



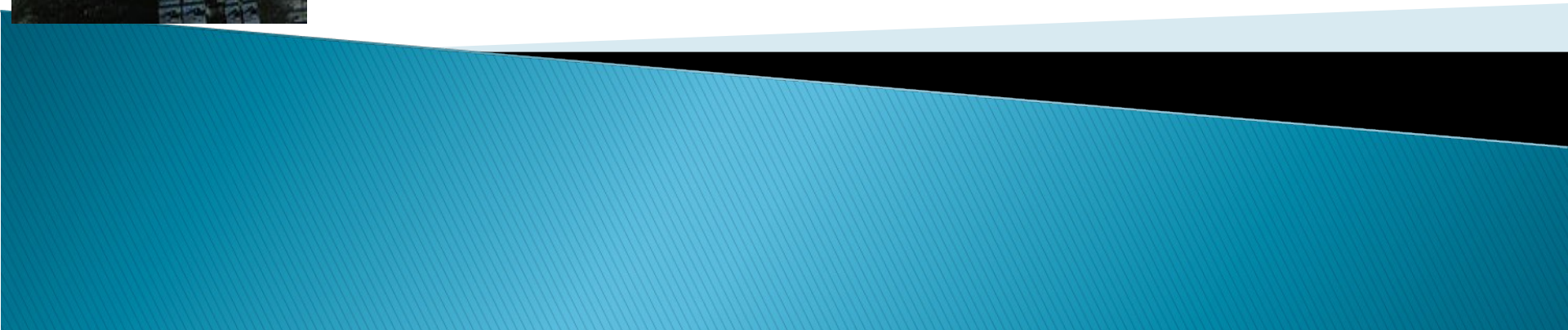
ADDIS ABABA SCIENCE & TECHNOLOGY UNIVERSITY

SCHOOL OF CIVIL ENGINEERING & COTM

DEPARTEMENT OF COTM

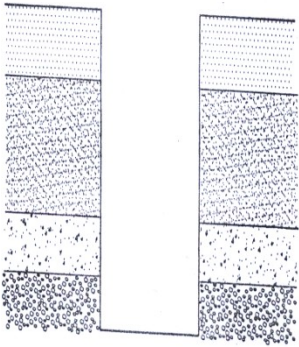
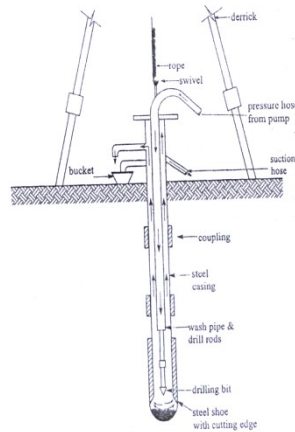
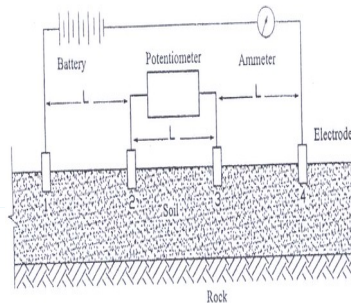
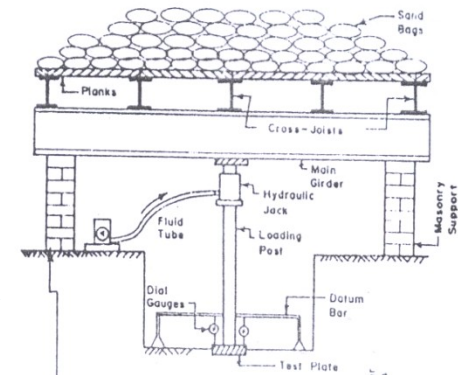
BUILDING CONSTRUCTION - I

CHAPTER-2
FOUNDATION (PART -2)



CONTENTS

- ☐ Introduction
- ☐ Site reconnaissance
- ☐ Site exploration
 - Depth of exploration
 - Spacing of exploration
 - Method of exploration
- ☐ Bearing capacity of a soil
- ☐ Soil samples
- ☐ Review questions



SITE INVESTIGATION AND SUB-SOIL EXPLORATION

1. INTRODUCTION

- Since the foundations have to transfer the load to the sub-soil, surface conditions at any given site must be adequately explored.
- Sub soil investigation is essential to gather information required both for the **design** and **construction** of foundation.
- Sub-soil investigation is done for the following purposes:

A. For New Structures

1. The selection of type and depth of foundations
2. The determination of bearing capacity
3. The prediction of settlement
4. The determination of ground water level
5. The evaluation of earth pressure against walls, basements, etc.
6. The provision against constructional difficulties.
7. The stability of soil and degree of compaction

SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

B. For Existing Structures

1. The investigation of safety of structure
2. The prediction of settlement
3. The determination of remedial measure if the structure is unsafe

□ Reasons for sub-surface investigation:

- ✓ Site suitability
- ✓ Efficient, economic design
- ✓ Anticipate immediate/future problems
- ✓ Confidence in design assumption

SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

2. SITE RECONNAISSANCE

- ❑ An inspection of the site and study of topographical features is often helpful.
- ❑ In site reconnaissance a study of the following features is useful:
 - ♠ Local topography ♠ Excavations ♠ Cuttings
 - ♠ Quarries ♠ Evidence of land slide
 - ♠ fills ♠ Water level in wells
- ❑ If there has been an earlier use of the site, information should be gathered, in particular about:
 - The under ground working if any,
 - Location of fills, and
 - Excavation.

SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

3 SITE EXPLORATION

- The object of site exploration is to provide **reliable, specific** and **detailed** information about the soil and ground water conditions for safe and economic design of foundations.
- Site exploration should yield precise information about the following :
 - i. The order of occurrence and extent of soil and rock strata,
 - ii. The nature and engineering properties of the soil and rock, and
 - iii. The location of ground water and its variation

3.1 Depth of exploration

- Depth (Significant Depth) shall be up to the level where the pressure increase will cause settlement or shear failure of foundations.

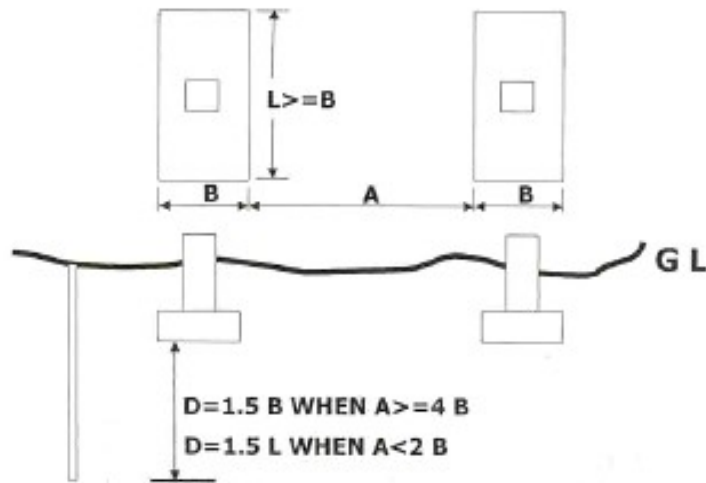
SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

Depth of exploration (Cont...)

