be drained off easily. It is plastic within a wide range of water content. Its permeability is very low. This keeps clays in damp condition for a considerable period after water has penetrated in to them. The capillary rise of moisture is also high. Clays have a property of shrinkage if dried and swelling when it is wet. The capacity of wet clays to bear load is very less. Buildings constructed on clayey soils are thus liable to gradual settlement.

The consolidation of clay is not complete even after several years after construction, sometimes creating problems of excessive or differential settlement of the building constructed over it. One must take additional care in selection, design and consider of the building in pure clayed soil.

Soil Classification Chart

Boulder	Gravel	San	Site	Clay

200m | 2.0mm | 0.06mm | 0.002mm

If a soil is made up of a combination of two different soil types the predominant ingredient is expressed as noun and less prominent ingredient as an adjective.

For example sandy silt indicates a soil which is predominately silt but contains a small amount of sand.

Note: The classification of soil based on grain size, according to Ethiopian Building Code of Practice, EBCS-7, 1995, is summarized in Table below.

Table: Classification of soils based on grain size (mm)

Basic Soil Type	Particle Size		
	Coarse	Medium	Fine
Stone	60-200 (Cobbles) >200 (Boulders)	-	-
Gravel	20-60	6-20	2-6
Silt	0.02-0.006	0.006-0.02	0.002-0.006
Clays	<0.002mm		

B) Classification of soils by physical properties

i) Rocks

Rocks are of three types according to their geological formation. These are Igneous, Sedimentary and Metamorphic rocks. (See construction materials-chapter 1)

ii) Cohesive soils

Soils relay for their strength on two physical properties. One is the property of cohesion, the molecular attraction small moist particles to one another. The other property is frictional, the roughness which prevents adjacent particles from sliding freely past one another.

For convenience, soils are classified according to whether or not their strength is due to cohesion. Thus we have cohesive and cohesion-less soils. Cohesive soils derive their strength from internal friction. These are soils, the particles of which stick together, such as clays.

Clays are classified as:

- Very stiff clay which is tough and difficult to remove with a pick;
- Stiff and sandy clay which cannot be molded by pressing with the finger; and
- Soft clay and silt which can be molded by strong pressure with the finger.

Clays are subject to shrinkage and cracking in hot weather followed by expansion in wet weather.

iii) Non-cohesive/Granular Soils

The strength or bearing capacity of such soils depends upon the grading, packing and average size of particles. The better the grading, the tighter the packing will be and the larger the average size, the higher load carrying capacity of non-cohesive soils. Non-cohesive soils vary considerable as base material for building sites. For instance, deep bed of dry compact gravel provides excellent support, while sub-soil of loose uniform sand, if not confined (by sheet pilling) may develop considerable settlement when loaded. A building to be erected on a loose sandy soil must be provided with either wide strip foundation or a raft foundation to ensure that the settlement is uniform.

iv) Peat

It is decayed vegetable matter, black or dark brown in color. It is highly compressible and quite unsuitable to receive foundation loads, even those of light structures. This is common type of soil in Netherland.

v) Made ground or Fill

It is an excavated soil that has been deposited in a depression. Such sites should be avoided. It it is to be used for building purpose, the foundations should be carried down to the original stratum or to be supported on piles.

3.2 Site Investigation

Before buildings are built on any land, it is essential for the builder to examine the proposed site and its soil in some detail. For instance, two adjacent housing sites may not have identical ground conditions, so the types of foundations used for each may have to vary. Therefore, a study of local topography, excavation, cuttings, escarpments, evidences of erosion and land slides, fills, water levels in wells and drainage pattern for the building site is often helpful in setting useful information. Furthermore, an Engineer must posse reasonably accurate information about soil conditions, its arrangement and physical properties before he is in a position to design a foundation.

