UNIT 1

SOIL EXPLORATION

- The field and laboratory studies carried out for obtaining the necessary information about the surface and sub surface features of the proposed area is known as soil exploration.

(Or)

- The determination of engineering properties of soil through different tests is called soil exploration

NEED FOR SOIL EXPLORATION

- To know the occurrence and extent of soil/rock strata
- To establish the ground water table and its fluctuations
- To acquire information required to recommend the bearing capacity
- To select the type and depth of foundation required
- To make settlement predictions
- To investigate the safety of existing structures and to suggest the remedial measures
- To identify environmental problems and their solution

Depth of exploration

- Depth of exploration is decided based on the intensity of loading and type of foundation considered.
- The depth up to which the increase in stress due to loading causes shear failure or excessive settlement of foundation is known as “Significant Depth”.
- The depth of exploration should be at least equal to significant depth.
- Significant depth is generally taken as the depth at which the vertical stress is 1/5 or1/10 of load intensity.

- Depth of exploration is generally taken as 1.5 to 2 times the width of foundation unless a hard rock is met within
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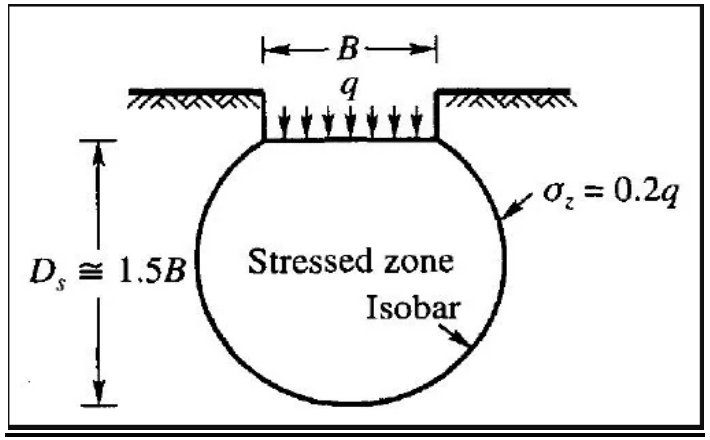
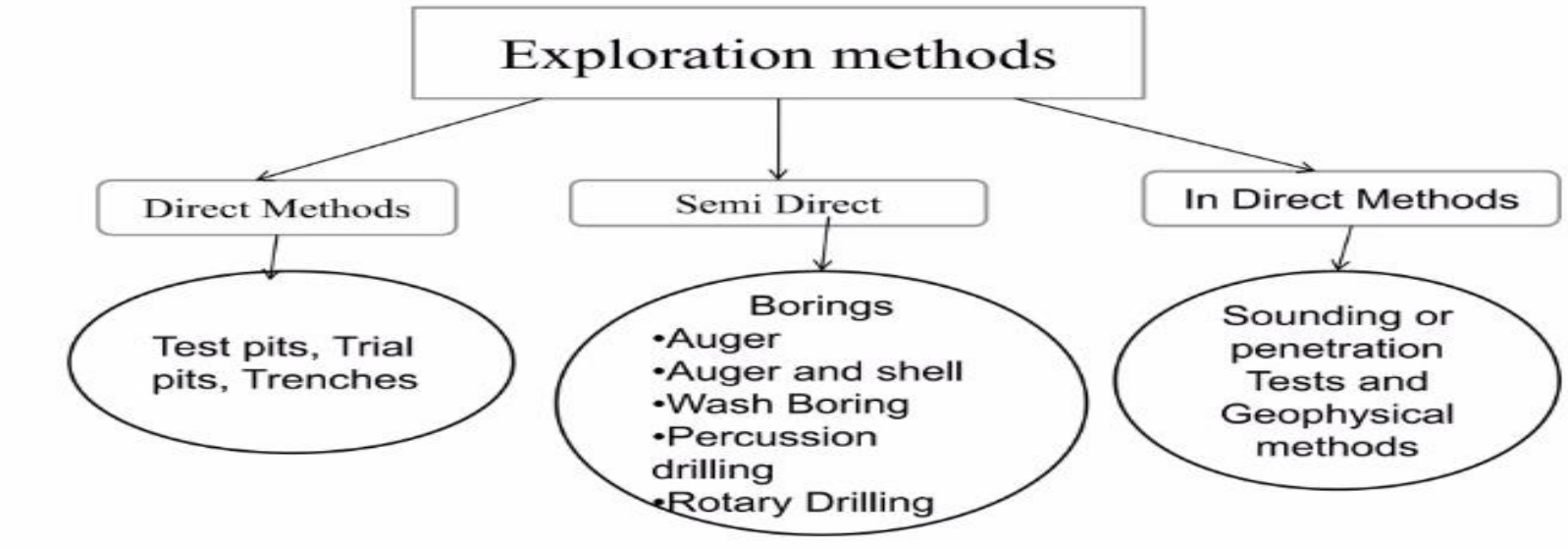