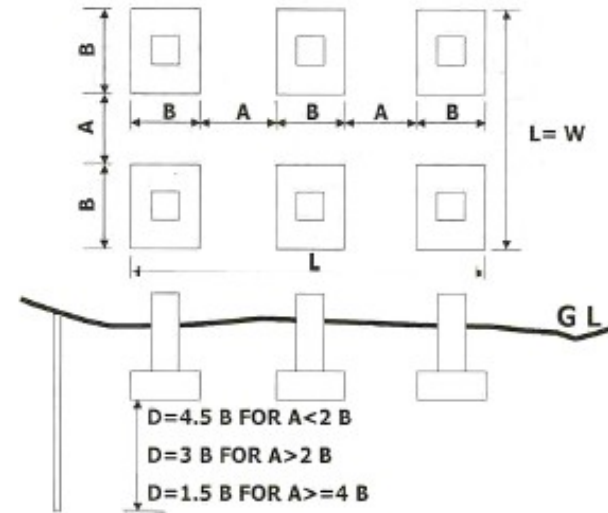
- ❑ Significant depth depends on the type of structure, its weight, size, shape and disposition of loaded areas, and the soil profile and its properties
- ❑ The significant depth may be assumed to be equal to **1.5** to **2.0** times the width of the loaded area.
- ❑ Guide rules for the depth of exploration:
 - 1) Isolated spread footing or raft: 1.5 times the width
 - 2) Adjacent footings with clear spacing less than twice the width: 1.5 times the length
 - 3) Pile foundation: 10 to 30 meters , or more, or at least 1.5 times the width of the structure.
 - 4) Base of the retaining wall: 1.5 times the base width or 1.5 times the exposed height of face of wall, which ever is greater.
 - 5) Floating basements: depth of construction

SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

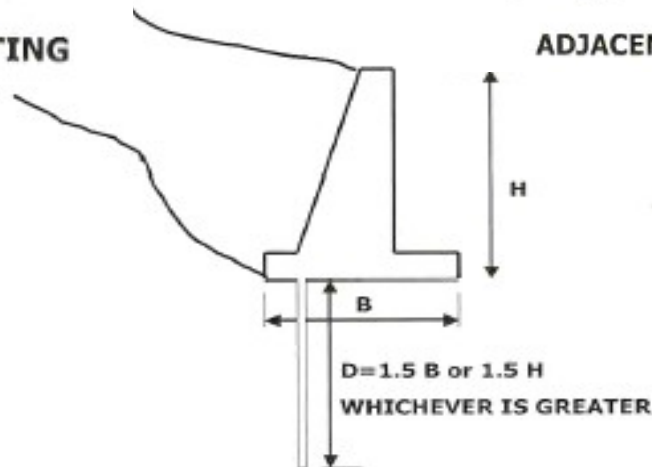
Depth of exploration (Cont...)



ISOLATED SPREAD OR MAT FOOTING



ADJACENT ROWS OF FOOTING



RETAINING WALL

SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

3.2 Spacing of exploration

- ❑ The number of borings should be sufficient so that a reliable model of the subsurface conditions can be established.
- ❑ The boring layout depend on the geology of the site, type of structure to be built, purpose of boring, nature of construction and the sub soil profile.

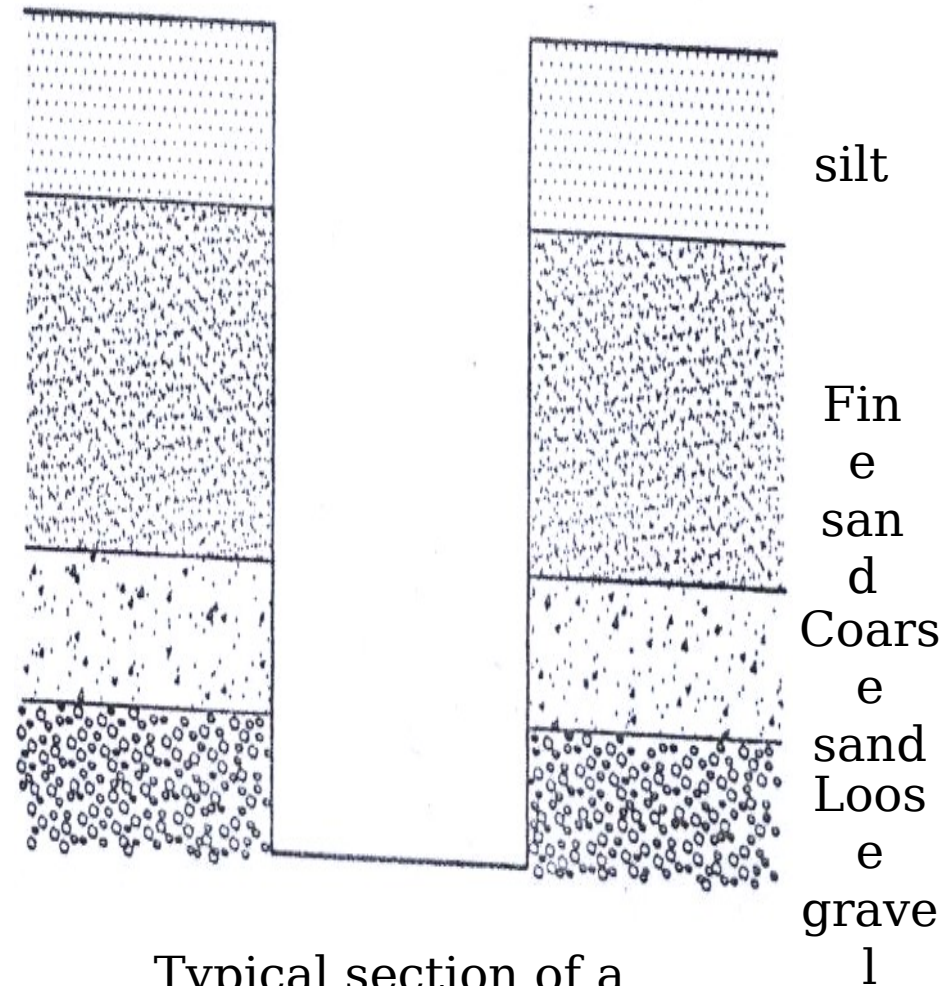
3.3 Methods of site Exploration

- ❑ The choice of particular exploration method depends on **nature of ground, topography** and **cost**.
- ❑ The various methods of site exploration may be grouped as follow:
 1. Open excavations
 2. Borings
 3. Sub-surface soundings
 4. Geophysical methods

SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

3.3.1 Open Excavation (Open Trial Pits)

- ❑ Trial pits are the cheapest method of exploration.
- ❑ Biggest advantage: soil strata can be inspected in their natural condition and samples (disturbed and undisturbed) can be taken.
- ❑ They are suitable for shallow depths, up to 3m.
- ❑ The cost of open excavation increases rapidly with depth.



