UNIT I

SITE INVESTIGATION AND SELECTION OF FOUNDATION

OBJECTIVES OF SITE EXPLORATIONS

- Determine the nature of the deposite of soil
- Determine the depth and thickness of various soil
- Determine the location of ground water table and the fluctuating of ground water table
- Determine the engineering properties of soil
- To ensure the safety of surrounding existing structures
- To know the sources of construction materials
- Selection of site for disposal of waste water

METHODS OF EXPLORATIONS

Site exploration

1. Reconnaisance
2. Priliminary
3. Detailed exploration

Reconnaisance

- It is the first method of site explorations or subsurface investigations
- It includes to visit the site and study the maps and other relevant records.

Priliminary

- To determine the depth thickness and the composition of soil strata
- It includes to determine the ground water table

Detailed exploration

- It includes to determine the engineering properties of soil in various soil strata
- It includes an extensive boring program sampling and testing of sample in the lab
- Field test such as,

  Vane shear test

  Plate load test

  Permeability test

Types of soil exploration

- The methods available for soil exploration may be classified as follow,

  Direct method (test pit)

  semi direct (boring or augering)

  Indirect method (sounding or penetration and geophysical method)

Semi direct method

Boring and augering

- Auger boring
- Wash boring
- Rotary boring
- Pre-caussion boring
- Auger and shell boring

Depth of exploration

- It required at a particular site depends upon the degree of variation of the subsurface data in the horizontal and vertical directions.
- It is not to possible to fix the number, disposition and depth of bearings without making a few priliminary borings or surroundings at the site. The depth of exploration is governed by the depth of the influence zone. The depth of influence zone depends upon the type of the structure ,intensity of loading, shape and disposition of the loaded area the soil profile and the physical characteristics of the soil.
- The depth up to which the stress increment due to super imposed loads can produce significant settlement and shear stresses is known as significant depth
- D= C(S)^0.7
- C=Constant(3 for light steel structure 6 for heavy steel)
- S=Number of storeys

Lateral extent of exploration

- The lateral extent of explorations and the spacing of bore holes depend mainly on the variation of the strata in horizontal direction
- For small and less important building even one bore hole or a trial pit is enough.
- Compact building covering an area of about 0.4 hec there should be 5 bore holes one @centre and 4 corners.
- For large multi storey building bore holes should be drilled at all the corners and also at important locations.
- The spacing between the boreholes is generally kept between 10 to 30 m depending upon the variation in the sub surface
- For highways bore holes b/w 150 mm to 300mm
- For concrete dams bore holes b/w 40 to 80mm

Pits and trenches

- The size of the pit should be sufficient to provide necessary working space.
- IS 4453-1967 recommends working space 1.2mX 1.2m at the bottom of the pit.
- The depth of the pit depends upon the requirement of the investigation
- Shallow pits - depth of 3m without any lateral support
- Deeper pits – below the ground water table the lateral support in the form of bracing and sheeting

Trenches

Drifts and shafts

Drifts :

They are the horizontal tunnels made in the hill sides to determine the nature and structure of the geological strata. According to IS 4453-1980 a drift should be 1.5 m wide and 2 m height in hard rock.

Shafts:

Large sized vertical holes made in the geological information are called as shafts

For circular diameter = 2.4m

For rectangular width = 2.4m

Drifts and shafts

Types of soil samples

- Disturbed samples
- Undisturbed samples

Disturbed samples

Undisturbed samples

Auger boring

- Augers are used in cohesive and soft soil above water table. In this boring there are two types of augers are used,

  Hand auger (15-20mm dia)

  Mechanically operated auger/power given auger

Hand augers are used only for the depth of 6m

Mechanically operated augers are used for greater depth. This type of boring are used for gravelly soil.