- For smaller and less important buildings, one bore hole or trail pit in the centre is sufficient.
- For a compact building site covering an area of about 0.4 hectare, one bore hole or trial pit in each corner and one in the centre should be adequate



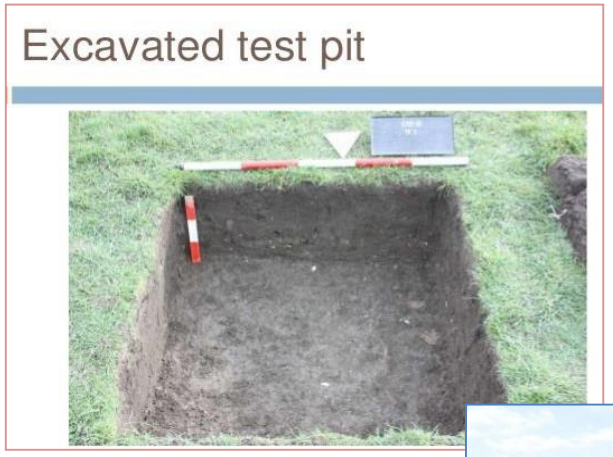
DIRECT METHODS (fordepth<6m)

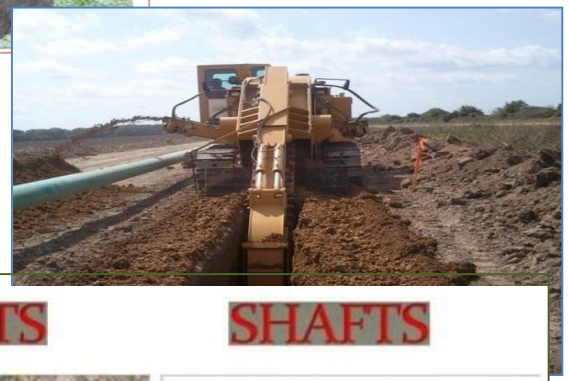
- **Trialpits**
  - Depth>3m lateralsupport
  - Proper ventilation and dewatering if necessary

- **Trenches**-long shallow continuous pit, exposing a line

- **Drifts(adits)**-horizontal tunnels along hillside,especially for rocks
  - Min1.5m(b)X2m(h)
  - Lateral support if unstable
  - Generally expensive
  - Helps to establish minimum excavation limits to reach sound rocks, & to locate failure and shear zones

- **Shafts:**Large vertical holes(min2.4mwidthordiameter)
  - ForD>4m
  - Propersupportandventilationrequired





SEMI DIRECT METHODS:

BORING:

- Drilling a hole into the soil strata upto a specified depth is known as boring.
- Different types of boring are:

1. Auger boring
2. Wash boring
3. Percusion boring
4. Rotary boring

AUGER BORING:

Auger boring is a cheap and simple means of soil exploration.

Method:

In auger boring, vertical holes are advanced by rotating the cross arm of the augerand pushing the auger into the ground. When the auger is filled with the soil, it is withdrawn. The soil is removed from the auger and examined. The auger is theninserted into the borehole, pushed into the bottom soil by rotation of the cross arm, and the process is repeated.

Helical augers, when used with casing, facilitate collection of undisturbed soil samples by fixing the sampler to the bottom of the drill rod. Field tests such as SPT may also be done by attaching the standard spilt-spoon sampler to the bottom of the drill rod after removing the helical screw.

- Augers may be Power driven (60-70m) and hand operated type(3 to 5m).

Types of Augers:

Following are the two types of augers:

i. Spiral or helical augers.

ii. Post-hole augers.

Wash Boring

Wash boring is one of the most commonly used economical method foradvancing boreholes in medium soft-to-firm clays and dense sands for soil exploration

Procedure:

The wash boring method of soil exploration is done in the following steps:

i. A casing is first driven into the ground to a depth of 1.5-3 m. A hollow drillrod, with a chisel-shaped chopping bit at its bottom, is inserted inside the casing.

ii. Water is pumped down into the drill rod that emerges as a strong jet throughthe small openings of the bit at the bottom of the drill rod.

iii. The jet disintegrates the soil in the borehole and carries the broken fragmentsupward through the annular space between the casing and the drill rod.

iv. This return water, carrying soil fragments, known as cuttings, is collected in asump tank through a T-shaped pipe fixed at the top of the casing.