Typical section of a test pit

SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

3.3.2 Boring Methods

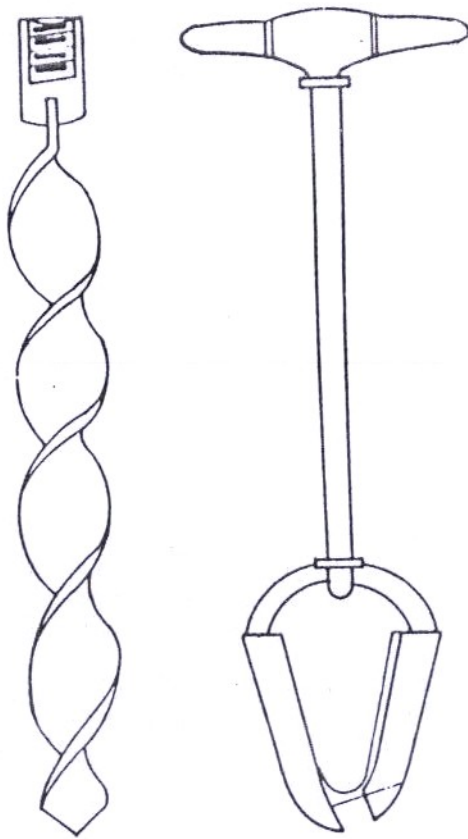
- ❑ Soil borings are probably the most common methods of subsurface exploration.
- ❑ The following are the various boring methods commonly used:
 - i) Auger boring ii) Auger and shell boring
 - iii) wash boring iv) Percussion boring and
 - v) Rotary boring

i. Auger Boring

- ❑ Augers are used in **cohesive** and other **soft soils** above water table.
- ❑ They may either be operated **manually** or **mechanically**.
- ❑ Hand Augers are used up to depth of **6m**.
- ❑ Mechanically operated augers are used for greater depth and they can also be used in gravelly soil.

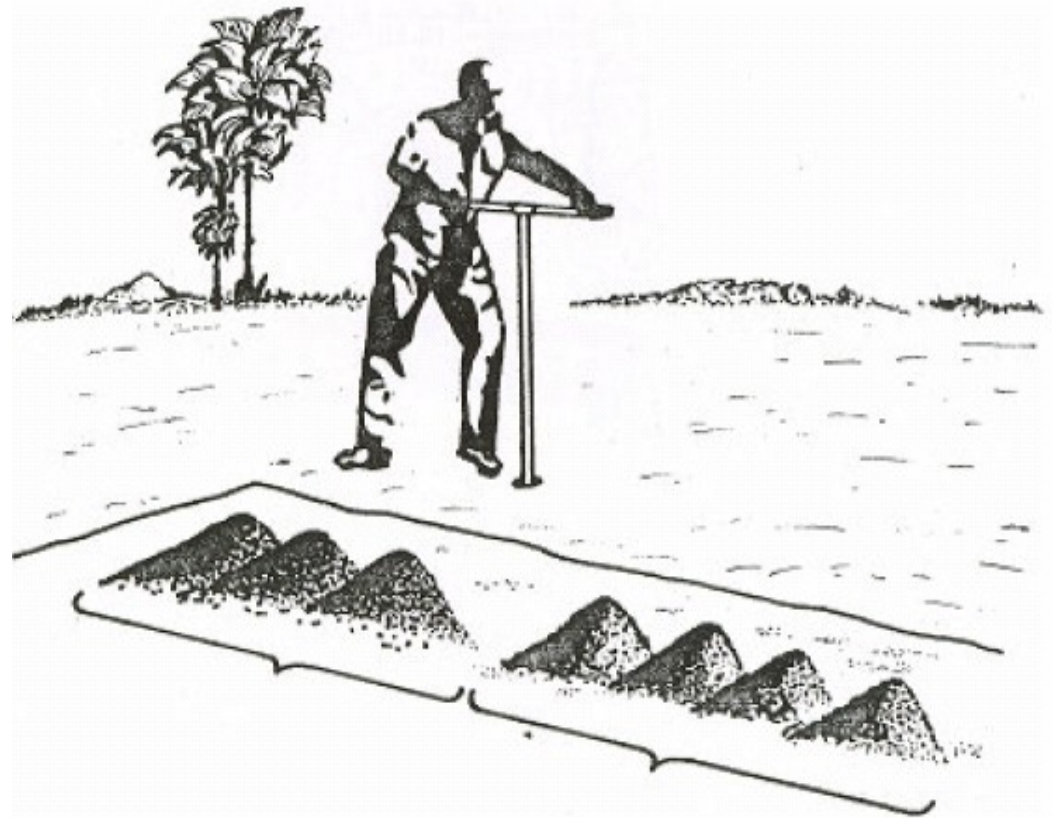
SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

Auger Boring (Cont...)



(a) HELICAL AUGER

(b) POST-HOLE AUGER.

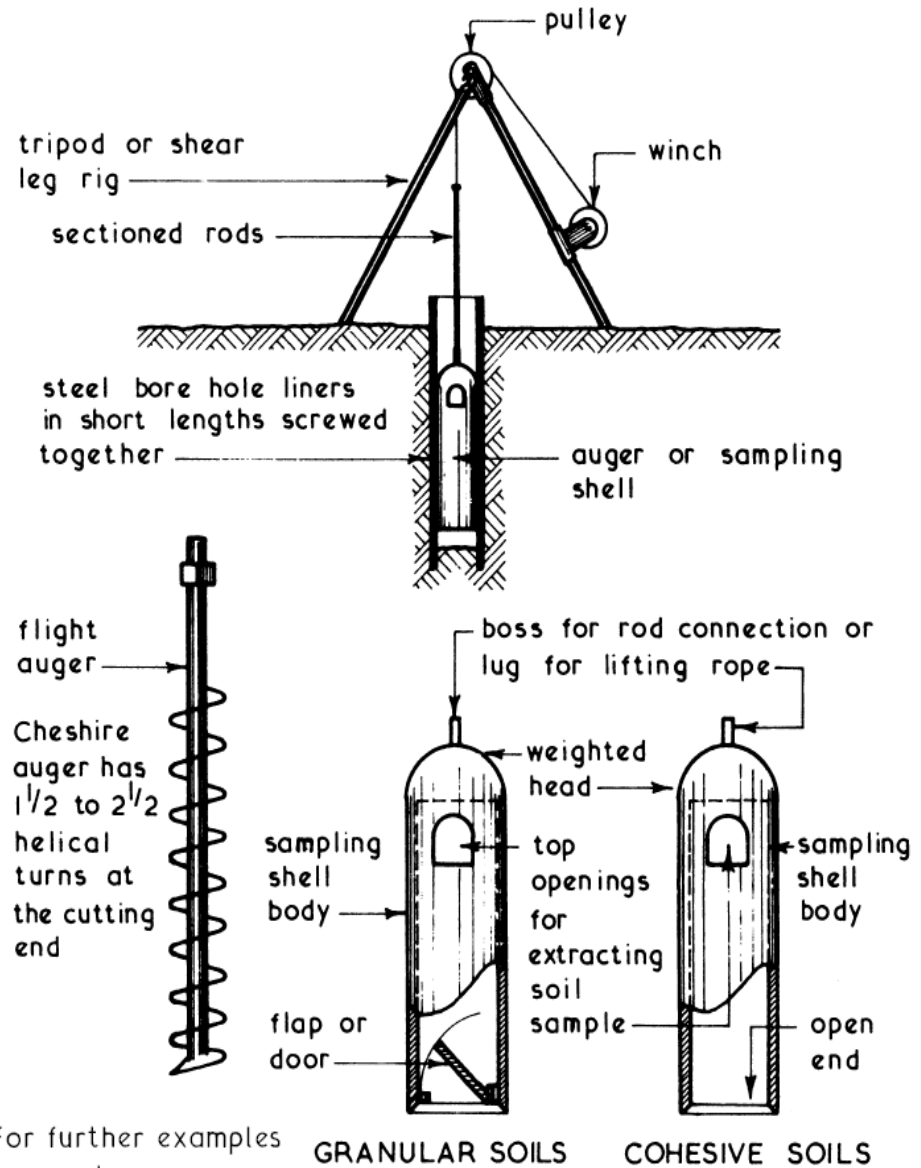


Hand Auger Sampling

SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

ii. Auger and shell Boring

- Cylindrical augers and shells with cutting edge at lower end can be used for deep boring.
- Hand operated rigs are used for depths up to 25m and mechanised rigs up to 50m.
- Augers are suitable for soft to stiff clay, shells for very stiff and hard clays.
- Small boulders, thin soft strata, or rock or cemented gravel can be broken by chisel bits attached to drill rods.