The auger is advanced by rotating it while pressing it in to the soil at the same time. The auger is filled with soil and it is taken out and then the soil sample are collected. The samples are used for identification purpose only,

Auger boring is purely satisfactory for highway exploration at shallow depth and for exploring barrow bit

Auger boring

Auger boring

Wash boring

- Wash boring is a fast and simple method for advancing holes in all types of soil.
- In this boring boulders and rocks cannot be penetrated into the soil.
- This method consist of first driving a causing through hollow drill rod with a sharp chisel and charping bit and a lower end is inserted
- Water is forced under pressure through a drill rod alternatively raise and drop and also rotated.

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- The cutting or forced up to the ground surface in the form of soil water slurry through the annular space between the drill rod and the casing. The water collected in the sump is used to circulating again.
- And then the collected samples are very disturbed it is not very useful for determining the engineering properties.
- The changes of colour of water is to indicate changing the soil strata.

Wash boring

Rotary boring

- Rotary boring (or) rotary drilling is a very fast method of advancing hole for both rocks and soil.
- The drill bit is fixed to the lower end of the drill rod it is rotated by the suitable chunk.
- It is always kept in the form contact with a bottom of soil. The drill mud is usually a water solution of bentenoid with or without admixtures.

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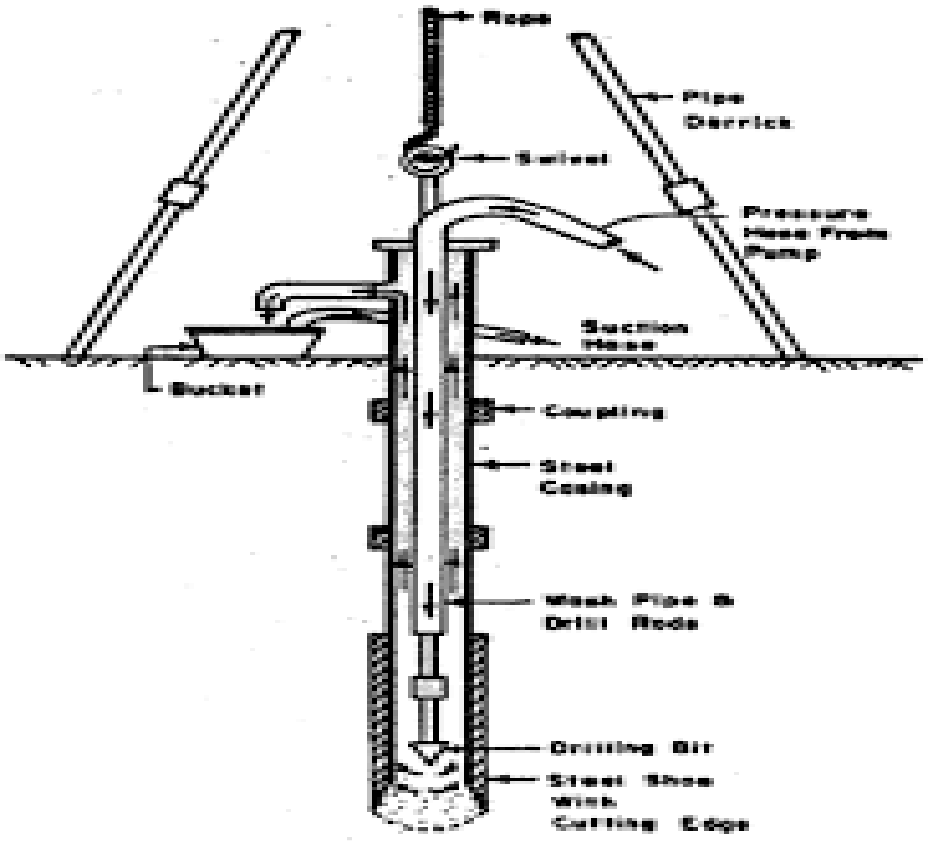
- It is continuously forced on the hollow drill rods. The mud retaining upwards bringing the cutting to the surface.
- The soil samples are collected and testing in the laboratories.