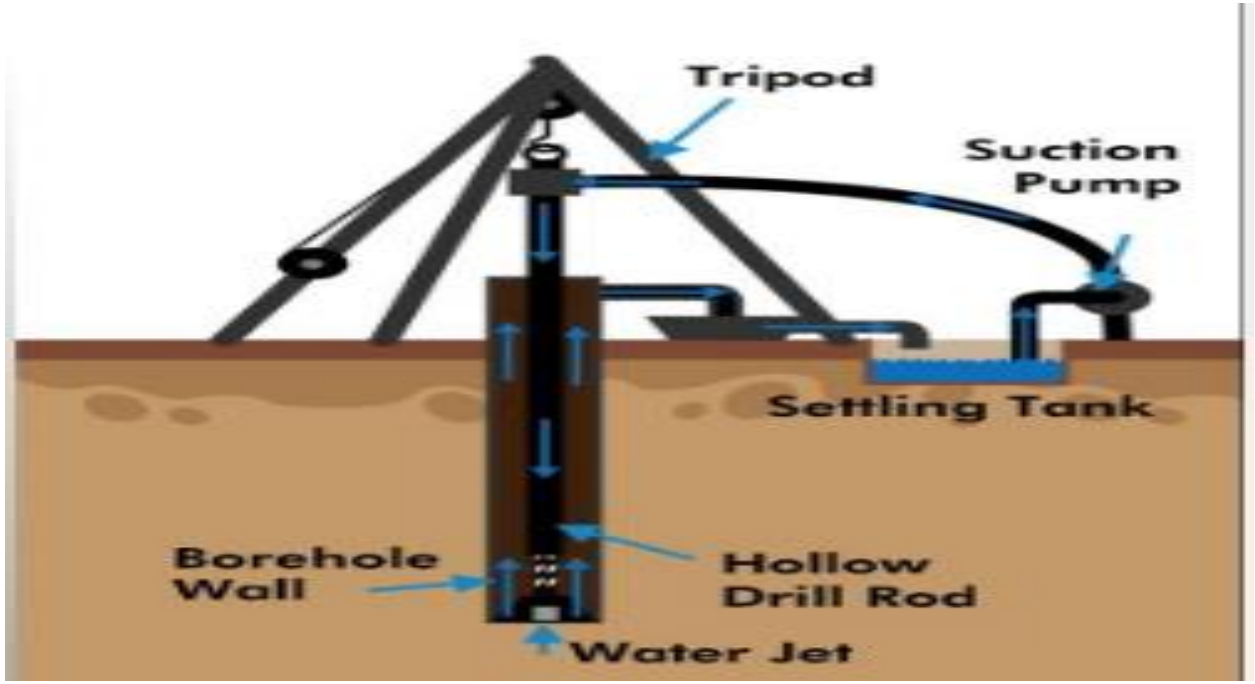
v. The hole is further advanced by alternately raising and dropping the chopping bit by a winch. The drill rod is supported through a swivel joint, wire rope, and a pulley by a triangular or equivalent frame. The swivel joint facilitates turning of the drill rod.

vi. The process of raising, dropping, and turning of the drill rod is continued evenbelow the bottom of the casing until the borehole begins to collapse.

vii. At this stage, the casing is further driven into the borehole and extended at the top by providing additional pieces.

viii. Soil samples can be collected by attaching soil samplers to the bottom of the drill rod, after removing the chopping bit. The soil sampler is pushed into the bottom of the borehole vertically after cleaning and then withdrawn. The undisturbed soil sample is brought along with the soil sampler.

ix. Bentonite slurry (5% bentonite mixed in water as solution) may be generally used instead of water as the drilling fluid, which stabilizes the walls of the borehole.



Percussion Drilling:

The percussion drilling method of advancing boreholes is of common use indrilling water wells; it is also known as cable tool drilling or churn drilling.

Advance of the borehole in this method is made by the following procedure:

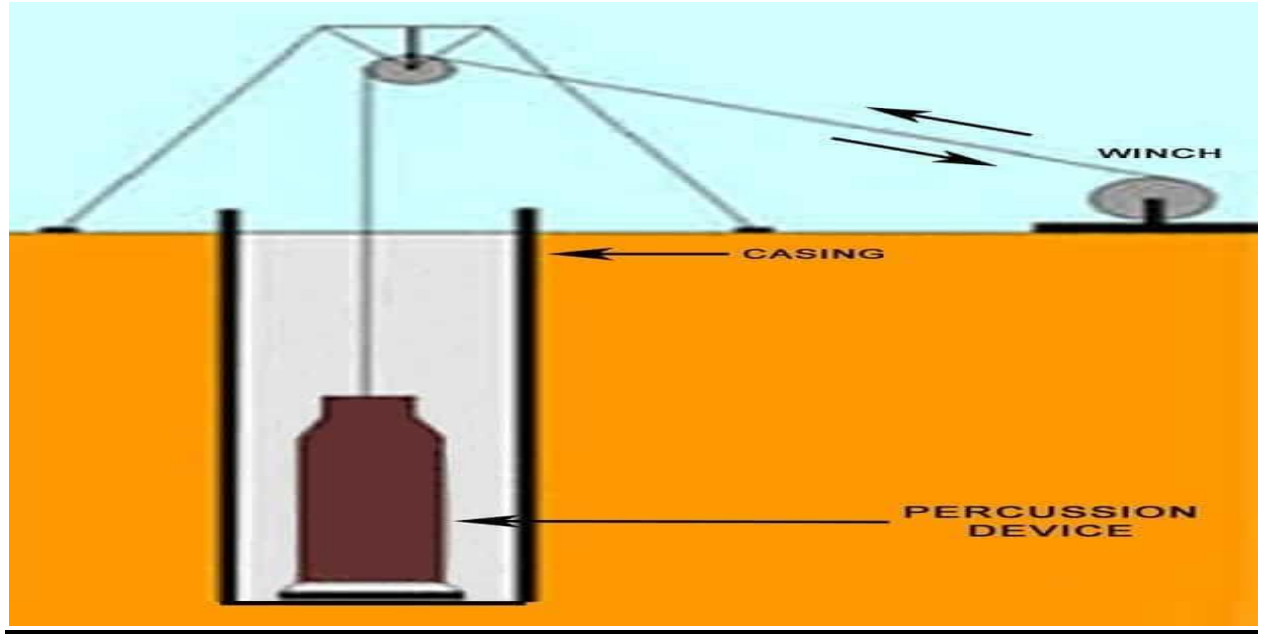
i. Alternately raising and dropping a combination of heavy drilling tools to break down the material at the bottom and to form slurry of the material.

ii. The combination of drilling tools consists of a drill rod with a chisel-shaped chopping bit at its lower end. The chopping bit has beveled edges for cutting the material at the bottom of the borehole.

iii. Periodically removing the slurry using bailers.

iv. The amount of water introduced into the hole in this method is kept to the minimum required to form the slurry. In soft soils and cohesionless material below GWT, no water is generally used in this method.

v. Changes in the soil profile are indicated by the rate of progress of drilling, color of the slurry, and examination of the contents of the slurry.



Rotary Boring or Drilling:

Rotary boring or drilling is a very fast method of advancing holes in rocks and soils.

Method of Drilling Borehole:

In this method, the borehole is advanced by rotating a hollow drill rod, which has a cutting bit at its lower end. The drill rod is rotated by a drill head, provided at the top

of the drill rod. The drill head consists of a rotary drive mechanism and an arrangement for applying downward pressure.

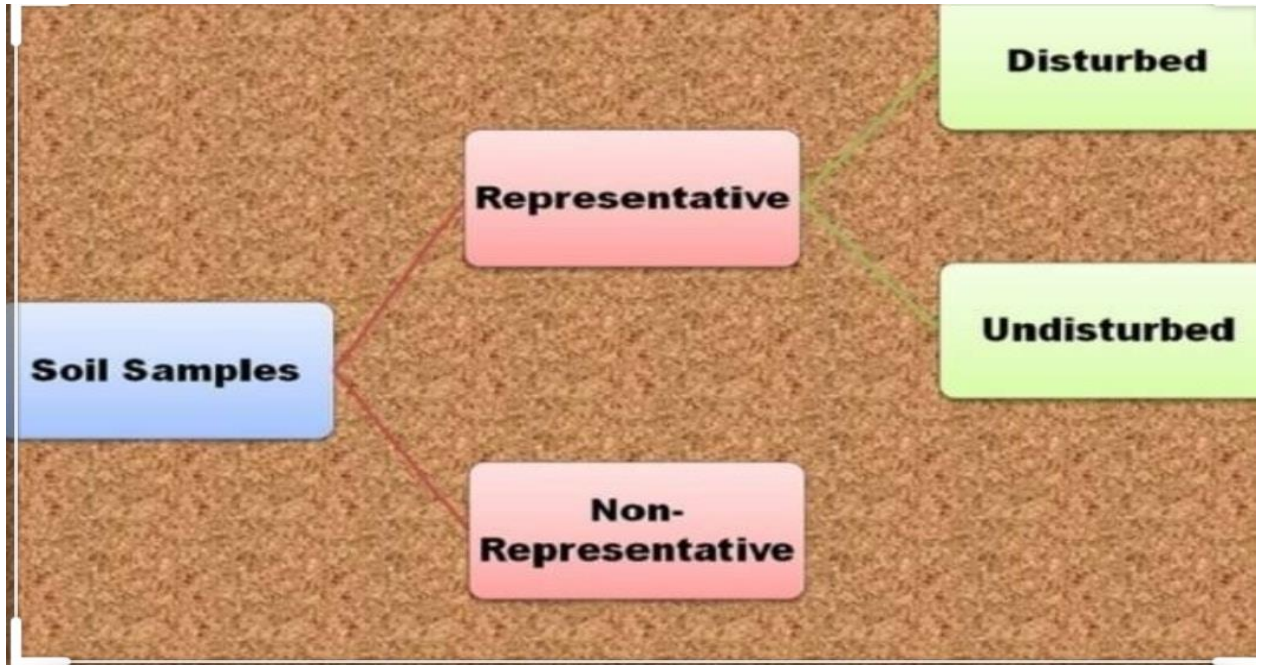
As the drill rod is rotated, the cutting bit shears of chips of the material penetrated. A drilling mud, usually a water solution of bentonite with or without other admixtures, is continuously forced down the hollow drill rod.