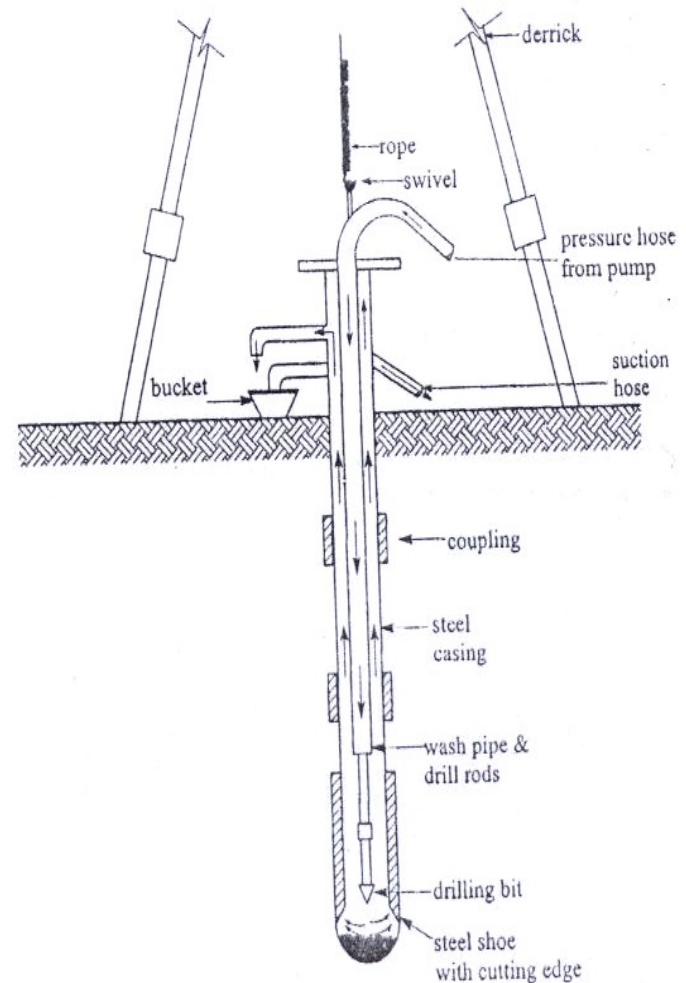
SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

iii. Wash Boring

- Is a fast and simple method for advancing holes in all types of soils.
- Boulders and rocks can't be penetrated by this method.

Steps:

- Driving a casing with hollow drilled rod with sharp chisel or chopping bit
- Forcing water under pressure
- Resulting in Chopping and jetting action
- Forcing the cutting up ward and reviewing the color of wash

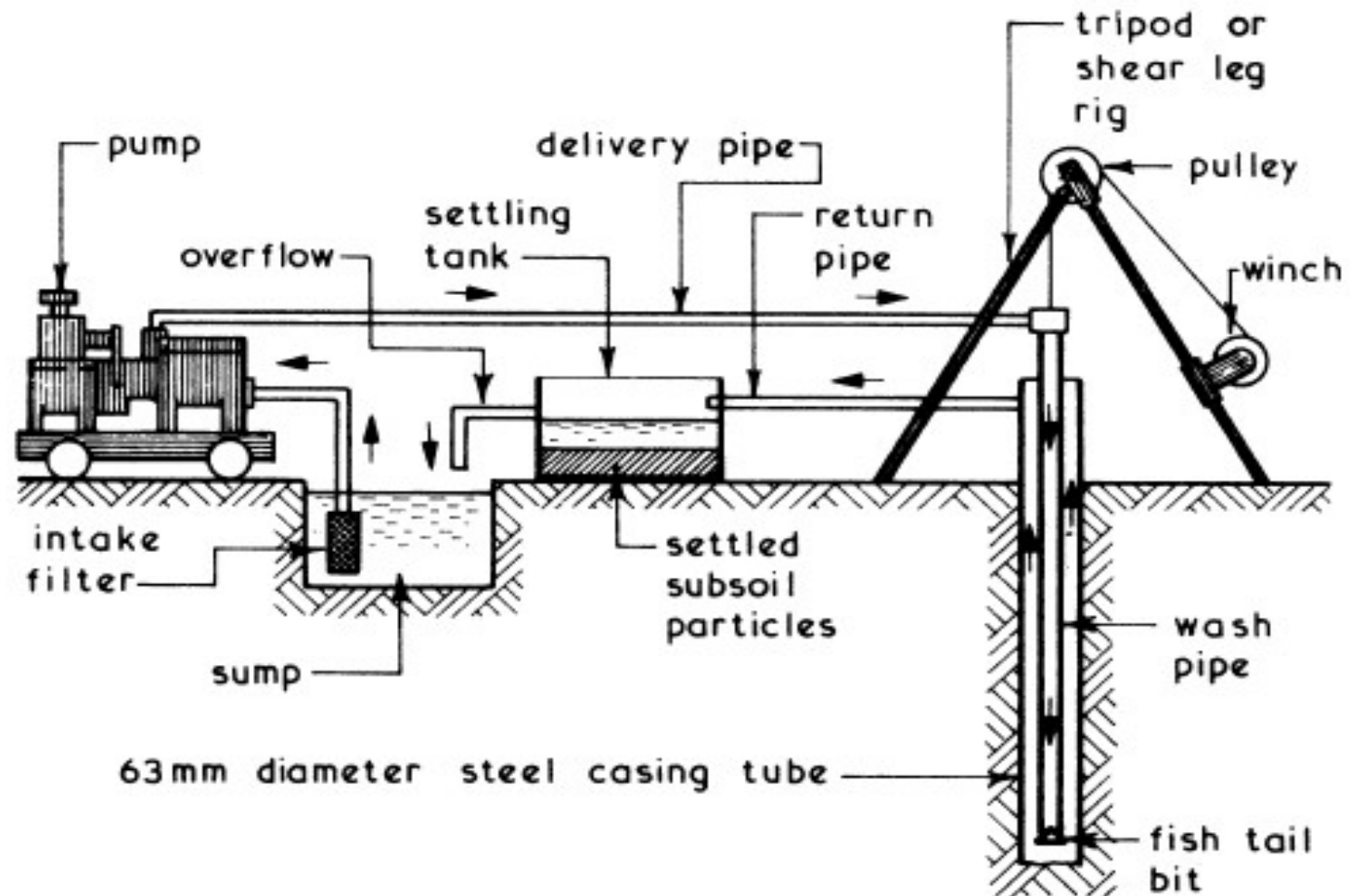


Typical wash boring arrangement

SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

iii. Wash Boring (Cont...)