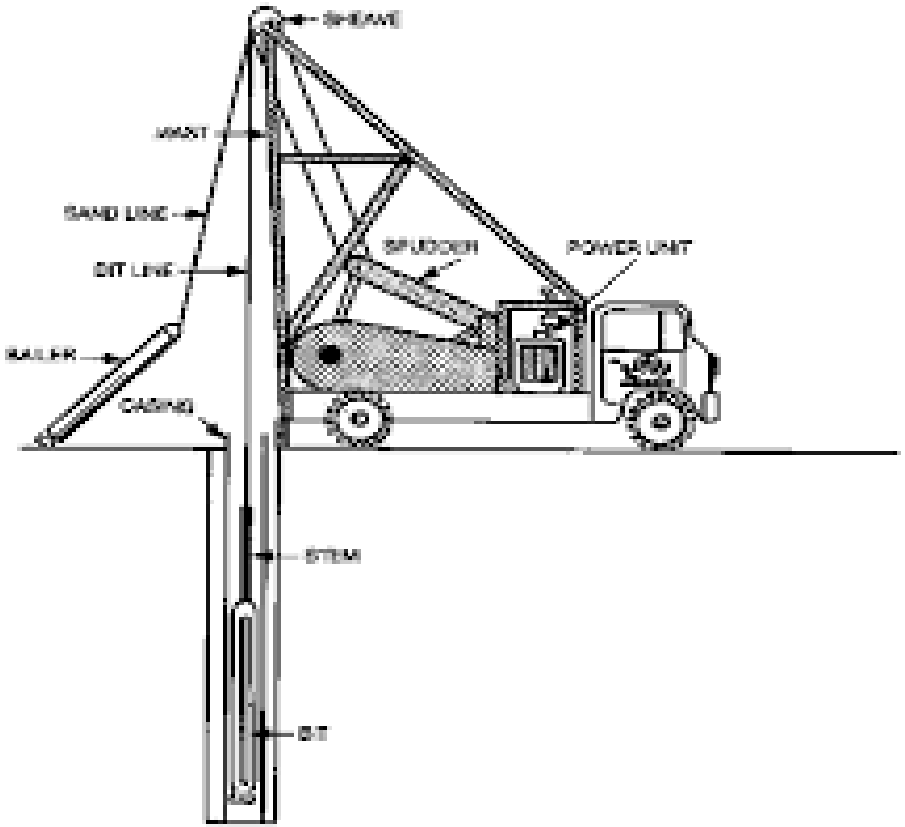
Rotary boring



Pre-caussion boring

- It is used for making holes in rocks and other hard strata. A heavy chisel is alternatively lifted and dropped in vertical hole.
- The materials get pulverized. The water forms a slurry with the pulverized material which is removed by a sand pump. The main advantage is it can be used for all types of materials.
- The major disadvantages is the material at the bottom of the hole is disturbed by heavy blows of chisel.

Precaussion boring



Auger and shell boring

- It is used for drilling holes and for obtaining rocks. A core barrel filled with a drilling bit is fixed to a hollow drilled rod.
- As the drilling rod is rotated bit and cut an hole, the core is removed from its bottom and is retained by a core lifter and brought to the ground surface.
- The core barrel may consist of a single tube or double tube. A double tube barrel gives a good quality sample of the rock.