Types of Rotary Boring:

There are following two methods of rotary boring:

i. Straight rotary method.

ii. Reverse rotary method.



DISTURBED SOIL SAMPLE:

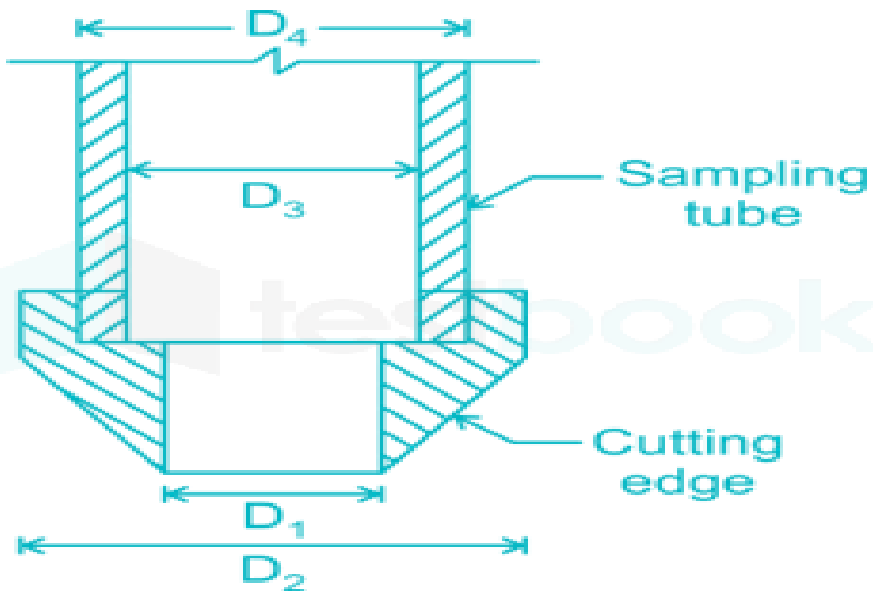
- The soil sample in which the entire soil structure is disturbed is known as disturbed soil sample.
- The void ratio , water content,grain size analysis will be different

UNDISTURBED SOIL SAMPLE: The soil sample in which the entire soil structure is not disturbed is known as undisturbed soil sample.

SAMPLER

- An equipment used to collect soil sample is known as sampler.
- They are two types of samplers

1. Thin walled sampler (undisturbed samples)
2. Thick walled sampler (disturbed samples)



- Area ratio ,Ar = $[(D_2^2 – D_1^2) / D_1^2] \times 100$
- Inside clearance = $[(D_3 – D_1) / D_1] \times 100$
- Outside clearance = $[(D_2 – D_4) / D_4] \times 100$

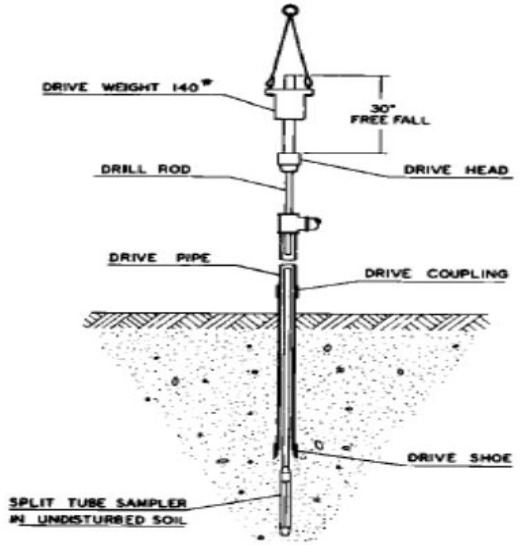
As per IS 1892-1979, to obtain the undisturbed samples