The field and laboratory investigations carried out to get essential information required for designing foundations are known as ***the soil exploration/investigation.*** Due to very complex nature of the deposits, no one method of exploration is best suited for all conditions. Thus the object of soil exploration may be outlined as follows:

1. Depth, extent, nature and variations of soil strata.
2. Physical properties of the soils encountered.
3. Depth to underlying rock bed when necessary.
4. Approximate values of strength and compressibility of soil.
5. the seasonal variation in ground water table.

The first step is to inspect the site and study the topographical features for deciding the future program of exploration.

Useful information can be gathered from the local people regarding:

- the type of soil
- seasonal variation of ground water table
- Highest flood level.
- Type of cracks and failures in the existing buildings of the area.

But for important, costly and multi- strayed building the detailed site investigation is essential.

Programme for Soil Investigation/Site Exploration

When a designer does not know the soil, it is necessary for investigations to be made on and about the site before the type of foundation can be decided upon. The first step in soil investigation is to carry out a preliminary survey of the site. Information can be collected from the residents of the area regarding the type of soil available at different levels and also the location of water table from season to season. A study of any nearby building will give a fair idea of the behavior of the soil at the site. A study of local topography, excavations cuttings and drainage pattern of the building site are also important to establish bases in investigation of soils. Besides, foundation designers use geological maps to aid the initial assessment of the ground conditions of a site. However, such maps may be misleading to persons without specialist knowledge.

Potential hazards will normally be reveled by a few strategically sited trial pits, which could be dug about 4m depth. In addition to a visual examination of the pits, it may be worth while, on some sites, to take samples of soil at critical depths and test them in the laboratory in order to obtain data which may well lead to more economical foundation design.

The proper program for a given project depends on;

a) Type of project ex large dam projects would usually require a move thorough sub-soil investigation the would a highway project
b) Importance of the project, and
c) Nature of the sub-soils involved (Eg: soft soils require more investigation than gravels).

In general the two obligatory steps in any sub-soil exploration may be outlined as follows:

i. An investigation of the general geological character of site
ii. To make exploratory drill holes that provide more specific information regarding the general character and the thickness of the individual strata.

Depth of Exploration

The required depth of exploration depends on:

a) the size and type of the proposed structure
b) design considerations, such as, safety against foundation
c) the character and sequence of the sub-surface strata.

The following Table gives suggested values of depth of borings for buildings having different width and having number of storyes.

A simple rule is that the boring should be 3 meter for each storey of a building.

For heavy embankments and dams etc., the depth should not be less than twice the height.

In deep cuttings the boring should be taken 2-3 metes below the bottom of excavation.

Table: Suggested values of depth of borings

Width of building in meters	Boring depth in meters						
	Number of storey						
	1	2	3	4	6	8	16
30	3.0	6.0	8.0	10.0	13.0	16	24
60	3.5	6.5	4.0	12.0	16.6	21	32.5
120	3.5	70	10.0	13.5	19.0	24	41

Ground Water Levels

The location of ground water level is essential for deep excavation, water logged sites and foundation works. Wells in the near vicinity of the site and bore holes should be used for recording water tables. Chemical analysis of water is recommended, when the soil or water contains constituents which cause corrosion and damage to the foundation and other buried materials.

Soil Investigation Methods

To test the nature and suitability of the soil of a building site, as well as determine its bearing capacity, either in situ or laboratory tests may be made.

The various methods used for site explorations are classified as follow:-

1. Open test pit
2. Borings

   a. Tube boring b. Auger boring C. Wash boring d. Percussion boring

   e. Diamond drilling f. Rotary drilling
3. Geophysical methods
4. Subsurface sounding test
5. Resistivity methods

3.3 Bearing Capacity

The foundation of any structure transmits the load of the structure to the soil underneath. A rational design of any foundation is based up on the bearing capacity of soil and hence determination of bearing capacity of soil in very important for a foundation engineer.

The preliminary and detailed soil investigation techniques will enable the engineer in charge to know the depth to bedrock, if any; character of soil; and elevation of ground water table. The next thing to determine is the type of foundation to be used, the depth to which it should be taken and its dimensions so that it can safely transmit the load from the building to the soil without any failure of significant settlement. For these determination, knowledge of the safe allowable pressure on the soil, known as the bearing capacity of the soil is necessary.