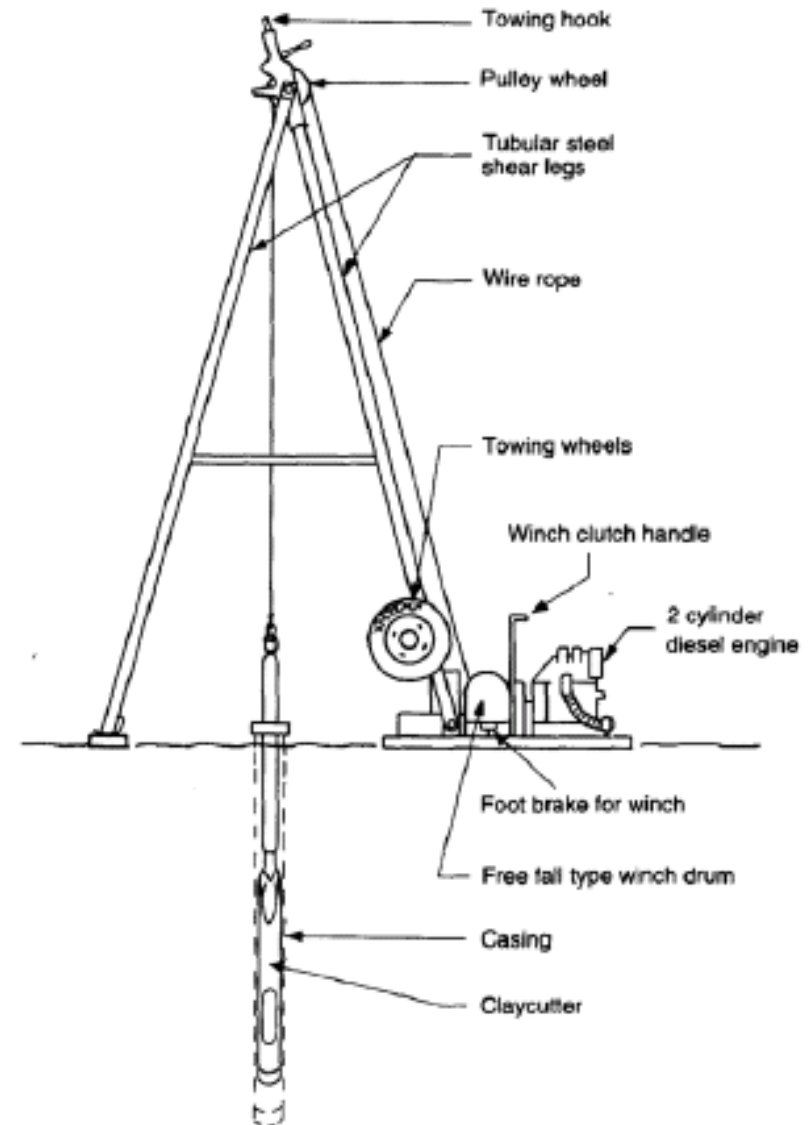
Typical Wash Boring Arrangement ~



SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

iv. Percussion Boring

- Soil and rock formations are broken by repeated blows of heavy chisel or bit suspended by a cable or drill rod
- Water is added to the hole during boring, if not already present.
- Suitable for advancing a hole in all types of soils, boulders and rock.

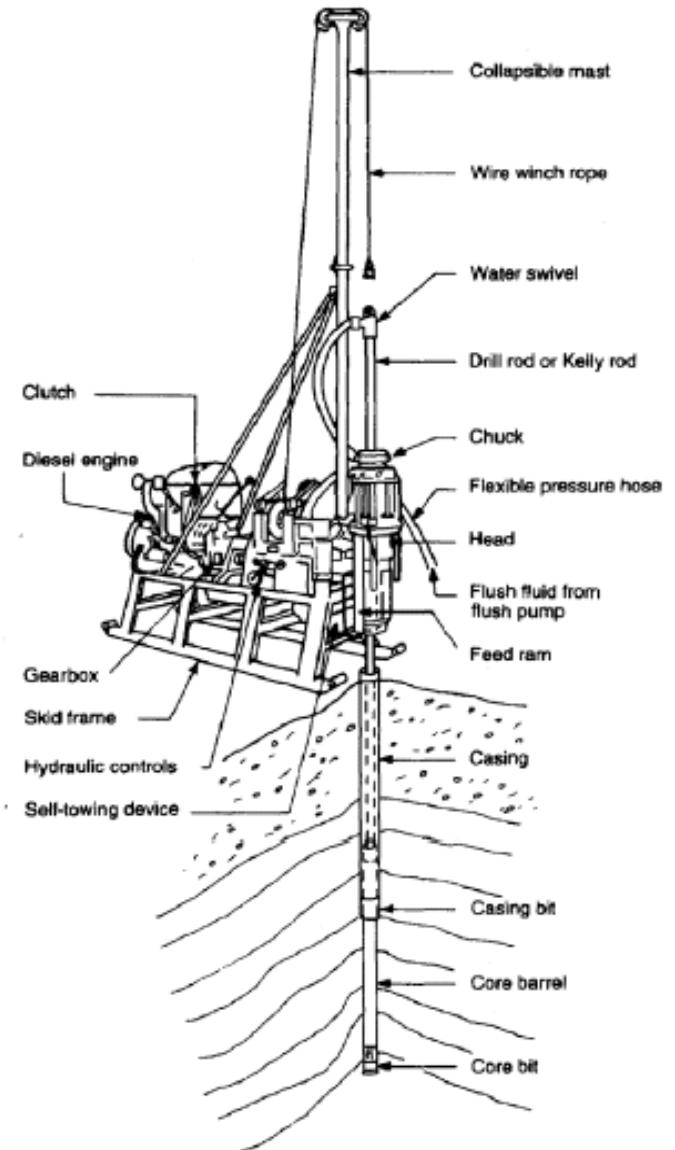


Light percussion
drilling rig

SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

v. Rotary Boring

- ❑ Rotary drilling is a very fast method of advancing hole in both rocks and soils.
- ❑ A drill bit, fixed to the lower end of the drill rods is always kept in firm contact with the bottom of the hole.
- ❑ A water solution of bentonite, with or without admixtures is continuously forced down.
- ❑ The mud coming up wards bring the cuttings to the surface. The method is also known as mud rotary drilling.



Small-scale Rotary
drill rig

SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

Rotary Boring (Cont...)