Auger and shell boring

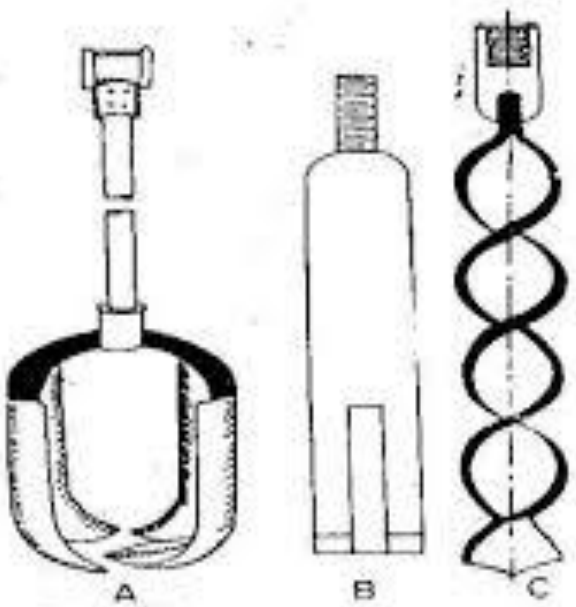


Fig (A) Post hole auger
(B) Shell type auger
(C) Screw auger.

Depth of boring

- The depth of exploration depends upon the type of
  - Proposed structure
  - total weight
  - size of the structure
  - shape of the structure
  - position of loaded area
  - soil profile
  - physical properties of soil

  That constitute each and individual stratum. It should be one and half times the width of footing below the foundation level.

Types and depth of foundation

Types of foundation	Depth of exploration
Isolated spread footings (or) raft (or) adjacent footing with clear spacing equal or greater than four times the width	1 ½ times the width
Adjacent footing with clear spacing less than twice the width	1 ½ times the length
Pile foundation	10 to 30 m (or) more (or) atleast (or) 1 ½ times the width of the structure
Base of retaining wall	1 ½ times the base of width
Footing basement	Depth of construction
Dams	1 ½ times the bottom width of each dams
Roads cuts and fills	1m below foundation level

Depth of boring

Number of storeys	Depth of boring
Single storey	3.5m depth
Two storey building	6m depth
Three	10m depth
Four	16m depth
Five	24m depth

Spacing of boring

Nature of project	Spacing of boring
Highway	300 to 600 m
Earth dam	30 to 60 m
Borrow pits	30 to 120 m
Multi storeyed building	15 to 30 m
Single storey factory	30 to 90 m

Design features affecting the sample

- Area ratio
- Inside clearance
- Outside clearance
- Inside wall friction
- Design of non return value
- Method of applying force

Area ratio

Ar = (max c/s area of the cutting edge)/(area of the soil sample)

$$Ar = (D2^2 - D1^2) / D1^2 \times 100$$

D1 = inner dia of the cutting edge

D2 = outer dia of the cutting edge

Inside clearance

Ci = (D3-D1) / D1 X100

D3 = Inner dia of sampling tube

The inside clearance allows elastic expansion of the sample when it enters the tube. It helps to reducing the frictional drag on the sample for an undisturbed sample the Ci between 0.5 to 3%

Outside clearance

It can be defined as,

Co =(D2-D4) / D4 X100

D4 = Outer dia of the sampling tube

For reducing the driving force the outside clearance should be small as possible. Co value 0.02%

Inside wall friction

- The friction on the inside wall causes disturbance of the sample.
- The inside surface of the sample should be smooth.

Design of non return value

- The non return value provided on the sampler should be of proper design. It should have an orifice of large area to allow air water or slurry to escape quickly when the sampler is driven.
- It should immediately close when the sampler is withdrawn.

Method of applying force

- The degree of disturbance depends upon the method of applying force during sampling and upon the rate of penetration of the sampler

Method of sampler

- Split spoon sampler
- Stationery sampler
- Thin walled sampler
- Rotary sampler

Split spoon sampler

- It is basically a thick walled steel tube and it split in to lengthwise. The standard size of the split spoon sampler is of 35mm internal diameter and 50.8 mm external diameter.
- The sampler is an driven by forcing it in to the soil by blows from a hammer.
- The soil samples are collected in to the sampler. The two half of the barrel are separated and thus exposed.
- The sample may be placed in a glass jar and sealed. In this sampler liner are inserted in side the split spoon sampler

Split spoon sampler

Split spoon sampler

Split spoon sampler

Stationary sampler

- It consist of simple cylinder and the piston system. During lowering the sampler the hole of the lower end of the sampler escaped close with the piston.
- The desired sampling elevation is reached the piston rod is clamp. The sampler is more suitable for sampling soft soil and saturated sands

Thin walled sampler

- The sampling tube shall be made of steel, brass or aluminium. The lower end of tube is level to form a cutting edge and its tapered to reduce wall friction.
- The inside dia of the steel tube is 38mm and outside dia of the tube is 40mm. The sampler is lower at the bottom of the borehole by attaching it to the drill rod.
- Then the sampler is prevent by forcing it in to the soil by blows from a hammer or a piston.