Bearing capacity may be defined as the largest intensity of pressure which may be applied by a structure or a structural member to the soil which supports it with out causing excessive settlement or danger of failure of the soil in shear.

Ultimate Bearing Capacity, qu (UBC) is the minimum gross pressure intensity at the base of the foundation at which the soil fails in shear. It is the maximum load, which a soil can carry just at the time of failure.

Net ultimate Bearing capacity- NUBC is the minimum net pressure intensity causing shear failure of soil.

Safe Bearing Capacity:- is Ultimate Bearing Capacity (UBC) divided by a suitable factor of safety (F.S). The value of F.S may range from 2-5 even more. This value of bearing capacity is used while designing foundation.

Factors affecting Bearing Capacity

Bearing capacity depends on a number of factors which are given below.

1. Type of soil and its physical properties such as density shear strength etc.
2. Amount of allowable total and differential settlement.
3. Position of water table
4. Physical features of the foundation.

The physical features of foundation that affect the value of B.C are

i. Type of the foundation
ii. Size of the foundation
iii. Shape of the foundation
iv. Depth of foundation below ground level
v. Rigidity of the structure.

Methods of Determining Bearing Capacity

Bearing capacity of a soil can be generally determined from local experience in the construction of similar building, by examining the soil (in laboratory and in filed) and using bearing capacity values obtained from standard building codes for a particular type of soil. For multi-storeyed building and important projects it is necessary to carry out a field test and/or laboratory test on the soil to determine the safe bearing capacity of soils. Presumed design bearing resistance of different ground types, as given in EBCS 7, 1995 are shown in Table below.

Bearing capacity may be determined at the site or by theoretical methods. The bearing capacity of a soil can be determined by plate load test; test pilling; penetration test and from laboratory investigation. Among these methods the following tests that are done at the site for the determination of bearing capacity will be discussed.

1. Plate load test
2. Standard dynamic penetration test.

Plate Loading Test

The best procedure to find out the bearing capacity of a soil is to test a full sized foundation under its design load for a considerable time to observe its complete settlement. But such procedure can not be adopted due to the high cost of testing, large amount of load that will be required, and large length of time for testing.

Hence a short term test is used and the test is known as plate load test. The plate may be square or circular in shape.

Table: Presumed design bearing resistance under vertical static loading

Table 3.4: Presumed Design Bearing Resistances[1] under Vertical Static Loading

Supporting Ground type	Description	Compactness[2] or Consistency[3]	Presumed design bearing resistance (kPa)
Rocks	Massively crystalline igneous and Metamorphic rock (granite, basalt, gneiss)	Hard and sound	5600
	Foliated metamorphic rock (slate, schist)	Medium hard and sound	2800
	Sedimentary rock (hard shale, siltstone, sandstone, limestone)	Medium hard and sound	2800
	Weathered or broken-rock (soft Limestone)	soft	1400
	Soft Shale	soft	850
	Decomposed rock to be assessed soil		
Non-cohesive Soils	Gravel, sand and gravel	Dense Medium dense Loose	560 420 280
	Sand	Dense Medium dense Loose	420 280 140
Cohesive Soils	Silt	Hard Stiff Medium stiff Soft	280 200 140 70
	Clay	Hard Stiff Medium stiff Soft Very soft	420 280 140 70 Not Applicable

[1] The given design bearing values do not include the effect of the depth of embedment of the foundation.

[2] Compactness: dense: $N > 30$,
medium dense: N is 10 to 30
loose: $N < 10$, where N is standard penetration value

[3] Consistency: hard: $q_u > 400$ kPa,
stiff: $q_u = 100$ to 200 kPa
medium stiff: $q_u = 50$ to 100 kPa
soft: $q_u = 25$ to 50 kPa,
where q_u is unconfined compressive strength

Procedure to conduct plate load test

1. A pit of the size 5BpX5Bp, where Bp is the size of the plate, is excavated to a depth equal to the foundation (Df).

   The size of the plate may vary from 300 to 750 mm square. The minimum size is 300 mm square. For clayey, silty and sandy soils the size of the plate should be 600mm square but for gravely and dense sandy soils 300 mm square plate can be used. The size of the test plate should be as large as possible depending upon the capacity of loading device. is usually 03mx0.3m. It is made of steel and is 25mm thick. Occasionally, circular plates are also used.