- Area ratio, $A_r \leq 10\%$
- Inside clearance, C_i should be 0.5-3%
- Outside clearance, C_o should lie between 0 and 2%
- Recovery ratio, L_r = length of sample retained in the sample / depth of penetration

should be between 96-98%

Split spoon sampler

- The dimensions of the split spoon are 50 mm external diameter and 35 mm internal diameter.
- Samples are generally taken at intervals of about 1.53 m
- When a material encountered in the field is fine sand below the water table, a special device such as “spring core catcher” is placed inside the split spoon

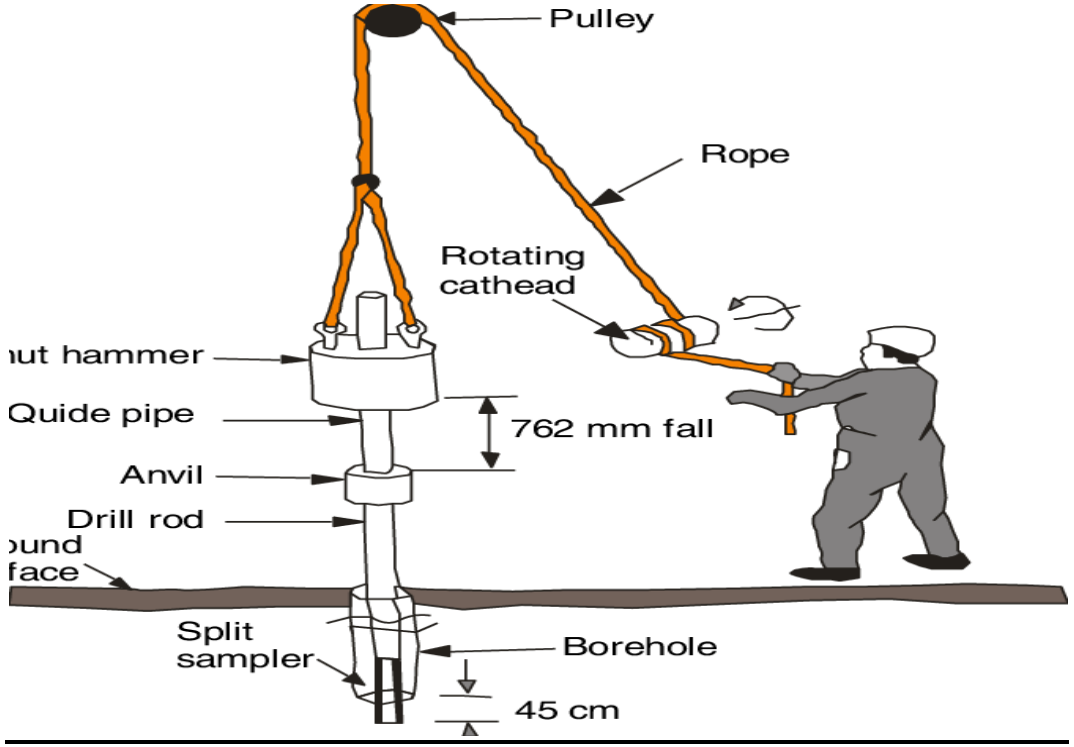


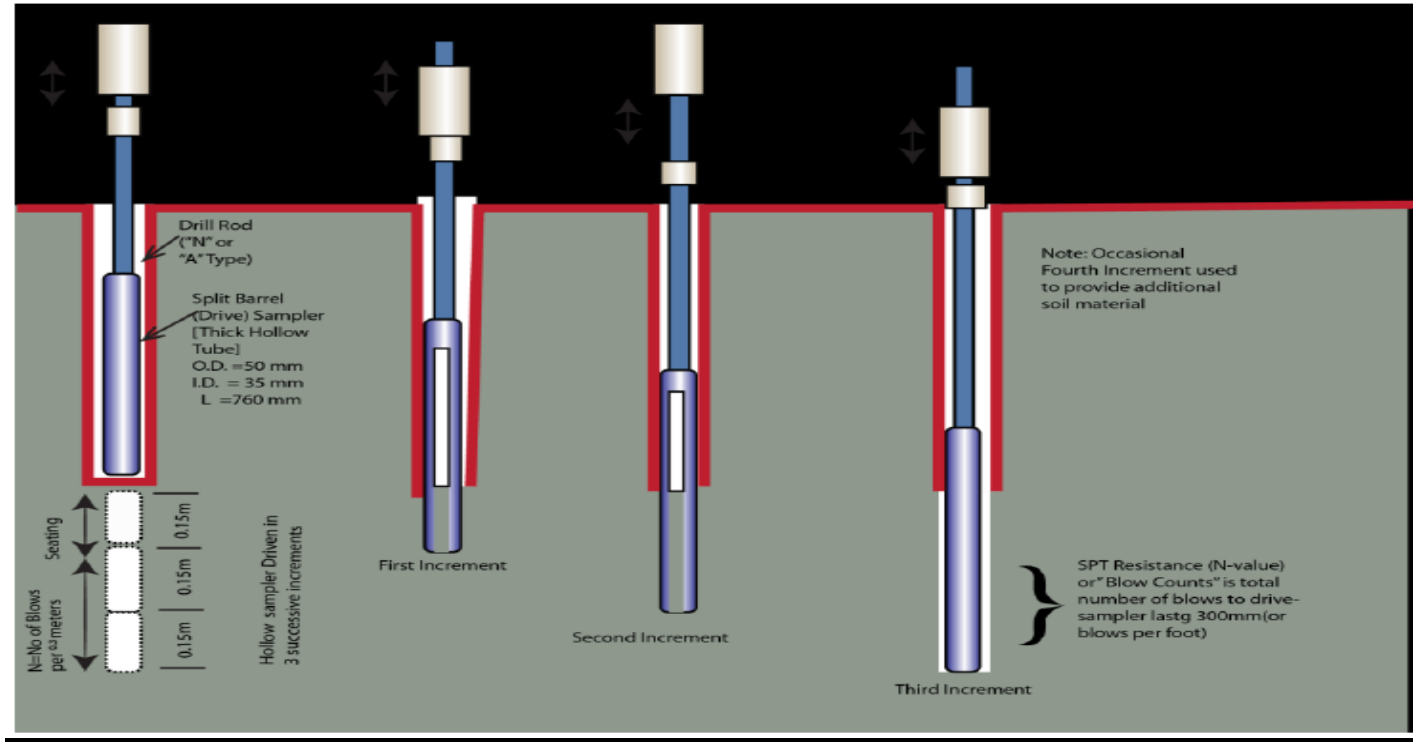
INDIRECT METHODS

STANDARD PENETRATION TEST(SPT)

- Generally used for cohesionless soil.
- This test is used to determine relative density , angle of shearing resistance , UCC.
- A bore hole is made using drilling tools and a hammer of weight 63.5 kg falling from a height of 75cm at the rate of 30 blows / minute.
- After reaching the specified depth , the drilling tool is replaced by a split spoon sampler to collect the soil sample.
- First 15cm penetration is taken as seating drive and the no of blows required for that penetration is discarded.

- No of blows required for next 30cm penetration after seating drive is taken as staNdard penetration number (N)





Corrections for n

1. **Overburden pressure**

The corrected N value is given by

$$N' = C_N N$$

N' = corrected value of observed N

C_N= correction factor for overburden pressure

C_N = 0.77 log (20 /P)

Where, p = effective overburden pressure at the depth at which N value is measured in kg/cm^2

2.Dilatancy Correction

- This correction is applied, when the soil encountered is fine sand and silt below the water table