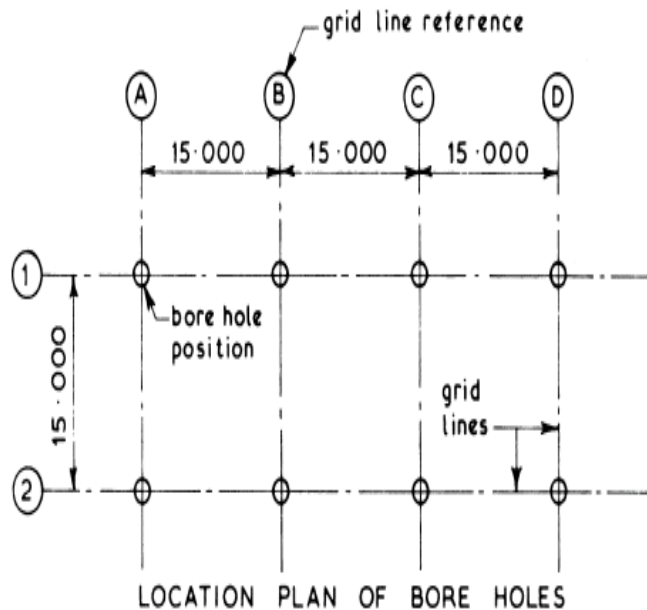
SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

Record of borings

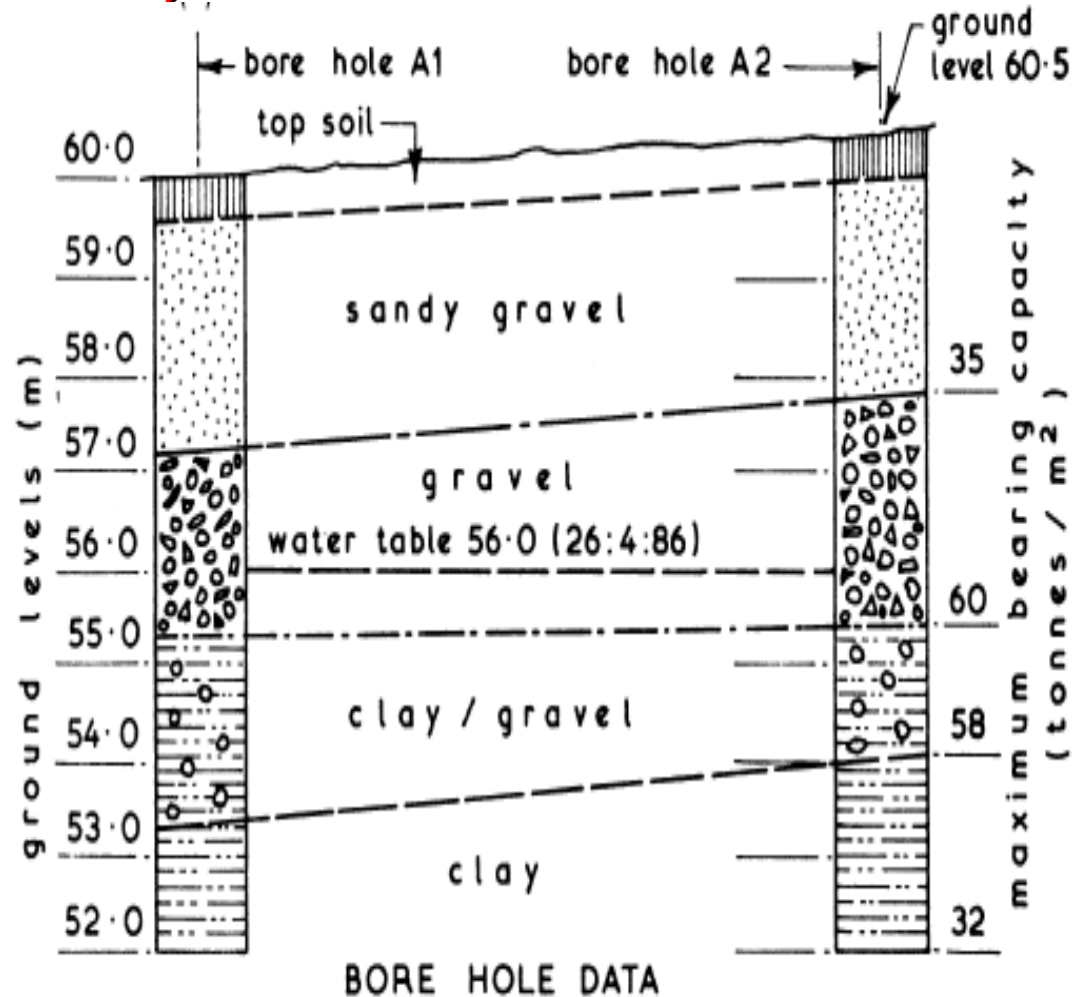
- ❑ In all exploration work accurate and explicit record of borings shall be kept.
- ❑ Soil/rock samples are collected at various depths, during boring.
- ❑ These samples are tested in the laboratory for identification and classification.
- ❑ The samples are properly suitably preserved and arranged serially according to the depth at which they are found.
- ❑ Boring chart should be prepared for each bore hole.
- ❑ A site plan should be prepared, showing the disposition of various bore holes on it.

SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

Record of borings (Cont...)



Bore holes can be taken on a 15.000 to 20.000 grid covering the whole site or in isolated positions relevant to the proposed foundation(s)



SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

3.3.3 Sub-surface soundings

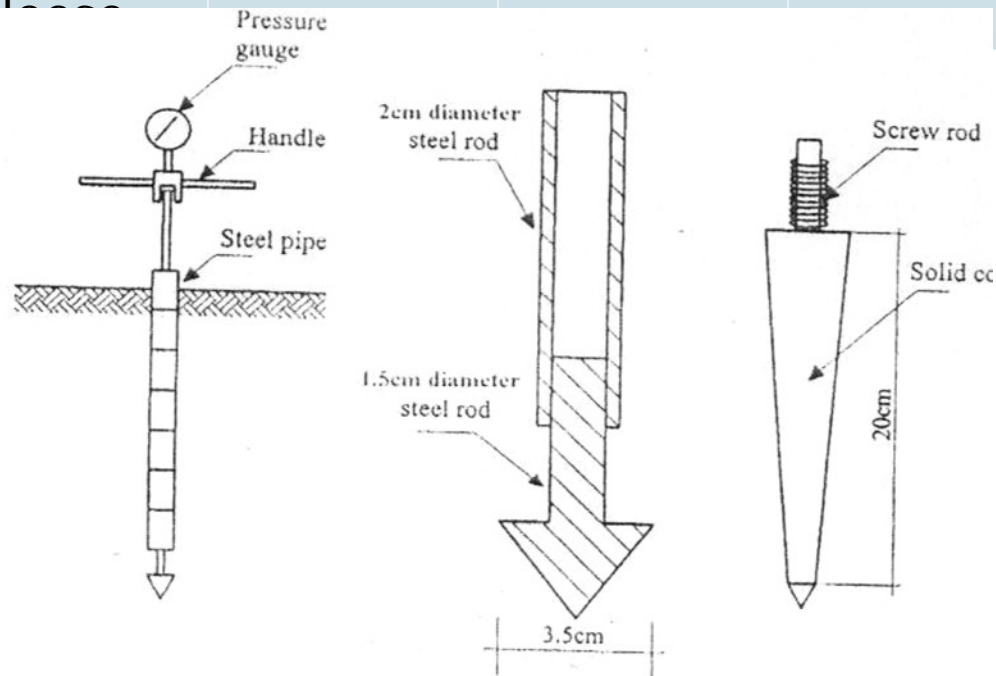
- ❑ Sounding methods consist of measuring the resistance of the soil with depth by a means of **PENETROMETER** under static and dynamic loading.
- ❑ The penetrometer may consist of a sampling spoon, a cone or other shaped tool.
- ❑ The resistance to penetration is empirically correlated with some of the engineering properties of soil, such as density index, consistency, bearing capacity etc.
- ❑ These tests are useful for general exploration of erratic soil profiles, for finding depth to bed rock, to have an approximate indication of the strength and other properties of the soil.
- ❑ The two commonly used tests are :
 - Standard penetration test
 - Cone penetration test

SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

Sub-surface soundings (Cont...)