2. A central hole of the size BpxBp is excavated in the pit which have the same area as that of the test plate. The depth of the central hole should be such that the ratio of depth and width of the loaded area is the same for the actual foundation. It is obtained from the following relation also refer to figure below:

$$\frac{D_P}{B_P} = \frac{D_F}{B_F}$$

   Where: B_F is the width of the pit

   Bp is the size of the plate

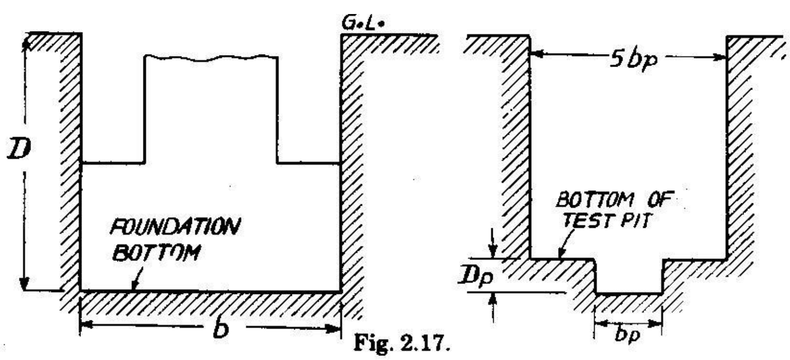
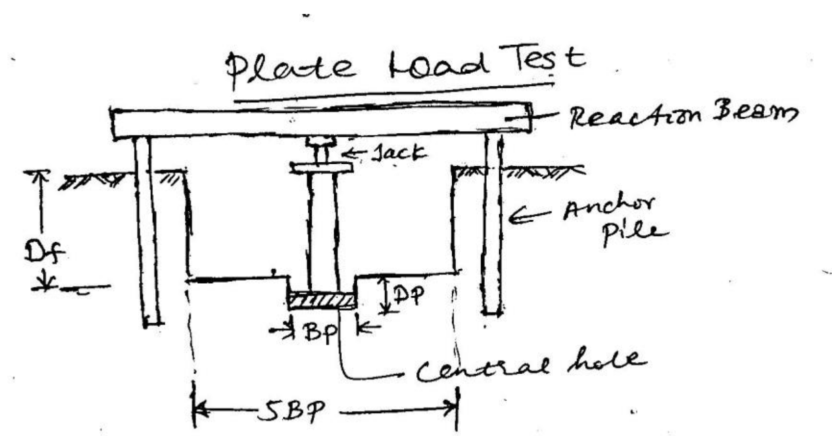


Fig. 2.17.

Figure: A test pit and central hole

3. The plate is placed in the central hole and the load is applied by means of hydraulic jack. The reaction to the jack is provided by means of a reaction beam. See figure below.
4. A seating load of $7KN/m^2$ is first applied, which is released after some time.

5. The load is then applied in increments of about 20% of the estimated safe load or one-tenth of the ultimate load.
6. The settlement is recorded after 1,5,10,20,40,60 minutes and further after an interval of one hour. These hourly observations are continued for clayey soils until the rate of settlement is less than 0.2mm per hour and for others less than 0.02mm per hour. The test is conducted until failure or at least until the settlement of about 25 mm has occurred.
7. A graph is then plotted for the settlement and applied load. One could then establish the bearing capacity of the soil from the plot and other empirical relations. **Typical intensity and settlement plots are shown below**