1) If **N > 15;**

N' = 15+ (N – 15) / 2

N= value obtained after overburden pressure correction

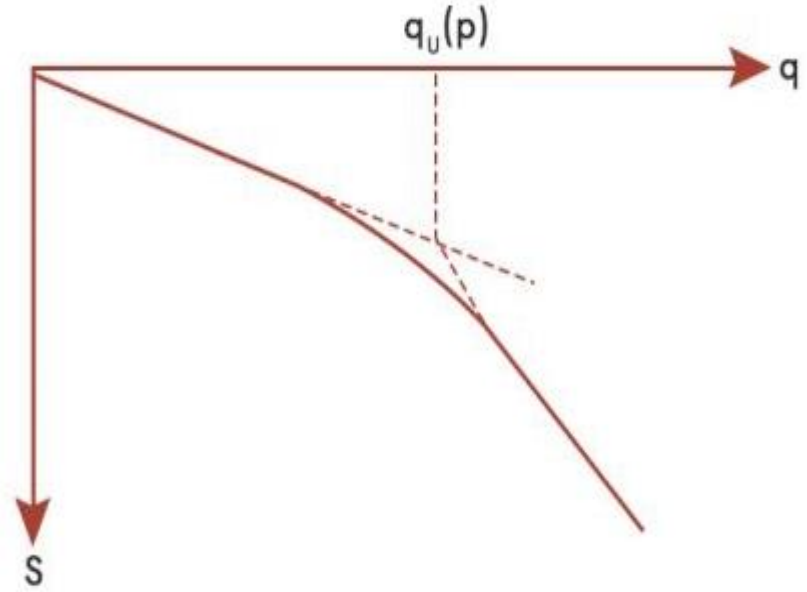
N' = Corrected value for dilatancy

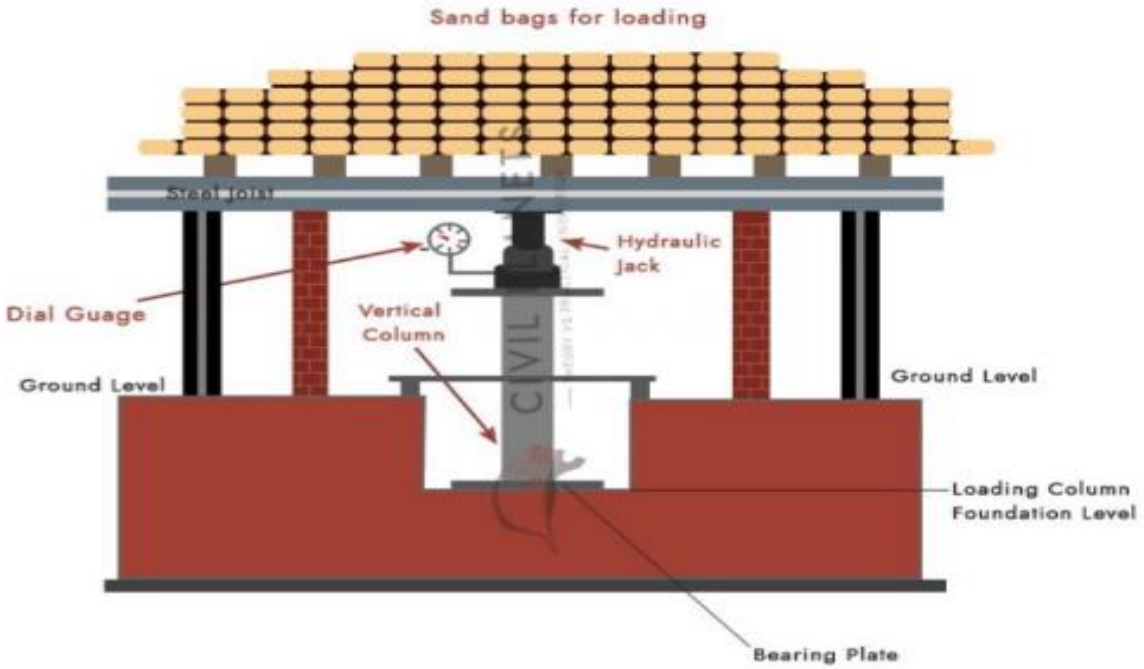
2) If **N≤ 15, N' = N**

PLATE LOAD TEST:

- The plate load test is performed on-site to determine the ultimate bearing capacity of soil at the desired depth.
- The plate is placed at the desired depth, then the load is applied gradually and the settlement for each increment of the load is recorded.
- At one point a settlement occurs at a rapid rate, the total load up to that point is calculated and divided by the area of the plate to determine the **ultimate bearing capacity** of soil at that depth.
- The ultimate bearing capacity is then divided by a safety factor (typically 2.5~3) to determine the **safe bearing capacity**.

- **PROCEDURE:**
- Excavate the land at recommended foundation depth.
- The width of the pit should be greater than 5 times of the mild steel plate.
- Make a depression about 25mm center to the pit and embed the plate correctly.
- Now place a vertical steel column over the plate and place the hydraulic jack over the column.
- Fix the dial gauge at the bottom.
- Now apply a seating load about 70gm/cm^2 to prevent undulation from happening beneath to the plate.
- Then apply the load about 7 Kn/Sqm and release it within a few seconds. Now apply the load again with an increment of 20% with the help of hydraulic jack.
- Now record the settlement value at 1 min, 5min, 10min, 20min, 40min, and 60min and after that for every one-hour until the settlement reaches 25mm.
- The reading of 3 gauges calculates the average settlement.
- Ultimate bearing capacity = Ultimate bearing load x width of pit / size of pit
- Safe Bearing Capacity = Ultimate bearing capacity / Factor of Safety
- The factor of safety = 2 or 3





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SOIL INVESTIGATION REPORT

- A final document of subsoil investigation is known as soil investigation report.
- This report includes

1. Introduction
2. Borehole log
3. Method of investigation

4. Laboratory test results
5. Analysis of results
6. Recommendations

- **Introduction**

i. The nature and scope of sub soil investigation.

ii. Locations of bore holes and other field tests etc.

iii. Different test carried out in the field.

- **Borehole log**

i. Boring number and type of boring.

ii. Starting and completion dates of boring

iii. Diameter of boring

- In method of investigation the reason for choosing a particular method for field test is to be mentioned.
- Laboratory test results are presented in the form of tables and graph.
- The data obtained from field tests and laboratory tests are analyzed.
- Correlations between different test data are established.
- Finally recommendations in the report are generally for the types of foundations and their design