Thin walled sampler

Thin walled sampler

Penetration test

This test involves the measurement of the system to penetration of sampling spoon, a cone (or) other shaped tools under dynamic and static penetration.

This resistant is embrically with some engineering properties of soil such as density index consistency and bearing capacity. They can be classified in to 2 types,

Standard penetration test

Static cone penetration test

Standard penetration test

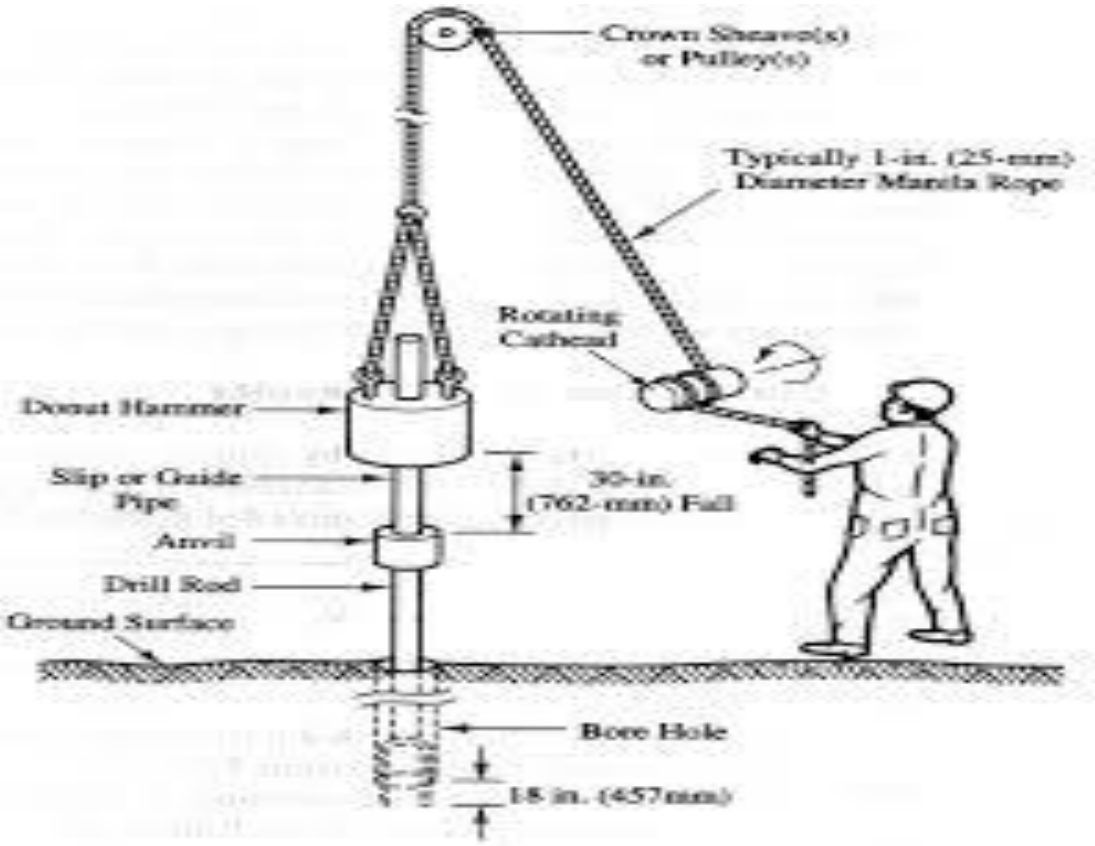
- The most important and most commonly used field test. This test is especially suited for cohesion less soil.