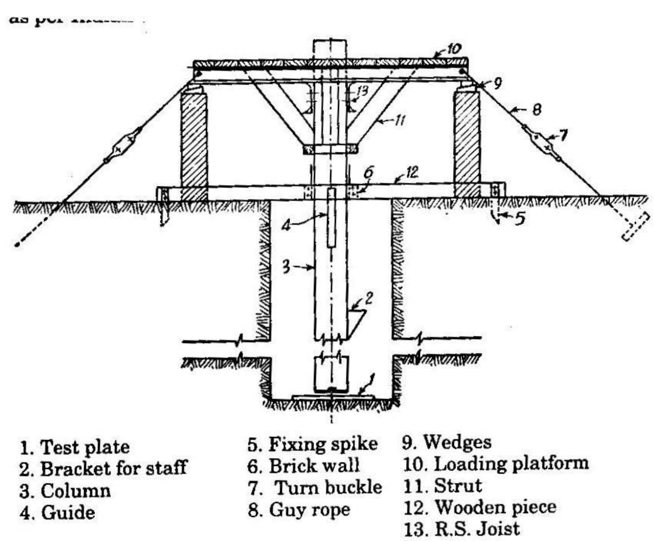
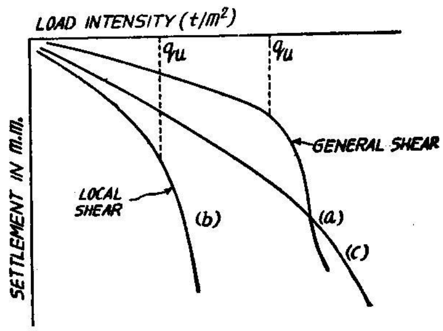


Figure: Plate Load Test Arrangement



q_u = Ultimate bearing capacity
Fig. 2.21.

Figure: Load versus Settlement Curves

Interpretation of q_{up} and S_p

- The ultimate load for the plate q_{up} is indicated by a break on the log-log plot between the load intensity, q and the settlements, S.
- If the break is not well-defined, the ultimate load is taken as that corresponding to a settlement of one-fifth of the plate width (B_p).
- On the natural plot ultimate load is obtained from the intersection of the tangents drawn as shown below

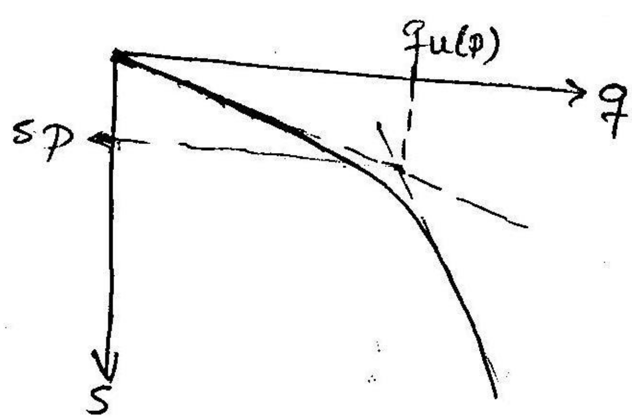


Figure: Natural plot between load and settlement

Results of the Test and Relation of q_{up} and q_{uf}

1. The ultimate bearing capacity of the proposed foundation q_{uf} can be obtained from the following relations:
   a. for clayey soils: $q_{u(f)} = q_{u(p)}$
   b. for sandy soils: $q_{u(f)} = q_{u(p)} * \frac{B_f}{B_p}$
2. The plate load test can also be used to determine the settlement for a given intensity of loading (q_o). The relationship between the settlement of the plate (S_p) and that of the foundation (S_f) for the same load intensity are given below.
   a. For clayey soils, $S_f = S_p * \frac{B_f}{B_p}$

      Where Sp is obtained from load intensity-settlement curve
   b. For sandy soils: $S_f = S_p \left[\frac{B_f (B_p + 0.3)}{B_p (B_f + 0.3)} \right]^2$

Limitation of the Plate Load Test

The plate load test has the following limitations

1. Size effect

- The results of a plate load test reflect the strength and the settlement characteristics of the soil within the pressure bulbs.
- As the pressure bulb depends up on the size of the loaded area, it is much deeper for the actual foundation as compared to that of the plate.
- The plate load test does not truly represent the actual conditions if the soil is not homogeneous and isotropic to a large depth.