The Relation between N-values, ϕ , and relative density of sand particles

N	4	4-10	10-30	30-50	>50
ϕ	25-30°	27-32°	30-35°	35-40°	38-43°
Relative density	Very loose	Loose	Medium	Dense	Very dense



Typical types
of
penetrometer
s

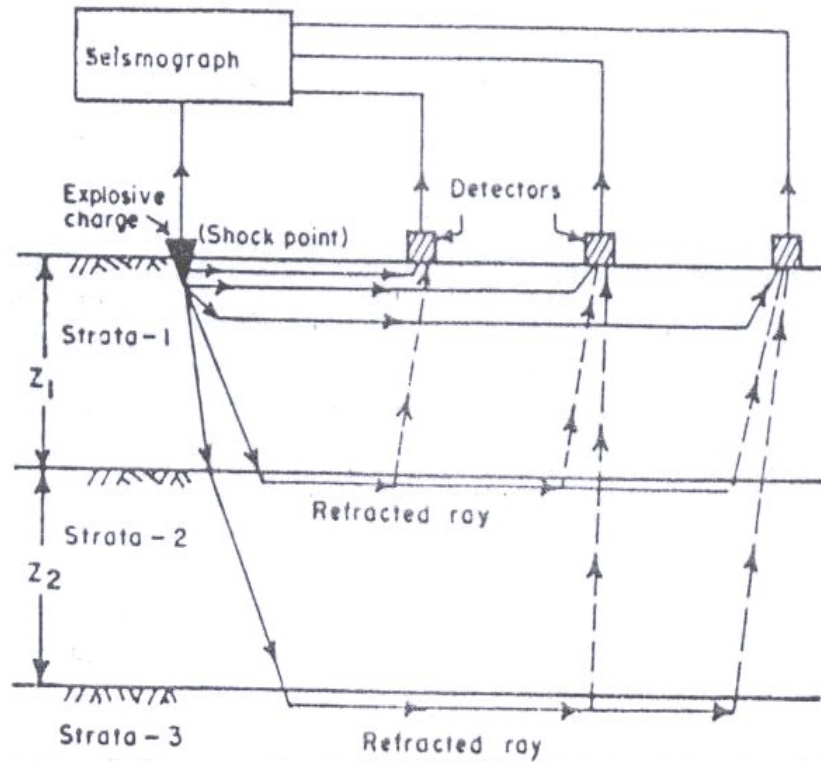
SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

3.3.4 Geo-physical methods

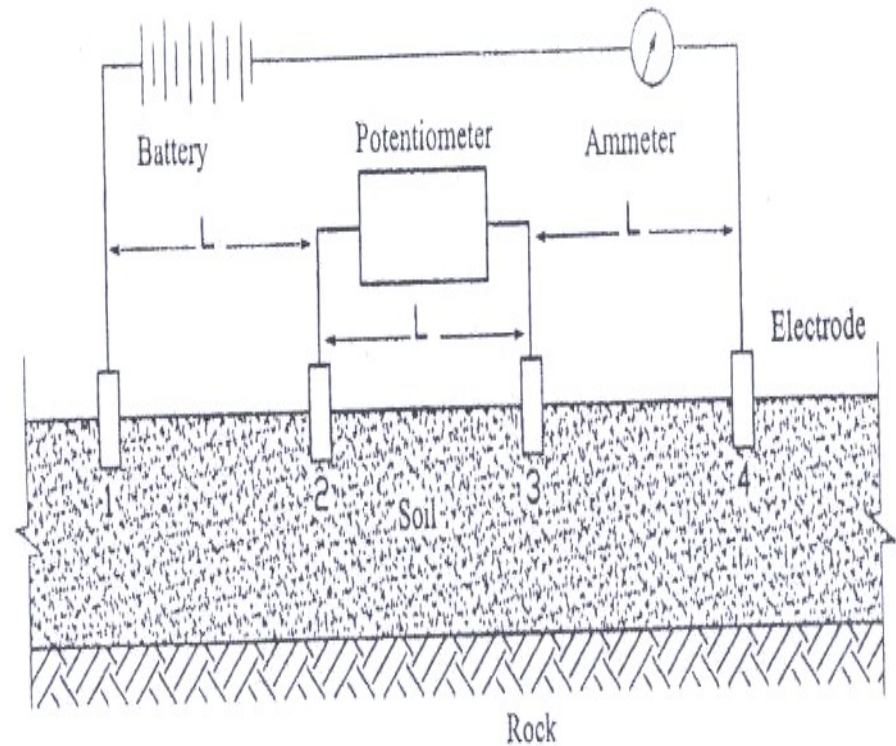
- ❑ They are used when
 - The depth of exploration is very large
 - The speed of investigation is of primary importance.
- ❑ These methods were developed in connection with prospecting of useful minerals and oils.
- ❑ The major method of geophysical investigations are:
 - Gravitational methods
 - Magnetic methods
 - Seismic refraction method
 - Electrical resistivity method
- ❑ **Seismic refraction** and **electrical resistivity** methods are the most commonly used for civil engineering purpose

SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

Geo-physical methods (Cont...)



**Seismic refraction
method**

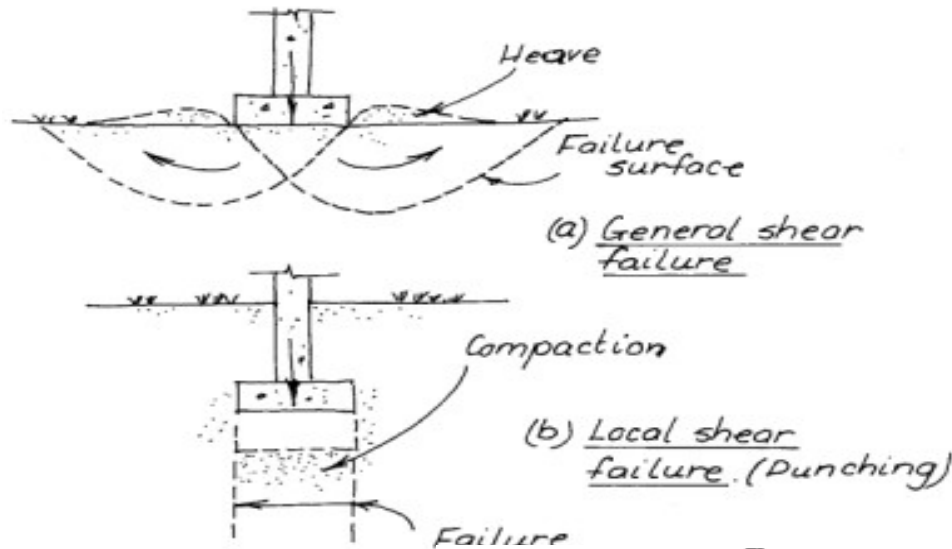


**Resistivity
method**

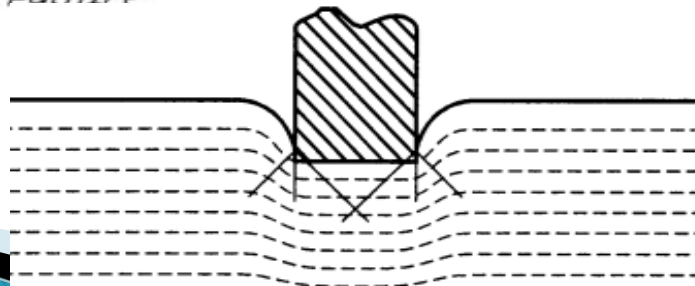
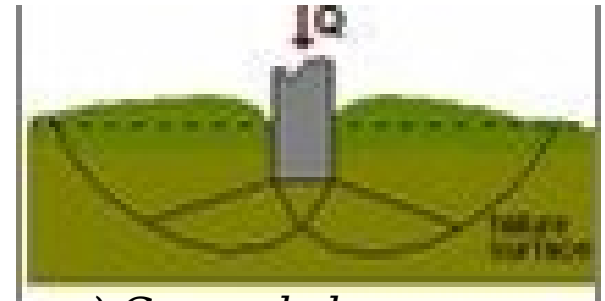
SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