Typical equipements

- Drill rod
- Split spoon sampler
- Hammering equipement
- Casing pipe

It is useful for finding out a relative density of cohesionless soil. And the angle of shearing resistance of the cohesionless soil. Then unconfined compression strength of cohesive soil.

Standard penetration test



Standard penetration test

Standard penetration test procedure

- This test is performed in a clean hole of 55 -150mm dia.
- First assembling the tripod the nuts are tightened so that the tripod is stable keep the tripod joints should be flexible. A strong rope is inserted in to the pulley to the centre of the hole. A rope is centered to the hole. A split spoon is attached to bottom of the core barrel and lowered in to the position at the bottom of the bore hole.
- The sampler is driven in to the ground by the drop hammer weighing 63.5 kg falling through a height of 76cm at the rate of 30 blows per minute.

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- The number of hammer blows is counted. The split spoon sampler removing by hammering it reversely.
- Bring the sampler to the surface and open it remove the sample and war pit are seal in a plastic bag to retain moisture.

Correction for N values

- Over burden correction
- Dilatancy correction

Over burden correction

The following expression is used to find N value

- N´=Cn.N
- N= measured N value
- N´=Standard penetration value
- Cn= 0.77 log (2000/p)
- P= over burden pressure in KN/m^2

Dilatancy correction

- If the stratum consist of fine sand and silt below under water table dilatancy correction should be applied. (or) N value is greater than 15 using this expression
- Ne=15 + (No -15)

Static cone penetration test

- It is commonly abbreviated as cone penetration test. It is used for getting continuous record of resistance of soil by penetrating steadily under static pressure.
- A cone with a base of $10cm^2$ and an angle of 60^o at the vertex
- The cone is carried at the lower end of the steel driving rod which passes through the steel with external diameter equal to the base of the cone.