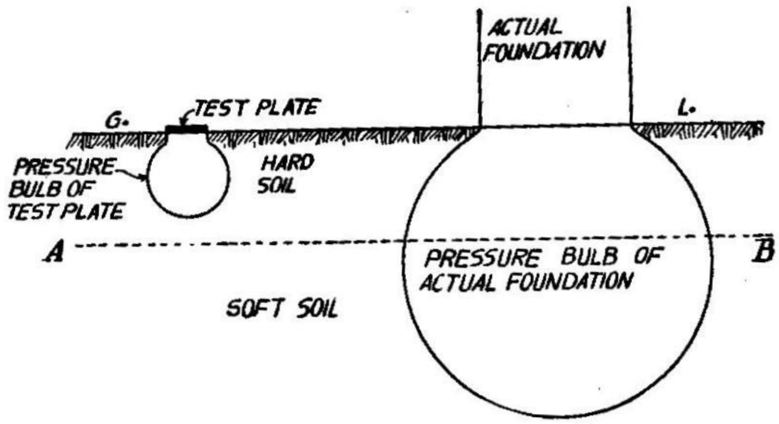


Figure: Pressure bulb

2. Scale Effect

The ultimate bearing capacity of saturated clays is independent of the size of the plate but for cohesion-less soils, it increases with the size of the plate. To reduce scale effect, it is desirable to repeat the plate load test with plates of two or three different sizes and extrapolate the bearing capacity for the actual foundation and take the average of the values obtained.

3. Time Effect

A plate load test is essentially a test of short duration. For cohesive/clayey soils, it does not give the ultimate settlement. The load- settlement curve is not truly representative.

4. Interpretation of failure load

The failure load is not well defined, except in the case of general shear failure. An error of personal interpretation may be involved in other types of failure.

5. Reaction Load

It is not practicable to provide a reaction of more than 250 KN. Hence, the test a plate of size larger than 0.6m width is difficult.

5. Water table

The level of water table affects the bearing capacity of the sandy soil. It the water table is above the level of the footing, it has to be lowered by pumping before placing the plate. The test should be performed at the water table level if it is within about 1m below the footing.

Housel Method

A practical method has been suggested by Mr. Housel for determining bearing capacity by means of **plate bearing test.** The method is very much useful if the soil stratum is reasonably homogeneous in depth.

In this method it is assumed that the load is transmitted to the soil as the sum of two components.

One component is that which is carried by the soil column directly beneath foundation and the other is that which is carried by the soil around the perimeter of the foundation.

The first component is a function of area where as the second component is a function on length of the perimeter of the foundation.

$$P = A*Q = A*n + P.m$$

Where: Q= Total load in kg

q=Bearing capacity in (kg/m^2)

A= area in m^2

P= length of perimeter in m

n= Compressive stress of soil column directly beneath the foundation in [kg/m^2]

m= Perimeter Shear in [kg/m]

Let the ratio of perimeter P to the area A be x.

$$\text{Then} \quad q = \frac{Q}{A} = mx + n$$

The values of m and n can be found by loading two or more test plates which have different areas and different lengths of perimeter. Experiment on these test plates should be performed on the same soil and at the same elevation as that of the proposed foundation. Loading should be done until maximum allowable foundation settlement is reached. The load on each test plate which is required to produce this settlement is recorded. Using the appropriate value of Q, A and P in the equation; the value of m and n can be found by solving two simultaneous equations. By using the value of m and n thus determined; the value of the allowable load on actual foundation can be determined.

Standard Penetration Test

The standard penetration test is the most commonly used in–situ test, especially for cohesion-less soils which cannot be easily sampled.

The test is extremely useful for determining the relative density and the angle of shearing resistance of cohesion less soils. It can also be used to determine the unconfined compressive strength of cohesive soils.