3.4 Bearing capacity of soils

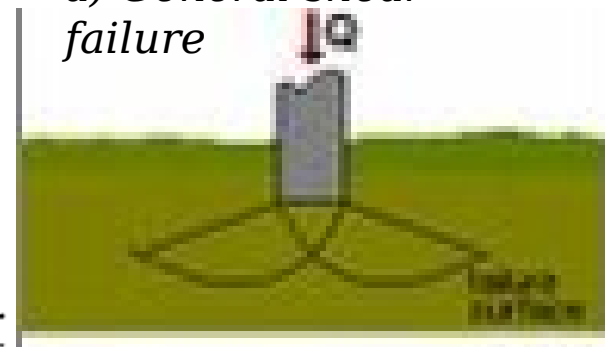
- The supporting power of a soil or rock is referred to as its bearing capacity.
- The ultimate bearing capacity is the minimum gross pressure intensity at the base of the foundation at which the soil fails in shear.



c) Punching shear failure



a) General shear failure

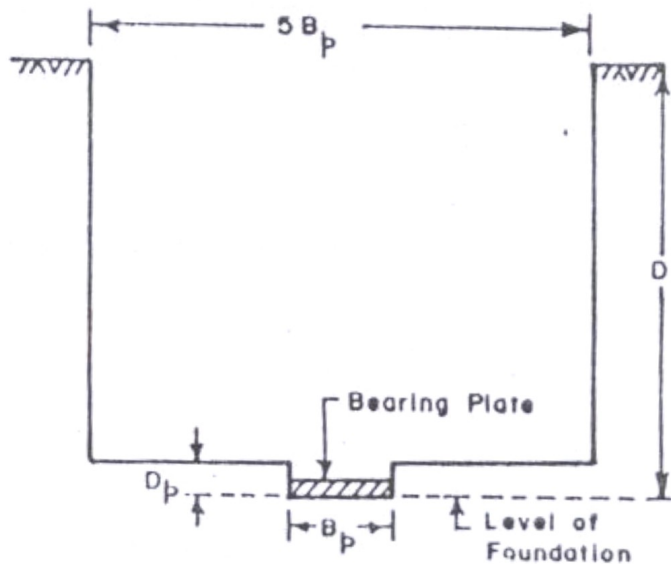


b) Local shear failure

SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

Bearing capacity of soils (cont...)

- The bearing capacity of soil can be determined by:
 - a) Analytical methods involving the use of soil parameter
 - b) Plate load test on soil
 - c) Penetration test



Test Pit

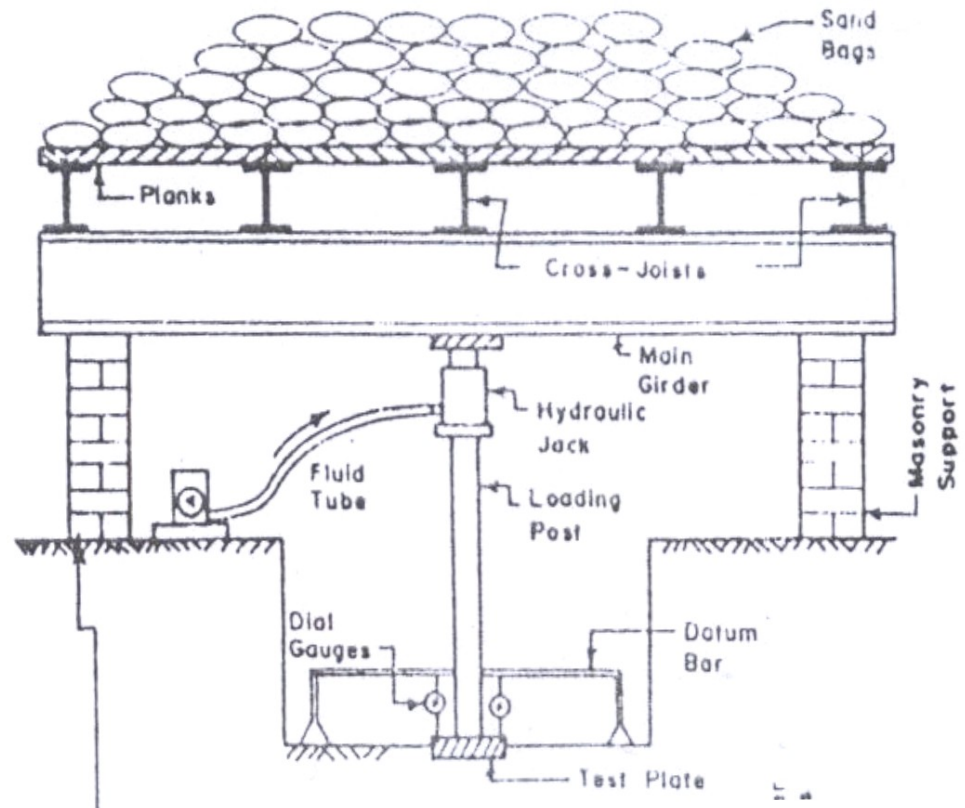


Plate load test: Gravity loading

SITE INVESTIGATION AND SUB-SOIL EXPLORATION (CONT...)

3.5 Soil samples

□ Soil samples can be of two types:

- i. Disturbed samples
- ii. Undisturbed samples.

i. Disturbed sample

- ❖ Disturbed sample is that in which the natural structure of soil gets partly or fully modified and destroyed.
- ❖ The soil sample is representative of the natural soil by maintaining the original proportion of the various particles intact.

ii. Undisturbed sample

- ❖ Undisturbed sample is that in which the natural structure and properties remain reserved.
- ❖ The sample disturbance depends upon the design of the samplers and the method of sampling.

REVIEW QUESTIONS

1. Explain the purposes for which sub-soil investigation is done.
2. In site reconnaissance what are the things we need to examine.
3. How do you decide the depth of exploration? Mention the recommended depth of exploration for various types of foundations.
4. What do you understand by a trial pit? When do you adopt this method?
5. Explain in brief the various methods of boring for sub-soil exploration.
6. What do you understand by a bore hole? How do you maintain the details of various types of strata obtained during boring?
7. Write a short note on sub-surface soundings.
8. What do you understand by geo-physical methods? Enumerate various methods used.

REVIEW QUESTIONS (CONT...)

9. What do you understand by ultimate bearing capacity? Enumerate the different methods to determine the bearing capacity of soil.
10. Explain in detail the plate load test for determining safe bearing capacity of soil.
11. Differentiate clearly between disturbed sample and undisturbed sample.

THANK YOU!