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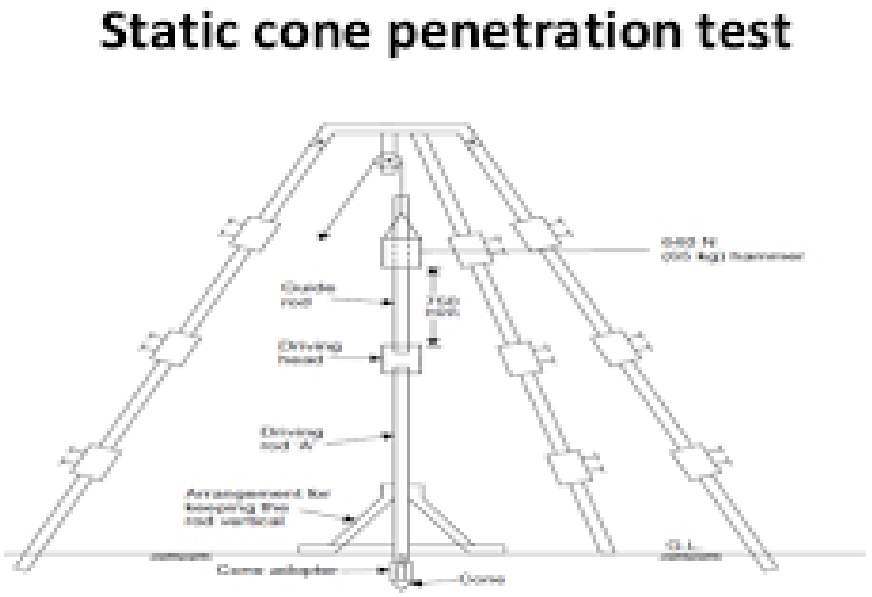
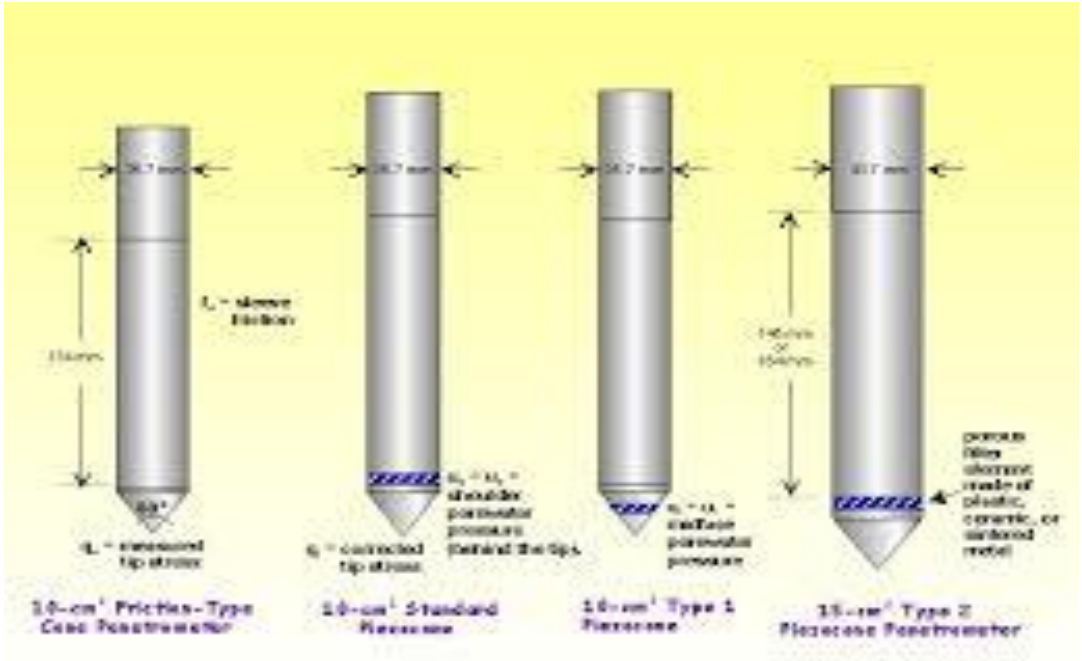
- Either cone (or) tube (or) both together can be forced in to the soil by means of jacks. The cone is first forced down for a distance of 8 cm and the maximum value of resistance is recorded.
- The steel tube is than pushed down upto the cone and both together are further penetrated through the depth of 20cm to give the total cone resistance and the frictional resistance along the tube.

Static cone penetration test



Static cone penetration test



Normalization of qc value

- Similar to standard penetration value ‘N’ and cone penetration test value qc also require normalization to the standard overburden pressure of 100 KN/m^2 using the relation
- qcn =Cn.qc
- qcn = normalised value
- Cn = various overburden pressure

Bore log(sub soil investigation report)

- Scope of the investigation
- Description of the field exploration programme
- Methods of exploration
- Description of the subsoil conditions such as static penetration test, cone penetration test
- Details of the lab test
- Depth of ground water table and changes in water level
- Discussion of the results
- Recommendation about the bearing pressure type of foundation

Liquefaction

- The shear strength due to oscillatory motion is known as liquefaction of sand.
- In the case of partial liquefaction the structure may undergo excessive settlement and the complete failure may not occur.
- If the deposits are compacted to a void ratio smaller than the critical void ratio the chances of liquefaction are reduced.

Liquefaction

Factors affecting liquefaction

- Soil type
- Particle size and gradation
- Density
- Length of drainage path
- Surcharge loads
- Characteristics of vibration
- Age of soil deposits
- Trapped air

Prevention of liquefaction

- Providing deep foundation
- Compaction of soils
- Replacing the liquefiable soil
- Grouting the soil
- Ground water pumping
- Drainage of soil
- Providing stone columns
- Application of surcharge