The standard penetration test is conducted in a bore hole using a standard split-spoon sampler.

Procedure

1. A bore hole is drilled to the desired depth by using drilling tools
2. The drilling tools are removed and a casing pipe should be driven to the bottom of the hole.
3. The sampler is fitted to the end of the drill rod and lowered into the bottom of the hole.
4. The sampler is driven in to the soil by a drop hammer of 63.5 kg mass falling through a height of 750mm at the rate of 30 blows per minute.

   The number of blows required to drive 150mm of the sampler is counted.

   The sampler is further driven by 150mm and the number of blows is recorded.

   Like wise, the sampler is once again further driven by 150mm and the number of blows is recorded.

The number of blows recorded for the last two 150mm intervals are added to give the standard penetration number (N). In other words, the standard penetration number is equal to the number of blows required for 300mm of penetration beyond a seating drive of 150mm.

It the numbers of blows for 150mm drive exceeds 50, it is taken as a refusal and the test is discontinued.

The standard penetration number is corrected for dilatancy and overburden correction as explained below.

a. Dilatancy correction:- Silty fine sands and fine sands below the water table develop pore pressure which is not easily dissipated. Therefore pressure increases the resistance of the soil and hence the penetration number (N).
b. Overburden pressure correction:- In granular soils, the overburden pressure affects the penetration resistance.

Correlation of N with Engineering Properties

- The value of the standard penetration number N depends up on relative density of the cohesion less soil and the unconfined compressive strength of the cohesive soil.
- If the soil is compact or stiff, the penetration number is high.
- The angle of shearing resistance (Φ) of the cohesion less soil depends up on the number N. In general, the greater the N-value, the greater is the angle of shearing resistance.
- The consistency and the unconfined shear strength of the cohesive soils can be approximately determined from the SPT number N. As the correlation is not dependable, it is advisable to determine the shear strength of the cohesive soils by conducting shear tests on the undisturbed samples or by conducting in-site vane shear test.

Table- The average value of angle of shearing resistance (Φ) for different range of N.

(correlation between N and Φ).

N	**Denseness**	**Φ**
0 – 4	Very loose	$25\text{-}32^0$
4 – 10	Loose	$27 – 35^0$
10 – 30	Medium	$30^o – 40^o$
30 – 50	Dense	$35^o – 45^o$
>50	Very dense	$>45^o$

The approximate value of the unconfined shear strength for different ranges of N can be determined from table below. The unconfined compressive strength can also be determined from the following relation.

$$q_u = 12.5 * N$$

Where, q_u is unconfined compressive strength (KN/m^2)

Correlation between N and qu

N	**Consistency**	**Qu (KN/m^2)**
0 – 2	Very soft	<25
2 – 4	Soft	25 – 50
4 – 8	Medium	50 - 100
8 – 15	stiff	100 – 200
15 30	Very stiff	200 – 400
>30	Hard	>400

Method of Improving the Bearing Capacity of Soils

1. The bearing capacity can be improved by increasing the depth of footing.
   This method is only used at places where the sub soil water level is much below and deep excavations do not increase the cost of the structure disproportionately
2. By providing good drainage, the bearing capacity of certain soils can be improved.
3. Granular materials, like sand, gravel or crushed stone is blended into the natural soil and the mixture is well compacted. The layer of soil thus formed is much stronger and is of improved bearing capacity.
4. By confining the soil in an enclosed area with the help of sheet piles. This method is especially suitable for shallow foundations in sandy soils.
5. By driving sand piers. This reduces the voids of natural soil and thus bearing capacity of soil is increased.
6. Cement grout can be injected under pressure in the foundation to seal off any cracks or fissures which otherwise reduce the bearing capacity of the soil. This mostly employed for fissured rocks.
7. Chemical treatment: chemical solution like silicate is injected under pressure in to the soil.

Assignment _ 3

- Why it is necessary to investigate the site before constructing new building? Also describe the necessity of site investigation after constructing the building. Describe briefly.